

## Memo

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<b>To:</b>	Steve Raugust	<b>Date:</b>	April 1, 2014
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<b>Project Title:</b>	Copper Flat	<b>Project #:</b>	191000.03
<b>Subject:</b>	Copper Flat Pit Lake Modeling Report Errata		

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SRK Consulting, Inc. (SRK) conducted a predictive geochemical modeling exercise to assess potential future pit lake chemistry associated with the Copper Flat project, New Mexico. This work was undertaken to evaluate the future environmental impacts of the project from a National Environmental Policy Act (NEPA) perspective as well as a State regulatory compliance perspective. The approach and results of the modeling exercise were presented in the '*Predictive Geochemical Modeling of Pit Lake Water Quality at the Copper Flat Project, New Mexico*' report submitted in September 2013 (SRK, 2013). Since the September 2013 report was submitted, an error has been noted relating to the water balance discussion in Section 3.3. This errata has been prepared to provide a correction to the September 2013 report.

Information provided in Section 3.3 on page 20 of the September 2013 report should be revised as follows to be consistent with the final hydrologic model for the pit and the actual values used in the numerical predictions:

- The pit footprint area is **143 acres**;
- The final post-closure water elevation is estimated to be **4,900 feet**;
- The pit lake will have a final surface area of **18.6 acres**; and
- The final pit water balance will be **100 acre-feet** per year, comprising 63 acre-feet per year of precipitation/run-off and 37 acre-feet per year of groundwater inflow.

The correct water balance was used in the numerical predictions; therefore, the reporting error in Section 3.3 does not affect the predicted pit lake chemistry presented in the September 2013 report. The pit water balance stage curves presented in Figure 3-5 and Figure 3-6 of the report are also correct. Therefore, no revisions to the figures or the pit lake model results presented in the September 2013 report are required as a result of this error.

# Predictive Geochemical Modeling of Pit Lake Water Quality at the Copper Flat Project, New Mexico

Report Prepared for

**THEMAC Resources Group Ltd.**



Report Prepared by



SRK Consulting (U.S.), Inc.  
SRK Project Number 191000.03  
September 2013

# **Predictive Geochemical Modeling of Pit Lake Water Quality at the Copper Flat Project, New Mexico**

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Appendix A: Example of PHREEQC Input File

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## Executive Summary

SRK Consulting, Inc. (SRK) has undertaken a predictive geochemical modeling exercise to assess potential future pit lake chemistry associated with the Copper Flat project, New Mexico. This work has been undertaken to evaluate the future environmental impacts of the project from a National Environmental Policy Act (NEPA) perspective as well as a State regulatory compliance perspective. The work forms part of the geochemical characterization study to assess the Acid Rock Drainage and Metal Leaching (ARDML) potential of the project. This report describes the approach taken for the pit lake predictive modeling, details the assumptions made and presents the results of the pit lake geochemical predictions.

The Copper Flat project is a porphyry copper-molybdenum deposit located on the western margin of the Rio Grande Rift. The deposit also contains minor, but potentially recoverable, gold and silver mineralization. The deposit is hosted by a small quartz monzonite stock that intrudes a sequence of andesitic volcanic rocks. Geochemical testwork identified the potential for sulfide bearing rocks in the area to potentially release trace metals and sulfate and have limited generation of acidic drainage. A numerical geochemical predictive model was developed in PHREEQC and calibrated to the existing pit lake to ensure all active geochemical mechanisms could be accounted for.

Waters in the future pit lake at Copper Flat are predicted to be moderately alkaline (pH ~8), primarily due to the buffering capacity of the inflowing groundwater. During the initial stages of pit infilling (i.e., during the first six months post-closure), removal/flushing of soluble salts from the pit walls is likely to result in a flush in sulfate, cadmium, molybdenum, selenium, sodium, chloride and sulfate concentrations in the early pit lake. The effects of this initial flush will be dissipated by inflowing groundwater and precipitation and pit lake chemistry will then evolve over time, with several parameters increasing in concentration as a result of evapoconcentration effects. This is similar to the trends observed in the existing pit lake, where elemental concentrations have increased since the start of pit infilling.

The model simulations demonstrate that all of the modeled chemical parameters are expected to be below New Mexico livestock standards (NMAC 20.6.4.900) in the 100 years post closure pit lake, with the exception of selenium. Vanadium concentrations are reported above the livestock standard; however, due to limitations on mineralogical controls, the current geochemical code over predicts the concentration of vanadium, as demonstrated by the calibration model. Once this is taken into account, vanadium is not expected to exceed the livestock standard.

Mercury concentrations are anticipated to increase over time, but remain below the livestock standard (0.01 mg/L) through year 100, post closure. Mercury concentrations are predicted to be marginally above the wildlife standard of 0.00077 mg/L by year 25. However, this exceedance is minimal, and may not represent a true ecological risk to wildlife within the Copper Flat project area.

SRK has provided NMCC with a plan of action for a Screening Level Ecological Risk Assessment (SLERA) to quantitatively evaluate the potential toxicological risks posed by the future pit lake at Copper Flat. A SLERA is a Tier 1 approach that utilizes both site-specific data and published ecological data to determine if further evaluation of potential ecological risks may be warranted. However, the predicted concentrations of selenium and mercury in the future Copper Flat pit lake are unlikely to present an environmental or ecological risk.



# 1 Introduction

## 1.1 Purpose and Scope

SRK Consulting, Inc. (SRK) has undertaken a predictive geochemical modeling exercise to assess potential future pit lake chemistry associated with the Copper Flat project, New Mexico. The purpose of the exercise is to evaluate the future environmental impacts of the project from a National Environmental Policy Act (NEPA) perspective as well as a State regulatory compliance perspective. The work forms part of the geochemical characterization study to assess the Acid Rock Drainage and Metal Leaching (ARDML) potential of the project. This report describes the approach taken for the pit lake predictive modeling, details the assumptions made, and presents the results of the pit lake geochemical predictions.

## 1.2 Background

The Copper Flat project is a porphyry copper/molybdenum deposit located in the Las Animas Mining District in South Central New Mexico, in Sierra County located approximately 150 miles south of Albuquerque, New Mexico and approximately 20 miles southwest of Truth or Consequences, New Mexico (straight-line distances). Access from Truth or Consequences is by 24 miles of paved highway and 3 miles of all-weather gravel road. The Copper Flat project location is shown in Figure 1-1.

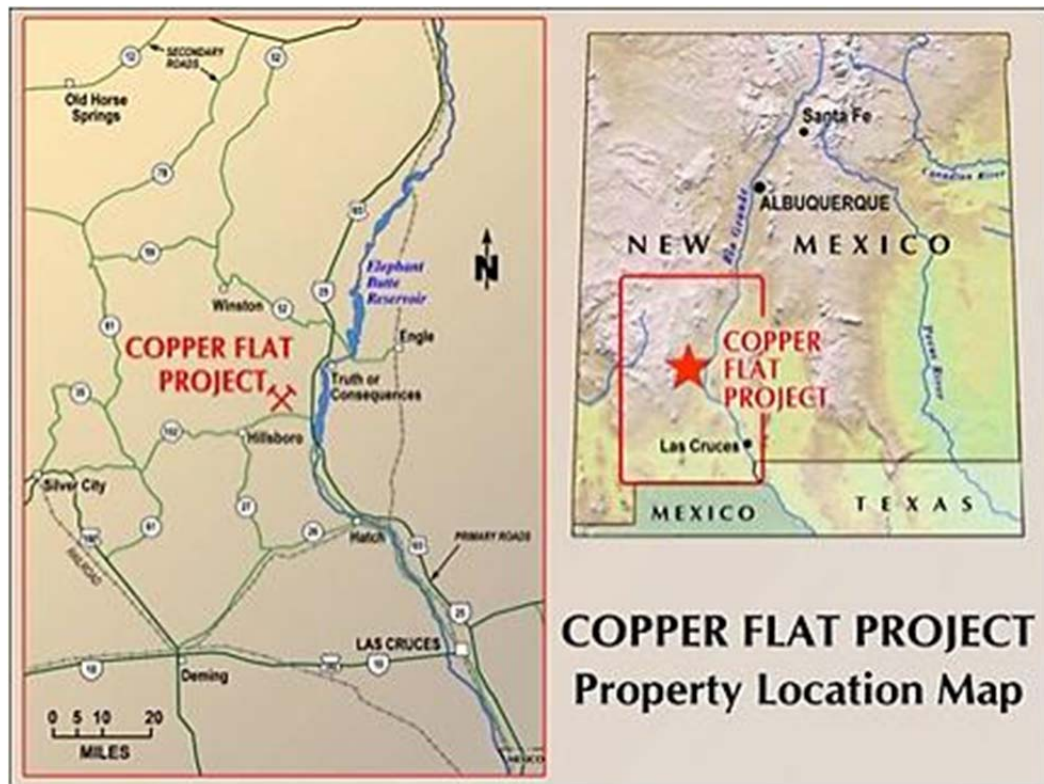


Figure 1-1: Project Location

### 1.2.1 Climate

The regional climate is high desert, and is generally hot with a July average of 76°F (maximum 107°F), and January average of 39°F (record minimum 1°F). The area is generally dry with about 13 inches of average annual precipitation, which occurs mostly as rainfall during July to September.

Winters are cold and dry. Snowfall is possible from October through April, but more typically occurring between December and February. The average annual total is 8 inches of snowfall. Prevailing wind direction is predominantly from the west, and secondarily from the north, and averages 10 to 15 miles per hour. Wind speeds in excess of 50 mph may occur as major storms pass through the area.

### 1.2.2 Prior Mining Operations

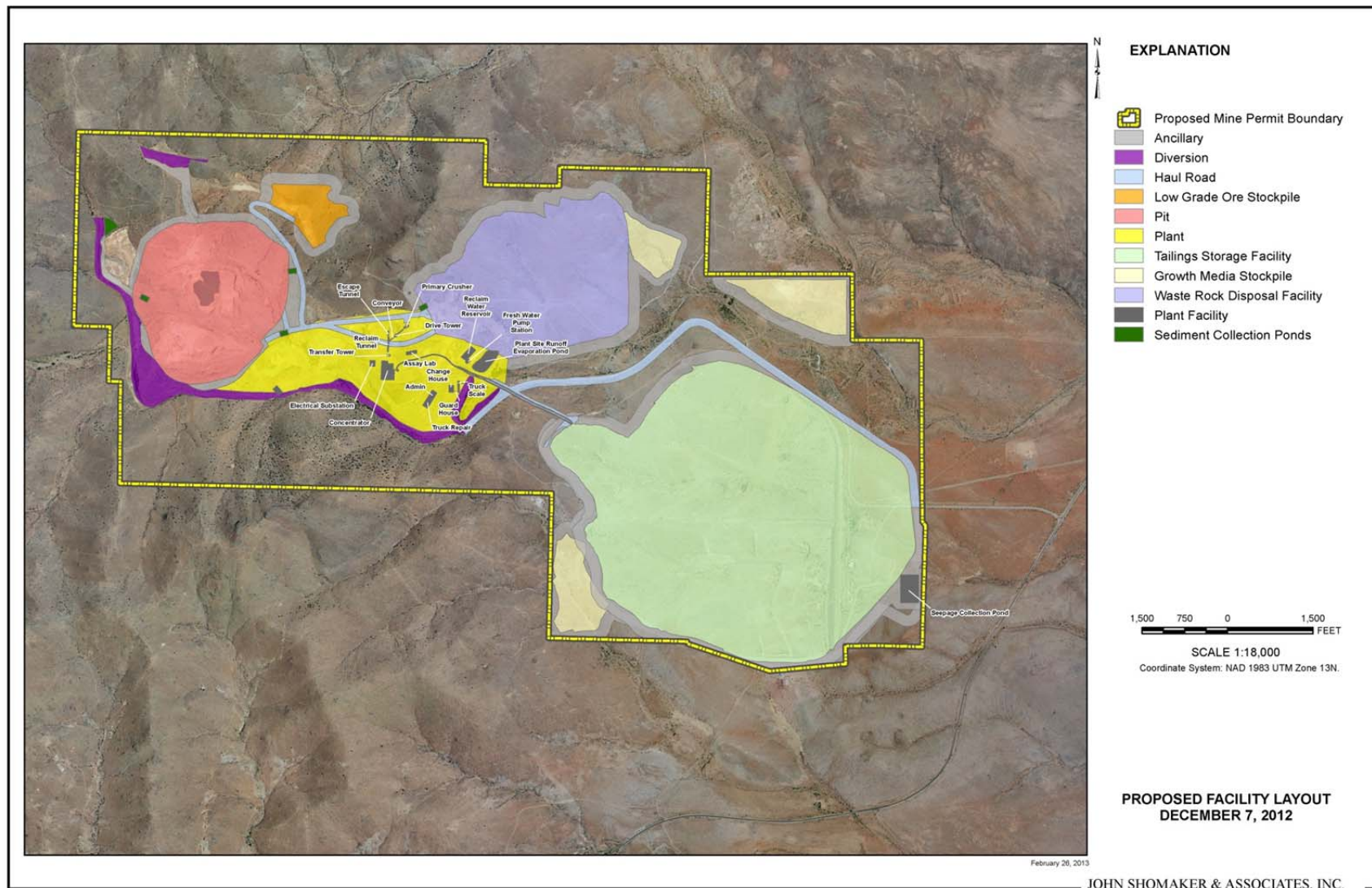
Mining activities in the Hillsboro Mining District began in the 1800s. Gold was mined from shafts and adits at the Copper Flat project and from placer workings developed along drainages to the east and southwest of Black and Animas Peaks. Gold mining was further developed during the early 1900s and continued until World War II. Today, small scale placer mining continues. Copper exploration began in the 1950s and continued to the early 1980s, when Quintana Minerals Corporation defined 60 Mt of reserves sufficient to operate for a 10 year mine life at an extraction rate of 15,000 tons per day (tpd). Operations included the development of the open pit, waste rock piles, TSF and other mine disturbances observed today, but mining stopped after 3 months due to low metal prices. No commercial mining activities have occurred at Copper Flat since 1982. The mine was under maintenance status until 1986, when mine facilities were dismantled and some areas were partially reclaimed. During the 1990s several companies submitted plans to reopen the mine but none of the plans were realized. Existing surface disturbances and facilities in the project area include the following:

- A pit lake;
- Waste rock disposal facilities (WRDFs);
- Mine and mill foundations (buildings have been removed);
- Site grading and roads;
- A 115-kilovolt power line;
- A 20-inch welded steel water line from the production well field to the base of the tailings storage facility (TSF);
- A diversion channel re-routing Grayback Arroyo around the mine site; and
- A TSF containing approximately 1.2 Mt of tailings from historic mining operations.

### 1.2.3 Mine Plan

The proposed project consists of an open pit mine, flotation mill, TSF, WRDFs, a low grade ore stockpile (LGOS) and ancillary facilities. The proposed project is expected to produce approximately 100 million tons of copper ore and 60 million tons of waste rock during the mine life, with extraction taking place by conventional truck and shovel methods using 30-foot high benches. Because the deposit cannot be mined sequentially, backfilling of the pit will not take place.

Beneficiation will be achieved through the use of a conventional concentrator using standard crushing, grinding and flotation technologies. Milling will also include a molybdenum processing circuit. The nominal ore throughput rate is 25,000 tpd and an operational life of approximately 11 years is projected. The proposed layout of the mine facilities is shown in Figure 1-2.



**Figure 1-2: Copper Flat Facility Layout**

From: THEMAC Resources Group Ltd (2012). Mine Operation and Reclamation Plan, Copper Flat Mine Project, Sierra County, New Mexico.

## 1.2.4 Geology and Mineralization

The Copper Flat project is a porphyry copper-molybdenum deposit located on the western margin of the Rio Grande Rift. The deposit also contains minor, but potentially recoverable, gold and silver mineralization. The deposit is hosted by a small quartz monzonite stock having a porphyritic texture that intrudes a sequence of andesitic volcanic rocks of similar age covering an area approximately 4 miles in diameter.

### Regional Geology

The Copper Flat project lies within the Mexican Highlands portion of the Basin and Range Physiographic Province. The project is located in the Hillsboro Mining District in the Las Animas Hills, which are part of the Animas Uplift, a horst on the western edge of the Rio Grande valley. The Animas Uplift is separated from the Rio Grande by nearly 20 miles of Santa Fe Group alluvial sediments, referred to as the Palomas Basin of the Rio Grande valley. To the west of the Animas Uplift is the Warm Springs valley, a graben that parallels the Rio Grande valley. Further west, the Black Mountains form the backbone of the Continental Divide, rising to about 9,000 feet above sea level. The regional geology is discussed in more detail in the *Baseline Data Report for the Copper Flat Mine* (BDR) (INTERA, 2012). The focus of this report is on the local and Copper Flat ore body geology.

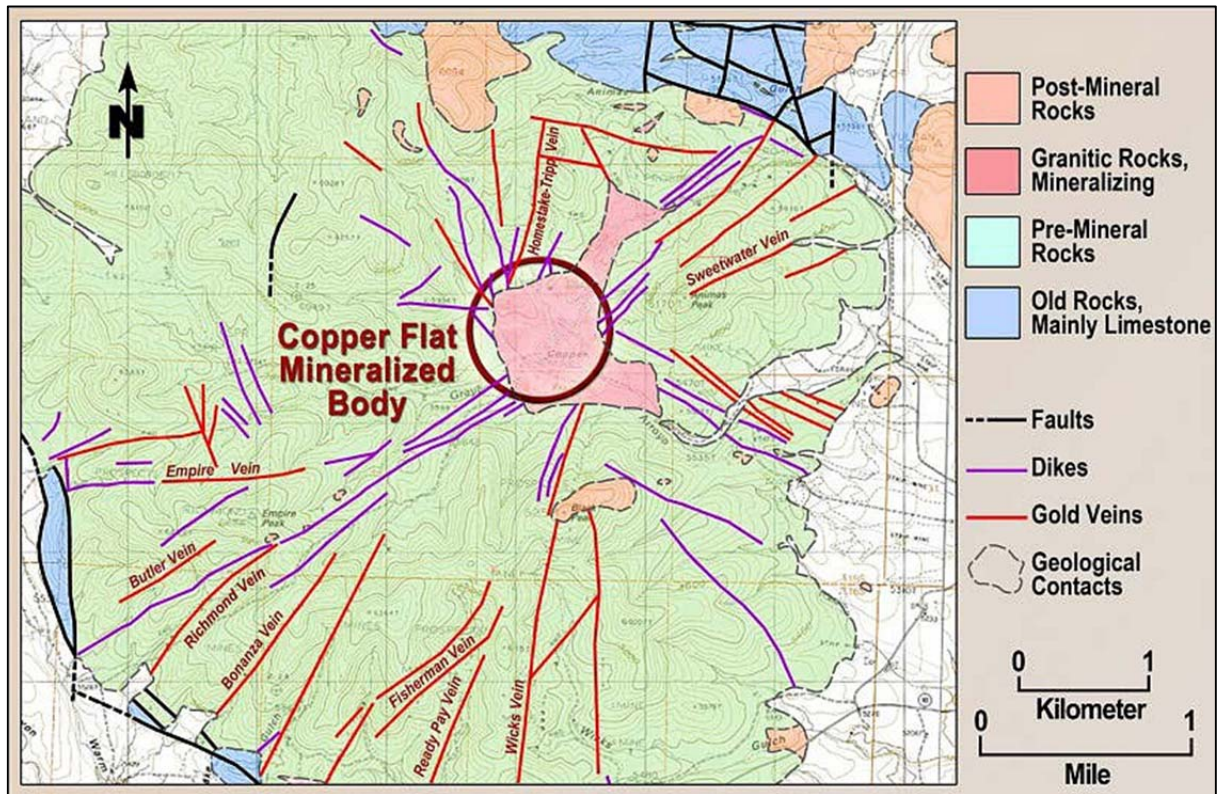
Basement rocks in the area consist of Precambrian granite and Paleozoic and Mesozoic sandstones, shales, limestones, and evaporites. Sedimentary units that crop out within the Animas Uplift include the Ordovician Montoya Limestone, the Silurian Fusselman Dolomite, and the Devonian Percha Shale. The Cretaceous-age Laramide orogeny, which was characterized by the intrusion of magma associated with the subduction of the Farallon plate beneath the North American plate, affected this region between 75 and 50 million years ago (Ma). Volcanic activity during the late Cretaceous and Tertiary periods resulted in localized flows, dikes, and intrusive bodies, some of which were associated with the development of the nearby Tertiary Emory and Good Sight-Cedar Hills calderas. Later basaltic flows resulted from the tectonic activity associated with the formation of the Rio Grande rift. Tertiary and Quaternary alluvial sediments of the Santa Fe Group and more recent valley fill overlie the older Paleozoic and Mesozoic units in the area.

### Local Geology

The district geology described below is modified from McLemore et al. (2000) and Raugust (2003). The predominant geologic feature of the Hillsboro Mining District is the Cretaceous Copper Flat stratovolcano, a circular body of Cretaceous andesite that is 4 miles in diameter (Figure 1-3). The Hillsboro Mining District comprises the Las Animas Hills, a low range formed by the Animas Hills horst at the western edge of the Rio Grande Rift. Faults that bound the Animas Hills horst are related to the tectonic activity of the Miocene-age Rio Grande Rift (Dunn, 1982). Due to the difference in ages and in spite of its close proximity, there is no known connection between the Rio Grande rift and the Copper Flat volcanic/intrusive complex. The Copper Flat volcanic/intrusive complex has been interpreted as an eroded stratovolcano based on the presence of agglomerate and flow band textures in some of the andesite (Richards, 2003).

The Copper Flat Quartz Monzonite (CFQM) intrudes the core of the volcanic complex. The CFQM stock has a surface expression of approximately 0.4 mi<sup>2</sup> and has been dated by the argon-argon (<sup>40</sup>Ar/<sup>39</sup>Ar) techniques to be 74.93 ± 0.66 million years old (McLemore et al., 2000). The surrounding andesite has also been dated using argon-argon techniques to be 75.4 ± 3.5 million years old (McLemore et al., 2000).





**Figure 1-3: Geology of the Copper Flat Mine (Dunn, 1982)**

### **Geology of the Copper Flat Orebody**

The Copper Flat andesite is generally fine-grained with phenocrysts of plagioclase (andesine) and amphibole in a groundmass of plagioclase and potassium feldspar and rare quartz. Some agglomerates or flow breccias are locally present, but the andesite is generally massive. Magnetite is commonly associated with the mafic phenocrysts, and accessory apatite is commonly found.

Although the depth of erosion is uncertain, the center of the stratovolcano was eroded to form a topographic low. To the east of the site, this andesite body is in fault contact with Santa Fe Group sediments, which are at least 2,000 feet thick in the immediate Copper Flat area and thickening to the east. Near-vertical faults characterize the contacts on the remaining perimeter of the andesite body; these faults juxtapose the andesite with Paleozoic sedimentary rocks. Historical drill holes indicate the andesite is locally more than 3,000 feet thick. This feature, combined with the concentric fault pattern, indicate that the local geology represents a deeply eroded Cretaceous-age volcanic complex. A detailed geologic map of the Copper Flat orebody is provided in Figure 1-4 and a south-north geologic cross section through the Copper Flat orebody is provided in Figure 1-5.

Copper Flat Quartz Monzonite (CFQM) intrudes the core of the volcanic complex. Sulfide mineralization is present as veinlets and disseminations in the CFQM, but is most strongly developed in and adjacent to the west end of a steeply dipping breccia pipe that is centrally located within the CFQM stock and elongated in the northwest-southeast direction (Figure 1-5).



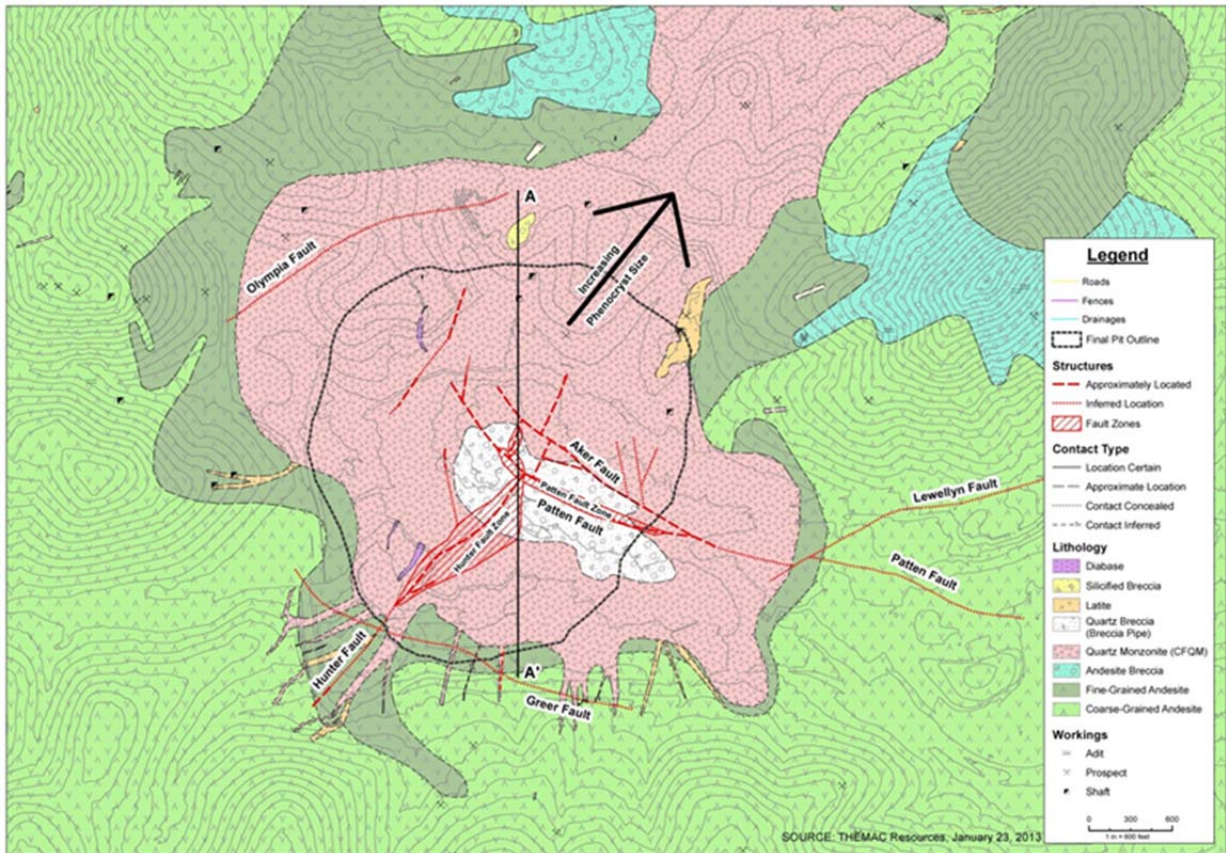


Figure 1-4: Detailed Geologic Map of the Copper Flat Orebody (THEMAC, 2013)

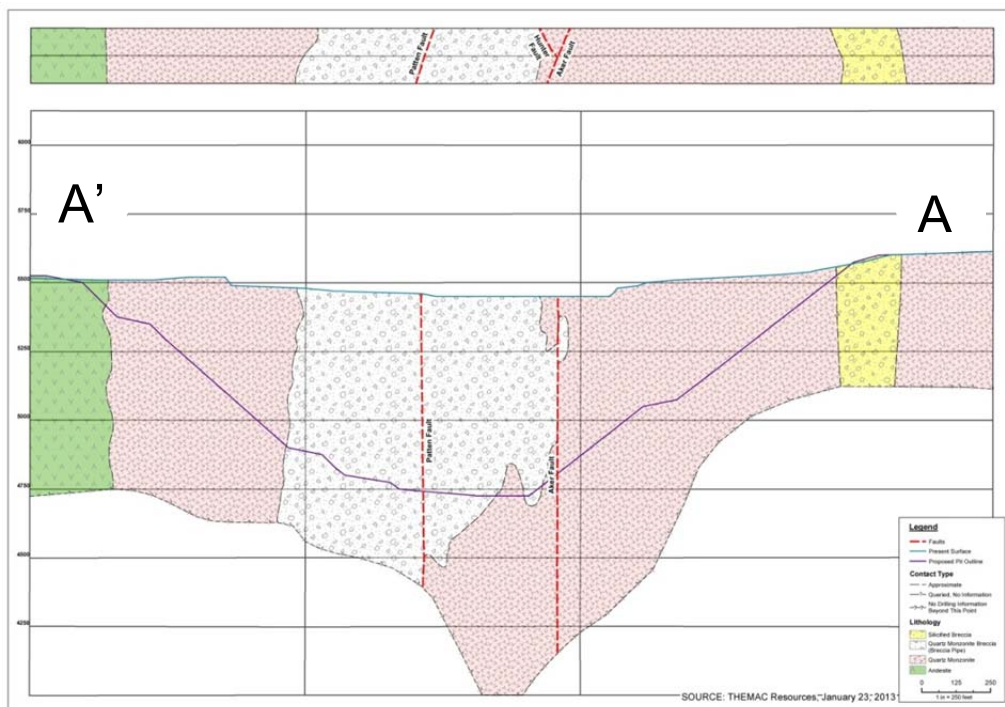


Figure 1-5: Geologic Cross Section through the Copper Flat Orebody (THEMAC, 2013)

## Lithology

The CFQM intruded into the center of the andesite sequence at the intersection of two principal structures that trend respectively N50°W and N20°E. The CFQM is an irregular-shaped stock underlying a surface area of approximately 0.40 square miles and has been dated to approximately 75 Ma. In the few exposures in which the CFQM is in contact with the andesite, the andesite shows no obvious signs of contact metamorphism. The CFQM is a medium- to coarse-grained, holocrystalline porphyry composed primarily of potassium feldspar, plagioclase, hornblende, and biotite; trace amounts of magnetite, apatite, zircon, and rutile are also present, along with localized mineralized zones containing pyrite, chalcopyrite, and molybdenite. About 15 percent of the monzonite is quartz, which occurs both as small phenocrysts and as part of the groundmass; however, quartz is absent in some parts of the stock.

Numerous dikes, some of which are more than a mile in length and mostly of latite composition, radiate from and cut the CFQM stock. Most of the dikes trend to the northeast or northwest and represent late stage differentiation of the CFQM stock. Diabase has been mapped in contact with the CFQM at Copper Flat. Immediately south of the quartz monzonite, the andesite is coarse-grained, perhaps indicating a shallow intrusive phase. An irregular mass of andesite breccia along the northwestern contact of the quartz monzonite contains potassium feldspar phenocrysts and andesitic rock fragments in a matrix of sericite with minor quartz. This may represent a pyroclastic unit. Magnetite, chlorite, epidote, and accessory apatite are also present in the andesite breccia.

## Structure

Three principal structural zones are present at Copper Flat, the most prominent of which is a northeast-striking fault that trends N 20°-40°E that includes the Hunter and parallel faults or the Hunter fault zone. In addition, west-northwest striking zones of structural weakness (N50°-70°W) are marked by the Patten and Greer faults, and east-northeast striking zones are marked by the Olympia and Lewellyn faults. All faults have a near-vertical dip; the Hunter fault system dips 80°W, the Patten dips approximately 70°S-80°S, and both the Olympia and Lewellyn fault systems dip between 80°S and 90°S. These three major fault zones appear to have been established prior to the emplacement of the CFQM and controlled subsequent igneous events and in the case of the Patten and Hunter controlled mineralization.

As previously stated, the CFQM emplacement is largely controlled by the three structural zones. The southern contact parallels and is cut by the Greer fault, although the contact is cut by the fault, and the southeastern and northwestern contacts are roughly parallel to the Olympia and Lewellyn faults, respectively. The CFQM stock is principally elongated along the Patten fault, as well as along the Hunter fault zone.

Although latite dikes strike in all the three principal fracture directions, most of the dikes strike northeast. The northeast trending fault zones contain a high proportion of wet gouge, often with no recognizable rock fragments. Reportedly in underground exposures the material comprising the Hunter fault zone has the same consistency as wet concrete and has been observed to flow in underground headings. Based on recent drilling the Patten fault consists of a mixture of breccia and gouge. However, the material in the east-northeast fault zones contains only highly broken rock and minor gouge. The width of individual structures in all three systems varies along strike from less than a foot to nearly 25 feet in the Patten fault east of the Project. Despite intense brecciation, the total displacement along the faults does not appear to exceed a few tens of feet. At the western edge of the CFQM intrusion, a younger porphyritic dike was emplaced in a fault that offsets an early latite dike, indicating that fault movement occurred during the time that dikes were being emplaced.

Post-dike movement is evident in all the three principal fault zones, and both the Hunter and Patten fault systems show signs of definite post-mineral movement. Fault movement has smeared sulfide deposits and offset the breccia pipe as well as the zones within the breccia pipe. Post-mineral

movement along faults has resulted in wide, strongly brecciated fault zones. Some of the post-mineral dikes have been emplaced within these fault zones.

NMCC has mapped the pit area and diversion cuts in detail at 1 inch equals 40 feet (1:480) and has examined the pre- and post-mineral stress orientations in the andesite and CFQM. Findings indicate no significant difference in the stress fields before and after mineralization. During NMCC's mapping efforts, the Greer and Olympia previously mapped fault locations could not be verified; therefore, these faults were labeled as inferred.

## Mineralization

The CFQM hosts mineralization dominated by pyrite and chalcopyrite with subsidiary molybdenite, minor bornite and minor but recoverable amounts of gold and silver. The mineralization is focused along intersecting northeast- and northwest-trending faults, and these intersections may have originally controlled emplacement of the CFQM.

Although copper occurs almost exclusively as chalcopyrite locally accompanied by trace amounts of bornite, minor amounts of chalcocite and copper oxide minerals are locally present near the surface and along fractures. The supergene enrichment typical of many porphyry copper deposits in the Southwest is virtually non-existent at Copper Flat. During the early mining days, a 20 to 50-foot leached oxide zone existed over the ore body, but this material was stripped during the mining activities that occurred in the early 1980s. Most of the remaining ore is unoxidized and consists primarily of chalcopyrite and pyrite with some molybdenite and locally traces of bornite, galena and sphalerite. Recently completed mineralogical studies indicate that fine grained disseminated chalcopyrite is often intergrown with pyrite and occurs interstitial to silicate minerals. Deposition of chalcopyrite and molybdenite (76.2 Ma) occurred within the same mineralizing event as the pyrite.

Sulfide mineralization is present as veinlets and disseminations in the CFQM, but is most strongly developed in and adjacent to the west end of a steeply dipping breccia pipe, that is centrally located within the CFQM stock and elongated in the northwest-southeast direction roughly along, but south of the Patten fault. The sulfide mineralization first formed in narrow veinlets and as disseminations in the quartz monzonite with weakly developed sericitic alteration. This stage of mineralization was followed by the formation of the breccia pipe with the introduction of coarse, "clotty" pyrite and chalcopyrite along with veinlet controlled molybdenite and milky quartz, and the development of strong potassic alteration.

The breccia pipe, which can best be described as a crackle breccia, consists largely of subangular fragments of mineralized CFQM, with locally abundant mineralized latite where dikes exposed in the CFQM projected into the brecciated zone that range in size from an inch to several inches in diameter. Andesite occurs only as mixed fragments partially in contact with intrusive CFQM and appears to represent the brecciation of relatively unaltered andesite xenoliths in the CFQM. The matrix contains varying proportions of quartz, biotite (phlogopite), potassium feldspar, pyrite, and chalcopyrite, with magnetite, molybdenite, fluorite, anhydrite, and calcite locally common. Apatite is a common accessory mineral. Breccia fragments are rimmed with either biotite or potassium feldspar, and the quartz and sulfide minerals have generally formed in the center of the matrix.

Two types of breccia within the quartz monzonite breccia pipe have been identified as distinguishable units based on the dominant mineral filling the matrix between clasts. Recent drilling has shown that the two breccia types, biotite breccia and feldspar breccia, grade into one another as well as with the CFQM. Interestingly, from a recovery perspective, metallurgical testing has shown that the mineralization behaves virtually the same irrespective of the lithology.

The total sulfide content ranges from 1 percent (by volume) in the eastern part of the breccia pipe and the surrounding CFQM to 5 percent in the CFQM to the south, north, and west. Sulfide content is highly variable within the breccia, with portions in the western part of the breccia containing as much as 20 percent sulfide minerals. The strongest copper mineralization is concentrated in the



western half of the breccia pipe and in the adjoining stockwork veined CFQM in the vicinity of the intersection of the Patten fault and the Hunter fault zone. Sulfide mineralization is concentrated in the CFQM and breccia pipe, and drops significantly at the andesite contact. Minor pyrite mineralization extends into the andesite along the pre-mineral dikes and in quartz-pyrite-bearing structures, some of which were historically prospected for gold.

Molybdenite occurs in some steeply dipping quartz veins or as thin coatings on fractures. Minor sphalerite and galena are present in both carbonate and quartz veinlets in the CFQM stock. Preliminary 2011 evaluations of the mineralization at Copper Flat indicate that copper mineralization concentrates and trends along the N50°W structural influences, whereas the molybdenum, gold and silver appear to favor a N10°-20°E trend.

### 1.2.5 Hydrology

Hydrological information pertaining to the Copper Flat project has been summarized from the Baseline Data Report (INTERA, 2012) and is provided herein to provide a context for the pit lake modeling. The mine permit area is located in the Lower Rio Grande watershed, which includes approximately 5,000 square miles in Catron, Socorro, Sierra, and Doña Ana Counties and is dominated by the Rio Grande and its tributaries as well as the two large reservoirs of Elephant Butte and Caballo. Numerous tributaries drain into the Rio Grande from the west, but none contribute perennial flow to the Rio Grande. The mine permit area is drained by ephemeral streams (arroyos) within the Greenhorn Arroyo Drainage Basin. The Greenhorn Arroyo Drainage Basin is composed of Greenhorn Arroyo, Grayback Arroyo, and Hunkidori Gulch. The Grayback Arroyo passes through the permitted mine area and is diverted around the existing mine pit. Drainages within this watershed are ephemeral, flowing in response to heavy or sustained precipitation events. Water quality data for the Grayback Arroyo are summarized in Table 1-1.

**Table 1-1: Summary of Hydrochemical Information in the Grayback Arroyo (INTERA, 2012)**

Details	pH (s.u.)	Chloride (mg/L)	Sulfate (mg/L)	TDS (mg/L)
<i>Min</i>	7.42	0.71	11	78
<i>Max</i>	7.92	130	2,900	4,500

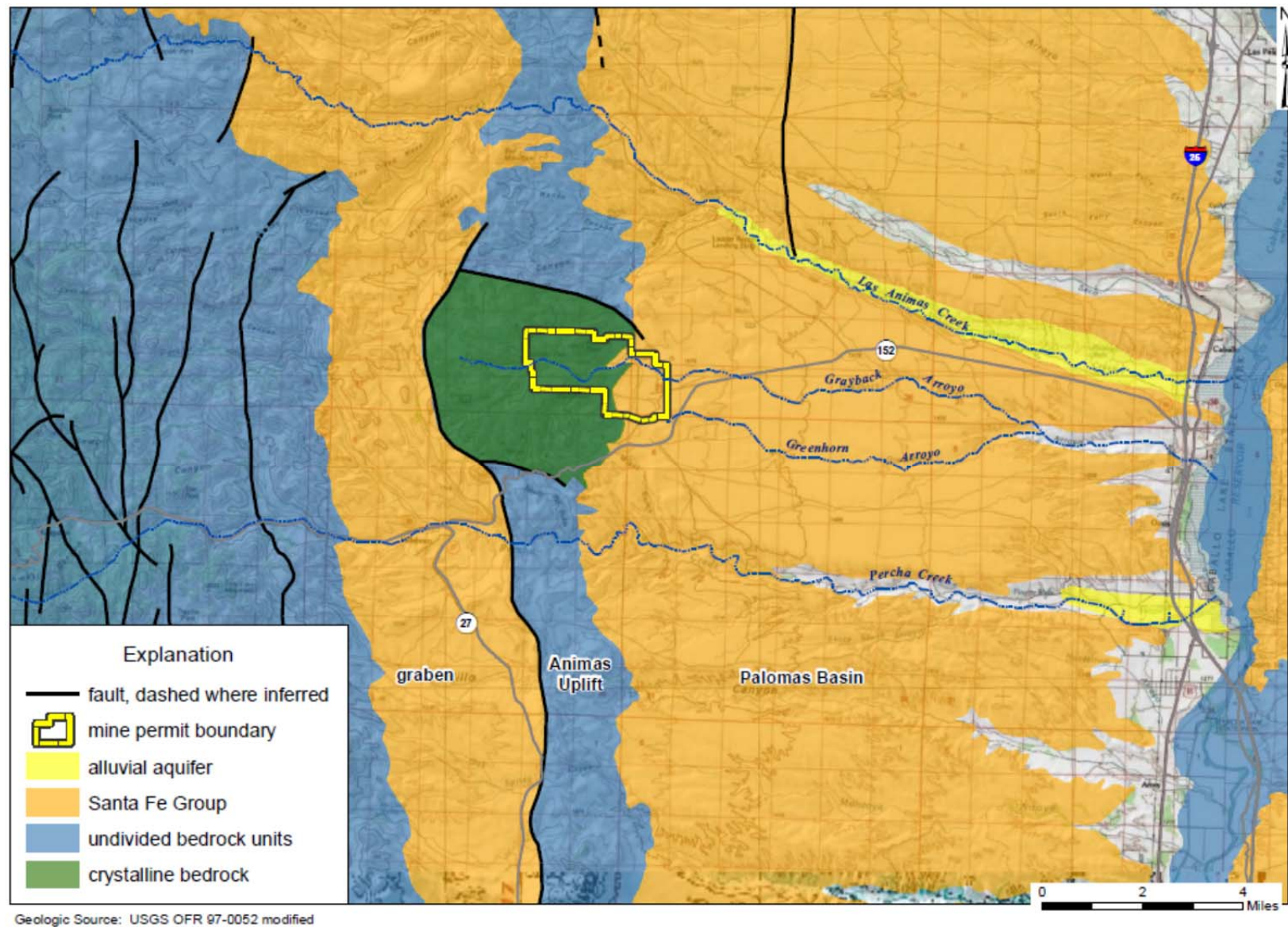
Surface waters in the Grayback Arroyo are typically characterized by higher major ion and trace element concentrations, with sulfate concentrations up to 2,900 mg/L and TDS up to 4,500 mg/L.

### 1.2.6 Hydrogeology

Hydrogeological information pertaining to the Copper Flat project has been summarized from the Baseline Data Report (INTERA, 2012) and is provided herein. This report identifies three aquifers within the Copper Flat project area (Figure 1-6) including:

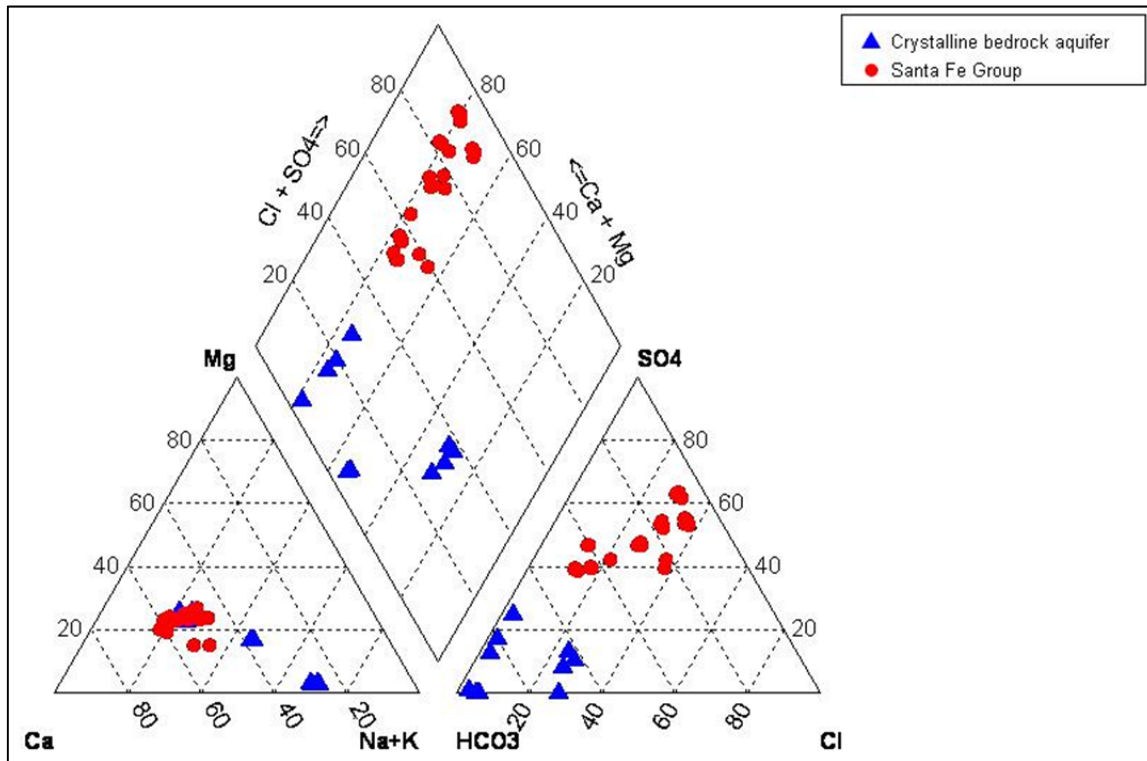
1. Crystalline bedrock aquifer;
2. Santa Fe Group aquifer; and
3. Quaternary alluvial aquifer.

Details of these aquifers are provided below.



**Figure 1-6: Map Showing Location of Crystalline Bedrock, Santa Fe Group Sediments and Alluvial Aquifer Zones (JSAI, 2012)**

- 1. Crystalline Bedrock Aquifer:** Groundwater is present within the crystalline volcanic rocks (quartz monzonite and andesite) that constitute much of the western portion of the mine permit area. Though the rocks themselves have practically no inter-granular permeability, faulting and jointing of the monzonite have created locally permeable zones through which water can move. Groundwater flow is generally from west to east, with the exception of the area surrounding the pit lake, which behaves as an evaporative sink. The permeability of the andesite is extremely low ( $<0.003$  feet/day), whereas the permeability of the monzonite rocks averages 0.1 feet/day due to localized secondary porosity from fracturing. Groundwater in the Crystalline Bedrock Aquifer is characterized by moderately alkaline pH ( $\sim 8$  s.u.) and can generally be classed as sodium / calcium plus bicarbonate ( $\text{Na} / \text{Ca} + \text{HCO}_3$ ) type waters based on their major ion signature (Figure 1-7).
- 2. Santa Fe Group Aquifer:** Overlying and adjacent to the crystalline bedrock aquifer is the Santa Fe Group Aquifer system, which receives recharge from precipitation. The aquifer is located approximately 1 mile downgradient of the existing pit lake, and the low hydraulic conductivity of the andesite limits cross formational flow. The sediments of the Santa Fe Group are stratified, contain a wide variety of grain sizes, and, in general, dip to the east. The direction of groundwater flow is from west to east and the groundwater elevation contours indicate groundwater flows from the andesite to the alluvium and Santa Fe Group sediments. Groundwater in the Santa Fe Group Aquifer is characterized by circum-neutral to moderately alkaline pH ( $7 - 8$  s.u.) and can generally be grouped into the calcium plus bicarbonate ( $\text{Ca} + \text{HCO}_3$ ) or calcium plus sulfate ( $\text{Ca} + \text{SO}_4$ ) hydrochemical facies based on major ion chemistry (Figure 1-7). The sulfate signature of some of the groundwater samples is associated with wells within the Santa Fe Group Aquifer near the existing TSF, which are known to be influenced by a sulfate plume from the historic tailings.
- 3. Quaternary Alluvial Aquifer:** This aquifer is comprised of channel and floodplain gravels, sands and silts and represents the uppermost aquifer in the vicinity of the Copper Flat project. The alluvial aquifer is typically recharged by infiltration of rainfall.



**Figure 1-7: Piper Plot of Major Ion Chemistry of Groundwater in the Mine Permit Area (analyses from 2010 and 2011 only)**

### 1.2.7 Pit Lake

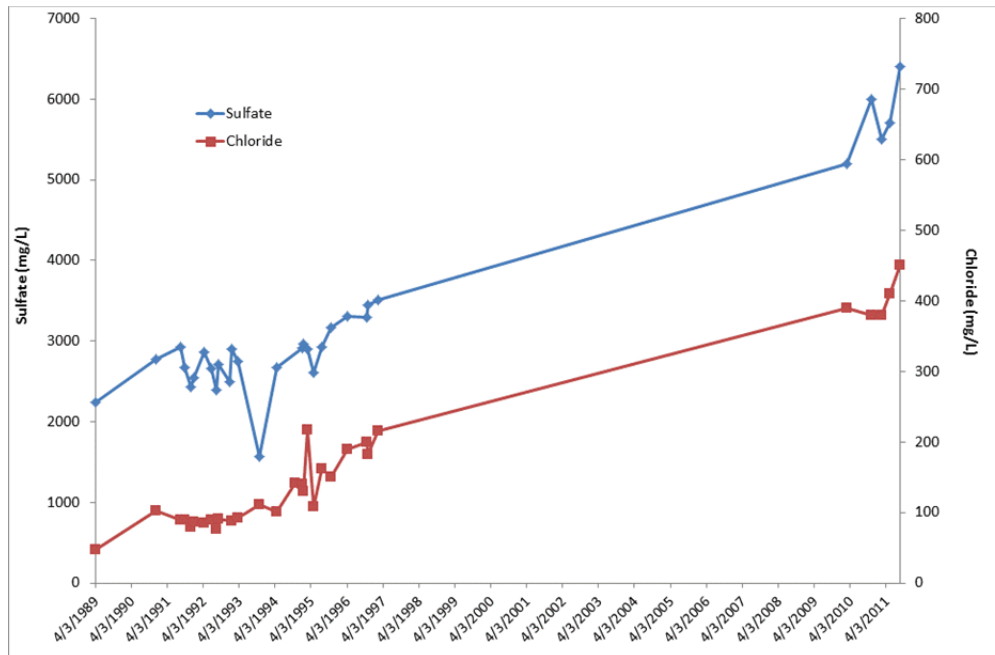
During the late 1980s and early 1990s, a pit lake formed in the existing pit. During this period, the pit lake was approximately 13.8 acres, but has subsequently reduced in size as a result of evaporation and limited precipitation (i.e., drought conditions). A recent evaluation by JSAI (2011) indicates that the pit lake currently covers an area of approximately 5.2 acres and contains approximately 60 acre-feet. of water. Bathymetric measurements carried out as part of the INTERA (2012) baseline data collection program indicate that the depth of the existing pit lake varies between 28 and 36 feet. Water levels are typically highest in the winter month of January and lowest in the summer month of July. The analytical results do not indicate the presence of a chemocline or any chemical stratification in the lake. However, the temperature profiles for the winter and summer sampling showed a greater than 1°C per meter change, indicating the presence of a thermocline. The pit currently represents a hydraulic sink, with evaporation from the lake surface exceeding groundwater inflow and surface runoff.

Existing pit lake water quality was assessed as part of the INTERA (2012) baseline data collection program, which included collection of samples from the deepest part of the pit lake in September 2010, January 2011, April 2011 and July 2011. The results of this monitoring program are summarized in Table 1-2 and demonstrate that pit lake waters are currently characterized by circum-neutral to moderately alkaline pH (6 – 7.86 s.u.), with sulfate concentrations between 5,200 mg/L and 6,400 mg/L and total copper concentrations up to 11 mg/L. Furthermore, concentrations of sulfate, chloride, TDS, manganese, magnesium, cobalt, fluoride, sodium and potassium have all increased between 1989 and 2011. In particular, evapoconcentration effects have increased the concentrations of sulfate and chloride (Figure 1-8), resulting in supersaturation of pit lake waters and subsequent precipitation of salts (primarily gypsum) around the rim of the existing pit lake. These precipitated solids now form a thick crust on the pit walls (Figure 1-9). The pH of existing pit lake



waters has generally increased over time most likely through a combination of groundwater alkalinity and localized buffering by wall rock silicate and carbonate mineralogy.

Comparison of existing pit lake chemistry in with NMAC 20.6.4900 surface water standards for livestock watering and wildlife demonstrates that both cadmium and copper are above the respective standards for these parameters (Table 1-2).



**Figure 1-8: Plot of Sulfate and Chloride Concentrations in Existing Pit Lake**



**Figure 1-9: Precipitated Salts around Rim of Existing Pit Lake**

**Table 1-2: Existing Pit Lake Chemistry (Average Concentration from 2010 – 2011)**

		<i>NMAC 20.6.4.900 Surface Water Standards</i>		Average concentration measured in period 2010 - 2011
		<i>Livestock</i>	<i>Wildlife</i>	
<b>pH</b>	s.u.	6.6 - 9		7.35
<b>Bicarbonate</b>	mg/L	-	-	35.7
<b>Aluminum</b>	mg/L	-	-	0.502
<b>Arsenic</b>	mg/L	0.2	-	0.003
<b>Boron</b>	mg/L	5	-	0.16
<b>Calcium</b>	mg/L	-	-	592
<b>Cadmium</b>	mg/L	0.05	-	0.06
<b>Cobalt</b>	mg/L	1	-	0.34
<b>Chromium</b>	mg/L	1	-	0.012
<b>Copper</b>	mg/L	0.5	-	0.60
<b>Fluoride</b>	mg/L	-	-	17.0
<b>Iron</b>	mg/L	-	-	0.04
<b>Mercury</b>	mg/L	0.01	0.00077	<0.002
<b>Potassium</b>	mg/L	-	-	31.0
<b>Magnesium</b>	mg/L	-	-	677
<b>Manganese</b>	mg/L	-	-	44.0
<b>Molybdenum</b>	mg/L	-	-	0.02
<b>Sodium</b>	mg/L	-	-	792
<b>Nickel</b>	mg/L	-	-	0.058
<b>Lead</b>	mg/L	0.1	-	<0.005
<b>Antimony</b>	mg/L	-	-	<0.001
<b>Selenium</b>	mg/L	0.05	0.005	0.03
<b>Uranium</b>	mg/L	-	-	0.12
<b>Vanadium</b>	mg/L	0.1	-	<0.05
<b>Zinc</b>	mg/L	25	-	4.87
<b>Sulfate</b>	mg/L	-	-	5,900
<b>Chloride</b>	mg/L	-	-	412



*Indicates value is greater than NMAC 20.6.4900 surface water standard*

*-*

*Indicates no standard for parameter*

## 2 Geochemical Characterization Testwork Summary

SRK has conducted a geochemical characterization program for the Copper Flat project, which has included the testing of 91 waste rock samples, 41 samples representative of low grade ore and 11 samples of tailings material to investigate the potential for ARDML generation. The results of this program are presented in the *Geochemical Characterization Report for the Copper Flat Project, New Mexico* (SRK 2012) and the main findings are summarized below.

Waste rock and ore sample intervals were selected from both exploration core holes drilled within the proposed pit boundaries in 2009, 2010 and 2011 and from the surface of existing WRDs and pit walls on site. Samples were selected to represent the range of waste rock and ore material types that will be encountered during future mining. Tailings samples were collected from the metallurgical program and from the existing (historic) TSF on site. The static test methods used for the geochemical characterization program include multi-element analysis using four-acid digest and ICP-MS analysis, modified Sobek Acid Base Accounting (ABA), Net Acid Generation (NAG) test and the Nevada Meteoric Water Mobility Procedure (MWMP). These static tests were selected to address total acid generation or neutralization potential of the samples and concentration of constituents in leachates derived from the material. However, these static tests do not consider the temporal variations that may occur in leachate chemistry as a result of long-term changes in oxidation, dissolution and desorption reaction rates. To address these factors, kinetic testing was also carried out as part of the geochemical characterization program and includes 32 humidity cell tests (HCTs) conducted on samples of waste rock, ore and tailings according to the ASTM D-5744-96 methodology.

The results of the characterization program demonstrate that the acid generating potential of the Copper Flat waste rock is largely dependent on the sulfide mineral content, with sulfide concentrations varying from less than analytical detection limits to a maximum of 2.52 wt%. The static testwork results indicate that the transitional waste material (i.e. mixed sulfide/oxide) is likely to be potentially acid forming based on a generally higher sulfide mineral content and the presence of secondary oxide minerals that formed as a result of supergene weathering. In contrast, the diabase, andesite and tailings are likely to be non-acid forming materials. The main material type for the project consists of sulfide (i.e., non-oxidized) Quartz Monzonite and Breccia, which typically exhibited either non-acid forming characteristics or a low potential for acid generation. This is related to the encapsulation of sulfide minerals in a quartz matrix or occasionally in potassium feldspar. In addition, the sulfide minerals in the Copper Flat deposit are crystalline and often coarse grained and as such have slow weathering reaction kinetics. It is likely that the Copper Flat materials will offer limited silicate buffering (neutralizing) capacity; although this is unlikely to be high magnitude, it may modify/buffer pH in the near neutral range.

The Copper Flat waste rock and ore materials were found to be enriched in copper, sulfur and selenium in whole rock chemistry, which relates to the primary mineralization (predominantly chalcopyrite -  $\text{CuFeS}_2$ ). Silver, arsenic, cadmium, molybdenum, lead, thallium, uranium, tungsten, and zinc were also found to be enriched in one or more material types, with the greatest levels of enrichment occurring in the sulfide and transitional ore material types. Many of these elements are typically associated with copper porphyry deposits, which explain their enrichment in the Copper Flat materials (and more specifically in the ore grade samples). The diabase and andesite material types typically showed much lower levels of elemental enrichment, which is likely related to the lack of primary mineralization in these lithological units.

MWMP tests were conducted on a total of 49 waste rock and tailings samples to provide an indication of elemental mobility and metal(loid) release from the Copper Flat materials during meteoric rinsing. Metal mobility and release was also assessed from the results of the ongoing HCT program, the results of which are summarized in Appendix B. In general, metal leaching from the

Copper Flat materials was found to be low and the majority of leachates generated during the MWMP and HCT test programs could be classed as near-neutral, low-metal waters. However, several of the grab samples of transitional material collected from historic waste rock dumps produced acidic leachates and showed the potential for higher metal release than observed for the unoxidized sulfide materials. The higher release of acidity and metals from these samples likely represents the flushing of soluble acidic sulfate salts from the material surface that were produced by the prolonged weathering (over geological time) of the material.

### **3 Pit Lake Predictive Geochemical Model**

During mining operations, dewatering will keep the pit operational and limited water will pond within the pit itself. At the end of open pit mining operations, dewatering will cease and a pit lake will ultimately form. Pit lake water quality predictions were made at selected time intervals (beginning when the pit lake starts to fill after mining and dewatering operations cease). Water quality predictions were made for the time periods of 0.5, 1, 2, 5, 10, 25, 50, 75, and, 100 years after the start of pit lake formation. These predictions were based on mass load mixing of waters from different sources and allowing the resulting mix to establish thermodynamic equilibrium under imposed conditions by dissolving or precipitating specified solids, with attenuation of trace elements through sorption reactions.

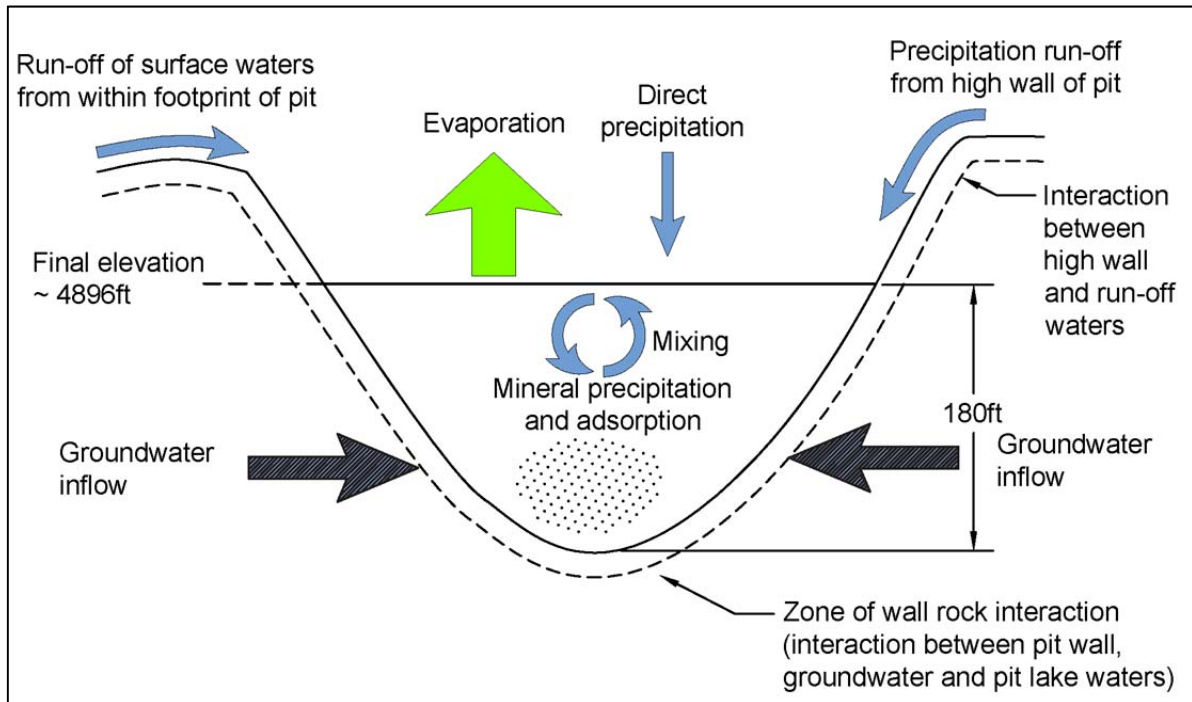
#### **3.1 Conceptual Model**

A conceptual geochemical model was developed for the Copper Flat pit lake from a review of background and site-specific data in addition to experience with similar projects. The conceptual model assumes that a lake will form within the pit after dewatering operations cease as a result of inflow of groundwater into the pit, direct precipitation onto the pit lake and run-off from the pit walls. Data that were used as inputs to the model were derived from the following sources:

- Geological and mine planning information from the Baseline Data Report (INTERA, 2012) and the geologic block model;
- Hydrologic and hydrogeologic information from the JSAI (2012) pit lake water balance;
- Geochemical data from laboratory humidity cell tests performed on representative waste rock lithologies and then scaled to field conditions. These data were utilized to provide source term data for chemical leaching of exposed rock in the pit walls;
- Precipitation chemistry data from long-term monitoring at the Gila Cliff Dwellings National Monument meteorological station, New Mexico; and
- Groundwater chemistry data from the ongoing groundwater monitoring program.

Full details of these input data are provided in the following sections. The conceptual geochemical model for the Copper Flat pit is provided in Figure 3-1.





**Figure 3-1: Conceptual Model**

## 3.2 Geologic Model

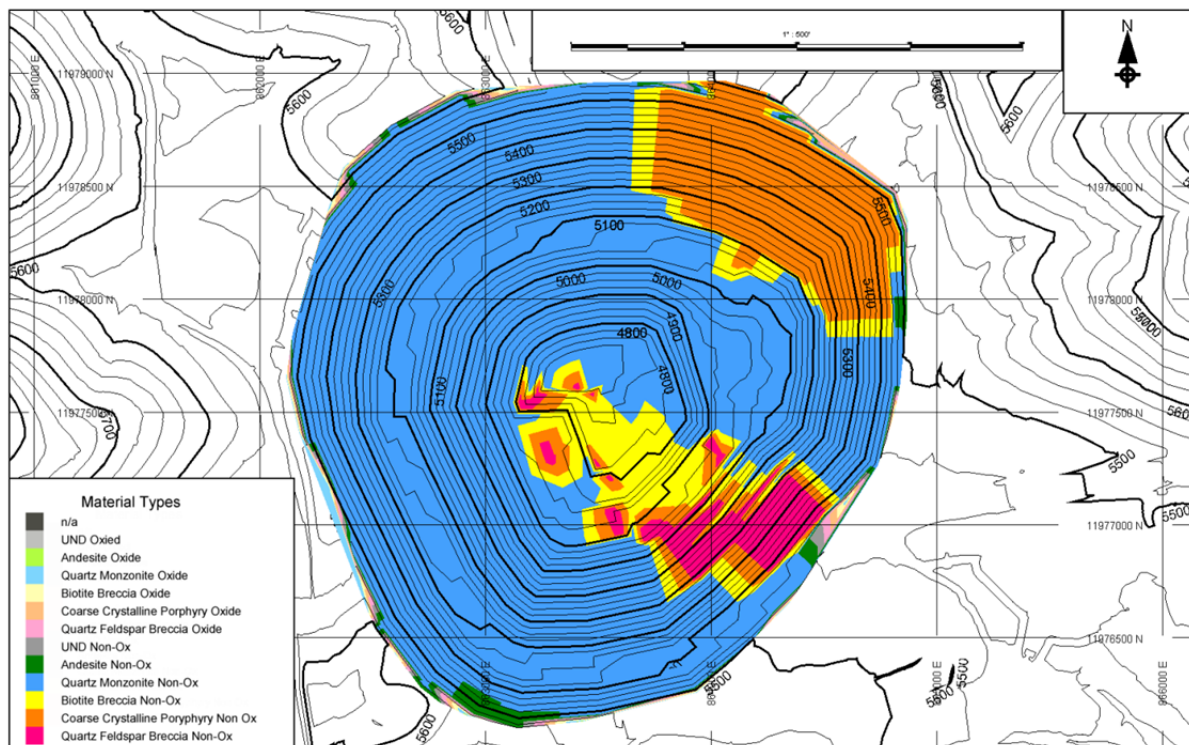
### 3.2.1 Pit Wall Surface Areas

The proportional surface areas of the main lithologies that will be exposed in the final pit walls have been calculated from the geologic block model. The three dimensional surface areas of each lithology in the pit walls at the end of mine life are provided in Table 3-1 and are illustrated in Figure 3-2. This demonstrates that unoxidized quartz monzonite represents the dominant lithological unit that will be exposed in the final pit walls.

The geological block model was used to calculate the three dimensional surface area of each material type that will be exposed in the pit wall both above and below the water level as pit filling progresses. Three dimensional surface areas were calculated for each of the modeled time steps (i.e. for 0.5, 1, 2, 5, 10, 25, 50, 75, and 100 years after the start of pit lake formation).

**Table 3-1: 3D Surface Areas of Pit Wall Rock Material Types**

Material type	Oxidation	3D surface area (ft <sup>2</sup> )	3D surface area (m <sup>2</sup> )	Proportion
Andesite	Oxide / transitional	9,173	852	0.12%
Biotite breccia		-	-	-
Quartz feldspar breccia		6,703	623	0.09%
Quartz monzonite		79,578	7,393	1.01%
Coarse crystalline porphyry		27,277	2,534	0.35%
Undefined		47,881	4,448	0.61%
Andesite	Sulfide (non-ox)	86,611	8,046	1.10%
Biotite breccia		316,873	29,438	4.02%
Quartz feldspar breccia		491,257	45,639	6.23%
Quartz monzonite		5,794,482	538,325	73.5%
Coarse crystalline porphyry		1,022,725	95,014	13.0%
Undefined		-	-	-

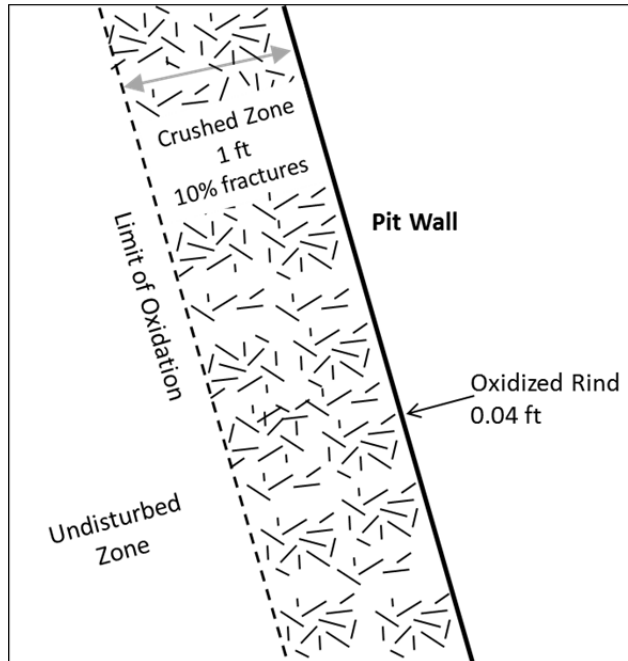


**Figure 3-2: Exposed Material Types in Final Pit Walls**

### 3.2.2 Calculation of Pit Wall Rock Available for Leaching

During the period of dewatering the pit walls will be exposed to oxygenated conditions and will weather to form secondary minerals, including soluble salts. As the pit wall resaturates during rebound of the groundwater table, soluble salts and other weathering products will dissolve into the ambient groundwater that drains into the pit. In addition, dissolution of these soluble salts by run-off waters in the unsaturated high wall of the pit may occur. In order that laboratory leach data can be used to determine the mass release of solutes under field leaching conditions, it was necessary to determine the total mass of material available for leaching in the pit walls based on the exposed surface areas of each lithology in both the unsaturated high wall and in the submerged pit walls.

1. An estimate of the reactive mass in the future pit high wall was made based on information provided by NMCC. Blasting practices at Copper Flat will include pre-split drilling and smooth wall blasting, which is considered best practice for geotechnical stability and will effectively reduce fracturing within the final pit walls. As such, a maximum estimated 1 foot thickness of reactive rock in the pit walls has been used as a conservative input to the model. It is assumed that fracturing in this zone will average 10% (Siskind and Fumanti, 1974). In addition, mineralogy work carried out by SRK on humidity cell tests undertaken on previous projects identified that particles generally show water infiltration and products of reactivity up to 0.04 feet into the rock fragments. Therefore a reactive rim of 0.04 feet thickness has also been assumed in the pit walls (Figure 3-3).
2. Water flow is assumed to be mobile within the crushed zone and oxidized rind and it is assumed that only this outermost layer is leached by precipitation that falls on the pit high wall. Therefore, the mass of rock calculated within the crushed zone and reactive rind is equivalent to the mass of rock available for leaching by surface run-off from the exposed high wall during life-of-mine (LOM) scenarios and also for the submerged high wall within the oxic pit lake zone during pit infilling. This is expanded on in Section 3.4.2. Although oxidation of sulfide minerals will occur within the fluctuation zone, it is unlikely that these oxidation products will be leached until pit infilling occurs and the inflow of groundwater becomes significant in the highwall post closure.
3. The calculated volumes were multiplied by approximate material densities to give a reactive mass of material taken for either the highwall, footwall or overburden materials. The calculations assumed an average rock density of 169 lb/ft<sup>3</sup> (2700 kg/m<sup>3</sup>) (Young and Olhoeft, 1976).



**Figure 3-3: Future Pit Wall Conceptual Model**

### 3.3 Hydrogeologic Model

Hydrogeologic modeling for the Copper Flat pit lake was undertaken by JSAI (2012). Post-mining pit water levels and a water balance were simulated assuming the pit geometry and watershed shown in Figure 3-4. The pit footprint area is 141 acres and the watershed area affecting the pit is approximately 230 acres. Upon cessation of mining, pumping will cease in and around the pit, allowing the pit to refill over a number of years (SRK, 1995). The primary solution inputs to the pit are assumed to be groundwater inflow, direct precipitation onto high walls of the pit and run-off from the pit walls (JSAI, 2012). Evaporation represents the dominant solution loss.

The final post-closure pit water elevation is estimated to be at an elevation of approximately 4,896 feet. The resulting lake would cover an area of about 17 acres with a depth of approximately 180 feet. The water level of the lake would fluctuate a few feet seasonally depending on precipitation and evaporation rates, rising during periods of lower evaporation (winter months) and decreasing during summer months.

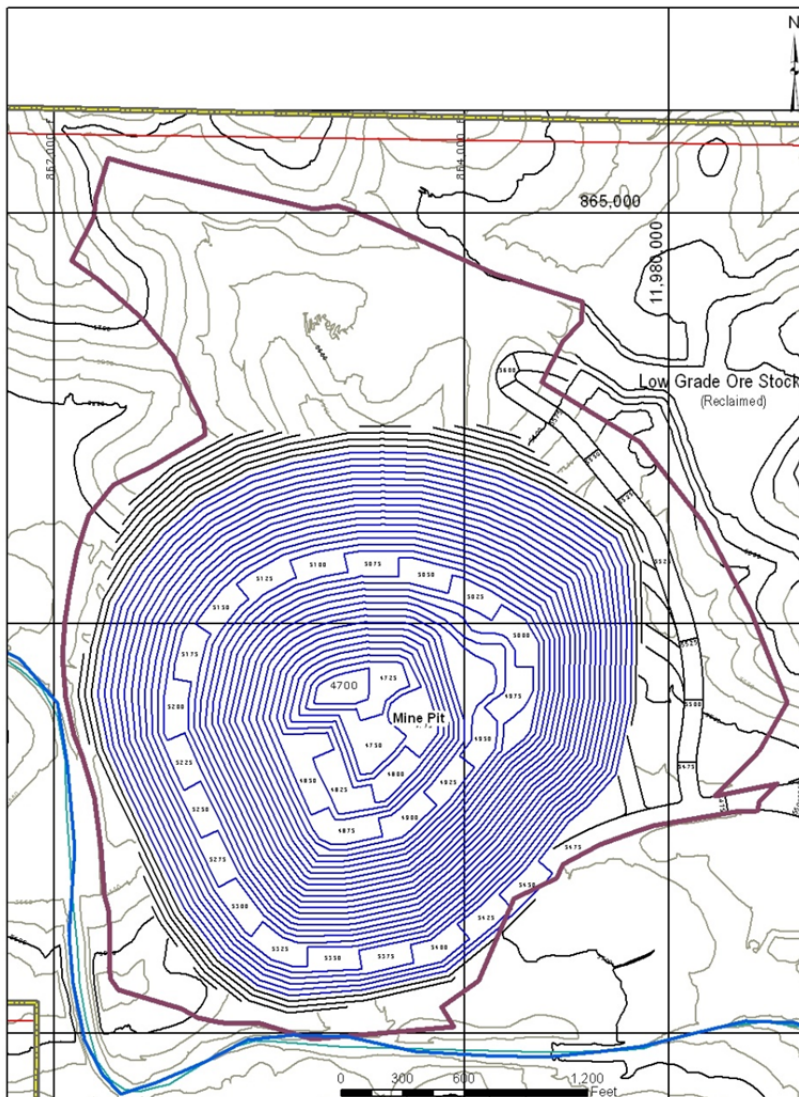
The pit is expected to form a hydrologic sink, capturing groundwater flowing from all directions (INTERA, 2012; JSAI, 2011). Surface water from within the footprint of the pit will also be captured. Even with surface water inflows, the pit lake area is expected to be a hydraulic sink with evaporation rates greatly exceeding precipitation and groundwater inflows over most of the year (THEMAC Resources Group Ltd., 2012). Full details of the pit lake water balance can be found in the JSAI (2012) report.

Mine pit lakes can develop vertical density stratification that may be seasonal or permanent. The density of water is a function of both its temperature and its salinity or total dissolved solids (TDS) content. Freshwater is densest at a temperature of about 4°C. At a given temperature, water density increases with increasing TDS. As TDS increases, the temperature of the maximum density of water also decreases (Atkins et al., 1997; Parshley and Howell, 2003).

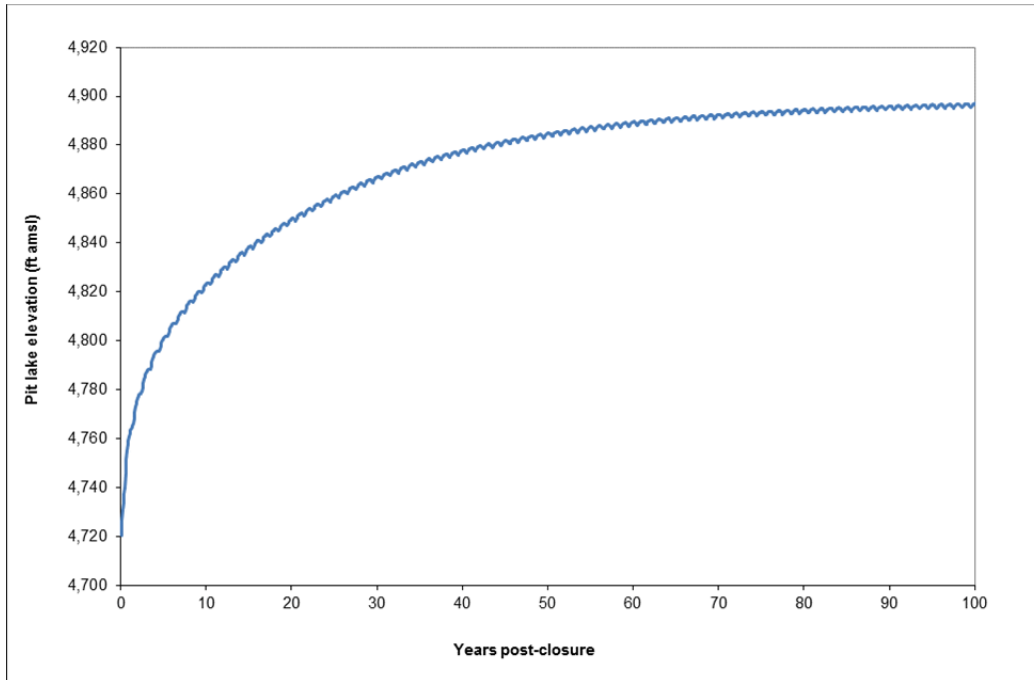
Long-term (multi-year) or permanent density stratification can occur if a lake has a significant vertical variation in TDS due to large differences in the TDS of various source waters to the lake and/or to

processes in the lake that increase the TDS. This in turn affects the density of the deeper water. For example, if a lake contains enough organic matter to deplete oxygen in the hypolimnion, then during the summer, ferric hydroxide that precipitates at the surface will sink, become reduced, and dissolve in the basal anoxic water, raising the TDS content and the density of the bottom water.

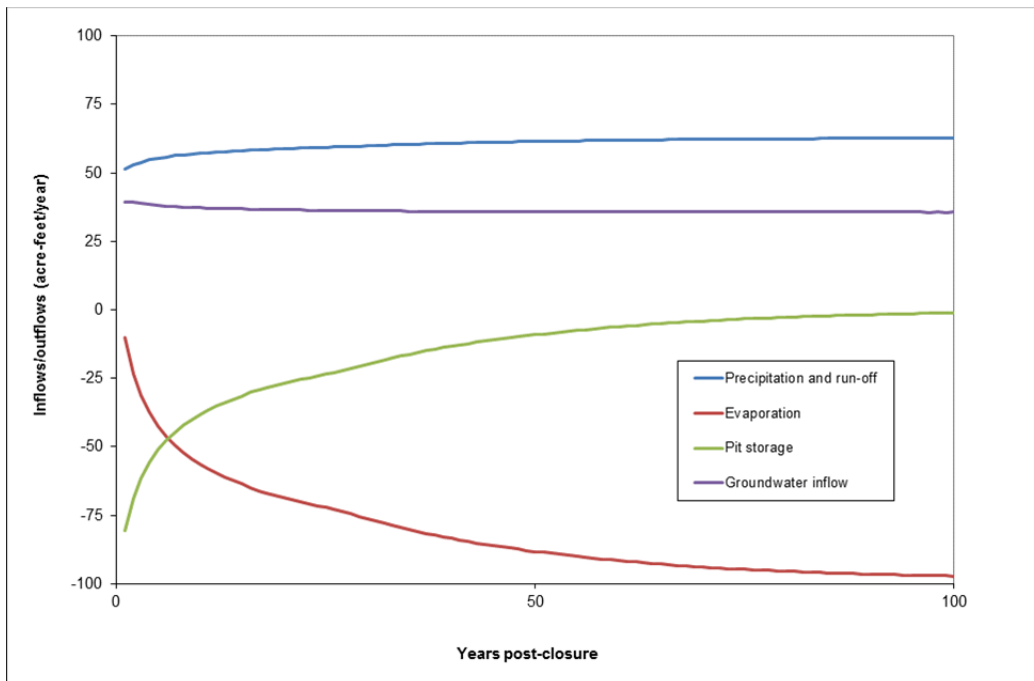
Water below the hypolimnion will generally become anoxic and will continuously dissolve any ferric hydroxide precipitates falling into it from above. This process further increases the TDS of the hypolimnion and strengthens the density gradient between it and the overlying layer, perpetuating the stratification. Sulfidization in the hypolimnion will lead to natural attenuation of metals and metalloids as well as sulfur. Few studies reporting site-specific limnological data have been published to date (Atkins et al., 1997; Parshley and Howell, 2003). For Copper Flat, the presence of solute material that will modify pit lake chemistry (i.e., sulfide minerals and gypsum) will likely prevent permanent chemical stratification or layering of the lake. This was validated in the 1990s from depth sampling of the pit lake at Copper Flat (SRK, 1996), and in 2010 and 2011 from baseline data collection (INTERA, 2012). The results from this study demonstrated no stratification existed in the pit lake.



**Figure 3-4: Ultimate Open Pit and Watershed**



**Figure 3-5: Pit Lake Elevation**



**Figure 3-6: Pit Lake Flux**

## **3.4 Solution Inputs**

### **3.4.1 Groundwater Chemistry**

Groundwater discharging into the pit lake will be a combination of inflowing regional groundwater plus additional solutes acquired through oxidation, desorption or dissolution reactions within the weathered pit walls. Therefore the chemistry of the groundwater source term for the Copper Flat pit lake model was represented by both hydrochemical data from the groundwater monitoring wells in addition to geochemical data from the ongoing HCT program.

Representative groundwater chemistry data were obtained from the groundwater monitoring program. Groundwater data collected from wells GWQ96-22A, GWQ96-22B, GWQ96-23A, and GWQ96-23B between 1996 and 2011 were used in the model, as these wells are the most representative of groundwater in the quartz monzonite and andesite bedrock. These lithologies will make up the majority of the final pit walls (Figure 3-2). Groundwater chemistry was then reacted in PHREEQC with source term for leaching of wallrock represented by the HCT leachate chemistries in the proportions defined by the geological block model (i.e. according to the surface areas of the various lithologies exposed in the final pit walls).

The average groundwater chemistry used as the input to the pit lake PHREEQC model is presented in Table 3-2 along with a comparison to NMWQCC groundwater standards and NMAC 20.6.4.900 wildlife habitat and livestock watering standards. From this comparison, all constituents are below the NMWQCC groundwater standards with the exception of fluoride, iron and manganese. In comparison to the wildlife habitat and livestock watering standards, all constituents are below the respective standards.



**Table 3-2: Groundwater Chemistry used in the PHREEQC Model**

Parameter	Units	NMWQCC groundwater standards*	NMAC 20.6.4.900 standards for livestock watering	NMAC 20.6.4.900 standards for wildlife	Groundwater chemistry (average of samples collected from wells GWQ96-22A, GWQ96-22B, GWQ96-23A and GWQ96-23B between 1996 and 2013)
pH	s.u.	6 – 9	-	-	7.85
HCO <sub>3</sub>	mg/L	-	-	-	394
Aluminum	mg/L	5	-	-	0.41
Antimony	mg/L	-	-	-	0.002 <sup>†</sup>
Arsenic	mg/L	0.1	0.2	-	0.003
Boron	mg/L	0.75	5	-	0.14
Barium	mg/L	1	-	-	0.09
Calcium	mg/L	-	-	-	87.1
Cadmium	mg/L	0.01	0.05	-	0.002 <sup>†</sup>
Chloride	mg/L	250	-	-	49.1
Cobalt	mg/L	0.05	1	-	0.006 <sup>†</sup>
Chromium	mg/L	0.05	1	-	0.006 <sup>†</sup>
Copper	mg/L	1	0.5	-	0.014
Fluoride	mg/L	1.6	-	-	2.02
Iron	mg/L	1	-	-	1.49
Mercury	mg/L	0.002	0.01	0.00077	0.000002 <sup>†</sup>
Potassium	mg/L	-	-	-	3.10
Magnesium	mg/L	-	-	-	19.8
Manganese	mg/L	0.2	-	-	0.66
Molybdenum	mg/L	1	-	-	0.02
Sodium	mg/L	-	-	-	117
Nickel	mg/L	0.2	-	-	0.025 <sup>†</sup>
Lead	mg/L	0.05	0.1	-	0.005 <sup>†</sup>
Sulfate	mg/L	600	-	-	96.9
Silica	mg/L	-	-	-	13.8
Silver	mg/L	0.05	-	-	0.018
Selenium	mg/L	0.05	-	0.005	0.003
Uranium	mg/L	0.03	0.05	-	0.002
Vanadium	mg/L	-	0.1	-	0.0009 <sup>†</sup>
Zinc	mg/L	10	-	-	0.04
Ion balance	%	-	-	-	0.60%



Indicates exceedance of NMWQCC

†

Indicates parameter is uniformly below detection limits in groundwater and was excluded from the PHREEQC input

‘-’

Indicates no standard for parameter

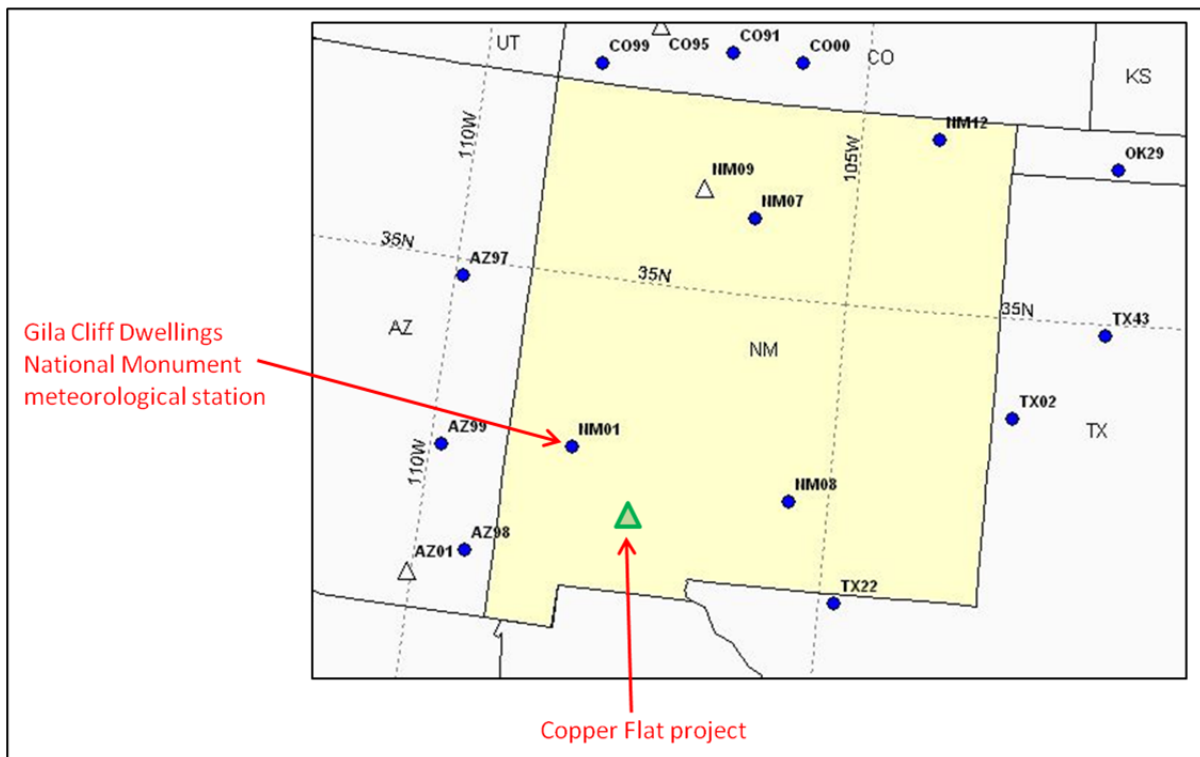


### 3.4.2 Wall Rock Chemistry

The mass of pit wall rock available for chemical weathering reactions in both the unsaturated high wall and the submerged pit wall was calculated from the three dimensional surface areas (Table 3-1) and using the estimated fracture density from SRK's experience with other ARD studies (see Section 3.2.2). All calculations used to determine the reactive rock mass in the pit walls assumed an average rock density of 169 lb/ft<sup>3</sup> (2700 kg/m<sup>3</sup>) (Young and Olhoeft, 1976). The fracture density was used to determine the changes in run-off chemistry as precipitation that falls directly on the pit walls migrates through the reactive fracture zones. The modified chemistry of the precipitation from these pit rim reactions was then used as the source term contribution to the pit. Scaled and averaged data from kinetic humidity cell tests completed for representative samples as part of the SRK (2012) geochemical characterization program were used as the source term solutions for the pit wall run-off. The solutions used as inputs to the geochemical model are provided in Table 3-3.

### 3.4.3 Precipitation Chemistry

For the purposes of the geochemical model, the primary wall rock lixiviant for the high walls was assumed to be rainwater. Representative rainwater chemistry data were obtained from monthly monitoring carried out between 1985 and 2011 at the Gila Cliff Dwellings National Monument meteorological station, Catron County, New Mexico (NADP, 2012) (Figure 3-7). In the absence of any site-specific rainwater chemistry, this is considered the most representative precipitation chemistry available for use in the modeling exercise. For the purpose of the model, average rainwater chemistry data for the period 1985 to 2011 were used (see Table 3-4).



**Figure 3-7: Location of Gila Cliff Dwellings National Monument Meteorological Station**

**Table 3-3: Source Term Chemistry for Each Material Type in the Pit Walls**

	Units	Andesite <i>Cells SRK 0864 and SRK 0866</i>	Biotite breccia - oxide/ transitional <i>Cells SRK 0854 and SRK 0872</i>	Biotite breccia - sulfide <i>Cells 604811, 604854, 604862, 604867 and 605033</i>	Quartz feldspar breccia - oxide/ transitional <i>Cells 604767 and 604787</i>	Quartz feldspar breccia - sulfide <i>Cells 604767 and 604787</i>	Quartz Monzonite - oxide/ transitional <i>Cells 604569 and SRK 0867</i>	Quartz Monzonite - sulfide <i>Cells 604562, 604606, 604653, 604656, 604669, 604673 and 605153</i>	Coarse crystalline porphyry - oxide/ transitional <i>Cell CF-11-02 (0-27)</i>	Coarse crystalline porphyry - sulfide <i>Cell CF-11-02 (367-408)</i>
Percentage of waste (%)		1.06%	0.05%	1.10%	0.09%	4.48%	2.78%	75.4%	0.93%	14.0%
pH	s.u.	7.38	5.52	7.91	7.80	7.80	7.12	6.82	7.94	7.80
Alkalinity	mg/L as HCO <sub>3</sub>	11.1	3.44	54.4	28.1	28.1	15.6	30.1	33.2	21.6
Aluminium	mg/L	0.008	0.27	0.01	-	-	0.05	0.01	0.01	0.05
Arsenic	mg/L	-	0.0006	0.0005	-	-	-	-	-	-
Boron	mg/L	-	-	0.01	0.01	0.01	0.02	0.01	0.01	0.01
Calcium	mg/L	9.23	23.8	28.9	17.4	17.4	19.0	15.4	10.7	7.69
Cadmium	mg/L	-	0.002	-	-	-	0.0004	-	-	-
Chloride	mg/L	0.39	0.30	1.09	0.83	0.83	0.57	1.41	0.78	1.26
Chromium	mg/L	0.0002	-	-	-	-	-	-	-	-
Copper	mg/L	0.002	17.4	0.011	-	-	0.51	0.035	-	0.006
Fluoride	mg/L	0.46	0.31	1.23	0.92	0.92	0.66	0.71	0.94	0.60
Iron	mg/L	0.002	0.47	-	-	-	0.059	0.002	0.006	0.004
Mercury	mg/L	0.000005	-	-	-	-	-	0.00001	0.00005	0.00002
Potassium	mg/L	1.00	0.99	5.05	2.53	2.53	1.73	3.46	2.66	1.95
Magnesium	mg/L	1.41	1.41	4.17	3.92	3.92	2.46	2.76	1.95	0.53
Manganese	mg/L	0.01	0.28	0.04	0.12	0.12	0.28	0.09	0.02	0.008
Molybdenum	mg/L	0.008	0.033	0.013	0.011	0.011	0.006	0.011	0.005	0.002
Sodium	mg/L	1.91	0.40	2.93	1.94	1.94	-	3.16	2.87	2.49
Nickel	mg/L	0.0005	0.0045	0.0005	0.0006	0.0006	0.0061	-	-	-
Lead	mg/L	0.0001	0.0016	-	-	-	-	0.0003	-	0.0002
Sulfate	mg/L	23.4	97.6	52.6	39.5	39.5	51.8	32.6	13.8	8.57
Antimony	mg/L	0.0001	0.0002	0.0002	0.0002	0.0002	0.0015	0.0002	-	0.0001
Selenium	mg/L	0.0003	0.002	0.003	0.002	0.002	0.001	0.001	-	-
Uranium	mg/L	0.0005	0.003	0.008	0.022	0.022	0.004	0.008	0.004	0.003
Vanadium	mg/L	0.002	0.001	0.006	0.003	0.003	0.002	0.003	-	-
Zinc	mg/L	0.0009	0.16	0.001	0.005	0.005	0.013	0.004	0.0005	-
Ion balance (%)		0.44%	-21.8%	0.61%	1.29%	1.29%	-2.57%	0.50%	1.99%	1.66%

- Indicates parameter was uniformly below analytical detection limits in the HCT effluent leachates and was excluded from the PHREEQC model input for the specified material type

**Table 3-4: Precipitation Chemistry used in the Model**

Parameter	Units	Concentration
pH	s.u.	4.93
Ca	mg/L	0.21
Mg	mg/L	0.02
Na	mg/L	0.08
K	mg/L	0.03
Cl	mg/L	0.12
SO <sub>4</sub>	mg/L	0.86
NH <sub>4</sub>	mg/L	0.17
NO <sub>3</sub>	mg/L	0.83

### 3.5 Mineral and Gas Phase Equilibration

For the purpose of the predictive geochemical model, it was assumed that the leachates produced from each lithology in the pit walls would mix evenly and completely. Under these circumstances the solutes in these waters will react with each other and may form chemical precipitates if the concentrations and geochemical conditions (Eh, pH, pCO<sub>2</sub>, pO<sub>2</sub>, and ionic strength) allow super saturation to occur. The geochemical model required the specification of a number of equilibrium phases that were allowed to precipitate if they become oversaturated. The suite of minerals chosen was based on the geology and mineralization of the deposit and an understanding of the types of minerals commonly observed in waste rock leachates.

The relative saturation of all minerals was calculated by comparing the calculated concentration of dissolved ionic pairs with their theoretical thermodynamic limit. Where these values were equal, the saturation index was zero and the solution was said to be at equilibrium with that mineral. At equilibrium, any amount of the mineral that dissolves will precipitate to maintain the relative solute: mineral balance. The minerals that were allowed to form in the geochemical model are given in Table 3-5. Precipitates will sink to the bottom of the pit lake and be removed from future chemical interactions as a sediment layer accumulates on the pit bottom. These precipitated mineral phases are unlikely to re-dissolve unless the pH or redox conditions of the pit lake change substantially. As such, the model assumes that precipitated mineral phases are removed from the system and that subsequent re-dissolution of these phases does not occur.

**Table 3-5: Equilibrium Phases Included in the Pit Lake Geochemical Model**

<b>Equilibrium phase*</b>	<b>Ideal formula</b>
Alunite	$\text{KAl}_3(\text{SO}_4)_2(\text{OH})_6$
Anhydrite	$\text{CaSO}_4$
$\text{Ag}_2\text{Se}$	$\text{Ag}_2\text{Se}$
Barite	$\text{BaSO}_4$
$\text{Ba}_3(\text{AsO}_4)_2$	$\text{Ba}_3(\text{AsO}_4)_2$
Boehmite	$\text{AlOOH}$
Brochantite	$\text{Cu}_4^{2+}(\text{SO}_4)(\text{OH})_6$
Brucite	$\text{Mg}(\text{OH})_2$
Calcite	$\text{CaCO}_3$
Carnotite	$\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot \text{H}_2\text{O}$
$\text{Cr}_2\text{O}_3$	$\text{Cr}_2\text{O}_3$
Chrysotile	$\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$
Diaspore	$\alpha\text{-AlOOH}$
Epsomite	$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
Ferrihydrite	$5\text{Fe}_2\text{O}_3 \cdot 9\text{H}_2\text{O}$
Fluorite	$\text{CaF}_2$
Gibbsite	$\text{Al}(\text{OH})_3$
Gummite	$\text{UO}_3$
Gypsum	$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
$\text{HgSe}$	$\text{HgSe}$
Magnesite	$\text{MgCO}_3$
Malachite	$\text{Cu}_2^{2+}(\text{CO}_3)(\text{OH})_2$
Mirabilite	$\text{NaSO}_4 \cdot 10\text{H}_2\text{O}$
$\text{Ni}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$	$\text{Ni}_3(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$
$\text{NiCO}_3$	$\text{NiCO}_3$
Otavite	$\text{CdCO}_3$
Pyromorphite	$\text{Pb}_5(\text{PO}_4)_3\text{Cl}$
Rhodochrosite	$\text{Mn}^{2+}\text{CO}_3$
Rutherfordine	$\text{UO}_2\text{CO}_3$
Schoepite	$\text{UO}_2(\text{OH})_2 \cdot \text{H}_2\text{O}$
Sepiolite	$\text{Mg}_4\text{Si}_6\text{O}_{15}(\text{OH})_2 \cdot 6\text{H}_2\text{O}$
$\text{SiO}_2$ (am-ppt)	$\text{SiO}_2$
Tenorite	$\text{Cu}^{2+}\text{O}$
$\text{U}_3\text{O}_8$	$\text{U}_3\text{O}_8$
$\text{UO}_3$	$\text{UO}_3$
$\text{UO}_2(\text{OH})_2$ (beta)	$\text{UO}_2(\text{OH})_2$ (beta)

### 3.6 Adsorption

In solution, trace element concentrations are mostly controlled by adsorption onto common mineral phases or are removed from solution through a process of co-precipitation. The models assumed that trace metals may be removed from solution via sorption onto freshly generated mineral precipitates such as iron oxides. Ferrihydrite ( $5\text{Fe}_2\text{O}_3 \cdot 9\text{H}_2\text{O}$ ) was selected as a sorption surface because it is a common sorption substrate in oxygenated natural waters and because the trace element sorption thermodynamic properties of these reactions are well defined by numerous empirical studies. Adsorption of soluble phases to hydrous ferric oxides (HFO) is highly pH dependent as is the solubility of HFO itself. Below a pH of around 4.5, only minimal sorption of most dissolved metal species is observed (Stumm and Morgan, 1996). The mass of ferrihydrite used in the models was assumed to be identical to the mass of the mineral phase ferrihydrite precipitated in the previous model iterations and is controlled by the chemistry of the system. The model assumes that the ferrihydrite is characterized by both strong (HFO\_s) and weak (HFO\_w) surface adsorption sites. In order to be consistent with the properties of ferrihydrite published by Dzombak and Morel (1990) the geochemical models assumed a surface site density of 0.2 moles of weak sites and 0.005 moles of strong sites per mole of ferrihydrite.

As with mineral phase precipitation, the adsorbed mass of trace elements removed through this mechanism is assumed in the conceptual model to be permanently removed from the system following incorporation and co-precipitation with the HFO phase. In the case of a major shift in pH or redox conditions, it is possible that material adsorbed to the HFO surface may be released. However, based on the HCT results available to date, a major shift in pH conditions is not likely.

### 3.7 Evapoconcentration

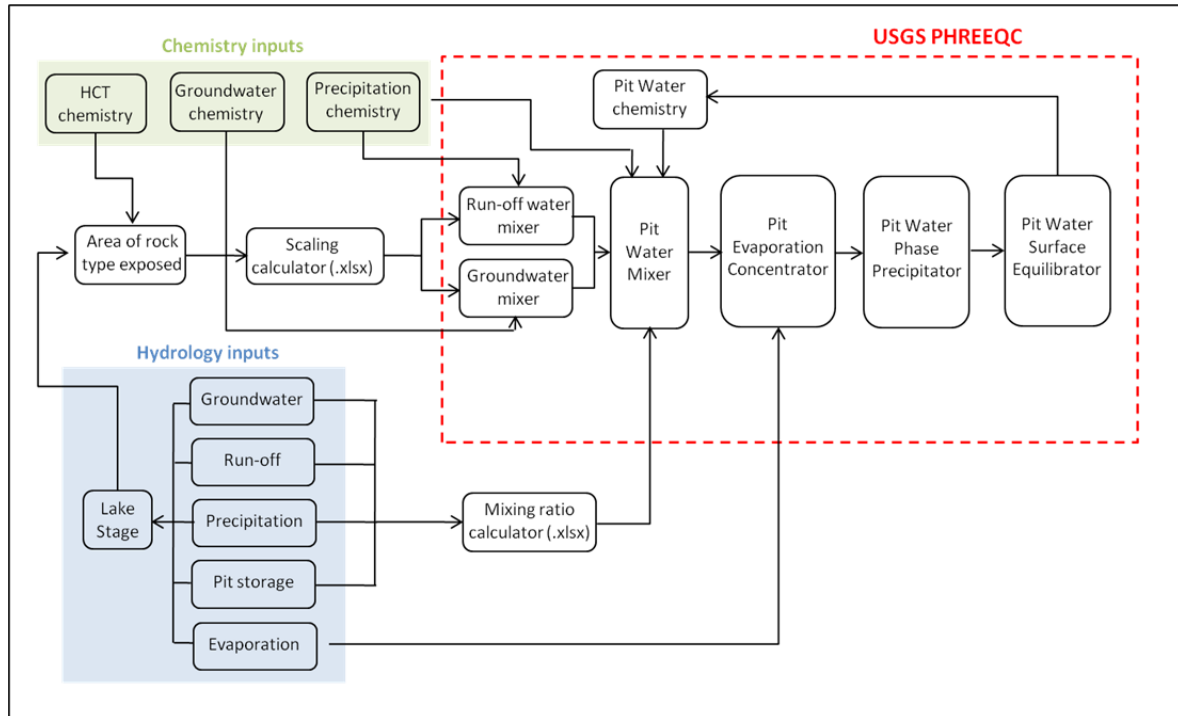
The pit lake will lose water through direct evaporation from the pit lake surface, thus solutes within the pit lake will evapoconcentrate. The only mechanism for removing solutes within the pit lake is the formation and settling of chemical precipitates and the adsorption of trace elements onto these particulates. The only mechanism for removal of water from the lake is evaporation.

### 3.8 Model Logic and Coding

The conceptual model developed for the Copper Flat pit lake (Section 3.1) has been translated into a numerical model using a geochemical thermodynamic equilibrium code and several limiting and simplifying assumptions. Water chemistry predictions were made using the USGS code PHREEQC, which has been rigorously tested and is the industry standard for pit lake, waste rock dump and tailings facility geochemical predictions. The PHREEQC models used a modified version of the minteq.v4 thermodynamic database supplied with the v2.17.4761 version of PHREEQC (released August 12th 2010). This database is widely used for geochemical modeling and was selected for this study because it includes the full range of elements for consideration in this water quality prediction as well as key sorption reactions for iron oxyhydroxides. The database was modified to include sorption data for manganese species.

The PHREEQC model consists of several components including the input data file, the thermodynamic database, the executable code and the output file. The input file consists of a series of logic statements and commands that define each of the components of the system and explains how these components interact. The input file is read by the executable code and commands are executed in a stepwise manner. Influent component waters were speciated and mixed to generate a series of intermediate waters, solid phases, and adsorbed phases. Selected outputs are specified and parceled out to various output files for analysis of results.

A logic flow diagram for the structure of the input code is provided in Figure 3-8 and discussed below. An example of the PHREEQC input code is provided in Appendix A.



**Figure 3-8: Copper Flat Pit Lake Model Execution Mechanics**

The steps in the modeling process include the following items:

1. Define run-off water input specific to each exposed rock type. The run-off solution chemistries are comprised of scaled kinetic test cell leachate concentrations for each material type. These leachates are scaled to the water:rock ratio from the cell to the field based on the estimated presence of fractures in the wallrock and the thickness of the reaction rind.
2. Define the run-off solution mixing ratios. Mixing ratios are based on the amount of each material type that is sub-aerially exposed in the pit high wall at each time step.
3. Define the groundwater input. Groundwater chemistry is based on a mass addition function that combines the existing mass found within the groundwater with the mass of solute (per unit surface area and rock mass) released in the kinetic tests for specific material types exposed in the final pit walls. This is scaled to the water:rock ratio from the cell to the field, based on the estimated thickness of the reaction rind within the fractured wallrock.
4. Define groundwater solution mixing ratios based on the exposed surface area for each material type within the pit wall below the pit lake surface (i.e. within the submerged pit wallrock). As with the run-off mixing ratio, this ratio is dependent on the pit lake elevation and changes at each simulated time step.
5. Define precipitation water chemistry based on representative chemical analyses of rainwater.
6. Perform a master mixing calculation where run-off waters, groundwater, atmospheric precipitation and existing pit lake waters are mixed in ratios defined by the site-wide water balance for each time step.
7. Evapoconcentration. The resulting pit water is concentrated by a factor equivalent to the calculated evapoconcentration determined by the site-wide water balance for each determined time step. A fixed percentage of water is removed as a reverse titration of water. At the end of each titration, the volume of water is readjusted to one liter.

8. Equilibrate and precipitate. Once mixed, the model is equilibrated with atmospheric gases and select mineral phases are allowed to precipitate at the calculated pH, with pE fixed at a subatmospheric value equal to  $12 - \text{pH}$ .
9. Calculate sorption. After mineral precipitation, trace elements were allowed to adsorb onto iron oxyhydroxides (i.e. ferrihydrite). The total mass of ferrihydrite is equivalent to the mass predicted to be generated during the previous reaction step. This assumption is conservative in that it does not account for sorption to other minerals such as aluminum oxide or clay, or to iron oxides present in the pit wallrock.
10. Save chemistry for the next time step. At the end of each time step, the predicted pit water chemistry is exported to a spreadsheet for analysis.
11. The model was terminated after sufficient iterations to simulate water quality over a 100-year filling period.

### 3.8.1 Treatment of Analytical Detection Limits

When analysis of HCT effluent leachates or source inflow groundwater identified certain elements to be uniformly at or below the analytical method detection limit (ADL) for a particular material type, that element was exempted from the PHREEQC evaluation. This prevents false exceedances of water quality standards that may arise as an artifact of the modeling exercise from the scaling of humidity cell data to field conditions or from equilibration of groundwater source data that are below analytical detection limits.

Nitrate was excluded from the geochemical predictions due to the lack of mineralogical controls in PHREEQC code. The exemption of nitrate is supported by the data as this parameter is consistently below analytical detection limits in both the humidity cell effluent leachates and the groundwater surrounding the pit. Nitrate is also below detection limits in the existing pit lake, supporting the assumption that this parameter is unlikely to be a problem during future operations.

## 3.9 Geochemical Modeling Assumptions

Despite site-specific data collection activities, several assumptions and model boundaries must be defined to construct a numerical model that predicts future water quality. Specific assumptions of the pit lake numeric models include:

1. Modeling is limited to predicting water quality under transient conditions with “steady-state” assumed for each time period modeled.
2. The geochemical model framework is defined by the water inputs and losses to/from the system.
3. The models are defined by the elements, mineral phases, gas phases, and chemical species specified in the model input files.
4. The models are limited to inorganic reactions and do not take into account the complexities associated with biologically mediated reactions.
5. The models are limited to thermodynamic equilibrium reactions and do not simulate the effects of reaction kinetics and rates.
6. The models rely on an external database of thermodynamic constants for mineral phase precipitates and sorbed surface complexes. These thermodynamic constants are valid at 25°C and 1 atmosphere of pressure.

7. The models assume atmospheric equilibrium with oxygen and carbon dioxide gas, with pH + pE equal to 12 (based on calculations by Baas-Becking et al., 1960 to define stability limits of natural waters).
8. The models do not consider the effects associated with the formation and precipitation of mineral species other than those specified. Due to kinetic constraints, a portion of the potentially oversaturated mineral phases will not actually precipitate. A select suite of minerals is therefore specified that are allowed to precipitate based on relevance for the environment in question, site-specific knowledge, experience in evaluating kinetic constraints and relevance of key phases for given styles of mineralization (Eary, 1998).
9. The models assume that solution input chemistry can be simulated using laboratory leachate chemistries from HCT tests.

### 3.10 Analysis of Model Input Variability

The various parameters that have been used as data inputs for the pit lake geochemical model have been assessed to determine their relative significance in influencing the model results. For the purpose of this exercise, each parameter has been assigned a qualitative value based on the degree to which it influences the final predicted solution chemistry:

- “Minor” represents less than 1% control on the final model output;
- “Moderate” represents between 1% and 10% control on the final model output; and
- “Significant” represents between 10% and 50% control on the final model output.

The results of this exercise are displayed in Table 3-6.



**Table 3-6: Analysis of Pit Lake Model Input Variability**

Category	Parameter	Assumptions / data used in model	Source	Control on final model results*
<b>Hydrogeologic information</b>	Pit lake water balance	100-year water balance provided by JSAI, including water elevation and surface area, groundwater inflows, direct precipitation, run-off and evaporation data.	JSAI, 2012	Significant. The water balance defines the mixing ratios for the PHREEQC input solutions.
<b>Chemical inputs</b>	Groundwater chemistry	Baseline groundwater chemistry data from the ongoing monitoring program: <ul style="list-style-type: none"> <li>Average of data for wells GWQ96-22A, GWQ96-22B, GWQ96-23A and GWQ96-22B.</li> </ul>	INTERA, 2012	Significant during the early years post-closure when groundwater is likely to represent the dominant solution input to the pit lake.
	Precipitation chemistry	Averaged precipitation chemistry from Gila Cliff Dwelling National Monument Meteorological Station (1985-2011)	NADP, 2012	Minor. The precipitation chemistry represents a near-pure solution chemistry. In the absence of site-specific data, published precipitation chemistry from this meteorological station in New Mexico is the best representation of precipitation chemistry in the area.
	HCT chemistry	Averaged HCT chemistry from the ongoing HCT programs.	SRK	Significant. The solutions generated by the HCT programs represent the main chemical inputs to the PHREEQC models.
<b>Geological information</b>	Pit wall surface area and lithologic composition	Pit wall surface areas were calculated for each simulated time step using the geologic block model and pre-feasibility study pit shell.	SRK/ THEMAC	Significant. The lithological composition of the pit wall defines the mixing ratios for the PHREEQC input solutions.
<b>Geochemical model assumptions</b>	Mass of pit wall rock available for reaction	Mass of future pit wall available for reaction was calculated assuming an oxidized rind of 0.04 feet thickness and a fractured zone of 1 feet thickness (with 10% fractures).	SRK/ THEMAC	Moderate. The values were assigned based on communication with NMCC regarding future blasting practices for the project and are considered a conservative estimate.
	Equilibrium/mineral phases	Alunite, Ag <sub>2</sub> Se, albite, anhydrite, azurite, barite, boehmite, brochantite, brucite, calcite, chrysotile, Cr <sub>2</sub> O <sub>3</sub> , diaspore, epsomite, ferrihydrite, fluoride, gypsum, gibbsite, gummite, kaolinite, magnesite, malachite, mirabilite, otavite, pyromorphite, rhodochrosite, rutherfordine, schoepite, sepiolite, SiO <sub>2</sub> , tenorite, U <sub>3</sub> O <sub>8</sub> , UO <sub>3</sub> , UO <sub>2</sub> (OH) <sub>2</sub>	SRK	Moderate. Mineral precipitation will influence final solution chemistry. Equilibrium phases were selected based on knowledge of site-specific geologic and mineralogic conditions and were then verified and refined by calibrating with the existing pit lake chemistry.

\* Minor: <1%  
Moderate: 1 - 10%  
Significant: 10 - 50%

### 3.11 Comparative Guidelines

Simulated pit lake water quality has been compared to NMAC 20.6.4.900 wildlife habitat and livestock watering standards. There is no existing or planned future use for aquatic life in the open pit water body. A Use Attainability Analysis (UAA) is being pursued to remove the designated use of aquatic life; therefore, only wildlife habitat and livestock watering standards are considered in this report. The standards used in the assessment are provided in Table 3-7.

**Table 3-7: NMAC 20.6.4.900 Wildlife Habitat and Livestock Watering Standards**

Parameter	NMAC 20.6.4.900 standards for livestock watering	NMAC 20.6.4.900 standards for wildlife <sup>†</sup>
As	0.2	-
B	5	-
Cd	0.05	-
Cr	1	-
Co	1	-
Cu	0.5	-
Hg	0.01*	0.00077*
Pb	0.1	-
Se	0.05	0.005*
V	0.1	-
Zn	25	-

*Values in mg/L for dissolved constituent unless otherwise noted*

*\* Indicates standard applies to total (i.e. unfiltered) fraction*

*<sup>†</sup> - indicates no standard for parameter*

### 3.12 Existing Pit Lake Calculations

In addition to the predictions of future potential pit lake chemistry, numerical predictions have been undertaken to model the current (i.e. existing) pit lake chemistry to calibrate and verify the future pit lake geochemical predictions. A water balance for the period 1980 to 2014 was provided to SRK by JSAI and this was coupled with the results of the HCT testwork and data relating to the existing pit wall geology to carry out numerical simulations of existing pit lake water quality.

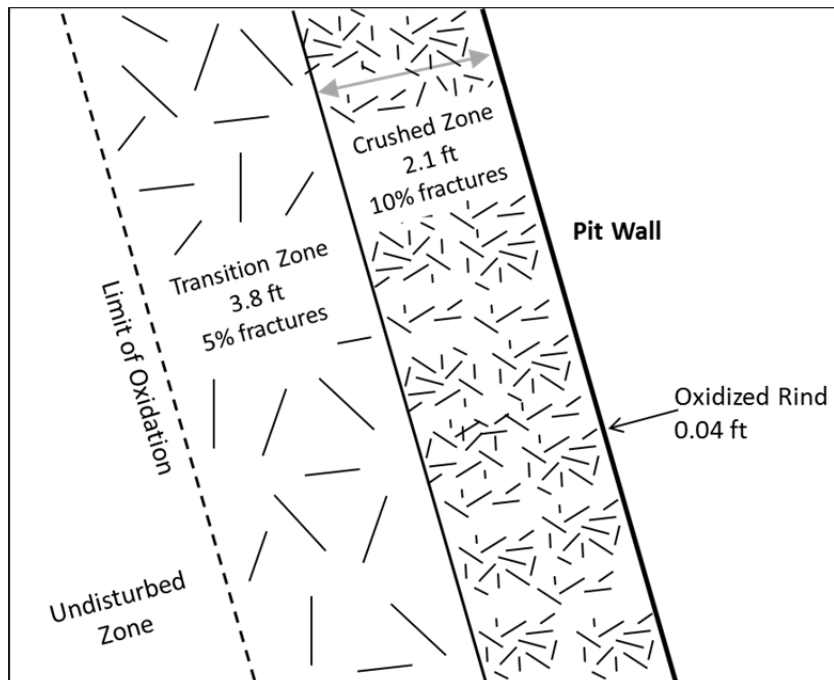
The water balance data used in the existing pit lake predictions are summarized in Figure 3-5 and Figure 3-6. In addition the pit wall surface areas (per lithology) are provided in Table 3-8. The method used to calculate existing pit lake water quality is the same as that described in Sections 3.2.2 to 3.8, above with the exception of the reactive mass assumed in the pit high wall.

During Quintana's operations, the existing pit at Copper Flat was not prepared using pre-split drilling and smooth wall blasting. Therefore, the existing pit wall has significantly deeper fracturing than predicted for the future final pit wall from the proposed operation. For this scenario, an estimate of the reactive rind thickness is provided by results from a U.S. Bureau of Mines experimental study on fracturing produced in the vicinity of large-diameter blast holes in Lithonia granite. From this study, a severely fractured zone (i.e., crushed zone) was identified that extends approximately 2 feet into the pit wall and a second zone (i.e., transition zone) characterized by a lesser degree of fracturing extends from 2 to 4 feet (Siskind and Fumanti, 1974). For this scenario it is assumed that oxygen infiltration extends no further than the predicted depth of fracturing of 2 feet, and that the percent of the rim rock mass fractured during mining will range from 5% within the crushed zone to 10% within the transition zone. This estimate of fracturing is supported by Atchison (1968). As described above,

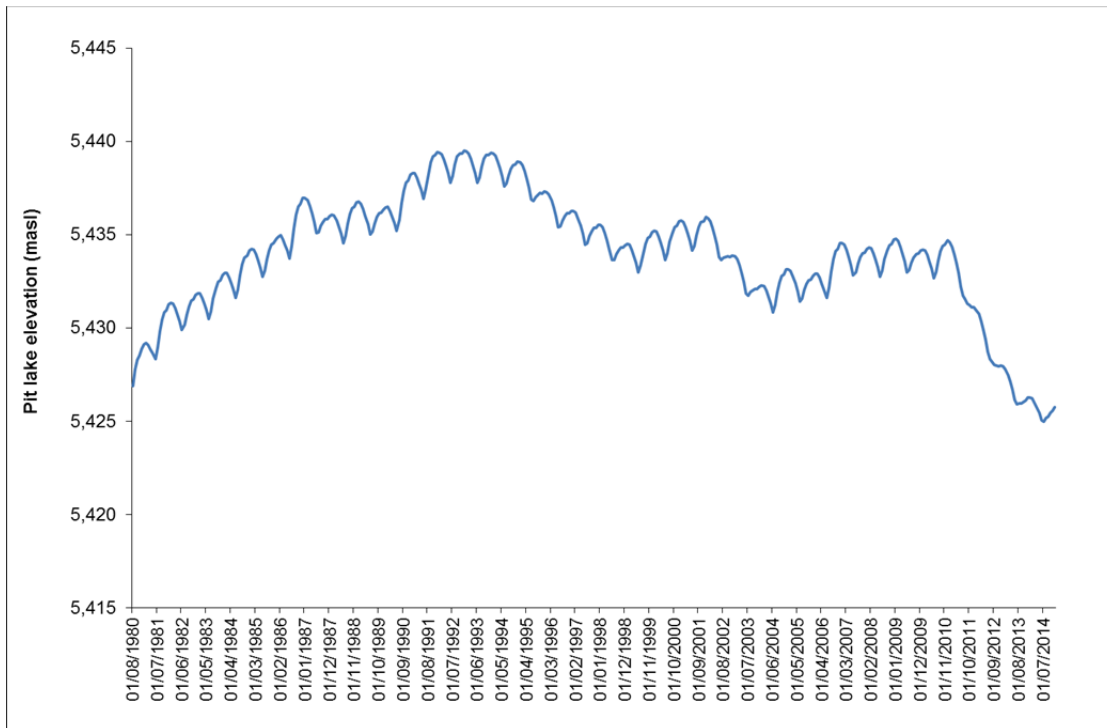
a reactive rim of 0.04 feet thickness has also been assumed in the pit walls. The conceptual model for the existing pit walls is provided in Figure 3-9.

**Table 3-8: Pit Wall Surface Areas Used in the Existing Pit Lake Calculations**

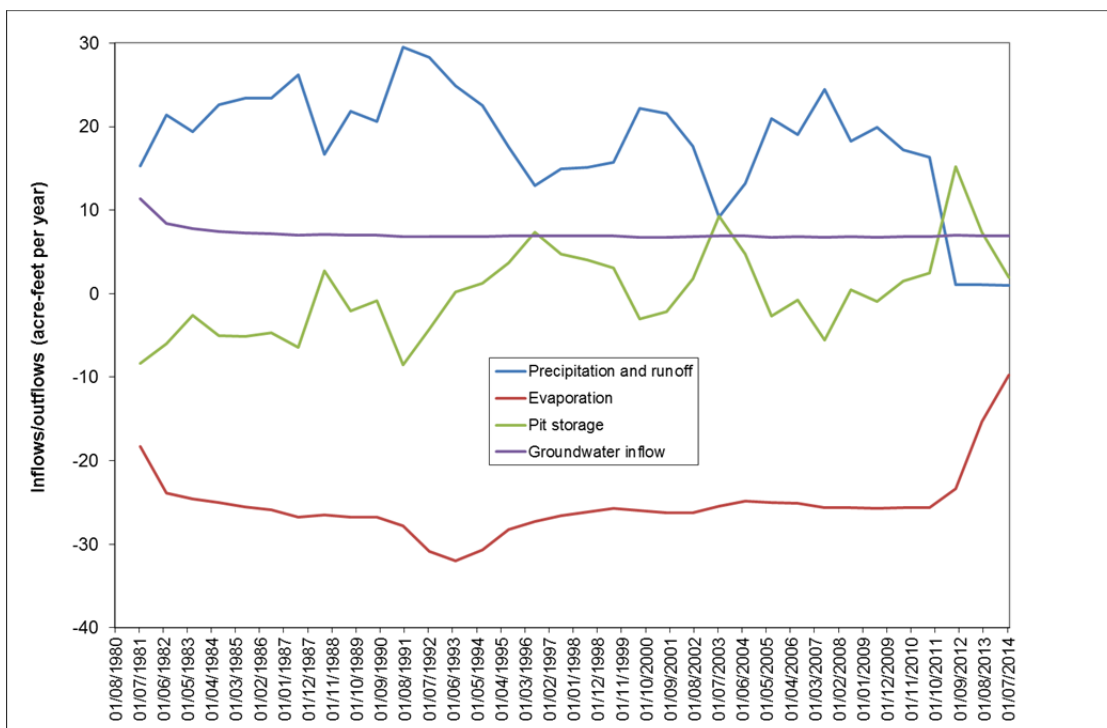
Material type	Oxidation	3D surface area (ft <sup>2</sup> )	3D surface area (m <sup>2</sup> )	Proportion
Biotite breccia	Oxide	137,327	12,758	13.2%
Quartz feldspar breccia		11,728	1,090	1.13%
Quartz monzonite		291,598	27,090	28.1%
Undefined		42,613	3,959	4.10%
Biotite breccia	Sulfide (non-ox.)	90,494	8,407	8.71%
Quartz feldspar breccia		46,096	4,282	4.44%
Quartz monzonite		414,065	38,468	38.9%
Undefined		5,154	478	0.50%



**Figure 3-9: Existing Pit Wall Conceptual Model**



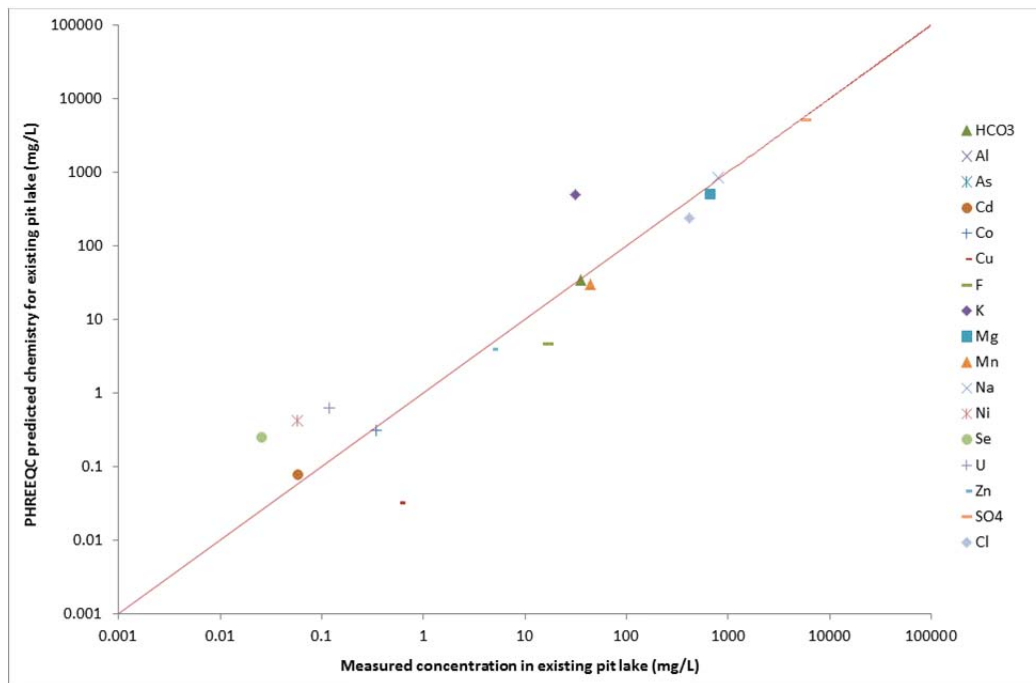
**Figure 3-10: Existing Pit Lake Water Level**



**Figure 3-11: Existing Pit Lake Inflows/outflows**

The results of the existing pit lake calculations are shown in Figure 3-12 and Table 3-9. The results show generally good correlation between measured and predicted pit lake water quality. This demonstrates that the input parameters used for the future pit lake water quality predictions are valid and the model approach produces generally reproducible results. However, the predicted concentrations for a number of parameters differ from the measured concentrations in the existing pit lake:

- The predicted concentrations of aluminum and iron are lower than the measured values. This discrepancy may relate to the fact that PHREEQC reports only truly dissolved phases. It is possible that aluminum and iron in the existing pit lake may exist in the form of fine-grained colloids that pass through a 0.45 µm filter, which explains the higher measured concentrations of these parameters.
- The predicted concentrations of antimony, boron, molybdenum, nickel, potassium, selenium, and vanadium are higher than the measured concentrations by an order of magnitude or more. This may relate to the lack of appropriate mineralogical controls for these elements in PHREEQC, resulting in a slight overestimate for these parameters. The over estimation and lack of attenuation or mineralogical controls is such that these elements cannot be accurately quantified by the modeling approach.



**Figure 3-12: Predicted vs. Measured Pit Lake Chemistry for the Existing Pit Lake**

**Table 3-9: Predicted vs. Measured Pit Lake Chemistry for the Existing Pit Lake**

			Measured chemistry in existing pit lake	PHREEQC predicted chemistry for existing pit lake
<b>pH</b>	<b>pH</b>	s.u.	7.35	7.90
<b>pe</b>	<b>pe</b>	s.u.	-	4.88
<b>Alk</b>	<b>Alkalinity as CaCO<sub>3</sub></b>	mg/L	-	74.8
<b>HCO<sub>3</sub></b>	<b>Bicarbonate</b>	mg/L	35.7	34.2
<b>Ag</b>	<b>Silver</b>	mg/L	<0.0025	0.001
<b>Al</b>	<b>Aluminum</b>	mg/L	0.502	0.0004
<b>As</b>	<b>Arsenic</b>	mg/L	0.003	0.0001
<b>B</b>	<b>Boron</b>	mg/L	0.16	2.44
<b>Ba</b>	<b>Barium</b>	mg/L	0.012	0.003
<b>Ca</b>	<b>Calcium</b>	mg/L	592	465
<b>Cd</b>	<b>Cadmium</b>	mg/L	0.06	0.08
<b>Co</b>	<b>Cobalt</b>	mg/L	0.34	0.30
<b>Cr</b>	<b>Chromium</b>	mg/L	0.012	0.0001
<b>Cu</b>	<b>Copper</b>	mg/L	0.60	0.03
<b>F</b>	<b>Fluoride</b>	mg/L	17.0	4.62
<b>Fe</b>	<b>Iron</b>	mg/L	0.04	0.0001
<b>Hg</b>	<b>Mercury</b>	mg/L	<0.002	0.001
<b>K</b>	<b>Potassium</b>	mg/L	31.0	492
<b>Mg</b>	<b>Magnesium</b>	mg/L	677	498
<b>Mn</b>	<b>Manganese</b>	mg/L	44.0	29.8
<b>Mo</b>	<b>Molybdenum</b>	mg/L	0.02	1.56
<b>Na</b>	<b>Sodium</b>	mg/L	792	831
<b>Ni</b>	<b>Nickel</b>	mg/L	0.058	0.42
<b>Pb</b>	<b>Lead</b>	mg/L	<0.005	0.00005
<b>Sb</b>	<b>Antimony</b>	mg/L	<0.001	0.09
<b>Se</b>	<b>Selenium</b>	mg/L	0.03	0.24
<b>U</b>	<b>Uranium</b>	mg/L	0.12	0.62
<b>V</b>	<b>Vanadium</b>	mg/L	<0.05	0.18
<b>Zn</b>	<b>Zinc</b>	mg/L	4.87	3.88
<b>SO<sub>4</sub></b>	<b>Sulfate</b>	mg/L	5,900	5,152
<b>Cl</b>	<b>Chloride</b>	mg/L	412	235
<b>TDS</b>	<b>Total Dissolved Solids</b>	mg/L	8,589	7,751

### 3.13 Future Pit Lake Results

The predicted pit lake chemistry for each of the post-closure time steps are summarized in Table 3-6 and are provided in Figure 3-13 to Figure 3-23 for selected parameters. These show predicted/modeled pit lake chemistry compared to New Mexico surface water standards for livestock and wildlife.

Pit lake waters are predicted to be moderately alkaline (pH ~8), with a magnesium plus sulfate (Mg + SO<sub>4</sub>) major ion signature. During the early stages of pit infilling (i.e. first six months post-closure), the prediction is that an early flush will occur in cadmium, molybdenum, selenium, sodium, chloride, and sulfate concentrations in the pit lake. This initial flush occurs due to dissolution of soluble sulfate salts that will have developed on the pit walls during life of mine. Inflowing groundwater and direct precipitation on the pit lake surface will then provide some dilution and the effects of this initial flush will be dissipated. The pit lake chemistry is expected to evolve over time, with several parameters increasing in concentration as a result of evapoconcentration effects. This is similar to the trends observed in the existing pit lake, where elemental concentrations (particularly boron, cadmium, fluoride, magnesium, manganese, molybdenum, sodium, and sulfate) have increased over time (Figure 3-22). The macrochemistry (Mg-Na-SO<sub>4</sub>) changes are reflected in the Piper plot in Figure 3-23, which shows a progressive change in pit lake major ion chemistry post-closure, with waters becoming increasingly dominated by sulfate and magnesium over time.

Pit lake chemistry is likely to be dominated by surface run off, evapoconcentration effects, and by equilibrium chemistry in the lake. Over time, the groundwater contribution will decrease as the pit lake is established. Both adsorption and the secondary mineral precipitation are likely to be the major controls on trace element chemistry. However, arsenic chemistry is likely to be controlled by sorption onto iron oxyhydroxides due to its strong affinity for these surfaces at the predicted pH of the pit lake.

Modeled pit lake chemistry has been compared against New Mexico surface water standards for livestock watering and wildlife and demonstrates following the initial flush post-closure, most parameters are expected to be below New Mexico livestock standards. The exception to this is selenium, which is predicted to exceed the livestock watering standard of 0.05 mg/L after 5 years. Mercury is also expected to increase in concentration over time, and is predicted to marginally exceed the stringent wildlife standard after approximately 15 years.

A number of parameters are predicted to increase in concentration over time, primarily as a result of evapoconcentration effects. The predicted increase in cadmium concentrations likely relates to both the presence of cadmium as a trace element in sphalerite in the Copper Flat mineralization (SRK, 2013) and also evapoconcentration effects over time with cadmium in the existing pit lake showing an increase from <0.005 mg/L in 1991 to 0.053 mg/L in 2011 (Appendix C). Nonetheless, cadmium concentrations are not expected to exceed the livestock watering standard of 0.05 mg/L in the future pit lake.

The predicted increase in boron concentrations over time may relate to the combined effects of evapoconcentration and the lack of appropriate mineralogical control in PHREEQC. Boron in the existing pit lake has been shown to increase slightly in concentration from <0.1 mg/L in 1989 to 0.18 mg/L in 2011 (Appendix C), indicating that marginal evapoconcentration effects may be taking place within the existing pit lake. However, the calibration model for the existing pit (Section 3.12) shows that PHREEQC overestimates boron concentrations by over fifteen-fold (over one order of magnitude), demonstrating that the mineralogical controls in PHREEQC may not be adequately controlling the boron chemistry. Although boron will be present at detectable concentrations in any future pit lake that forms, concentrations are not predicted to exceed the livestock watering standard of 5 mg/L.

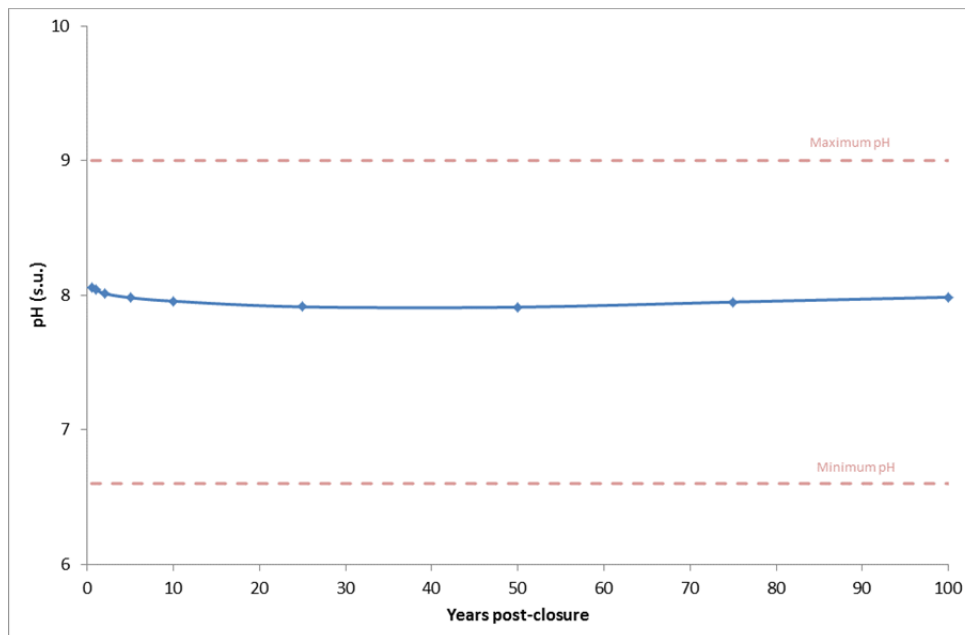
Mercury concentrations are predicted to be marginally elevated above the stringent wildlife standard for approximately 15 years post-closure, with estimated concentrations between 0.001 mg/L (at year



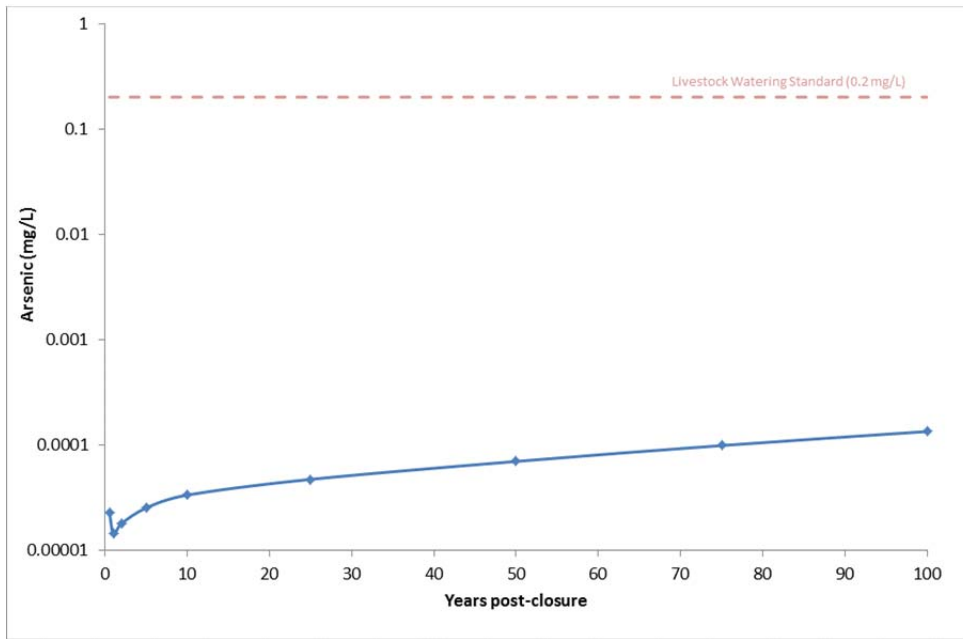
25) and 0.003 mg/L (at year 100) compared to the wildlife standard for total mercury of 0.00077 mg/L. However, concentrations are not predicted to be elevated above the livestock watering standard of 0.01 mg/L for total mercury. The calibration model (Section 3.12) was able to accurately predict mercury concentrations in the existing pit lake, therefore the predicted future concentrations are likely to be a reasonable representation of mercury chemistry in any future pit lake that will form.

Selenium is predicted to be elevated above the wildlife standard in the future pit lake with concentrations ranging from 0.09 mg/L (at year 1) to 0.79 mg/L (at year 100) in comparison to the wildlife standard of 0.005 mg/L. This likely relates to the observed release of selenium from the sulfide humidity cells, particularly during the first 25 weeks of testwork. Selenium is present at detectable concentrations (~0.035 mg/L) in the existing pit lake and there is likely to be evapoconcentration effects over time due to the mobility of selenium at moderately alkaline pH, which will limit the formation of selenium-bearing mineral phases. However, the calibration model for the existing pit lake overestimates selenium by eight-fold (approximately one order of magnitude; Section 3.12). Most likely similar over-estimation issues will occur in the predictions for the future pit lake as well. Nonetheless, it is likely that selenium will be present at detectable concentrations in any future pit lake that forms.

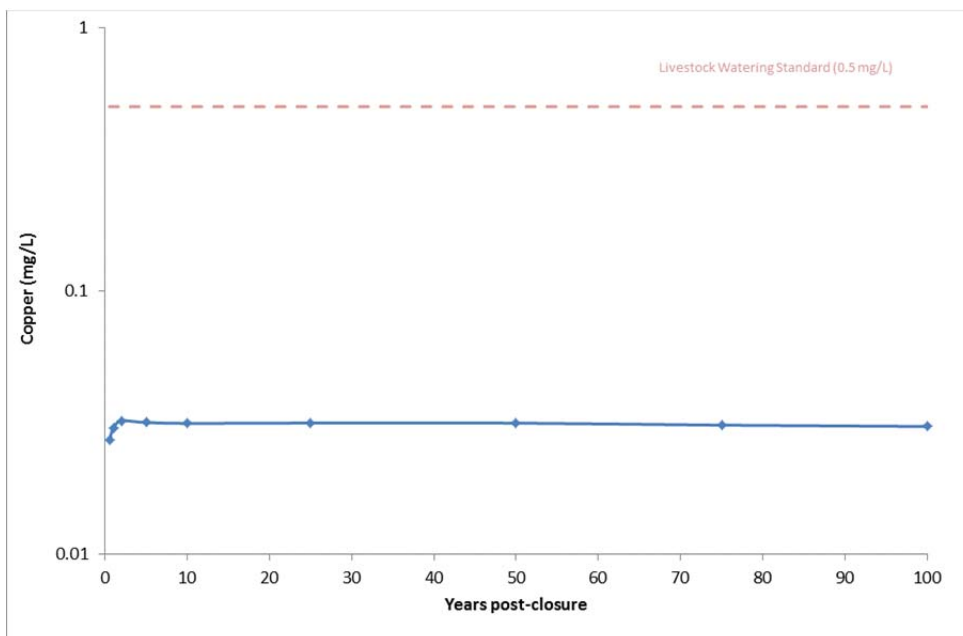
The model results predict that vanadium concentrations may become marginally elevated above the livestock watering standard approximately 75 years post-closure, with predicted concentrations of 0.14 mg/L (at year 100) compared to a standard of 0.1 mg/L. Although the sulfide humidity cells showed detectable release of vanadium during the first 20 weeks of testing (Appendix B), the calibration model for the existing pit lake overestimates vanadium by approximately four-fold (Section 3.12). These results suggest the predicted exceedances for vanadium for the future pit lake relate to the lack of appropriate mineralogical controls for this element within the PHREEQC database rather than evapoconcentration. Based on the calibration model, the vanadium concentrations in the future pit lake are estimated to be approximately 25% of the predicted concentration, which reduces vanadium concentrations to below the livestock watering standard. Therefore, vanadium is predicted to be below the livestock standard in the final Copper Flat pit lake.



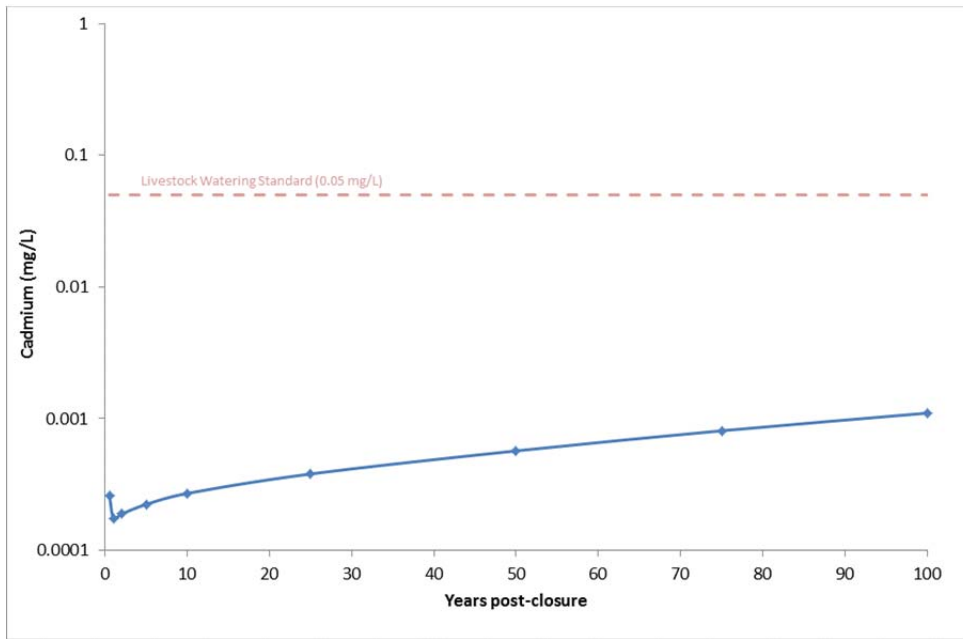
**Figure 3-13: Time-series Plot of Pit Lake Predicted pH**



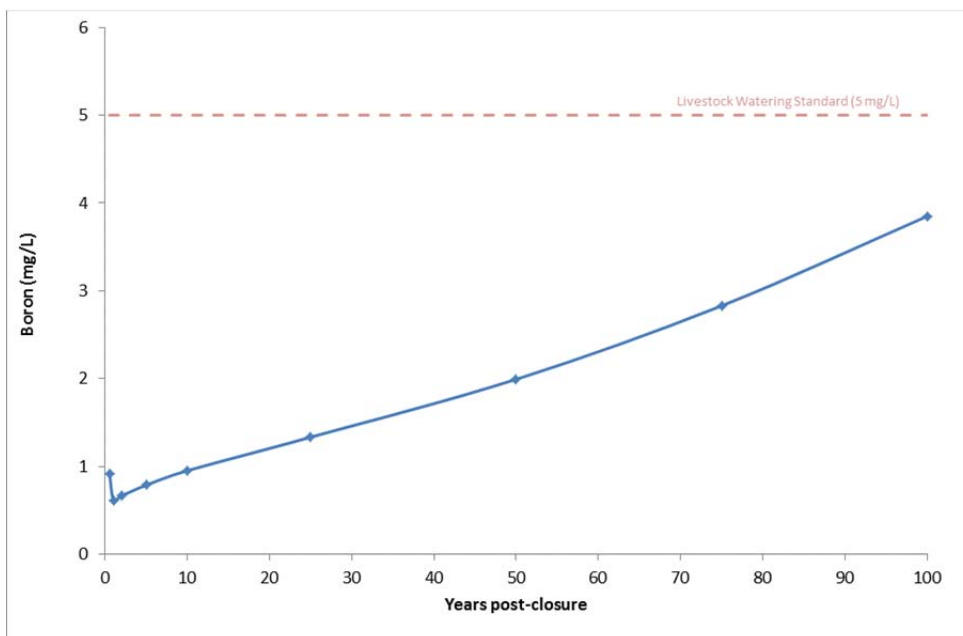
**Figure 3-14: Time-series Plot of Pit Lake Predicted Arsenic**



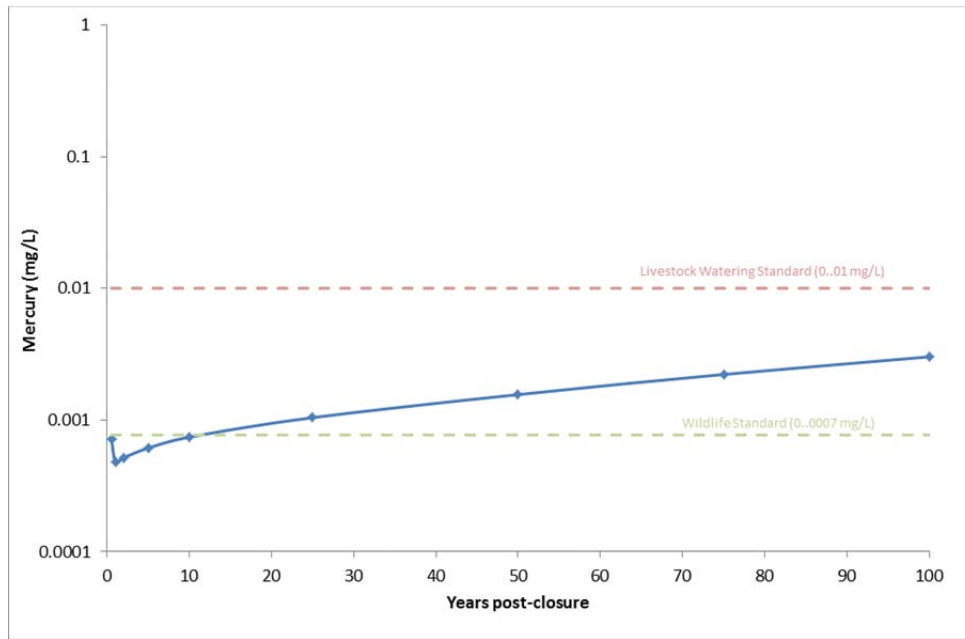
**Figure 3-15: Time-series Plot of Pit Lake Predicted Copper**



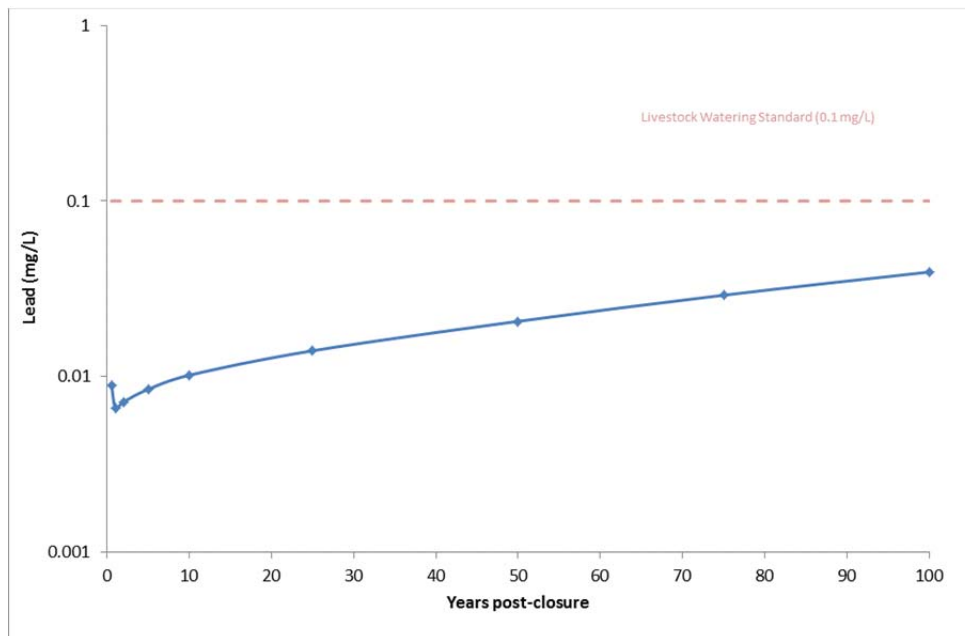
**Figure 3-16: Time-series Plot of Pit Lake Predicted Cadmium**



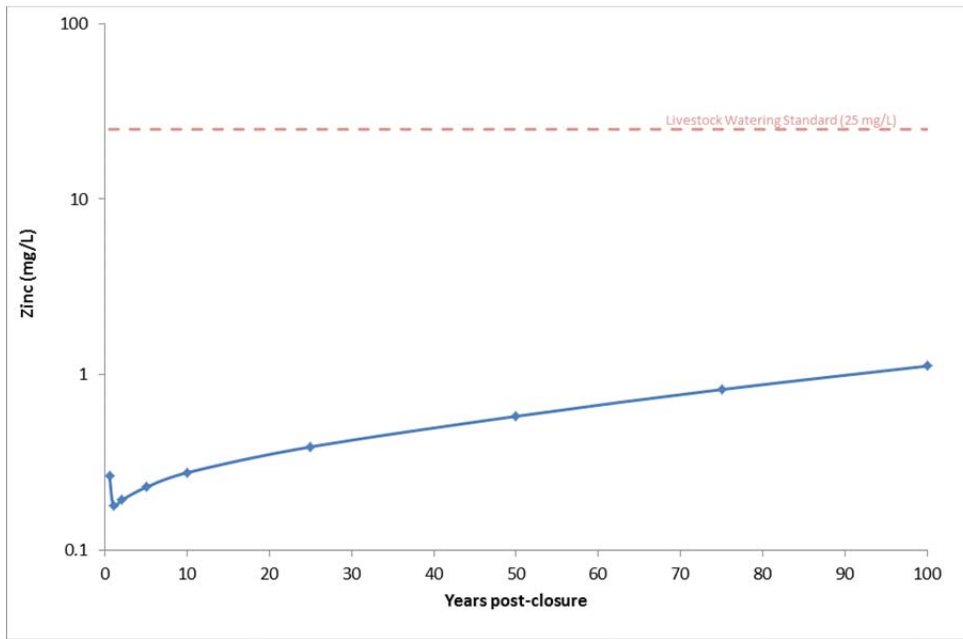
**Figure 3-17: Time-series Plot of Pit Lake Predicted Boron**



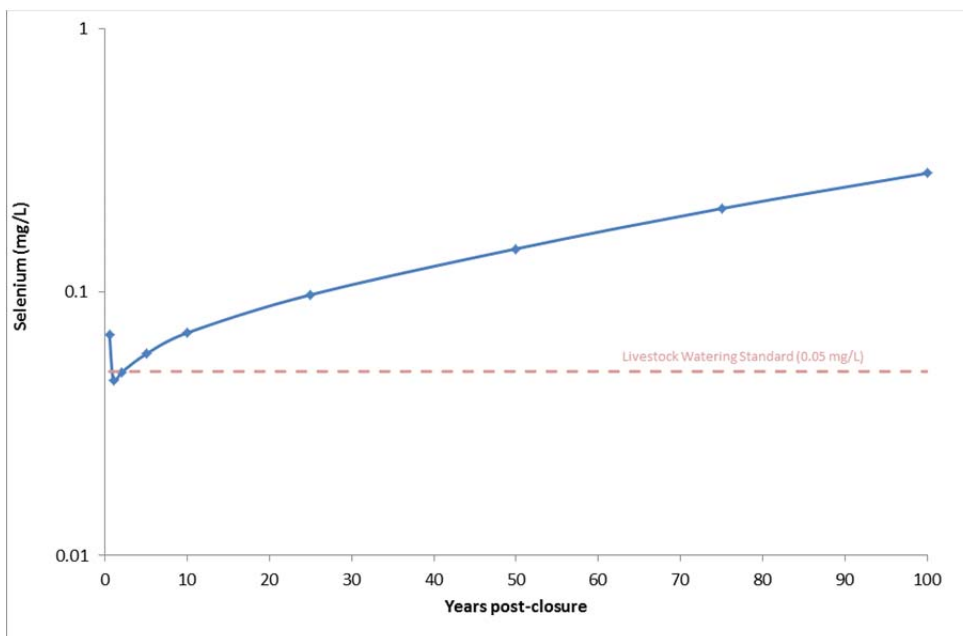
**Figure 3-18: Time-series Plot of Pit Lake Predicted Mercury**



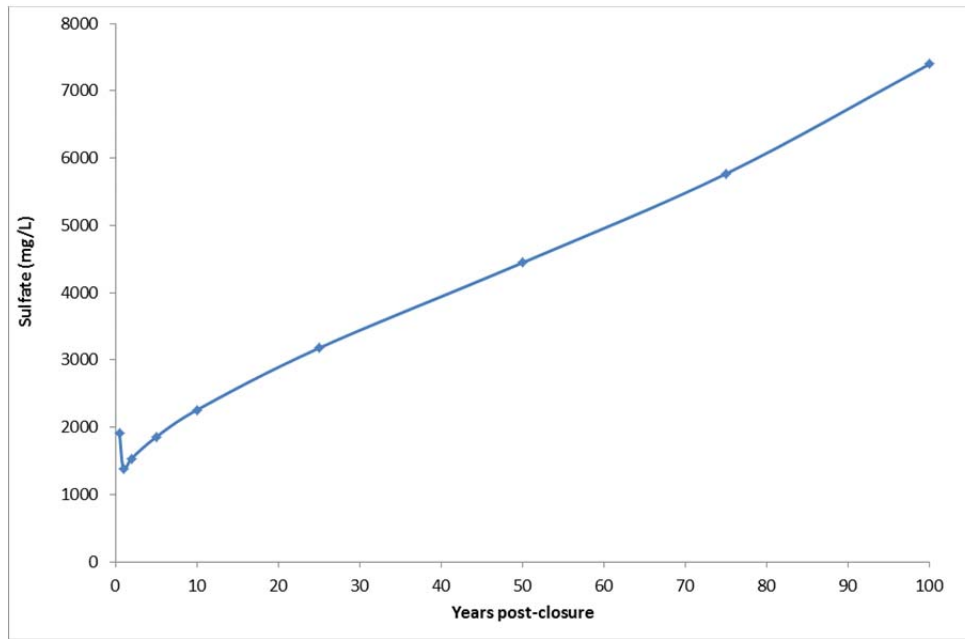
**Figure 3-19: Time-Series Plot of Pit Lake Predicted Lead**



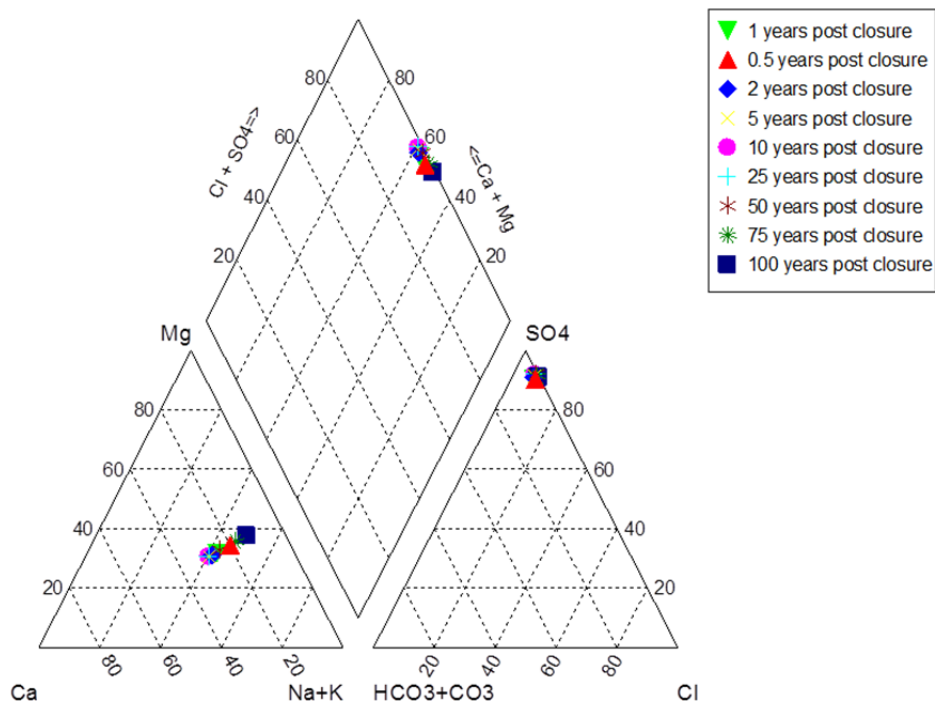
**Figure 3-20: Time-Series Plot of Pit Lake Predicted Zinc**



**Figure 3-21: Time-Series Plot of Pit Lake Predicted Selenium**



**Figure 3-22: Time-Series Plot of Pit Lake Predicted Sulfate**



**Figure 3-23: Piper Plot Showing Predicted Pit Lake Major Ion Chemistry**

**Table 3-10: Future Predicted Pit Lake Chemistry (Base Case Scenario)**

			NMAC 20.6.4900 Surface water standards		Years post-closure								
			Livestock	Wildlife	0.5	1	2	5	10	25	50	75	100
pH	pH	s.u.	6.6 - 9		8.06	8.04	8.01	7.98	7.95	7.91	7.91	7.95	7.98
pe	pe	s.u.	-	-	4.72	4.73	4.76	4.79	4.82	4.86	4.86	4.82	4.79
Alk	Alkalinity as CaCO <sub>3</sub>	mg/L	-	-	75.4	70.6	66.5	63.1	60.8	57.6	60.2	68.5	78.1
HCO <sub>3</sub>	Bicarbonate	mg/L	-	-	44.4	41.8	39.4	37.4	35.9	33.8	34.8	39.0	43.6
Ag	Silver	mg/L	-	-	0.0006	0.0004	0.0005	0.0005	0.0006	0.0007	0.001	0.001	0.002
Al	Aluminum	mg/L	-	-	0.0006	0.0006	0.0005	0.0005	0.0005	0.0004	0.0004	0.0005	0.0005
As	Arsenic	mg/L	0.2	-	0.00002	0.00001	0.00002	0.00003	0.00003	0.00005	0.0001	0.0001	0.0001
B	Boron	mg/L	5	-	0.92	0.62	0.67	0.79	0.95	1.33	1.99	2.83	3.85
Ba	Barium	mg/L	-	-	0.005	0.006	0.006	0.005	0.005	0.004	0.004	0.003	0.003
Ca	Calcium	mg/L	-	-	173	160	193	239	292	409	480	454	431
Cd	Cadmium	mg/L	0.05	-	0.0003	0.0002	0.0002	0.0002	0.0003	0.0004	0.001	0.001	0.001
Co	Cobalt	mg/L	1	-	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02
Cu	Copper	mg/L	0.5	-	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
F	Fluoride	mg/L	-	-	3.96	3.97	4.19	4.02	3.93	3.82	4.15	4.94	5.84
Fe	Iron	mg/L	-	-	5.07E-05	5.08E-05	5.25E-05	5.46E-05	5.66E-05	6.03E-05	6.14E-05	5.94E-05	5.76E-05
Hg	Mercury	mg/L	0.01	0.00077	0.0007	0.0005	0.0005	0.0006	0.0007	0.001	0.002	0.002	0.003
K	Potassium	mg/L	-	-	215	145	156	185	224	314	471	669	910
Mg	Magnesium	mg/L	-	-	180	121	131	155	188	264	395	558	758
Mn	Manganese	mg/L	-	-	5.9	3.98	4.30	5.09	6.2	8.6	12.9	18.3	25.0
Mo	Molybdenum	mg/L	-	-	0.55	0.42	0.47	0.58	0.71	1.00	1.37	1.74	2.17
Na	Sodium	mg/L	-	-	329	221	239	281	338	471	701	993	1,349
Ni	Nickel	mg/L	-	-	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03
Pb	Lead	mg/L	0.1	-	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04
Sb	Antimony	mg/L	-	-	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.05
Se	Selenium	mg/L	0.05	0.005	0.07	0.05	0.05	0.06	0.07	0.10	0.15	0.21	0.28
U	Uranium	mg/L	-	-	0.005	0.005	0.004	0.003	0.003	0.003	0.00	0.01	0.02
V	Vanadium <sup>1</sup>	mg/L	0.1	-	0.05	0.04	0.04	0.04	0.05	0.06	0.07	0.10	0.14
Zn	Zinc	mg/L	25	-	0.27	0.18	0.19	0.23	0.28	0.39	0.58	0.82	1.12
SO <sub>4</sub>	Sulfate	mg/L	-	-	1,907	1,374	1,536	1,853	2,256	3,176	4,445	5,767	7,398
Cl	Chloride	mg/L	-	-	124	83.6	90.3	107	128	179	267	378	514
TDS	Total Dissolved Solids	mg/L	-	-	2,985	2,155	2,394	2,869	3,475	4,862	6,814	8,887	11,441

Indicates exceedance of NMAC 20.6.4.900 standard for wildlife

Indicates exceedance of NMAC 20.6.4.900 standard for livestock watering

<sup>1</sup> Due to limitations on mineralogical controls, the geochemical code over predicts the concentration of vanadium as demonstrated by the calibration model.

-- indicates no standard for parameter



### 3.14 Model Limitations

The pit water quality predictions presented herein are considered the best representation of likely future water quality associated with the Copper Flat pit lake. However, it is recognized that there are a number of limitations associated with the predictive calculations including:

- Modeling was limited to predicting water quality within the pit lake for a 100-year time period. This length of time was chosen as a period of regulatory interest, and is not intended to imply that the pit lake geochemistry or hydrogeology will achieve steady-state, hydrogeochemical equilibrium at 100-years. The lake is expected to continue to evolve hydrologically and geochemically after this period of time, but uncertainties related to extending predictions beyond the 100-year period diminish the utility of longer-term predictions.
- The model does not consider the effects associated with the formation and precipitation of mineral species other than those specified. Due to kinetic constraints, a portion of the potentially oversaturated mineral phases will not actually precipitate. A select suite of minerals is therefore specified that are allowed to precipitate, based on relevance for the environment in question, site-specific knowledge, experience in evaluating kinetic constraints and relevance of key phases for given styles of mineralization, and literature review (Eary, 1999).
- The models rely on an external database of thermodynamic constants, which have been developed under controlled laboratory conditions and are valid at 25°C and 1 atmosphere of pressure. The nature of the thermodynamic databases means that the constants for all major elements and a large number of trace elements are well understood and have been rigorously tested and verified. However, constants for certain parameters (for example vanadium) are not as well understood. As such, the mineralogical controls on these elements in PHREEQC are poorly defined, which may affect their precipitation (i.e., removal) from solution in the predictive calculations. This limitation with the thermodynamic database is evidenced by the over-prediction of vanadium in the calibration model for the existing pit lake, demonstrating that the future pit lake prediction for vanadium is not a valid prediction.
- The results of the predictive calculations do not take into account site specific ecological risk. Model results indicate that mercury concentrations in the future Copper Flat pit lake are predicted to become marginally elevated above the wildlife standard approximately 15 years post-closure, with predicted concentrations between 0.001 mg/L and 0.003 mg/L compared to a standard of 0.00077 mg/L. Although above the stringent wildlife standard, the predicted mercury concentrations are uniformly (and significantly) below the livestock watering standard of 0.01 mg/L. Given that predicted mercury concentrations in the future pit lake are only marginally elevated above the wildlife standard, an ecological impact is unlikely. However, it is recommended that this is corroborated by coupling the results of the pit lake water quality predictions with site-specific ecological data to quantitatively evaluate potential toxicological risks.
- The model assumes that groundwater and surface water input chemistry can be simulated using laboratory kinetic (humidity cell) leachate chemistries, which are appropriately scaled to field conditions. The reactive surface area, ratio of water-to-rock and flushing rates in laboratory tests are different from actual field conditions. Grain size is smaller in the kinetic and static test cells and the resulting surface area for reactivity is greater. The laboratory test cells are operated at a higher water-to-rock ratio than would be expected in the field and are flushed more frequently, so that mineral-water reaction rates are enhanced. Because the future Copper Flat pit does not yet exist, field scale parameters cannot be measured, so scaling relies on published estimates of future groundwater flux and fracture density.

- The models have been developed using site-specific geochemical, hydrochemical, geological, hydrogeological and mine plan information. Therefore, changes in operational decisions may result in a change in the future pit lake water quality at Copper Flat.

## 4 Conclusions and Recommendations

SRK has undertaken a predictive geochemical modeling exercise to assess potential future pit lake chemistry associated with the Copper Flat project, New Mexico. The Copper Flat deposit is an alkalic copper-gold mineralized breccia pipe associated with, and genetically linked to, an alkalic porphyry system.

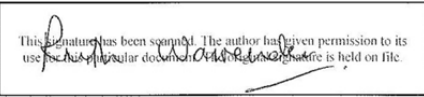
Waters in the future pit lake at Copper Flat are predicted to be moderately alkaline (pH ~8), primarily due to the buffering capacity of the inflowing groundwater. During the early stages of pit infilling (i.e., during the first six months post-closure), removal/flushing of soluble salts from the pit walls is likely to result in a flush in sulfate, cadmium, molybdenum, selenium, sodium, chloride, and sulfate concentrations in the early pit lake. The effects of this initial flush will be dissipated by inflowing groundwater and precipitation and pit lake chemistry will then evolve over time, with several parameters increasing in concentration as a result of evapoconcentration effects. This is similar to the trends observed in the existing pit lake, where elemental concentrations have increased since the start of pit infilling.

The model simulations demonstrate that all of the modeled chemical parameters are expected to be below New Mexico livestock standards (NMAC 20.6.4.900) in the 100 years post closure pit lake with the exception of selenium. Vanadium concentrations are reported above the livestock standard; however, due to limitations on mineralogical controls the current geochemical code over predicts the concentration of vanadium, as demonstrated by the calibration model. Once this is taken into account, vanadium is not expected to exceed the livestock standard.

Mercury concentrations are anticipated to increase over time, but remain below the livestock standard (0.01 mg/L) through year 100, post closure. Mercury concentrations are predicted to be marginally above the wildlife standard of 0.00077 mg/L by year 25. However, this exceedance is minimal, and may not represent a true ecological risk to area wildlife within the Copper Flat project area.

SRK has provided NMCC with a plan of action for a Screening Level Ecological Risk Assessment (SLERA) to quantitatively evaluate the potential toxicological risks posed by the future pit lake at Copper Flat. A SLERA is a Tier 1 approach that utilizes both site-specific data and published ecological data to determine if further evaluation of potential ecological risks may be warranted. However, the predicted concentrations of selenium and mercury in the future Copper Flat pit lake are unlikely to present an environmental or ecological risk.

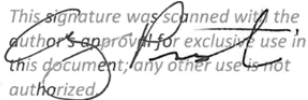
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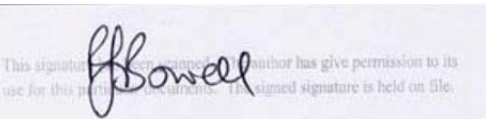


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Eur. Geol. Rob Bowen PhD C. Chem C. Geol  
Corporate Consultant (Geochemistry)

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## **Appendix A – Example of PHREEQC Input File**

Title Copper\_Flat\_base\_case\_v10

KNOBS

```
-iterations      10000
-convergence_tolerance 1e-007
-tolerance       1e-016
-step_size       100
-pe_step_size     5
end
```

SELECTED\_OUTPUT

```
-file            Copper_Flat_base_case_v10.out
-selected_out     true
-high_precision   true
-simulation       true
-state           true
-solution         true
-distance         false
-time            false
-step            false
-ph              true
-pe              true
-alkalinity       true
-ionic_strength   false
-water           false
-charge_balance   false
-totals           C(4) Ag Al As B Ba Ca Cd Co Cr
                  Cu F Fe Hg K Mg Mn Mo
                  Na Ni Pb Sb Se U V
                  Zn S(6) Cl N(3) N(5)
-saturation_indices Gypsum
```

end

SOLUTION 1 Average rainwater chemistry (1985-2011) - Station NM01 (Gila Cliff Dwellings National Monument), SW New Mexico. Data from National Atmospheric Deposition Program.

```
temp  25
pH     4.93
pe      4
redox N(-3)/N(5)
units mg/l
density
Ca     0.209
Mg     0.021
Na     0.075
K              0.030
Cl     0.117
CO2(g) -3.5
S(6)  0.862 as SO4
N(-3) 0.167 as NH4
N(5)  0.826 as NO3
C(4)  0.1
-water 1 # kg
end
```

SOLUTION 2 Average groundwater chemistry for wells GWQ96-22A, GWQ96-22B, GWQ96-23A and GWQ96-23B for samples collected between 1996 and 2011

```
temp  25
pH     7.85
units  mg/l
density 1
Alkalinity 475 as HCO3
Ag     0.019
Al     0.406585
As     0.0033375
B              0.13925
Ba     0.0908125
Ca     87.1
Cl     49.09090909
Cu     0.01375
F              2.02
```



```
Fe 1.485666667
K 3.1
Mg 19.765
Mn 0.656944444
Mo 0.02375
Na 116.9 charge
S(6) 199.88 as SO4
Se 0.002763636
Si 13.75
U 0.00178
Zn 0.0431
-water 1 # kg
end
```

TITLE Average HCT data

SOLUTION 3 Average HCT data for andesite oxide material (cells SRK 0864 and SRK 0866)

```
temp 25
pH 7.38
pe 4
redox pe
units mg/l
density 1
Alkalinity 11.08233 as HCO3
Al 0.00759
Ba 0.00261
Ca 9.22553
Cl 0.39385
F 0.46144
Fe 0.00193
K 0.99643
Mg 1.40610
Mn 0.00954
Mo 0.00764
Na 1.91012 charge
S(6) 23.36270 as SO4
Se 0.0003
U 0.00047
V 0.00169
Zn 0.00092
-water 1 # kg
END
```

SOLUTION 4 Average HCT data for biotite breccia - oxide/transitional (cells SRK 0854 and SRK 0872)

```
temp 25
pH 5.52
pe 4
redox pe
units mg/l
density 1
Alkalinity 3.44165 as HCO3
Al 0.27201
As 0.00058
Ba 0.00775
Ca 23.80767
Cd 0.00230
Cl 0.30258
Co 0.01016
Cu 17.37509
F 0.30884
Fe 0.46664
K 0.98984
Mg 1.40751
Mn 0.28452
Mo 0.03340
Na 0.40453 charge
Ni 0.00445
P 0.06138
Pb 0.00155
S(6) 97.56344 as SO4
Sb 0.00018
```

Se 0.00190  
U 0.00313  
V 0.00138  
Zn 0.15709

-water 1 # kg  
END

SOLUTION 5 Average HCT data for quartz feldspar breccia - oxide/transitional (cells 604767 and 604787)

temp 25  
pH 7.80  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 28.14382 as HCO3  
B 0.01018  
Ba 0.01079  
Ca 17.42309  
Cl 0.83411  
Co 0.00078  
F 0.91743  
K 2.53353  
Mg 3.91833  
Mn 0.12244  
Mo 0.01061  
Na 1.94262 charge  
Ni 0.00064  
S(6) 39.53068 as SO4  
Sb 0.00019  
Se 0.00217  
U 0.02169  
V 0.00281  
Zn 0.00497

-water 1 # kg  
END

SOLUTION 6 Average HCT data for quartz monzonite- oxide/transitional (cells 604569, SRK 0858 and SRK 0867)

temp 25  
pH 7.12  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 15.59277 as HCO3  
Al 0.05423  
B 0.01636  
Ba 0.00384  
Ca 18.95254  
Cd 0.00039  
Cl 0.56704  
Co 0.00388  
Cu 0.51303  
F 0.66195  
Fe 0.05913  
K 1.72751  
Mg 2.46441  
Mn 0.28491  
Mo 0.00590  
Na 2.02964 charge  
Ni 0.00609  
S(6) 51.75947 as SO4  
Sb 0.00146  
Se 0.00082  
U 0.00440  
V 0.00196  
Zn 0.01332

-water 1 # kg

END

SOLUTION 7 Average HCT data for coarse crystalline porphyry - oxide/transitional (cell CF-11-02, 0-27)

temp 25  
pH 7.94  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 33.19394 as HCO3  
Al 0.01347  
B 0.01075  
Ba 0.00086  
Ca 10.69469  
Cl 0.77608  
F 0.93545  
Fe 0.00638  
Hg 0.000049  
K 2.66412  
Mg 1.95477  
Mn 0.02025  
Mo 0.00545  
Na 2.86679 charge  
S(6) 13.81598 as SO4  
U 0.00449  
Zn 0.00048

-water 1 # kg

END

SOLUTION 8 Average HCT data for andesite sulfide material (cells SRK 0864 and SRK 0866)

temp 25  
pH 7.38  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 11.08233 as HCO3  
Al 0.00759  
Ba 0.00261  
Ca 9.22553  
Cl 0.39385  
F 0.46144  
Fe 0.00193  
K 0.99643  
Mg 1.40610  
Mn 0.00954  
Mo 0.00764  
Na 1.91012 charge  
S(6) 23.36270 as SO4  
Se 0.00033  
U 0.00047  
V 0.00169  
Zn 0.00092

-water 1 # kg

END

SOLUTION 9 Average HCT data for biotite breccia - sulfide (cells 604811, 604854, 604862, 604867 and 605033)

temp 25  
pH 7.91  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 54.42849 as HCO3  
Al 0.00611  
As 0.00046  
B 0.00974  
Ba 0.00750

Ca 28.87256  
Cl 1.09115  
Cu 0.01120  
F 1.23366  
K 5.04620  
Mg 4.17236  
Mn 0.04406  
Mo 0.01327  
Na 2.92761 charge  
Ni 0.00049  
S(6) 52.56098 as SO4  
Sb 0.00018  
Se 0.00304  
U 0.00810  
V 0.00552  
Zn 0.00135

-water 1 # kg

END

SOLUTION 10 Average HCT data for quartz feldspar breccia - sulfide (cells 604767 and 604787)

temp 25  
pH 7.80  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 28.14382 as HCO3  
B 0.01018  
Ba 0.01079  
Ca 17.42309  
Cl 0.83411  
Co 0.00078  
F 0.91743  
K 2.53353  
Mg 3.91833  
Mn 0.12244  
Mo 0.01061  
Na 1.94262 charge  
Ni 0.00064  
S(6) 39.53068 as SO4  
Sb 0.00019  
Se 0.00217  
U 0.02169  
V 0.00281  
Zn 0.00497

-water 1 # kg

END

SOLUTION 11 Average HCT data for quartz monzonite - sulfide (cells 604562, 604606, 604653, 604656, 604669, 604673 and 605153)

temp 25  
pH 6.82  
pe 4  
redox pe  
units mg/l  
density 1  
Alkalinity 30.08128 as HCO3  
Al 0.01335  
B 0.01290  
Ba 0.01934  
Ca 15.43303  
Cl 1.40889  
Cu 0.03484  
F 0.71091  
Fe 0.00212  
Hg 0.000011  
K 3.45609  
Mg 2.75632  
Mn 0.09332  
Mo 0.01148

```
Na      3.16032
Pb      0.00030
S(6)   32.59944 as SO4
Sb      0.00015
Se      0.00109
U        0.00841
V        0.00312
Zn      0.00429
```

```
-water  1 # kg
END
```

SOLUTION 12 Average HCT data for coarse crystalline porphyry - sulfide (cell CF-11-02, 367-408)

```
temp    25
pH      7.80
pe      4
redox   pe
units   mg/l
density 1
Alkalinity 21.56678 as HCO3
Al      0.05060
B       0.01144
Ba      0.00414
Ca      7.69375
Cl      1.26366
Cu      0.00619
F       0.59829
Fe      0.00380
Hg      0.000019
K       1.95046
Mg      0.53321
Mn      0.0050
Mo      0.00163
Na      2.49093 charge
Pb      0.00020
S(6)   8.57475 as SO4
Sb      0.00012
U       0.00261
```

```
-water  1 # kg
END
```

SOLUTION 13 Average HCT data for undefined material (uses average HCT data for all sulfide cells)

```
temp    25
pH      6.76
pe      4
redox   pe
units   mg/l
density 1
Al      0.01019
As      0.00058
B       0.01134
Ba      0.01445
Ca      19.54850
Cl      1.18326
Cu      0.03281
F       0.89545
Fe      0.00187
Hg      0.000009
K       3.69033
Mg      3.36360
Mn      0.08380
Mo      0.01167
Na      2.80849
Pb      0.00028
S(6)   39.46536 as SO4
Sb      0.00019
Se      0.00187
U       0.01100
V       0.00372
Zn      0.00391
```

-water 1 # kg  
END

Title Stage 1 Groundwater mix  
MIX 101

2	1
3	0
4	0
5	0
6	0
7	0
8	0
9	0.146261
10	0.137721
11	0.944512
12	0
13	0

Save solution 101  
end

REACTION 101  
H2O -1  
68.25511932 moles ### Addition step. Removes HTC water but solute mass remains  
## Retuns solution volume back to 1L

USE solution 101  
SAVE Solution 102

End  
Title Precipitate oversaturated phases in groundwater  
PHASES  
Fix\_pe  
e--e-  
log\_k 0

EQUILIBRIUM\_PHASES 101

Ag2Se	0	0
Anhydrite	0	0
Alunite	0	0
Ba3(AsO4)2	0	0
Barite	0	0
Boehmite	0	0
Brochantite	0	0
Brucite	0	0
Calcite	0	0
Carnotite	0	0
CaMoO4	0	0
Chrysotile	0	0
CO2(g)	-3.5	10
Co3O4	0	0
Cr2O3	0	0
Diaspore	0	0
Epsomite	0	0
Ferrihydrite	0	0
Fluorite	0	0
Gummite	0	0
Gypsum	0	0
HgSe	0	0
Hgmetal(1)	0	0
Kaolinite	0	0
Mg3(PO4)2	0	0
Mirabilite	0	0
O2(g)	-32	10
NiCO3	0	0
NiMoO4	0	0
Ni(OH)2	0	0
Ni3(AsO4)2:8H2O	0	0
Otavite	0	0
Pyromorphite	0	0
Rutherfordine	0	0
Schoepite	0	0
Sepiolite	0	0

```
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 102
SAVE Solution 103 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 101
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 101

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite    equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite    equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 101
USE Surface 101
USE Solution 103
SAVE Solution 104 #Initial Stage 1 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 1 Run-off mix
Mix 102
1      1
3      0.164376
4      0
5      0.120106
6      1.425941
7      0.488780
8      1.551968
9      5.454143
10     8.581411
11     102.312415
12     18.326068
13     0.857964

Save solution 105
end

REACTION 102
H2O    -1
7738.57 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 105
SAVE Solution 106

End

Title Precipitate oversaturated phases
PHASES
Fix_pe
e==e-
log_k    0

EQUILIBRIUM_PHASES 102
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
```



```
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 106
SAVE Solution 107 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 102
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 102

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 102
USE Surface 102
USE Solution 107
SAVE Solution 108 #Initial Stage 1 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 1 Pit lake Mix
Mix 103
104      0.610422
108      0.379793
1        0.009786

Save solution 109
end

Title Stage 1 Pit wall interaction mix calculator
MIX 104
109      1
3        0
4        0
5        0
6        0
7        0
8        0
9        0.0034523
10       0.0032507
11       0.0222938
12       0
13       0
```

```
Save solution 110
end

REACTION 104
  H2O    -1
  1.611063077 moles ### Addition step. Removes HTC water but solute mass remains
  ## Returns solution volume back to 1L
USE solution 110
SAVE Solution 111

End
Title Evaporate Stage 1 lake water to produce initial Stage 2 Lake water
REACTION 105

  H2O    -1
  7.70 moles ## Removes x m3 water, but solute mass remains the same
  ## This number must be adjusted manually for each cycle
USE solution 111
Save Solution 112

END

Title Return solution back to 1L

Mix 105
  112 1.1609
save solution 113
end

Title Precipitate oversaturated phases
PHASES
Fix_pe
  e--e-
  log_k  0

EQUILIBRIUM_PHASES 105
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
```

```

SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 113
SAVE Solution 114 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 105
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 105

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite  equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite  equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 105
USE Surface 105
USE Solution 114
SAVE Solution 115 #Initial Stage 1 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 106

    H2O    -0.0
    0 moles

USE solution 115
End
Title Stage 2 pit lake GW inflow
Title Stage 2 Groundwater mix
MIX 201
2      1
3      0
4      0
5      0
6      0
7      0
8      0
9      0.498800
10     0.178770
11     1.341815
12     0
13     0

Save solution 201
end

REACTION 201
H2O    -1
112.196996 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 201
SAVE Solution 202

End
Title Precipitate oversaturated phases in groundwater
PHASES
Fix_pe
e==e-
log_k  0

EQUILIBRIUM_PHASES 201
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0

```

```
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 202
SAVE Solution 203 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 201
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 201

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 201
USE Surface 201
USE Solution 203
SAVE Solution 204 #Initial Stage 2 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 2 Run-off mix
Mix 202
1      1
3      0.054390
4      0
5      0.039741
6      0.471822
7      0.161730
8      0.513523
9      1.609756
10     2.816288
11     33.632282
12     6.063818
13     0.283887

Save solution 205
```

end

```
REACTION 202
H2O      -1
2536.16 moles ### Addition step. Removes HTC water but solute mass remains
          ## Returns solution volume back to 1L
USE solution 205
SAVE Solution 206
```

End

```
Title Precipitate oversaturated phases
PHASES
Fix_pe
e--e-
log_k    0
```

```
EQUILIBRIUM_PHASES 202
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
```

```
USE solution 206
SAVE Solution 207 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 202
END
```

```
Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 202
```

```
-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008
```

```
USE EQUILIBRIUM_PHASES 202
USE Surface 202
USE Solution 207
SAVE Solution 208 #Initial Stage 2 Run-off Water After Mineral Precipitation and Sorption Loss
END
```

```
Title Stage 2 Pit lake Mix
Mix 203
204      0.229607
208      0.425741
1        0.025134
115      0.319518
Save solution 209
end
```

```
Title Stage 2 Pit wall interaction mix calculator
MIX 204
209      1
3         0
4         0
5         0
6         0
7         0
8         0
9         0.0044161
10        0.0015827
11        0.0118796
12         0
13         0
```

```
Save solution 210
end
```

```
REACTION 204
H2O      -1
0.993325278 moles ### Addition step. Removes HTC water but solute mass remains
          ## Returns solution volume back to 1L
USE solution 210
SAVE Solution 211
```

```
End
Title Evaporate Stage 2 lake water to produce initial Stage 2 Lake water
REACTION 205
```

```
      H2O      -1
      3.64 moles  ## Removes x m3 water, but solute mass remains the same
          ## This number must be adjusted manually for each cycle
USE solution 211
Save Solution 212
```

```
END
```

```
Title Return solution back to 1L
```

```
Mix 205
      212 1.0701
save solution 213
end
```

```
Title Precipitate oversaturated phases
PHASES
Fix_pe
e==e-
log_k    0
```

```
EQUILIBRIUM_PHASES 205
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
```

```

Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 213
SAVE Solution 214 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 205
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 205

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 205
USE Surface 205
USE Solution 214
SAVE Solution 215 #Initial Stage 2 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 206

    H2O -0.0
    0 moles

USE solution 215
End

Title Stage 3 pit lake GW inflow
Title Stage 3 Groundwater mix
MIX 301
2 1
3 0
4 0
5 0

```

```

6      0
7      0
8      0
9      1.040047
10     0.262434
11     1.883006
12     0
13     0

Save solution 301
end

REACTION 301
  H2O      -1
  176.9856208 moles ### Addition step. Removes HTC water but solute mass remains
                ## Returns solution volume back to 1L
USE solution 301
SAVE Solution 302

End
Title Precipitate oversaturated phases in groundwater
PHASES
Fix_pe
  e--e-
  log_k    0

EQUILIBRIUM_PHASES 301
  Ag2Se 0 0
  Anhydrite 0 0
  Alunite 0 0
  Ba3(AsO4)2 0 0
  Barite 0 0
  Boehmite 0 0
  Brochantite 0 0
  Brucite 0 0
  Calcite 0 0
  Carnotite 0 0
  CaMoO4 0 0
  Chrysotile 0 0
  CO2(g) -3.5 10
  Co3O4 0 0
  Cr2O3 0 0
  Diaspore 0 0
  Epsomite 0 0
  Ferrihydrite 0 0
  Fluorite 0 0
  Gummite 0 0
  Gypsum 0 0
  HgSe 0 0
  Hgmetal(1) 0 0
  Kaolinite 0 0
  Mg3(PO4)2 0 0
  Mirabilite 0 0
  O2(g) -32 10
  NiCO3 0 0
  NiMoO4 0 0
  Ni(OH)2 0 0
  Ni3(AsO4)2·8H2O 0 0
  Otavite 0 0
  Pyromorphite 0 0
  Rutherfordine 0 0
  Schoepite 0 0
  Sepiolite 0 0
  SiO2(am-ppt) 0 0
  Tyuyamunite 0 0
  U3O8 0 0
  UO3 0 0
  UO2(OH)2(beta) 0 0

USE solution 302
SAVE Solution 303 Initial Pit Water after Mineral Precipitation

```



```
SAVE EQUILIBRIUM_PHASES 301
END
```

```
Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 301
```

```
-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008
```

```
USE EQUILIBRIUM_PHASES 301
USE Surface 301
USE Solution 303
SAVE Solution 304 #Initial Stage 3 groundwater after Mineral Precipitation and Sorption Loss
END
```

```
Title Stage 3 Run-off mix
```

```
Mix 302
1      1
3      0.082928
4      0
5      0.060594
6      0.719390
7      0.246590
8      0.782971
9      2.020417
10     4.228018
11     50.854355
12     9.245537
13     0.432845
```

```
Save solution 305
end
```

```
REACTION 302
H2O -1
3815.51 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 305
SAVE Solution 306
```

```
End
```

```
Title Precipitate oversaturated phases
```

```
PHASES
```

```
Fix_pe
```

```
e--e-
log_k 0
```

```
EQUILIBRIUM_PHASES 302
```

```
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
```

```
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
USE solution 306
SAVE Solution 307 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 302
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 302

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 302
USE Surface 302
USE Solution 307
SAVE Solution 308 #Initial Stage 3 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 3 Pit lake Mix
Mix 303
304      0.226442
308      0.278993
1        0.027809
215      0.466756
Save solution 309
end

Title Stage 3 Pit wall interaction mix calculator
MIX 304
309      1
3         0
4         0
5         0
6         0
7         0
8         0
9         0.0045408
10        0.0011458
11        0.0082210
12        0
13        0

Save solution 310
end

REACTION 304
H2O      -1
0.772703721 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 310
SAVE Solution 311
```

```
End
Title Evaporate Stage 3 lake water to produce initial Stage 2 Lake water
REACTION 305

      H2O      -1
      7.43 moles  ## Removes x m3 water, but solute mass remains the same
                  ## This number must be adjusted manually for each cycle
USE solution 311
Save Solution 312

END

Title Return solution back to 1L

Mix 305
      312 1.1545
save solution 313
end

Title Precipitate oversaturated phases
PHASES
Fix_pe
  e--e-
  log_k  0

EQUILIBRIUM_PHASES 305
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 313
SAVE Solution 314 Initial Pit Water after Mineral Precipitation
```

SAVE EQUILIBRIUM\_PHASES 305  
END

Title Determine loss of metals due to HFO sorption and sedimentation  
SURFACE 305

-equilibrate with solution 1  
Hfo\_sOH Ferrihydrite equilibrium\_phase 0.005 64200  
Hfo\_wOH Ferrihydrite equilibrium\_phase 0.2  
-donnan 1e-008

USE EQUILIBRIUM\_PHASES 305  
USE Surface 305  
USE Solution 314  
SAVE Solution 315 #Initial Stage 3 Pit Water After Mineral Precipitation and Sorption Loss  
END

Title Use solution to allow model output  
REACTION 306

H2O -0.0  
0 moles

USE solution 315  
End

Title Stage 4 pit lake GW inflow  
Title Stage 4 Groundwater mix  
MIX 401

2	1
3	0
4	0
5	0
6	0
7	0
8	0
9	1.588204
10	0.354166
11	2.530506
12	0
13	0

Save solution 401  
end

REACTION 401  
H2O -1  
248.512974 moles ### Addition step. Removes HTC water but solute mass remains  
## Returns solution volume back to 1L

USE solution 401  
SAVE Solution 402

End  
Title Precipitate oversaturated phases in groundwater  
PHASES  
Fix\_pe  
e--e-  
log\_k 0

EQUILIBRIUM\_PHASES 401  
Ag2Se 0 0  
Anhydrite 0 0  
Alunite 0 0  
Ba3(AsO4)2 0 0  
Barite 0 0  
Boehmite 0 0  
Brochantite 0 0  
Brucite 0 0  
Calcite 0 0  
Carnotite 0 0  
CaMoO4 0 0  
Chrysotile 0 0

```

CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmatal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 402
SAVE Solution 403 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 401
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 401

-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 401
USE Surface 401
USE Solution 403
SAVE Solution 404 #Initial Stage 4 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 4 Run-off mix
Mix 402
1 1
3 0.084265
4 0
5 0.061571
6 0.730989
7 0.250566
8 0.795595
9 1.624757
10 4.225841
11 51.178282
12 9.394602
13 0.439824

Save solution 405
end

REACTION 402
H2O -1
3821.77 moles ### Addition step. Removes HTC water but solute mass remains
### Returns solution volume back to 1L
USE solution 405

```

SAVE Solution 406

End

Title Precipitate oversaturated phases

PHASES

Fix\_pe

e--e-

log\_k 0

EQUILIBRIUM\_PHASES 402

Ag2Se 0 0  
Anhydrite 0 0  
Alunite 0 0  
Ba3(AsO4)2 0 0  
Barite 0 0  
Boehmite 0 0  
Brochantite 0 0  
Brucite 0 0  
Calcite 0 0  
Carnotite 0 0  
CaMoO4 0 0  
Chrysotile 0 0  
CO2(g) -3.5 10  
Co3O4 0 0  
Cr2O3 0 0  
Diaspore 0 0  
Epsomite 0 0  
Ferrihydrite 0 0  
Fluorite 0 0  
Gummite 0 0  
Gypsum 0 0  
HgSe 0 0  
Hgmetal(l) 0 0  
Kaolinite 0 0  
Mg3(PO4)2 0 0  
Mirabilite 0 0  
O2(g) -32 10  
NiCO3 0 0  
NiMoO4 0 0  
Ni(OH)2 0 0  
Ni3(AsO4)2·8H2O 0 0  
Otavite 0 0  
Pyromorphite 0 0  
Rutherfordine 0 0  
Schoepite 0 0  
Sepiolite 0 0  
SiO2(am-ppt) 0 0  
Tyuyamunite 0 0  
U3O8 0 0  
UO3 0 0  
UO2(OH)2(beta) 0 0

USE solution 406

SAVE Solution 407 Initial Pit Water after Mineral Precipitation

SAVE EQUILIBRIUM\_PHASES 402

END

Title Determine loss of metals due to HFO sorption and sedimentation

SURFACE 402

-equilibrate with solution 1

Hfo\_sOH Ferrihydrite equilibrium\_phase 0.005 64200

Hfo\_wOH Ferrihydrite equilibrium\_phase 0.2

-donnan 1e-008

USE EQUILIBRIUM\_PHASES 402

USE Surface 402

USE Solution 407

SAVE Solution 408 #Initial Stage 4 Run-off Water After Mineral Precipitation and Sorption Loss

END

Title Stage 4 Pit lake Mix

```
Mix 403
404      0.268452
408      0.331540
1        0.051435
315      0.348573
Save solution 409
end
```

Title Stage 4 Pit wall interaction mix calculator

```
MIX 404
409      1
3         0
4         0
5         0
6         0
7         0
8         0
9        0.0027376
10       0.0006105
11       0.0043618
12        0
13        0
```

```
Save solution 410
end
```

```
REACTION 404
H2O      -1
0.428362415 moles ### Addition step. Removes HTC water but solute mass remains
          ## Returns solution volume back to 1L
USE solution 410
SAVE Solution 411
```

End

Title Evaporate Stage 4 lake water to produce initial Stage 5 Lake water

```
REACTION 405

H2O      -1
14.34 moles ## Removes x m3 water, but solute mass remains the same
          ## This number must be adjusted manually for each cycle
USE solution 411
Save Solution 412
```

END

Title Return solution back to 1L

```
Mix 405
412 1.3480
save solution 413
end
```

Title Precipitate oversaturated phases

PHASES

```
Fix_pe
e--e-
log_k  0
```

EQUILIBRIUM\_PHASES 405

```
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
```

```
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 413
SAVE Solution 414 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 405
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 405

-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 405
USE Surface 405
USE Solution 414
SAVE Solution 415 #Initial Stage 5 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 406

      H2O      -0.0
      0 moles

USE solution 415
End

Title Stage 5 pit lake GW inflow
Title Stage 5 Groundwater mix
MIX 501
2      1
3      0
4      0
5      0
6      0
7      0
8      0
9      2.044332
10     0.565829
11     3.283660
12     0
```



```

13      0

Save solution 501
end

REACTION 501
  H2O      -1
  327.4607223 moles ### Addition step. Removes HTC water but solute mass remains
                ## Returns solution volume back to 1L
USE solution 501
SAVE Solution 502

End
Title Precipitate oversaturated phases in groundwater
PHASES
Fix_pe
  e==e-
  log_k    0

EQUILIBRIUM_PHASES 501
  Ag2Se 0 0
  Anhydrite 0 0
  Alunite 0 0
  Ba3(AsO4)2 0 0
  Barite 0 0
  Boehmite 0 0
  Brochantite 0 0
  Brucite 0 0
  Calcite 0 0
  Carnotite 0 0
  CaMoO4 0 0
  Chrysotile 0 0
  CO2(g) -3.5 10
  Co3O4 0 0
  Cr2O3 0 0
  Diaspore 0 0
  Epsomite 0 0
  Ferrihydrite 0 0
  Fluorite 0 0
  Gummite 0 0
  Gypsum 0 0
  HgSe 0 0
  Hgmetal(1) 0 0
  Kaolinite 0 0
  Mg3(PO4)2 0 0
  Mirabilite 0 0
  O2(g) -32 10
  NiCO3 0 0
  NiMoO4 0 0
  Ni(OH)2 0 0
  Ni3(AsO4)2·8H2O 0 0
  Otavite 0 0
  Pyromorphite 0 0
  Rutherfordine 0 0
  Schoepite 0 0
  Sepiolite 0 0
  SiO2(am-ppt) 0 0
  Tyuyamunite 0 0
  U3O8 0 0
  UO3 0 0
  UO2(OH)2(beta) 0 0

USE solution 502
SAVE Solution 503 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 501
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 501

  -equilibrate with solution 1
  Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200

```

```

Hfo_wOH Ferrihydrite      equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 501
USE Surface 501
USE Solution 503
SAVE Solution 504 #Initial Stage 5 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 5 Run-off mix
Mix 502
1      1
3      0.085744
4      0
5      0.062651
6      0.743820
7      0.254964
8      0.809559
9      1.316995
10     4.136563
11     51.519548
12     9.559504
13     0.447544

Save solution 505
end

REACTION 502
H2O     -1
3830.13 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 505
SAVE Solution 506

End

Title Precipitate oversaturated phases
PHASES
Fix_pe
e--e-
log_k   0

EQUILIBRIUM_PHASES 502
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0

```

```
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 506
SAVE Solution 507 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 502
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 502

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 502
USE Surface 502
USE Solution 507
SAVE Solution 508 #Initial Stage 5 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 5 Pit lake Mix
Mix 503
504      0.237553
508      0.295248
1         0.063940
415      0.403259
Save solution 509
end

Title Stage 5 Pit wall interaction mix calculator
MIX 504
509      1
3         0
4         0
5         0
6         0
7         0
8         0
9         0.0018702
10        0.0005176
11        0.0030039
12        0
13        0

Save solution 510
end

REACTION 504
H2O      -1
    0.299565337 moles ### Addition step. Removes HTC water but solute mass remains
    ### Returns solution volume back to 1L
USE solution 510
SAVE Solution 511

End
Title Evaporate Stage 5 lake water to produce initial Stage 5 Lake water
REACTION 505

    H2O      -1
    18.14 moles  ## Removes x m3 water, but solute mass remains the same
```

```
## This number must be adjusted manually for each cycle
USE solution 511
Save Solution 512

END

Title Return solution back to 1L

Mix 505
    512 1.4846
save solution 513
end

Title Precipitate oversaturated phases
PHASES
Fix_pe
    e==e-
    log_k    0

EQUILIBRIUM_PHASES 505
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 513
SAVE Solution 514 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 505
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 505

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
```

```
Hfo_wOH Ferrihydrite  equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 505
USE Surface 505
USE Solution 514
SAVE Solution 515 #Stage 5 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 506

      H2O    -0.0
    0 moles

USE solution 515
End

Title Stage 6 pit lake GW inflow
Title Stage 6 Groundwater mix
MIX 601
2      1
3      0
4      0
5      0
6      0
7      0
8      0
9      2.537454
10     0.929520
11     5.109808
12     0
13     0

Save solution 601
end

REACTION 601
H2O    -1
476.5260208 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L
USE solution 601
SAVE Solution 602

End
Title Precipitate oversaturated phases in groundwater
PHASES
Fix_pe
e==e-
log_k  0

EQUILIBRIUM_PHASES 601
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
```

```

Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 602
SAVE Solution 603 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 601
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 601

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 601
USE Surface 601
USE Solution 603
SAVE Solution 604 #Initial Stage 6 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 6 Run-off mix
Mix 602
1      1
3      0.087293
4      0
5      0.063783
6      0.757257
7      0.259570
8      0.824184
9      0.987441
10     3.931922
11     51.056266
12     9.732198
13     0.455628

Save solution 605
end

REACTION 602
H2O -1
3786.72 moles ### Addition step. Removes HTC water but solute mass remains
    ## Returns solution volume back to 1L
USE solution 605
SAVE Solution 606

End

Title Precipitate oversaturated phases
PHASES
Fix_pe
e==e-

```

```

log_k      0

EQUILIBRIUM_PHASES 602
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 606
SAVE Solution 607 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 602
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 602

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 602
USE Surface 602
USE Solution 607
SAVE Solution 608 #Initial Stage 6 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 6 Pit lake Mix
Mix 603
604      0.280031
608      0.350395
1        0.098329
515      0.271245
Save solution 609
end

```

Title Stage 6 Pit wall interaction mix calculator

MIX 604

```
609      1
3        0
4        0
5        0
6        0
7        0
8        0
9        0.0009116
10       0.0003339
11       0.0018357
12       0
13       0
```

Save solution 610  
end

REACTION 604

```
H2O      -1
0.171190632 moles ### Addition step. Removes HTC water but solute mass remains
## Returns solution volume back to 1L
```

USE solution 610  
SAVE Solution 611

End

Title Evaporate Stage 6 lake water to produce initial Stage 7 Lake water

REACTION 605

```
H2O      -1
28.05 moles ## Removes x m3 water, but solute mass remains the same
## This number must be adjusted manually for each cycle
```

USE solution 611  
Save Solution 612

END

Title Return solution back to 1L

Mix 605

```
612 2.0199
save solution 613
end
```

Title Precipitate oversaturated phases

PHASES

```
Fix_pe
e--e-
log_k  0
```

EQUILIBRIUM\_PHASES 605

```
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
```



```

Gypsum 0 0
HgSe 0 0
Hgmatal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
USE solution 613
SAVE Solution 614 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 605
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 605

-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 605
USE Surface 605
USE Solution 614
SAVE Solution 615 #Initial Stage 7 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 606

      H2O    -0.0
    0 moles

USE solution 615
End

Title Stage 7 pit lake GW inflow
Title Stage 7 Groundwater mix
MIX 701
2      1
3      0
4      0
5      0
6      0
7      0
8      0
9      2.782365
10     1.018827
11     6.705689
12     0
13     0

Save solution 701
end

REACTION 701
H2O    -1
583.7622718 moles ### Addition step. Removes HTC water but solute mass remains
      ## Returns solution volume back to 1L

```

USE solution 701  
SAVE Solution 702

End  
Title Precipitate oversaturated phases in groundwater  
PHASES  
Fix\_pe  
e--e-  
log\_k 0

EQUILIBRIUM\_PHASES 701  
Ag2Se 0 0  
Anhydrite 0 0  
Alunite 0 0  
Ba3(AsO4)2 0 0  
Barite 0 0  
Boehmite 0 0  
Brochantite 0 0  
Brucite 0 0  
Calcite 0 0  
Carnotite 0 0  
CaMoO4 0 0  
Chrysotile 0 0  
CO2(g) -3.5 10  
Co3O4 0 0  
Cr2O3 0 0  
Diaspore 0 0  
Epsomite 0 0  
Ferrihydrite 0 0  
Fluorite 0 0  
Gummite 0 0  
Gypsum 0 0  
HgSe 0 0  
Hgmetal(l) 0 0  
Kaolinite 0 0  
Mg3(PO4)2 0 0  
Mirabilite 0 0  
O2(g) -32 10  
NiCO3 0 0  
NiMoO4 0 0  
Ni(OH)2 0 0  
Ni3(AsO4)2·8H2O 0 0  
Otavite 0 0  
Pyromorphite 0 0  
Rutherfordine 0 0  
Schoepite 0 0  
Sepiolite 0 0  
SiO2(am-ppt) 0 0  
Tyuyamunite 0 0  
U3O8 0 0  
UO3 0 0  
UO2(OH)2(beta) 0 0

USE solution 702  
SAVE Solution 703 Initial Pit Water after Mineral Precipitation  
SAVE EQUILIBRIUM\_PHASES 701  
END

Title Determine loss of metals due to HFO sorption and sedimentation  
SURFACE 701

-equilibrate with solution 1  
Hfo\_sOH Ferrihydrite equilibrium\_phase 0.005 64200  
Hfo\_wOH Ferrihydrite equilibrium\_phase 0.2  
-donnan 1e-008

USE EQUILIBRIUM\_PHASES 701  
USE Surface 701  
USE Solution 703  
SAVE Solution 704 #Initial Stage 7 groundwater after Mineral Precipitation and Sorption Loss  
END

Title Stage 7 Run-off mix

Mix 702

1	1
3	0.089025
4	0
5	0.065049
6	0.772284
7	0.264720
8	0.840536
9	0.849912
10	3.952694
11	50.870942
12	9.925285
13	0.464668

Save solution 705

end

REACTION 702

H2O -1

3783.36 moles ### Addition step. Removes HTC water but solute mass remains  
## Returns solution volume back to 1L

USE solution 705

SAVE Solution 706

End

Title Precipitate oversaturated phases

PHASES

Fix\_pe

e--e-

log\_k 0

EQUILIBRIUM\_PHASES 702

Ag2Se	0	0
Anhydrite	0	0
Alunite	0	0
Ba3(AsO4)2	0	0
Barite	0	0
Boehmite	0	0
Brochantite	0	0
Brucite	0	0
Calcite	0	0
Carnotite	0	0
CaMoO4	0	0
Chrysotile	0	0
CO2(g)	-3.5	10
Co3O4	0	0
Cr2O3	0	0
Diaspore	0	0
Epsomite	0	0
Ferrihydrite	0	0
Fluorite	0	0
Gummite	0	0
Gypsum	0	0
HgSe	0	0
Hgmetal(1)	0	0
Kaolinite	0	0
Mg3(PO4)2	0	0
Mirabilite	0	0
O2(g)	-32	10
NiCO3	0	0
NiMoO4	0	0
Ni(OH)2	0	0
Ni3(AsO4)2:8H2O	0	0
Otavite	0	0
Pyromorphite	0	0
Rutherfordine	0	0
Schoepite	0	0
Sepiolite	0	0
SiO2(am-ppt)	0	0
Tyuyamunite	0	0

```
U308 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
USE solution 706
SAVE Solution 707 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 702
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 702

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 702
USE Surface 702
USE Solution 707
SAVE Solution 708 #Initial Stage 7 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 7 Pit lake Mix
Mix 703
704      0.265124
708      0.331499
1        0.116823
615      0.286554
Save solution 709
end

Title Stage 7 Pit wall interaction mix calculator
MIX 704
709      1
3         0
4         0
5         0
6         0
7         0
8         0
9         0.0005677
10        0.0002079
11        0.0013682
12         0
13         0

Save solution 710
end

REACTION 704
H2O      -1
    0.119108371 moles ### Addition step. Removes HTC water but solute mass remains
    ## Returns solution volume back to 1L
USE solution 710
SAVE Solution 711

End
Title Evaporate Stage 7 lake water to produce initial Stage 8 Lake water
REACTION 705

    H2O      -1
    33.37 moles ## Removes x m3 water, but solute mass remains the same
    ## This number must be adjusted manually for each cycle
USE solution 711
Save Solution 712

END

Title Return solution back to 1L

Mix 705
    712 2.5036
```

```
save solution 713
end
```

```
Title Precipitate oversaturated phases
PHASES
Fix_pe
e--e-
log_k 0
```

```
EQUILIBRIUM_PHASES 705
```

```
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
```

```
USE solution 713
SAVE Solution 714 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 705
END
```

```
Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 705
```

```
-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008
```

```
USE EQUILIBRIUM_PHASES 705
USE Surface 705
USE Solution 714
SAVE Solution 715 #Initial Stage 8 Pit Water After Mineral Precipitation and Sorption Loss
END
```

```
Title Use solution to allow model output
```

REACTION 706

H2O -0.0  
0 moles

USE solution 715

End

Title Stage 8 pit lake GW inflow

Title Stage 8 Groundwater mix

MIX 801

2	1
3	0
4	0
5	0
6	0
7	0
8	0
9	2.923377
10	1.080869
11	7.244641
12	0
13	0

Save solution 801

end

REACTION 801

H2O -1  
624.9881919 moles ### Addition step. Removes HTC water but solute mass remains  
## Returns solution volume back to 1L

USE solution 801

SAVE Solution 802

End

Title Precipitate oversaturated phases in groundwater

PHASES

Fix\_pe

e--e-  
log\_k 0

EQUILIBRIUM\_PHASES 801

Ag2Se	0	0
Anhydrite	0	0
Alunite	0	0
Ba3(AsO4)2	0	0
Barite	0	0
Boehmite	0	0
Brochantite	0	0
Brucite	0	0
Calcite	0	0
Carnotite	0	0
CaMoO4	0	0
Chrysotile	0	0
CO2(g)	-3.5	10
Co3O4	0	0
Cr2O3	0	0
Diaspore	0	0
Epsomite	0	0
Ferrihydrite	0	0
Fluorite	0	0
Gummite	0	0
Gypsum	0	0
HgSe	0	0
Hgmetal(1)	0	0
Kaolinite	0	0
Mg3(PO4)2	0	0
Mirabilite	0	0
O2(g)	-32	10
NiCO3	0	0
NiMoO4	0	0
Ni(OH)2	0	0
Ni3(AsO4)2:8H2O	0	0

```
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 802
SAVE Solution 803 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 801
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 801

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donna 1e-008

USE EQUILIBRIUM_PHASES 801
USE Surface 801
USE Solution 803
SAVE Solution 804 #Initial Stage 8 groundwater after Mineral Precipitation and Sorption Loss
END

Title Stage 8 Run-off mix
Mix 802
1      1
3      0.090239
4      0
5      0.065936
6      0.782812
7      0.268330
8      0.851999
9      0.764027
10     3.962526
11     51.169480
12     10.060637
13     0.471005

Save solution 805
end

REACTION 802
H2O -1
3805.14 moles ### Addition step. Removes HTC water but solute mass remains
    ## Returns solution volume back to 1L
USE solution 805
SAVE Solution 806

End

Title Precipitate oversaturated phases
PHASES
Fix_pe
e--e-
log_k 0

EQUILIBRIUM_PHASES 802
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
```

```

Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmatal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 806
SAVE Solution 807 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 802
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 802

-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008

USE EQUILIBRIUM_PHASES 802
USE Surface 802
USE Solution 807
SAVE Solution 808 #Initial Stage 8 Run-off Water After Mineral Precipitation and Sorption Loss
END

Title Stage 8 Pit lake Mix
Mix 803
804 0.234754
808 0.291649
1 0.117458
715 0.356140
Save solution 809
end

Title Stage 8 Pit wall interaction mix calculator
MIX 804
809 1
3 0
4 0
5 0
6 0
7 0
8 0
9 0.0005281

```



```

10      0.0001953
11      0.0013088
12      0
13      0

Save solution 810
end

REACTION 804
  H2O      -1
  0.11291264 moles ### Addition step. Removes HTC water but solute mass remains
                ## Returns solution volume back to 1L
USE solution 810
SAVE Solution 811

End
Title Evaporate Stage 8 lake water to produce initial Stage 9 Lake water
REACTION 805

  H2O      -1
  33.58 moles ## Removes x m3 water, but solute mass remains the same
                ## This number must be adjusted manually for each cycle
USE solution 811
Save Solution 812

END

Title Return solution back to 1L

Mix 805
  812 2.5275
save solution 813
end

Title Precipitate oversaturated phases
PHASES
Fix_pe
  e--e-
  log_k    0

EQUILIBRIUM_PHASES 805
  Ag2Se 0 0
  Anhydrite 0 0
  Alunite 0 0
  Ba3(AsO4)2 0 0
  Barite 0 0
  Boehmite 0 0
  Brochantite 0 0
  Brucite 0 0
  Calcite 0 0
  Carnotite 0 0
  CaMoO4 0 0
  Chrysotile 0 0
  CO2(g) -3.5 10
  Co3O4 0 0
  Cr2O3 0 0
  Diaspore 0 0
  Epsomite 0 0
  Ferrihydrite 0 0
  Fluorite 0 0
  Gummite 0 0
  Gypsum 0 0
  HgSe 0 0
  Hgmetal(1) 0 0
  Kaolinite 0 0
  Mg3(PO4)2 0 0
  Mirabilite 0 0
  O2(g) -32 10
  NiCO3 0 0
  NiMoO4 0 0
  Ni(OH)2 0 0
  Ni3(AsO4)2:8H2O 0 0

```

```
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0

USE solution 813
SAVE Solution 814 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 805
END

Title Determine loss of metals due to HFO sorption and sedimentation
SURFACE 805

    -equilibrate with solution 1
    Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
    Hfo_wOH Ferrihydrite equilibrium_phase 0.2
    -donnan 1e-008

USE EQUILIBRIUM_PHASES 805
USE Surface 805
USE Solution 814
SAVE Solution 815 #Initial Stage 9 Pit Water After Mineral Precipitation and Sorption Loss
END

Title Use solution to allow model output
REACTION 806

    H2O    -0.0
    0 moles

USE solution 815
End

Title Stage 9 pit lake GW inflow
Title Stage 9 Groundwater mix
MIX 901
2      1
3      0
4      0
5      0
6      0
7      0
8      0
9      2.975314
10     1.099871
11     7.427096
12     0
13     0

Save solution 901
end

REACTION 901
    H2O    -1
    639.0667165 moles ### Addition step. Removes HTC water but solute mass remains
    ## Retuns solution volume back to 1L
USE solution 901
SAVE Solution 902

End
Title Precipitate oversaturated phases in groundwater
PHASES
Fix_pe
e==e-
log_k    0
```

EQUILIBRIUM\_PHASES 901

Ag2Se 0 0  
Anhydrite 0 0  
Alunite 0 0  
Ba3(AsO4)2 0 0  
Barite 0 0  
Boehmite 0 0  
Brochantite 0 0  
Brucite 0 0  
Calcite 0 0  
Carnotite 0 0  
CaMoO4 0 0  
Chrysotile 0 0  
CO2(g) -3.5 10  
Co3O4 0 0  
Cr2O3 0 0  
Diaspore 0 0  
Epsomite 0 0  
Ferrihydrite 0 0  
Fluorite 0 0  
Gummite 0 0  
Gypsum 0 0  
HgSe 0 0  
Hgmatal(1) 0 0  
Kaolinite 0 0  
Mg3(PO4)2 0 0  
Mirabilite 0 0  
O2(g) -32 10  
NiCO3 0 0  
NiMoO4 0 0  
Ni(OH)2 0 0  
Ni3(AsO4)2·8H2O 0 0  
Otavite 0 0  
Pyromorphite 0 0  
Rutherfordine 0 0  
Schoepite 0 0  
Sepiolite 0 0  
SiO2(am-ppt) 0 0  
Tyuyamunite 0 0  
U3O8 0 0  
UO3 0 0  
UO2(OH)2(beta) 0 0

USE solution 902

SAVE Solution 903 Initial Pit Water after Mineral Precipitation

SAVE EQUILIBRIUM\_PHASES 901

END

Title Determine loss of metals due to HFO sorption and sedimentation

SURFACE 901

-equilibrate with solution 1  
Hfo\_sOH Ferrihydrite equilibrium\_phase 0.005 64200  
Hfo\_wOH Ferrihydrite equilibrium\_phase 0.2  
-donnan 1e-008

USE EQUILIBRIUM\_PHASES 901

USE Surface 901

USE Solution 903

SAVE Solution 904 #Initial Stage 9 groundwater after Mineral Precipitation and Sorption Loss

END

Title Stage 9 Run-off mix

Mix 902

1 1  
3 0.090729  
4 0  
5 0.066293  
6 0.787059  
7 0.269786  
8 0.856621  
9 0.731379

10 3.970592  
11 51.312498  
12 10.115219  
13 0.473560

Save solution 905  
end

REACTION 902  
H2O -1  
3815.51 moles ### Addition step. Removes HTC water but solute mass remains  
## Returns solution volume back to 1L  
USE solution 905  
SAVE Solution 906

End

Title Precipitate oversaturated phases  
PHASES  
Fix\_pe  
e--e-  
log\_k 0

EQUILIBRIUM\_PHASES 902  
Ag2Se 0 0  
Anhydrite 0 0  
Alunite 0 0  
Ba3(AsO4)2 0 0  
Barite 0 0  
Boehmite 0 0  
Brochantite 0 0  
Brucite 0 0  
Calcite 0 0  
Carnotite 0 0  
CaMoO4 0 0  
Chrysotile 0 0  
CO2(g) -3.5 10  
Co3O4 0 0  
Cr2O3 0 0  
Diaspore 0 0  
Epsomite 0 0  
Ferrihydrite 0 0  
Fluorite 0 0  
Gummite 0 0  
Gypsum 0 0  
HgSe 0 0  
Hgmetal(l) 0 0  
Kaolinite 0 0  
Mg3(PO4)2 0 0  
Mirabilite 0 0  
O2(g) -32 10  
NiCO3 0 0  
NiMoO4 0 0  
Ni(OH)2 0 0  
Ni3(AsO4)2·8H2O 0 0  
Otavite 0 0  
Pyromorphite 0 0  
Rutherfordine 0 0  
Schoepite 0 0  
Sepiolite 0 0  
SiO2(am-ppt) 0 0  
Tyuyamunite 0 0  
U3O8 0 0  
UO3 0 0  
UO2(OH)2(beta) 0 0

USE solution 906  
SAVE Solution 907 Initial Pit Water after Mineral Precipitation  
SAVE EQUILIBRIUM\_PHASES 902  
END

Title Determine loss of metals due to HFO sorption and sedimentation

SURFACE 902

```
-equilibrate with solution 1
Hfo_sOH Ferrihydrite  equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite  equilibrium_phase 0.2
-donnan 1e-008
```

USE EQUILIBRIUM\_PHASES 902

USE Surface 902

USE Solution 907

SAVE Solution 908 #Initial Stage 9 Run-off Water After Mineral Precipitation and Sorption Loss  
END

Title Stage 9 Pit lake Mix

Mix 903

```
904      0.224670
908      0.278220
1        0.117685
815      0.379425
Save solution 909
end
```

Title Stage 9 Pit wall interaction mix calculator

MIX 904

```
909      1
3         0
4         0
5         0
6         0
7         0
8         0
9        0.0005144
10       0.0001902
11       0.0012842
12        0
13        0
```

Save solution 910  
end

REACTION 904

```
H2O      -1
0.110496872 moles ### Addition step. Removes HTC water but solute mass remains
          ## Returns solution volume back to 1L
```

USE solution 910

SAVE Solution 911

End

Title Evaporate Stage 9 lake water

REACTION 905

```
H2O      -1
33.65 moles ## Removes x m3 water, but solute mass remains the same
          ## This number must be adjusted manually for each cycle
```

USE solution 911

Save Solution 912

END

Title Return solution back to 1L

Mix 905

```
912 2.5363
save solution 913
end
```

Title Precipitate oversaturated phases

PHASES

Fix\_pe

e==e-

log\_k 0

EQUILIBRIUM\_PHASES 905

```
Ag2Se 0 0
Anhydrite 0 0
Alunite 0 0
Ba3(AsO4)2 0 0
Barite 0 0
Boehmite 0 0
Brochantite 0 0
Brucite 0 0
Calcite 0 0
Carnotite 0 0
CaMoO4 0 0
Chrysotile 0 0
CO2(g) -3.5 10
Co3O4 0 0
Cr2O3 0 0
Diaspore 0 0
Epsomite 0 0
Ferrihydrite 0 0
Fluorite 0 0
Gummite 0 0
Gypsum 0 0
HgSe 0 0
Hgmetal(1) 0 0
Kaolinite 0 0
Mg3(PO4)2 0 0
Mirabilite 0 0
O2(g) -32 10
NiCO3 0 0
NiMoO4 0 0
Ni(OH)2 0 0
Ni3(AsO4)2·8H2O 0 0
Otavite 0 0
Pyromorphite 0 0
Rutherfordine 0 0
Schoepite 0 0
Sepiolite 0 0
SiO2(am-ppt) 0 0
Tyuyamunite 0 0
U3O8 0 0
UO3 0 0
UO2(OH)2(beta) 0 0
USE solution 913
SAVE Solution 914 Initial Pit Water after Mineral Precipitation
SAVE EQUILIBRIUM_PHASES 905
END
```

Title Determine loss of metals due to HFO sorption and sedimentation  
SURFACE 905

```
-equilibrate with solution 1
Hfo_sOH Ferrihydrite equilibrium_phase 0.005 64200
Hfo_wOH Ferrihydrite equilibrium_phase 0.2
-donnan 1e-008
```

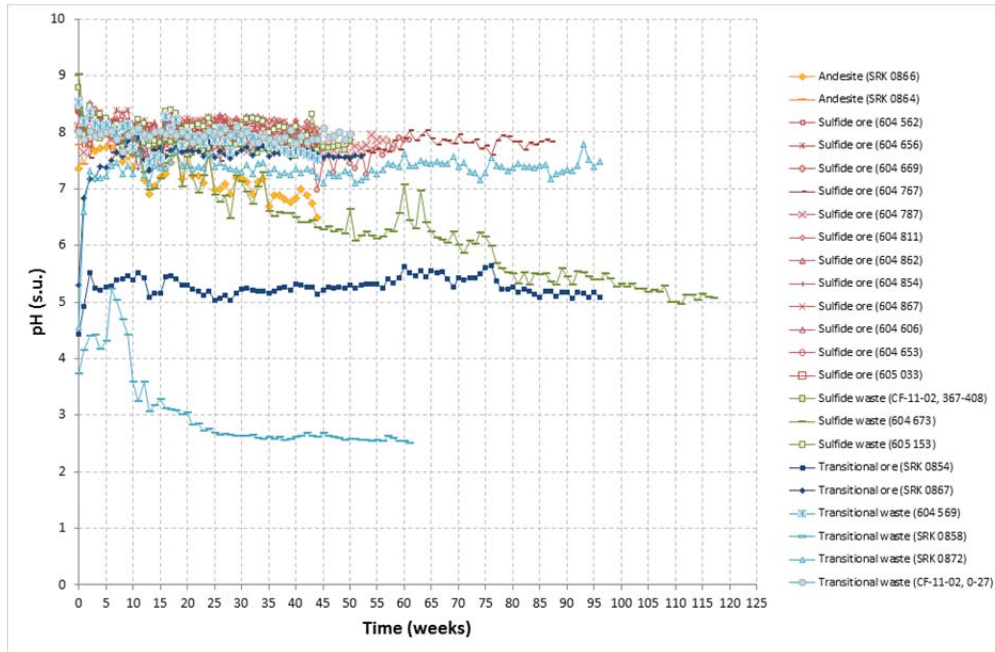
```
USE EQUILIBRIUM_PHASES 905
USE Surface 905
USE Solution 914
SAVE Solution 915 #Final Stage 9 Pit Water After Mineral Precipitation and Sorption Loss
END
```

Title Use solution to allow model output  
REACTION 906

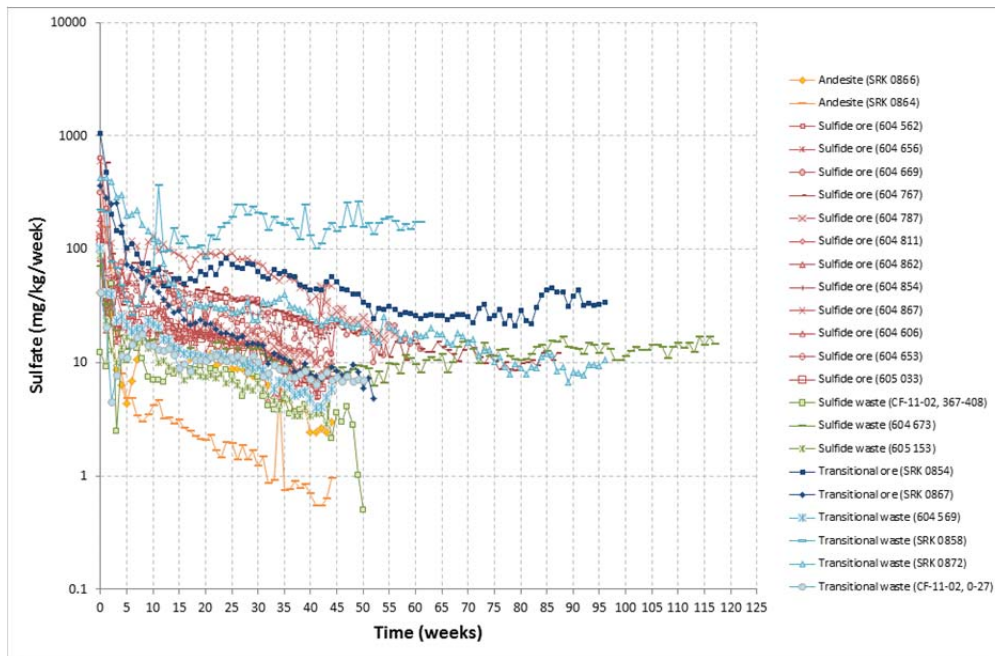
```
H2O -0.0
0 moles
```

```
USE solution 915
End
```

## **Appendix B – Humidity Cell Elemental Release Rate Graphs**

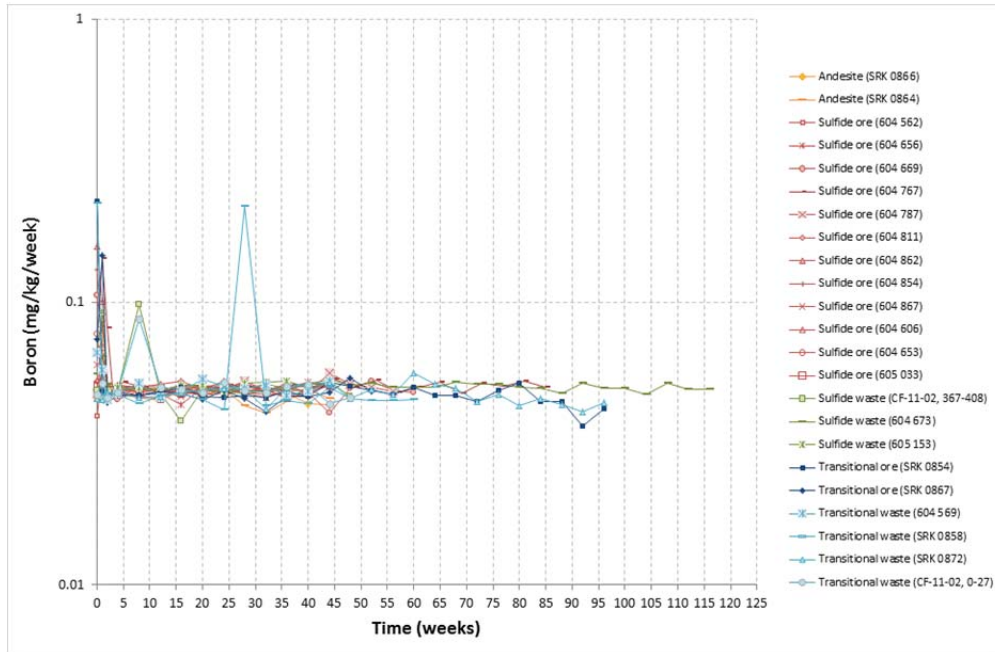


**Figure B-1: Humidity Cell Effluent pH**

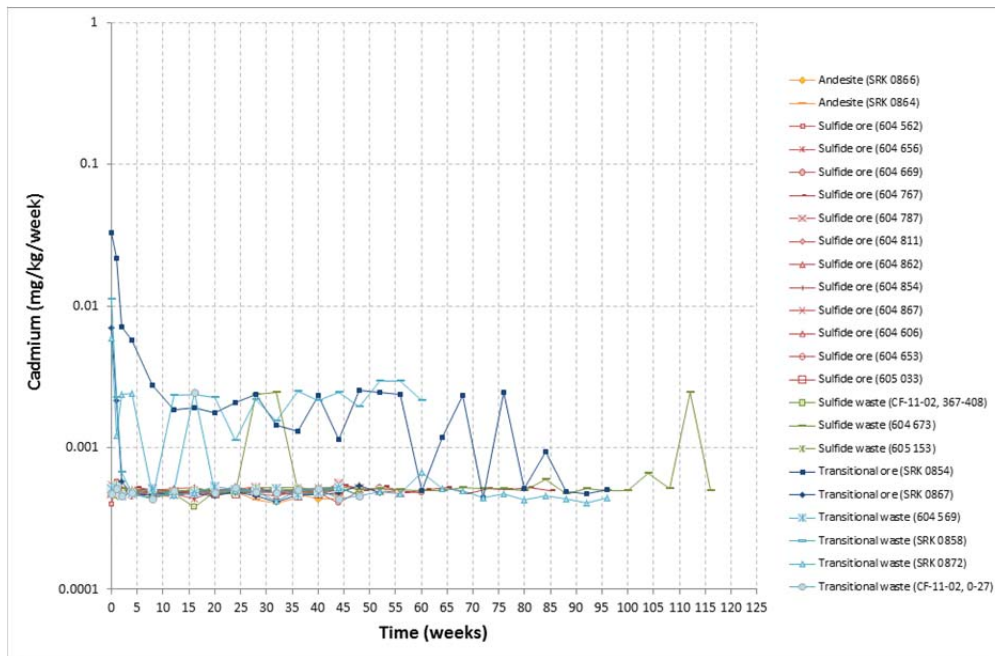


**Figure B-2: Humidity Cell Effluent Sulfate**





**Figure B-3: Humidity Cell Effluent Boron**



**Figure B-4: Humidity Cell Effluent Cadmium**

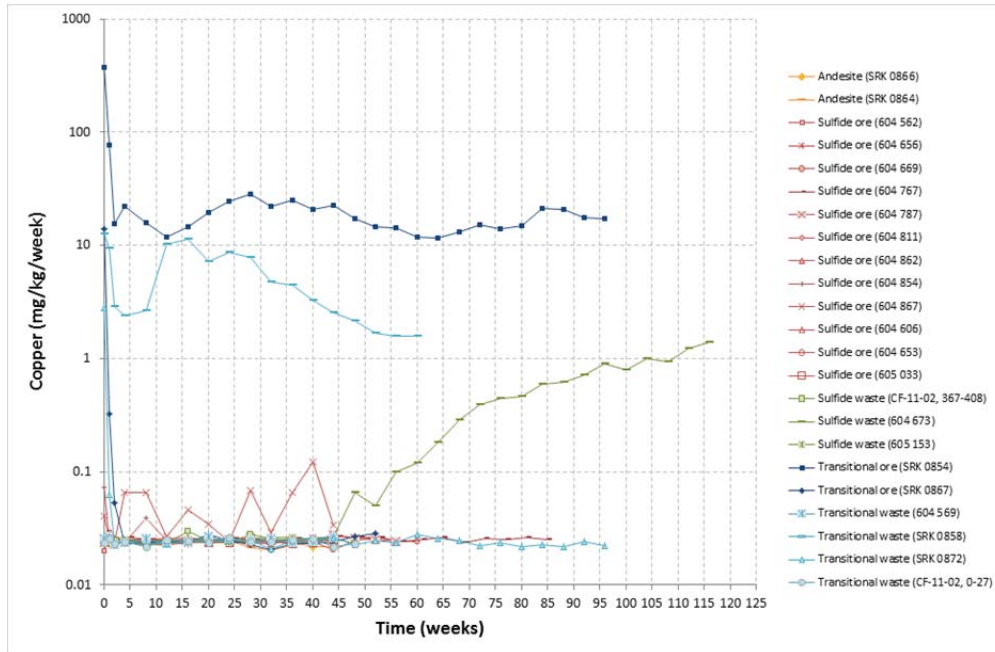


Figure B-5: Humidity Cell Effluent Copper

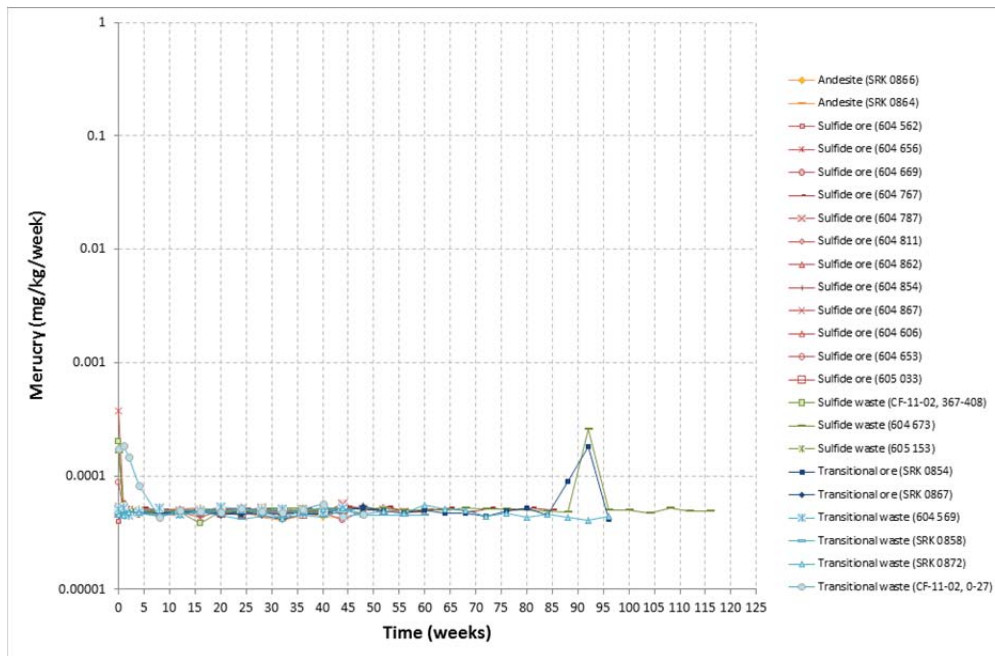
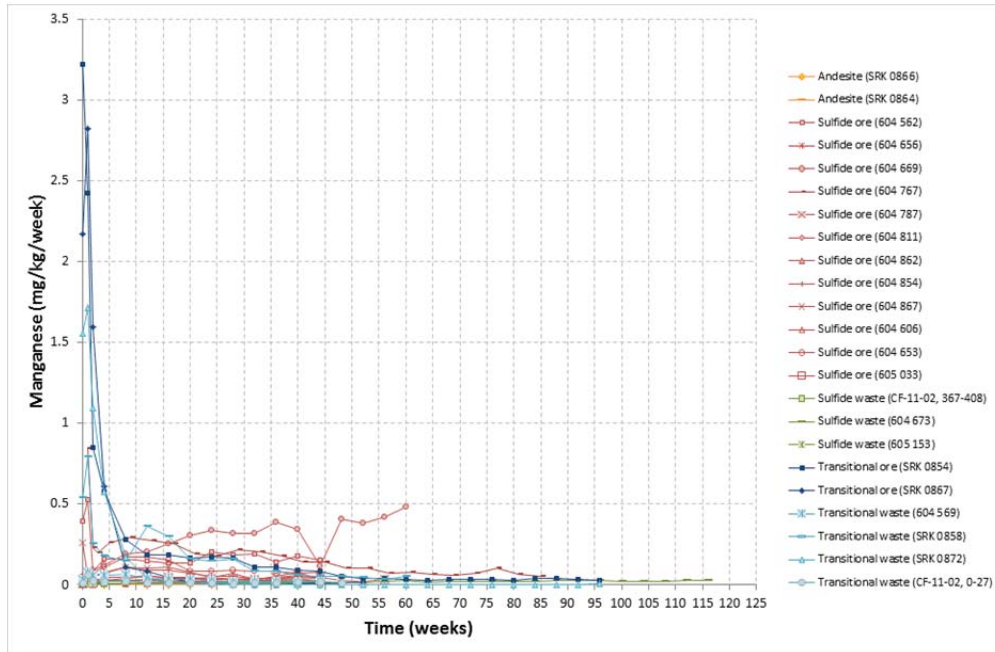
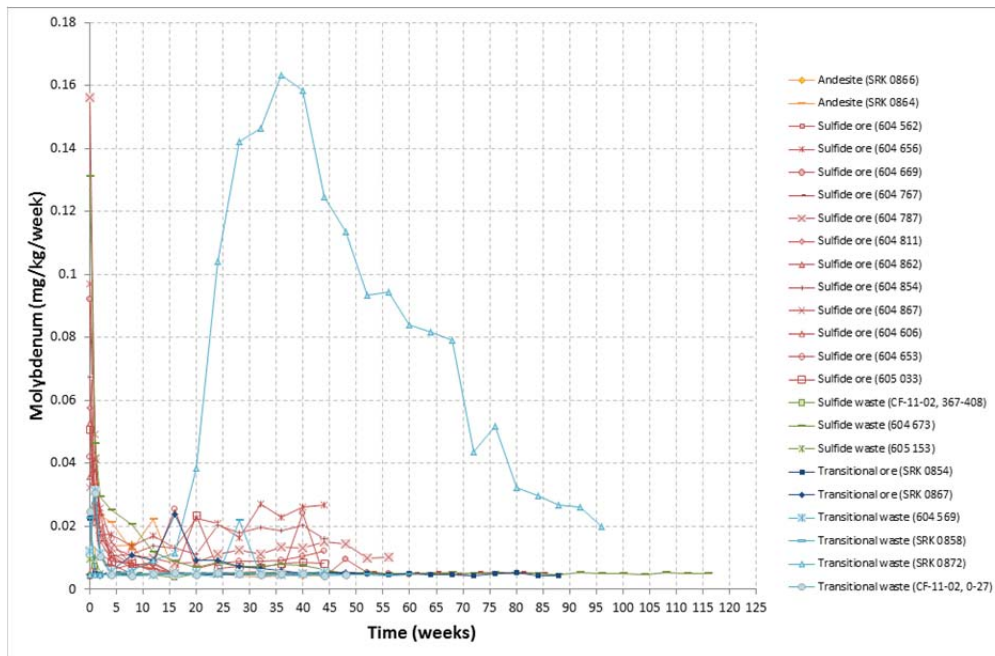


Figure B-6: Humidity Cell Effluent Mercury



**Figure B-7: Humidity Cell Effluent Manganese**



**Figure B-8: Humidity Cell Effluent Molybdenum**

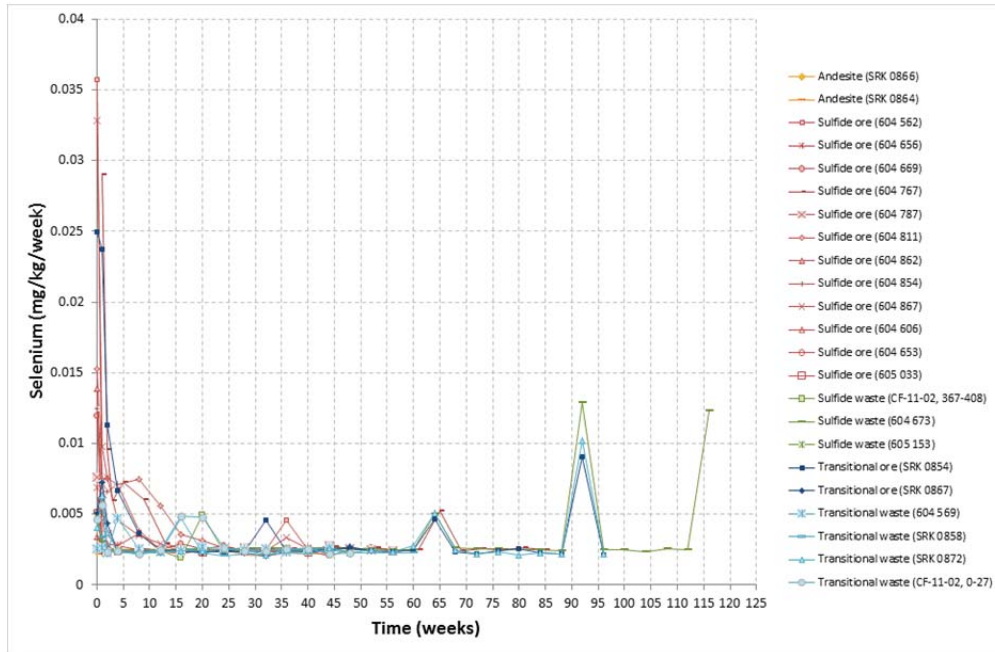


Figure B-9: Humidity Cell Effluent Selenium

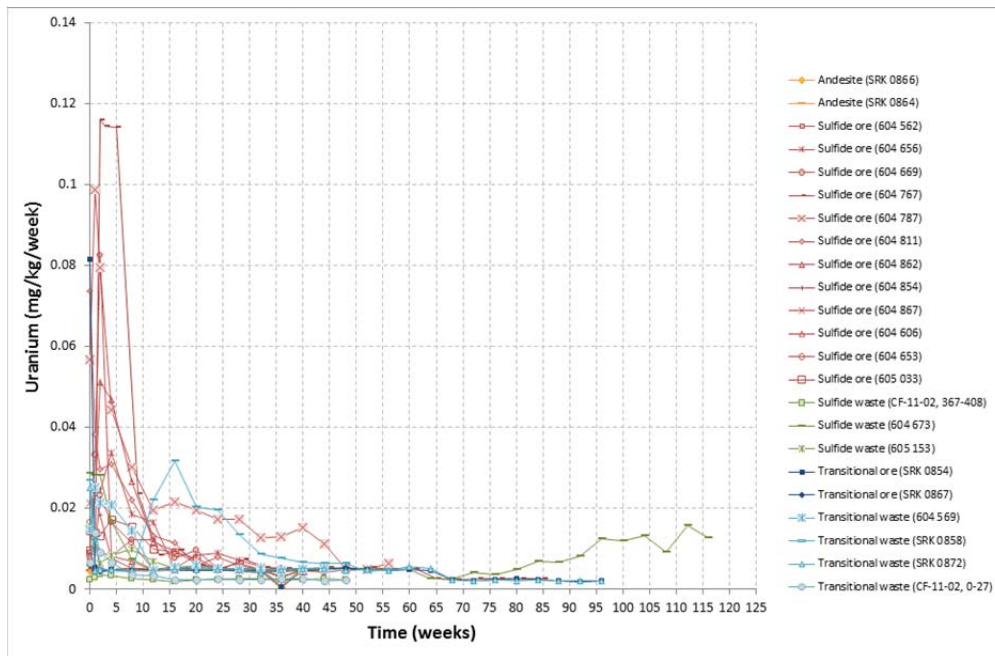


Figure B-10: Humidity Cell Effluent Uranium



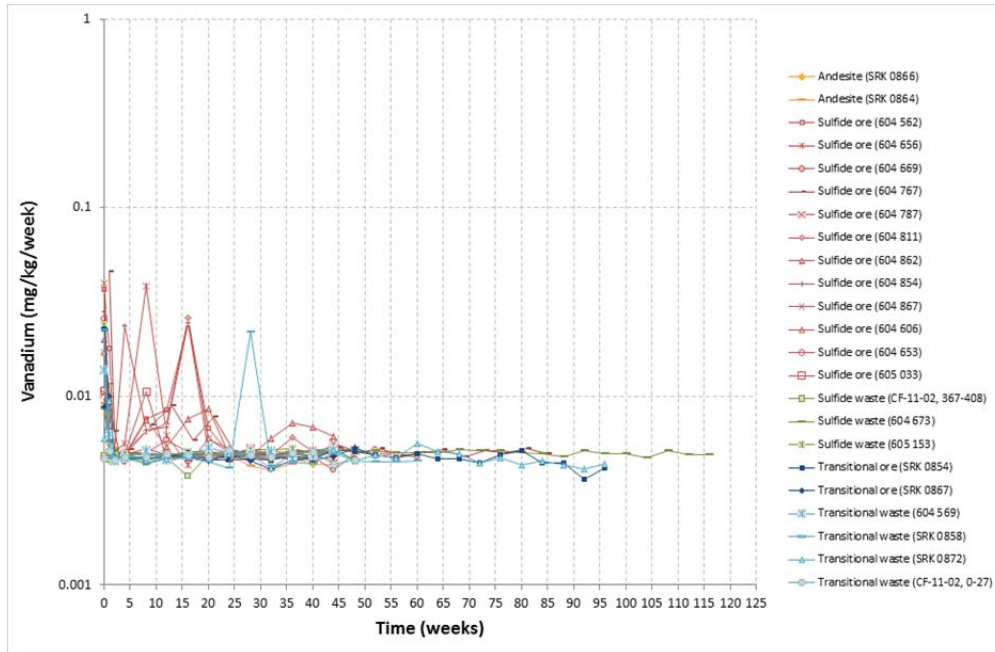


Figure B-11: Humidity Cell Effluent Vanadium

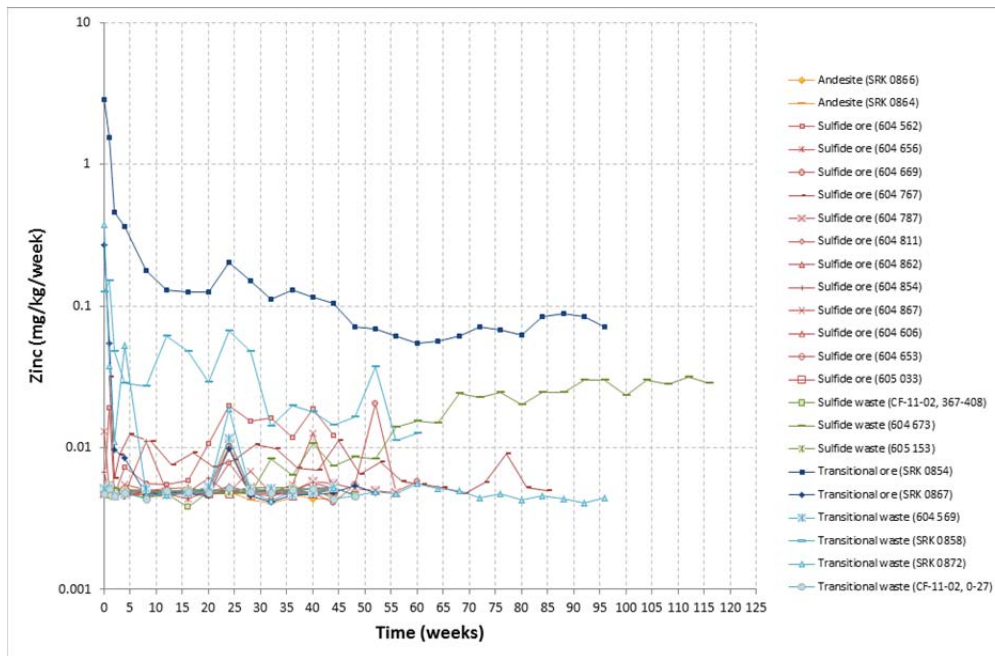
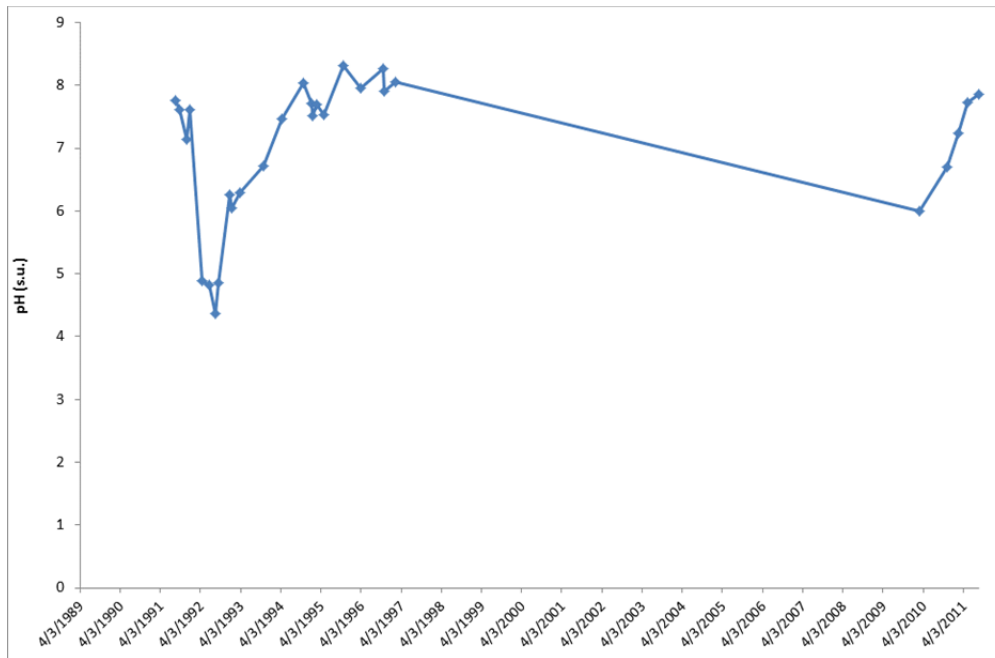
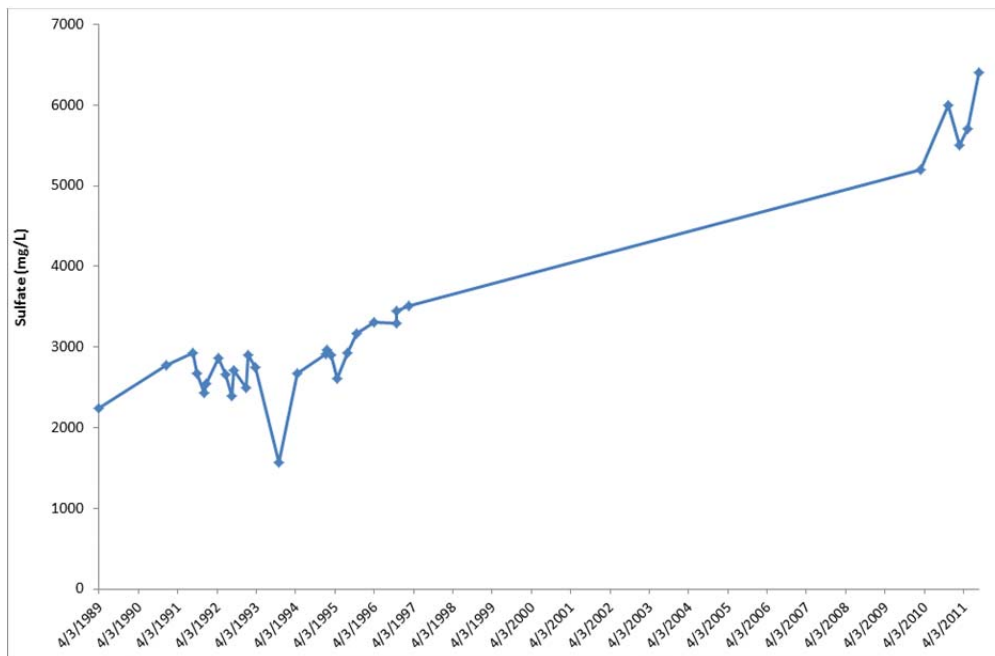


Figure B-12: Humidity Cell Effluent Zinc

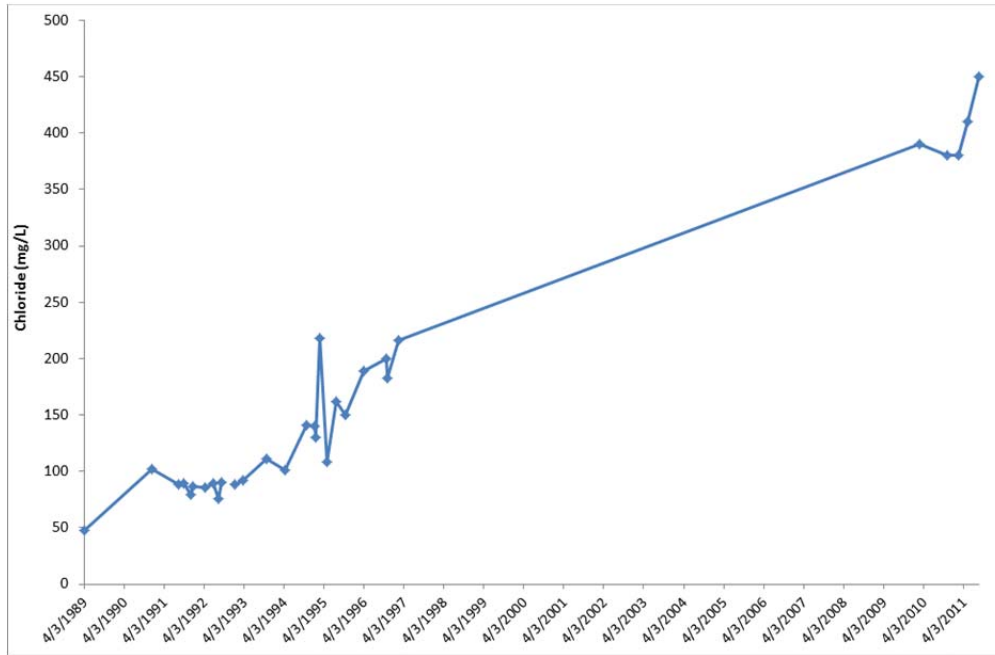
## **Appendix C – Existing Pit Lake Chemistry**



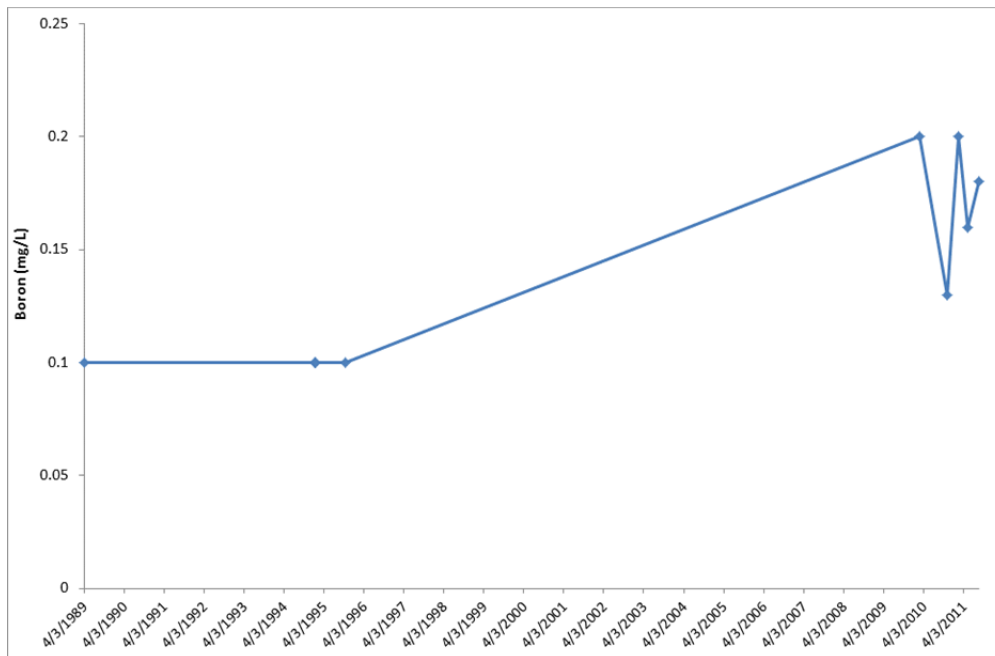
**Figure C-1: pH Trends in Existing Pit Lake**



**Figure C-2: Sulfate Trends in Existing Pit Lake**

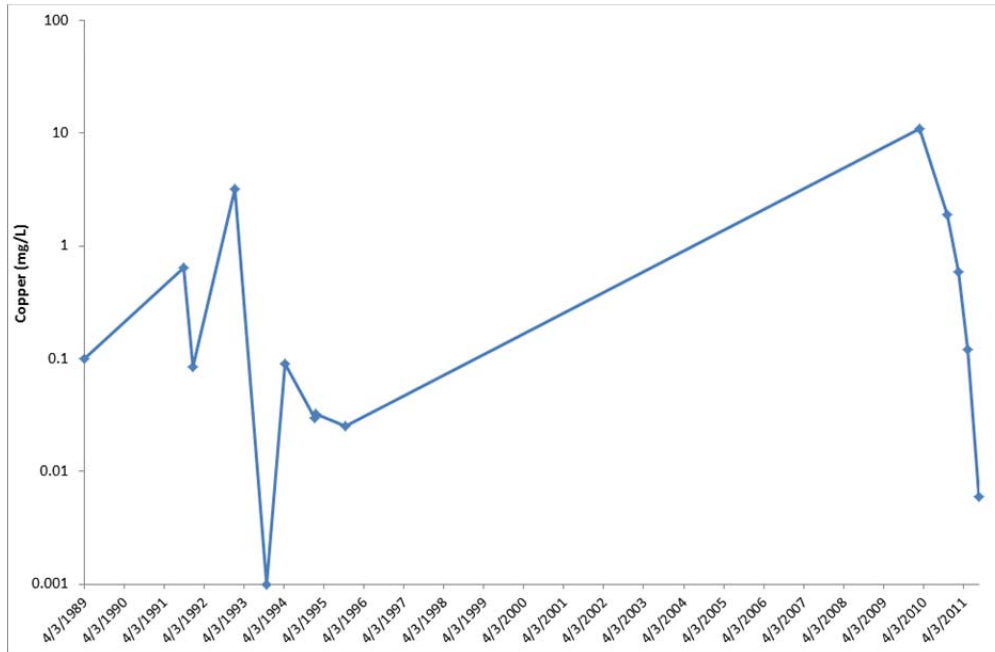


**Figure C-3: Chloride Trends in Existing Pit Lake**

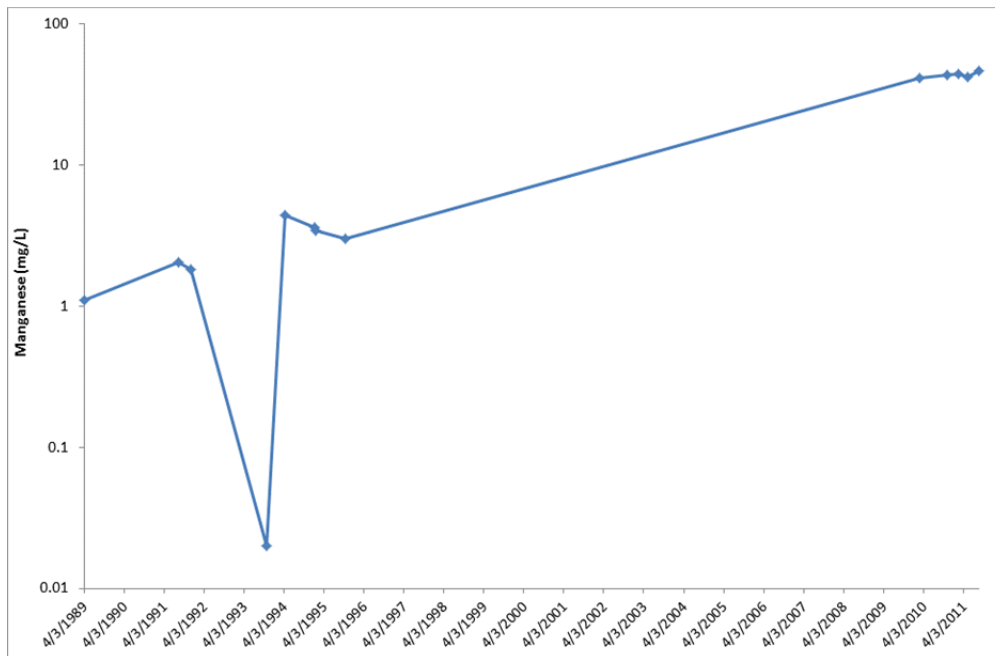


**Figure C-4: Boron Trends in Existing Pit Lake**

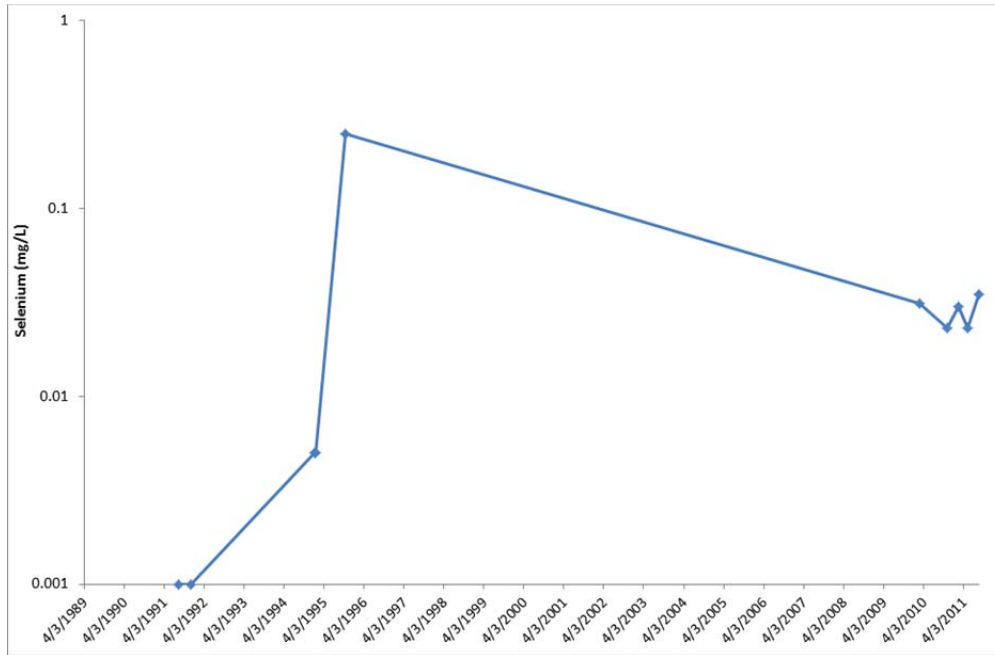




**Figure C-5: Copper Trends in Existing Pit Lake**



**Figure C-6: Manganese Trends in Existing Pit Lake**



**Figure C-7: Selenium Trends in Existing Pit Lake**