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BARITE HILL PROJECT
EVALUATION OF PIT
CLOSURE ALTERNATIVES

Prepared for:
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1.0 INTRODUCTION

1.1 Background

Mining operations at the Barite Hill Project located near McCormick, South Carolina were commenced in 1990 and mining in the main pit area was terminated in 1994. During the later stages of the mining operation, approximately 160,000 cubic yards of sulfide (pyrite) bearing waste rock encountered in the main pit were placed in a temporary stockpile area adjacent to the pit. Since mining operations were terminated, the pit has begun to refill and currently contains approximately 29.3 million gallons of water.

The stockpiled sulfide waste rock and sulfide bearing pit wall exposures exhibit acid generating conditions as a result of pyrite oxidation. The water contained in the pit is currently of low pH reflecting interaction with exposed pit wall sulfides and previously backfilled waste rock, and accumulation of acid products in runoff from the stockpiled waste rock and pit walls.

In order to mitigate acid generation in the long term, Barite Hill proposes to replace the sulfide waste in the main pit below the post closure pit water level and construct a cap of low permeability native soil over the backfilled waste rock and exposed sulfide bearing pit wall rock. Long term control of oxidation and acid generation will be affected by disposal of the waste rock backfill under subaqueous conditions.

A reduction in the quantity of water currently contained in the open pit will be required prior to placement of the backfill and, in order to establish acceptable groundwater quality at and following closure, pretreatment of the existing pit water. Field testing, as discussed below, indicates that the waste rock backfill contains readily leachable oxidation products (acidity, sulfate and dissolved metals) that will be available to interact with the pit water during backfilling operations. Amendment of the backfill with base additives to neutralize available acidity is proposed as a means of maintaining acceptable pit water quality during backfilling.

1.2 Scope

This report addresses approaches to the closure of the Main Pit including an evaluation of alternatives for management and/or treatment pit water and measures for managing and treating acid generating waste rock backfill. As part of the study, the site was visited to assess the condition of the waste rock backfill and initiate on-site physical and chemical testing; hydrogeologic conditions

were evaluated to develop an estimate of post closure groundwater levels in the main pit area; an investigation of locally available base additives that can be used to pretreat pit water and neutralize backfill was conducted; and a series of laboratory pit water and waste rock treatment tests was completed to evaluate the effectiveness of identified base additives.

2.0 SITE INSPECTION

Steffen Robertson and Kirsten (U.S.) Inc. (SRK) visited the Barite Hill site on May 31 and June 1, 1995 to initiate the evaluation of pit closure alternatives. While on site, a survey of the backfill and pit wall areas was conducted.

2.1 Stockpiled Backfill

The material proposed for pit backfill below the post closure pit water level was examined. Two material types were identified that consist of a blocky, siliceous dark gray schist, and a partially oxidized gray to gray green schist exhibiting slatey cleavage. The former is oxidized to a limited degree and constitutes the bulk of the material stockpiled for future backfill. The latter represents less that 10 percent of the stockpiled backfill.

To evaluate the backfill, a series of field paste pH and paste total dissolved solids (TDS) tests was conducted. These tests involved mixing approximately equal portions of solids and deionized water and measuring the pH and TDS content of the paste following agitation. The tests are used to estimate the stage or existence of acid generation and the presence of potentially leachable acid products (acidity, metals and salts).

All testing of backfill material indicated paste pH values in the range of 1.9 to 2.3 and paste TDS content greater than 2000 ppm. The tests indicate conditions favorable for advanced, biologically catalyzed oxidation of the backfill and high TDS content indicates storage of leachable oxidation products.

Runoff and seepage from the waste backfill area on the pit haulage ramp exhibited a pH of 1.5 and a TDS content of greater than 2000 ppm.

2.2 Pit Wall Areas

In conjunction with survey of the proposed backfill material, field paste testing was conducted at several locations on the 395 bench where sulfide bearing rocks are exposed on the pit walls. Field testing of the exposed sulfide bearing wall rock indicated low pH (0.9 to 1.9) and high TDS content. These test results indicate an advanced rate of oxidation in exposed pit wall sulfides and the presence of leachable acid products.

2.3 Clay Borrow Area

Several samples of the clay borrow material were also examined. The clay exhibited paste pH values near 4.3 and paste TDS content in the range of 30 to 90 ppm. The low TDS content indicates that the clay does not contain stored oxidation products and would not be anticipated to have a significant readily leachable metal or salt content. Surface water runoff collected in the clay borrow area exhibited a pH of 4.3 and a TDS content of 30 to 140 ppm. These results appear to confirm that the leachable content of the clay borrow material is low.

2.4 Pit Water

2.4.1 Water Quality

At the time of the site inspection, the field measurements indicated a pit water pH of 2.2 and a TDS content of greater than 2000 ppm. Pit water analyses for samples collected in March and June of 1995 are contained in Appendix A. Selected data are summarized in Table 2.1.

Laboratory analysis of the June 1995 sample indicated a TDS content of 3070 mg/l and sulfate content at 2390 mg/l. Metals present in significant concentrations include aluminum (14.6 mg/l), cadmium (1.15 mg/l), calcium (66.7 mg/l), copper (24.9 mg/l), iron (57.5 mg/l), manganese (5.67 mg/l), zinc (15.5 mg/l) and selenium (1.35 mg/l). Traces of barium, lead and nickel were also detected. Sodium concentration was 572 mg/l and chloride content was 208 mg/l.

In June, a laboratory pH value of 7.2 was reported for the pit water. Field measurements of pit water indicated a pH near 2.0. A bulk pit water sample received from Barite Hill in July 1995 had a pH of 3.4. A split from the bulk sample submitted to an outside analytical laboratory exhibited an acidity of 447 mg/l. Therefore, based on the field testing and supplemental analysis of the bulk pit water sample, the June 1995 laboratory pH value is considered to be in error.

Comparison of June 1995 to March 1995 data (Appendix A) indicates increasing trends in the concentrations of TDS and sulfate. Aluminum and iron exhibited marked increases in concentration in June while copper concentration decreased.

In March 1995, the laboratory pH value for the pit water was 5.9 while alkalinity occurred at a concentration of 11.7 to 16.2 mg/l. The absence of alkalinity in the June sample and the reduction

in pH exhibited from March to July suggests ongoing oxidation of the pit walls and the accumulation of acid products is affecting the pit water quality.

2.4.2 Pit Volume

The height versus capacity relationship for the main pit is shown in Appendix B. The height versus capacity relationship was developed from Barite Hill's final pit topography survey and was corrected for previously placed backfill. Pit water elevations were estimated by comparing photographs taken in June and September, 1995 to features recognizable on the pit topography map.

During the June 1995 site visit, the pit water level was approximately 385 feet and contained an estimated 24.7 million gallons. In the period between June and September 1995, the water level rose to an elevation of approximately 388 feet corresponding to an estimated volume of 29.3 million gallons.

3.0 SURVEY OF BASE ADDITIVES

A primary goal of closure is to create acceptable groundwater quality conditions in the post closure pit. This task will require pretreatment of the existing pit water, and amendment of backfill to neutralize available acidity and control metal solubility. A survey was conducted to identify locally available materials that could be used for pit water and waste rock treatment.

The following materials were identified:

- Slaked lime (produced as a by-product of acetylene manufacturing) from the SUNOX gas plant located in Blythewood, S.C.;
- Cement kiln dust produced by Giant Cement Corp., Harleyvillle, S.C.;
- Raw phosphate rock and processed phosphate rock from PCS Phosphate of Aurora, N.C.,
- Crushed limestone from Martin Marietta's Berkeley quarry in Eutawville, S.C.; and
- Crushed dolomitic limestone from Vulcan materials in Blacksburg, S.C..

In addition to the above raw materials and industrial waste by-products, the processed reagents sodium hydroxide (NaOH) and trisodium phosphate dodecahydrate (TSP, $NaPO_4 \bullet 12H_2O$) were also identified as potential candidates for pit water pretreatment and waste rock amendment.

Samples of the materials were obtained from the manufacturers/producers and used in a series of bench tests to determine their ability to neutralize waste rock and pit water and enable estimation of addition rates. Amendment testing is discussed in the following sections.

4.0 FIELD AND LABORATORY TESTING

4.1 General

Bench scale base addition tests were conducted on a pit water sample provided by Barite Hill in July 1995 and on a bulk waste rock sample collected by SRK during the June, 1995 site visit. An on-site test was conducted to determine the bulk porosity of the waste rock backfill and its leachable content of acidity.

4.2 Test Procedures

4.2.1 Pit Water Pretreatment Tests

Pit water pretreatment tests were conducted by adding the identified amendments to a one-liter sample of water and monitoring the pH of the treated sample. Two criteria were used to estimate base addition rates.

Compounds such as lime and caustic (NaOH) are used in water treatment to elevate pH and reduce metal concentrations by precipitating metal hydroxides. Previous experience has shown that a pH of 7.0 or above is required to affect a reduction in metal concentration if lime and caustic are used. Therefore, a treatment pH endpoint near 7.0 was assumed for estimation of base addition rates in tests utilizing NaOH, slaked lime, dolomite, limestone and lime kiln dust.

The addition of phosphate compounds to low pH waters containing elevated metal concentration results in an increase in pH and in the precipitation of metal orthphosphates in the form of MPO_4 or $M_3(PO_4)_2$ where "M" represents the metal. Most commonly occurring metals will react with phosphate to form orthophosphates that are insoluble in alkaline solutions. Experience with phosphate treatment indicates the selective precipitation of iron, copper, manganese and zinc occurs at a pH near 5.0. Further addition of phosphate and elevation of pH results in the precipitation of calcium orthophosphate. Therefore, in pretreatment tests with phosphate rock and TSP, a treatment endpoint pH of 5.5 was assumed for determination of addition rates.

Under field conditions, the ability to mix base additives with the pit water will be limited, particularly for the case of sparingly soluble additives such as limestone and dolomite. Therefore, additives were placed in the pit water samples without physical mixing or agitation to simulate field conditions in a "contact" test.

In a trial and error approach, base materials were added to pit water samples in sufficient quantity to produce the target pH endpoint. The time required for each additive to produce the desired endpoint was also noted to determine their relative reactivity. For materials which reacted rapidly with the pit water, treated water samples were decanted and shipped to an outside laboratory for analysis of selected constituents (constituents that occur in the pit water).

4.2.2 Waste Rock Neutralization Tests

A series of bench tests was conducted to evaluate the base addition rates that will be required to neutralize available acidity in the backfill. The tests involved mixing each of the identified additives with a 300 mg sample of waste rock backfill. The samples were then submerged in deionized water and the pH of the pore water and time required to reach the target pH endpoint was monitored. To determine pH, the sample containers were tilted and a pH probe was inserted in standing surface water. The pH endpoints discussed in Section 4.2.1 for phosphate and non-phosphate compounds were assumed for estimation of waste rock base addition requirements.

By trial and error, the minimum addition rates for each additive were determined using 300 mg backfill samples. For each additive that was indicated to be effective, a second test was conducted with a 2 kg sample and a similar addition rate. For materials that reacted relatively rapidly to neutralize the waste rock, upon achievement of the desired pH endpoint the pore fluid was drained from the sample and submitted to an outside analytical laboratory for analysis of selected constituents.

Following submergence of the samples, additional mixing or agitation was not undertaken. This procedure was adopted in order to simulate field placement of the backfill in the open pit where, following placement and submergence, additional mixing or agitation will not be possible.

4.2.3 On-site Testing of Bulk Waste Rock Properties

In order to determine the bulk porosity of the waste rock backfill and estimate pit water reduction requirements, a field test of the backfill was conducted. A test pit was excavated and lined with PVC membrane. The quantity of water required to fill the pit was first measured to determined the volume of the test pit. The pit was then drained, filled with backfill material and the quantity of water required to fill the void space in the backfill was measured. The backfill was placed at its ambient moisture content, therefore, the measured porosity represents a residual or available porosity.

It is anticipated that the backfill will be placed in the main pit by dozer spreading and grading or by direct placement in the pit water. This method of backfilling will result in a light to moderate degree of compaction, Therefore, the sulfide waste rock was subjected to light compaction during placement in the test pit to simulate the anticipated density of the in-pit backfill.

The pH and TDS content of the backfill pore water were monitored until equilibrium conditions were achieved. A sample of the pore water was collected after equilibration for measurement of available acidity.

4.3 Test Results

4.3.1 Pit Water Pretreatment Tests

Table 4.1 summarizes the results of the pit water pretreatment tests. Laboratory data sheets are contained in Appendix C. Based on the fast rate of reaction indicated in the bench pretreatment tests, pit water samples treated with TSP, NaOH, slaked lime and kiln dust were submitted for laboratory analysis of selected constituents.

Laboratory pH in treated samples varied significantly from the pH endpoint targets of 5.5 for phosphate compounds and 7.0 for the slaked lime, NaOH and kiln dust. These data indicate that the reactions may not have been complete at the time of sampling.

4.3.1.1 TSP Treatment

TSP treatment to a pH of 6.0 indicates good reduction of Al, Ba, Cd, Cu, Fe and Zn when compared to the July 1995 pit water quality data. TSP had little or no affect on the concentrations of Mn, Se and Ni, indicating selective precipitation of the former group of metals at sub-neutral pH. The excess phosphate in the TSP treated solution was low (17.3 mg/l). The addition of more TSP and a further increase in pH can be anticipated to reduce metal concentrations by precipitating additional orthophosphates.

The dominant constituent in the pit water is sulfate which accounts for approximately 60 to 75 percent of the TDS content. The TDS and sulfate concentrations in the TSP treated sample are similar to concentrations measured in the July 1995 pit water sample. Therefore, TSP treatment had no affect on sulfate concentration.

4.3.1.2 NaOH Treatment

With the exception of Ni, Cu, Mn and Zn, pit water treated to a pH of 8.6 with NaOH and TSP exhibit similar metal concentrations. Cu concentration was reduced to 3.55 mg/l (from approximately 25 mg/l in the July 1995 pit water sample), a slight increase over TSP treatment, Mn concentration was unaffected by NaOH treatment and Zn exhibited a further decrease in concentration over TSP treatment. Ni exhibited the lowest concentration in NaOH treated water. NaOH treatment had little affect on TDS as the sulfate concentration was not impacted by NaOH addition.

4.3.1.3 Slaked Lime Treatment

Slaked lime treatment to a pH of 11.1, with the exception of calcium, produced the lowest overall concentration of metals. The lowest concentrations of Cd, Fe, Mn, Se and Zn were produced. A reduction in sulfate concentration also occurred as a result of gypsum precipitation. The slaked lime treated water exhibited excess alkalinity as carbonate (40 mg/l) and as hydroxide at a concentration of 101 mg/l.

4.3.1.4 Kiln Dust Treatment

In comparison to the other compounds, kiln dust was relatively slow in reacting. At an addition rate of 15 grams per liter, a pH of 6.5 was achieved after more than one week of contact. At this pH level, kiln dust was less effective in reducing concentrations of Fe, Mn and Zn. Treatment to a higher pH would be anticipated to have effects that are similar to slaked lime treatment. As kiln dust contain calcium, a reduction in sulfate concentration was realized.

4.3.2 Waste Rock Neutralization Tests

The results of the analysis of treated waste rock sample pore water extracts are summarized in Table 4.2. Laboratory data is contained in Appendix C. Laboratory pH values again differ from the target pH endpoint values suggesting either continued reaction following pore water extraction and during sample transport, or addition of insufficient base additive to achieve the desired pH target value.

4.3.2.1 TSP Waste Rock Treatment

TSP addition at a rate of 4.5 percent by weight produced waste rock pore water with a pH of 7.6 based on outside laboratory measurement. The TSP treated sample extract exhibited a TDS content of 52,300 ppm and sulfate concentration of 35,300 mg/l. In contrast, the TDS content in the pore water from the on-site waste rock test (Section 4.3.3) was 86,000 ppm. The addition of TSP, in relation to treatment with calcium containing additives, appears to have minor effect on TDS content.

4.3.2.2 NaOH Waste Rock Treatment

Addition of NaOH to a waste rock sample at a rate of approximately 1.3 percent by weight produced a pore water extract with a laboratory measured pH of 6.3. At this pH level, aluminum occurred at 13.6 mg/l, barium occurred at 1.19 mg/l, copper occurred at 1.66 mg/l, iron occurred at 44.4 mg/l, and the concentrations of manganese and zinc were 6.24 and 16 mg/l, respectively. All other measured metals were detected in concentrations of less that 1 mg/l.

The TDS content of the treated sample extract was 67,200 mg/l and in comparison to the on-site test (86,000 mg/l), indicates a slight reduction. NaOH treatment also had little effect on sulfate concentration in the waste rock pore fluid.

4.3.2.3 Waste Rock Treatment with Slaked Lime

Addition of slaked lime at a rate of 2.8 percent by weight produced a treated sample extract with a laboratory measured pH of 5.5. In comparison to NaOH treatment, increases in aluminum (at 26.1 mg/l), copper (at 3.38 mg/l) iron (at 99.7 mg/l) and zinc (at 22.6 mg/l) were measured in the treated sample extract. Calcium concentration was also increased. For other metals, concentrations are similar in the NaOH and slaked lime treated extracts. As shown by slaked lime neutralization of pit water, it is anticipated that neutralizing the residual acidity (195 mg/l) and increasing pH with additional lime would substantially reduce metal concentrations.

Slaked lime addition produced a significant decrease in the TDS content. Sulfate concentration was 3900 mg/l, approximately 10 percent of the sulfate contained in TSP and NaOH treated sample extracts. The reduction in TDS content is assumed to be a result of the precipitation of gypsum.

4.3.2.4 Kiln Dust Waste Rock Treatment

The addition of kiln dust at a rate of five percent by weight produced a treated sample pore water extract with a pH of 4.1. Analysis indicates the lowest concentrations of aluminum, barium, cadmium, copper, iron, manganese, nickel and zinc were produced by kiln dust addition. Substantial decreases in TDS and sulfate also occurred.

While the extract pH was 4.1, the kiln dust treated sample exhibited bicarbonate alkalinity at 392 mg/l. These data are conflicting and a possible cause is the evolution of carbon dioxide in the sealed container during shipment which could reduce pH. Once carbon dioxide is allowed to dissipate, pH would be anticipated to increase.

The indicated level of metal reduction following kiln dust addition is inferred to be caused by the carbonate content of the kiln dust. While NaOH and slaked lime reduce metal concentrations by the formation of hydroxide precipitates, kiln dust addition has the potential to reduce metal concentration by both carbonate and hydroxide formation.

4.3.3 Bulk Waste Rock Properties

The on-site test of bulk waste rock backfill porosity indicated 59 cubic feet of water were required to fill the void space in 360 cubic feet of backfill. The test indicates an available porosity of 19 percent and a pore volume in the 160,000 cubic yards of backfill of approximately 6.14 million gallons.

Monitoring of pH and TDS content indicated that the pore water in the backfill test pit reached equilibrium conditions in approximately 5 days with a pH of 1.97 and a TDS content of 86,000 mg/l. A sample of the backfill pore water following equilibration had an acidity concentration of 8,700 mg/l (as $CaCO_3$ at pH 8.0).

Assuming a backfill density of 120 pound per cubic foot, the test pit contained approximately 21.6 tons of backfill. At the time of the test, available acidity was contained in the backfill at a concentration of approximately 740 mg/kg.

4.3.4 Supplemental Base Additive Testing

Both the slaked lime and lime kiln dust exhibited the ability to readily neutralize waste rock in the bench tests. Samples of these materials were subjected to standard neutralization potential tests to determine their calcium carbonate equivalent content. Both materials were obtained from outside stockpile areas and contain residual moisture. Test results (Appendix C) indicate a calcium carbonate equivalent content of 55 percent for the slaked lime. The lime sample had a solids content of 49.2 percent, therefore, the bulk calcium carbonate equivalent content of the lime is approximately 28 percent on a dry basis.

Tests indicated a calcium carbonate equivalent content of 50 percent and solids content of 79 percent in the kiln dust. Therefore, the calcium carbonate equivalent content of the bulk kiln dust is approximately 39 percent on a dry basis.

5.0 HYDROGEOLOGIC EVALUATION

5.1 Hydrogeologic Conditions

The hydrogeology of the Barite Hill site is complex due to the highly fractured, faulted and heterogeneous nature of the rock. Due to these complexities, anisotropic conditions are likely to exist. Hydrogeologic investigations have been conducted in the rinsed agglomerate disposal area, however, a general paucity of data exists in the main pit area with respect to water level measurements, hydraulic conductivity, and boundary conditions. Therefore, the post closure water level conditions were estimated on the basis of a statistical analysis of water levels in three nearby monitoring wells.

During operations, Barite Hill estimates groundwater inflow rates to the pit were a maximum of approximately 20 gpm. Little or no inflow was observed until the pit was advanced below the 385 level. The current water level is approximately 388 feet and the pit has been estimated to contain 29.3 million gallons.

5.2 Existing Conditions

Water levels for well GW-1 (northwest of the pit), GW-2 (northeast) and A3 (south) average 385 ft, 398 ft and 438 ft msl, respectively for the measurement period beginning in March 1991 and ending in March, 1995. The water table (or piezometric surface) south of the main pit appears to mimic surface topography indicating that shallow groundwater flow is to the south. The flow direction north of the pit can not be determined with available data, however, during high water table conditions, it is likely that groundwater will discharge into the northwest trending natural drainage located north and west of the open pit. Barite Hill reports that only intermittent flow has occurred in this drainage during mining operations as a result of surface water runoff following storm events.

At present, the pit appears to be refilling at a very slow rate. Water levels in wells proximal to the pit are probably being affected by pit inflow and are likely to rise when pit refilling is complete and discharge to the pit ceases. The lack of information concerning the hydraulic properties of the rock in the vicinity of the pit complicates estimation of post closure water levels.

5.3 Groundwater Monitoring

Virtually all water level data collected from wells GW-1, GW-2 and A3 were obtained during mining operations when the open pit acted as a sink. The limited data concerning pre-mining conditions, however, are within the range of fluctuation that occurred during mining. This suggests that post closure water levels around the open pit may not exhibit significant increases following pit closure. The variation of water levels in local monitoring wells are probably a result of local recharge and these fluctuations must be considered in estimating post closure water levels. Table 5.1 summarizes the range in observed water levels.

5.4 Estimation of Bulk Hydraulic Conductivity

The relative hydraulic conductivities of the backfill, backfill cover and pit wall rock will affect the groundwater surface gradients and water level in the post closure pit.

The bulk hydraulic conductivity of the rock in the vicinity of the pit was estimated by analogy to a pumping test, using estimated pit inflow rates and the local drawdown that occurred during pit dewatering. The thickness of the shallow bedrock aquifer was assumed to be 240 feet based on reports of a deep fracture zone at an elevation of 180 msl. For modelling purposes, pit dewatering was assumed to occur from a fully penetrating well located at the center of the open pit. The drawdown cone produced by dewatering was assumed to intersect the base of the pit walls (80 feet of drawdown). The steady state pumping rate was assumed to be 20 gpm based on data provided by Barite Hill.

These data were employed in an iterative application of the Theis equation to determine a hydraulic conductivity value that would result in the drawdown conditions and dewatering (pumping) rates. The calculations suggest a bulk hydraulic conductivity of 0.09 ft per day (3.18×10^{-5} cm/sec), a value that is within the range of hydraulic conductivities measured in pump tests in the rinsed agglomerate disposal area (Rinsed Agglomerate Disposal Facility, Design and Solution Control, Final Design Report", ETE Inc. and Water Waste and Land Inc., March 1990). Hydraulic computations are contained in Appendix D.

The hydraulic conductivity conditions in the backfill will be impacted by the physical properties of the material and the method of backfill placement. The backfill will be placed in residual water contained in the open pit following volume reduction. The physical conditions (density, hydraulic conductivity etc.) have not been defined for placement under these conditions, however, the

hydraulic conductivity of the backfill is anticipated to exceed that of the rock in the vicinity of the open pit.

With placement of the low permeability clay cover material over the backfilled waste rock, the backfill groundwater flow could approach confined conditions. The clay cover material placed over the waste rock backfill (clay borrow fill used to contour the post closure pit surface) is anticipated to have an in situ hydraulic conductivity of 1×10^{-5} to 1×10^{-6} cm/sec, a value that is similar to the estimated hydraulic conductivity of the intact pit area rock.

5.5 Estimation of Post Closure Water Levels

Figure 5.1 indicates the average or intermediate groundwater potentiometric surface level in the open pit following backfill and capping. The approximate configuration of the pit following backfill is also shown. The following assumptions and conditions were considered in estimating post closure water levels:

- The pit will be refilled with stockpiled backfill to an elevation of approximately 395 ft msl and capped with a low permeability cover.

- The cap will be graded to promote runoff to a drainage cut located on the north end of the main pit. The cap will reduce recharge in the post closure pit to minimal levels, therefore, a groundwater mound in the pit backfill is not anticipated.

- Local recharge south of the open pit will produce a groundwater divide causing groundwater to flow north through the backfilled pit. The elevation of the divide can be approximated by the water level in Well A3.

- When the pit fills, it will no longer act as a sink for groundwater. Steady-state post closure water levels are likely to be somewhat but not drastically higher than current levels.

- The highest post closure groundwater levels could produce seeps in the natural drainage located north and northwest of the pit at an elevation of approximately 395 ft msl. The average maximum water level in the pit will be midway between 395 ft msl and the elevation of the groundwater divide.

- The lowest post closure groundwater level would not produce seeps in the natural drainage north of the pit. The average minimum water level in the post closure pit will be midway between the levels in Wells A3, GW-1 and GW-2

- Fully confined flow conditions will develop in the backfill.

Due to anticipated differences in the hydraulic conductivity of the waste rock backfill (10^{-3} to 10^{-4} cm/sec) and the intact wall rock and clay cover (10^{-5} to 10^{-6} cm/sec), the backfill may channel flow and the hydraulic gradient in the pit area could be relatively flat. Whether fully confined conditions can be developed in the pit backfill cannot be determined with available data, however, use of this assumption leads to the estimation of the potentiometric surface in the vicinity of the post closure drainage cut where the depth of fill will be critical with respect to the development of seeps or quick conditions.

The minimum post closure pit water level (potentiometric level in the center of the pit) is estimated to be above 400 feet. This level was calculated by averaging the water levels of the monitor wells and subtracting three standard deviations. This is considered a minimum level because levels are anticipated to rise when inflow to the pit ceases.

The maximum post closure pit water level is estimated to be higher than 425 ft msl. This level was calculated by adding two standard deviations to the mean water level at A3 and averaging this level with 395 ft msl, the level of potential seeps in the natural drainage located north and west of the pit.

These estimates apply to the center of the open pit after a steady state condition is achieved. In the area proposed for the surface water drainage cut, estimated groundwater levels for low and high water table conditions range from approximately 395 to 410 ft msl.

Based on limited data and the analyses presented above, it is likely that the pit will fill to a level above the sulfide waste backfill. With the placement of the post closure drainage cut at an elevation of 405 feet msl, the cut would be above the anticipated groundwater level (near 400 feet msl) for average conditions. The potential for the development of a seep in the surface drainage cut or central drainage areas can not be discounted with available data. Placement of additional fill material and plugging the lower portion of the drainage cut could be undertake as a contingency measure should seeps or quick conditions develop.

5.6 Groundwater Quality

Table 5.2 contains a summary of the high, low and average concentration of constituents in groundwater that are contained in significant concentration in the pit water. It should be noted that during the period of monitoring (3/91 to 3/95), the main pit water level was affected by dewatering and local drawdown of the groundwater surface elevation. Therefore, the local groundwater flow during the period of monitoring was toward the open pit and it is not anticipated that the quality of water in local groundwater monitoring wells was impacted by mining operations.

Extreme values were measured for iron, aluminum and copper in monitor well GW-1 in the initial sampling events in 1991. In Table 5.2, the high values, which were assumed to be a result of incomplete well development, were discounted.

The primary constituents of the local groundwater are iron, aluminum, copper, manganese and zinc. In general, the concentration of metals and their variation in concentration is reduced in upgradient well A-3. The maximum concentrations of aluminum (84 mg/l), iron (238 mg/l) and copper (1.37 mg/l) were detected in monitoring well GW-1. The maximum concentration of zinc (3.83 mg.l) was detected in monitor well GW-2. The maximum concentration of manganese was 3.0 mg/l in well A-3.

Visual inspection of exposed pit walls indicated sulfide mineralization locally extends above the premine groundwater level to the near surface. Higher metal concentrations in down gradient wells GW-1 and GW-2 are considered to be indicative of in situ oxidation of the sulfides contained in the rocks in and adjacent to the open pit that has occurred over geologic time.

6.0 ALTERNATIVES EVALUATION

6.1 Amendment of Waste Rock

6.1.1 Material Requirements and Costs

Table 6.1 summarizes the base material quantities, for each of the effective additives, that would be required to produce the bench test pH conditions in 160,000 cubic yards of waste rock backfill. Addition rates are based on data presented in Sections 4.2 and 4.3. Some adjustment of these addition rates is anticipated as discussed below. Estimated material and shipping costs for each additive are also shown in Table 6.1.

Material quantities are based on a waste rock sample obtained in June 1995. With ongoing oxidation of the backfill prior to its placement in the pit, the leachable quantity of acidity may increase. Immediately prior to commencement of backfilling, additional testing of available acidity could be required to refine base material quantity requirements. Minor adjustment of these addition rates may also be required to reach optimum pH conditions in the backfill during placement. In all waste rock treatment tests, residual acidity levels are low (undetected to 75 mg/l) in comparison to the available acidity in the waste rock (8600 mg/l in the bulk test pore water). Therefore, increasing pH to further reduce metal solubility will not require significant additional base.

6.1.2 Treatment Methods and Costs

6.1.2.1 Solids Application

The lime, kiln dust and TSP are solids that could be mixed with the backfill concurrently with backfilling operations. While the quantities of each material vary, the costs associated with the placement of solid additives are anticipated to be similar.

These materials could be end dumped on the backfill, spread over the surface and blended with the backfill, prior to loading into haul trucks or dozing into the pit directly from the stockpiles. Incremental backfill amendment costs, assuming dozer spreading and grading, are estimated to be approximately $0.50 to $0.75 per cubic yard (1995 Means Site Work for dozer spreading with minimal haul distance). Total incremental handling costs associated with solid base additive application to waste rock are estimated to be $5,000 to $7,500.

Worker safety measures would include the use of protective clothing. As such, significant costs associated with the use of solid additives are not anticipated.

6.1.2.2 Liquid Application to Backfill

Sodium hydroxide in liquid form could be applied to the surface of the backfill with a conventional water truck prior to excavation and hauling, or dozing into the open pit. Incremental costs for a water truck and operator are estimated to be $7,000 per month.

The potential for the generation of noxious fumes during application of NaOH, and the hazards associated with its use will increase base application and handling costs. Costs for operator(s) training and safety equipment must also be considered in the case of NaOH addition.

NaOH would be delivered in a 50 percent by weight solution and would therefore include an equivalent weight of water (3432 tons). Use of liquid NaOH in the backfill would result in an incremental cost associated with a further 822,800 gallon reduction in the volume of water contained in the open pit. Water treatment costs are discussed below.

6.2 Pit Water Treatment

6.2.1 Material Requirements and Costs

Table 6.2 presents an estimate of material requirements and costs for treating the current pit water chemistry and volume to the bench test pH conditions.

These material quantities are estimated for treatment of the entire pit volume. The quantities shown in Table 6.2 are considered to represent near worst case treatment requirement. The potential for further accumulation of acid products in the pit water prior to the initiation of closure could increase treatment requirements.

It should be noted that the dominant constituent in the pit water is sulfate and that treatment by TSP or NaOH will not reduce sulfate (and TDS) content. Measures to alleviate accumulation of sulfate are discussed in below.

6.2.2 Treatment Methods

6.2.2.1 Pit Water Treatment with Solid Additives

Application of solid additives would require the construction of a sump or mixing system to enable their introduction into the pit water. Water could be pumped from the pit to the mixing area to dissolve the additive or produce a slurry which could then be returned to the pit.

TSP in granular form would be amenable to direct application from a belly dump container placed over the mixing sump. The kiln dust and slaked lime are moist, somewhat cohesive materials which would require additional handling during mixing. A hydraulic monitor could potentially be used to slurry these materials.

Because mixing within the pit will occur to a limited degree, it may be necessary to discharge the treated pit water at several locations in the pit. Equipment requirements would include a stainless steel water reclaim pump and treated water return pump (slurry pump).

Estimated costs for construction of a small sump area within the pit are approximately $5,000 for earthworks. Barite Hill estimates the cost of a stainless steel, diesel pump that would be suitable for reclaiming the pit water at $25,000. A pump of this type will probably be required for pit water volume reduction as discussed below. The treated water return pump would not require stainless steel construction and its cost is estimated at $15,000. Energy costs for pumping would be on the order of $2,500 to $3,000 per month for two pumps. Approximately $10,000 for piping and fittings is estimated for the water reclaim and treated water return system.

As an alternative to the use of a mixing sump, excess solid base additives could be applied to backfill to neutralize the pit water concurrently with backfilling. This option would result in a minor increase in backfill mixing and handling costs and would eliminate costs for additional pumps, piping and earthworks.

6.2.2.2 Water Treatment with Liquid NaOH

Barite Hill has investigated liquid NaOH application to the pit water by a system consisting of a diesel pump and a spray distribution system. The liquid NaOH would be introduced directly from tankers to a pumped pit water stream and mixed with a venturi arrangement in a closed system. This system would require a single stainless steel pump ($25,000 estimated cost) to reclaim the pit

water and return the NaOH and water to the open pit. A spray evaporation system could be modified for use in returning the NaOH and water to the pit. Energy costs for this approach are estimated by Barite Hill to be approximately $1,500 per month. Minor additional costs would be incurred for construction of a venturi mixing system that could be operated in a manner that minimizes health and safety risks associated with the use of caustic.

6.3 Pit Water Volume Reduction

The current pit water volume is estimated to be approximately 29.3 million gallons. Based on the results of the on site bulk porosity test, the available water storage capacity of the backfill is approximately 19 percent or 6.1 million gallons. Reduction of the pit water volume to this latter quantity would leave the backfill saturated following placement and the surface of the backfill free of excess water in preparation for placement of the reclamation cover (compacted saprolitic material from the clay borrow area). A reduction of approximately 23.2 million gallons will be required (based on September 1995 pit water volume estimates).

Two options have been identified for pit water reduction:

- Construction of a land application system in the clay borrow area; and
- Construction of an enhanced evaporation system within the open pit.

6.3.1 Land Application System

Approximately 4.5 acres in the clay borrow area could be developed for land application of pit water. For this option, treatment of the pit water to a quality acceptable for land application is presupposed. Based on an application rate of 2 inches per week (DHEC, "Land Treatment of Domestic Wastewater") preliminary calculations indicate a potential water loss of 200,000 gallons per week per acre or approximately 1 million gallons per month for a 4.5 acre system. The rate of solution loss in the land application area could be enhanced by spray evaporation resulting in an additional one to four percent spray loss during winter and summer months, respectively. The potential loss rate for spray evaporation in conjunction with land application could range from 1.4 to 2.5 million gallons per month for a 1000 gpm spray system. Assuming an average monthly loss of 1.95 million gallons, volume reduction would require approximately 12 months and result in energy costs of $18,000.

This approach will result in significant incremental costs associated with permitting of the land application area. The estimated costs to design, permit and construct (earthwork costs) the land application area are between $20,000 and $30,000.

Equipment requirements for the above system are assumed to include a 1,000 gpm diesel pump for the spray evaporation system, a smaller (75 to 100 gpm) pump to transfer treated water to the land disposal area, and piping systems for treated water delivery and spraying. Costs are estimated to be $15,000 for a 1000 gpm diesel pump (non-stainless steel), $5,000 for a smaller pump located in the open pit, and $10,000 for piping, the intake and spray system.

During volume reduction, continued interaction of the pit water and wall rocks, and accumulation of acid products from pit wall and backfill runoff could require periodic retreatment of the pit water in order to maintain a quality acceptable for land application.

6.3.2 In-Pit Evaporation

The spray application of pit water to exposed pit walls could increase solution loss rates over those that could be achieved in a land application system. Exposed surface areas in the open pit cover in excess of 8.5 acres of which approximately 5 acres would be exposed to direct sunlight throughout the year. Assuming a 1000 gpm system and a medium spray, the solution losses from pit wall spraying could range from 4 to 10 percent in winter and summer months, respectively (1.7 to 4.3 million gallons per month).

The equipment requirements and costs anticipated for the in-pit evaporation system include $25,000 for a stainless steel diesel pump and $10,000 for the intake, pipe and spray system. For an average monthly loss rate of 3 million gallons, volume reduction would require approximately 8 months and energy costs of $12,000.

The ability to mix treatment additives in a pond of reduced volume will be enhanced following volume reduction. This option will increase pump costs as a stainless steel pump will be required to handle untreated water. The reduction in the duration of pumping and the elimination of design, permitting and earthwork construction costs are anticipated to offset the cost of a stainless steel pump. In addition, the spray evaporation system could be modified for use in distributing the treated water or base additive slurry to the pit during or following volume reduction.

6.4 Oxidation Control During Volume Reduction

Ferric iron is a powerful and fast acting oxidant and its presence in the pit water could result in ongoing oxidation and the release of acidity and metals during the volume reduction process. Ferric iron will precipitate as ferric hydroxide in pH conditions above approximately 3.5. To reduce the potential for ongoing oxidation during the pit water volume reduction, pretreatment of the pit water to a pH near 4.0 could be employed with final treatment completed following volume reduction.

The addition of oxygen scavenging compounds such as sodium bisulfite and sodium sulfite could be employed to reduce dissolved oxygen content in the pit water and affect a further reduction in the ongoing rate of oxidation.

6.5 Sulfate Reduction

Treatment with compounds that do not contain calcium (NaOH, TSP) will not affect sulfate concentrations in pit water or backfill pore water. Addition of calcium from sources such as slaked lime and kiln dust will reduce sulfate content by causing gypsum precipitation.

7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

7.1.1 Long Term Oxidation Control

The analysis of hydrogeologic conditions indicates that the 160,000 cubic yards of waste rock backfill can be placed beneath the post closure pit water level. In conjunction with pretreatment of the fill and pit water to neutralize existing acidity, and the placement of a low permeability cover over the backfill and exposed sulfide bearing rock in the pit walls, it is anticipated that ongoing oxidation in the main pit area can be reduced to deminimus rates. Long term impact to local groundwater resources is not expected under these conditions.

7.1.2 Effectiveness of Base Addition

Testing of the treatment of waste rock backfill and pit water with the identified base additives indicates that water quality conditions similar to the pre-mine groundwater quality can be achieved in the main pit. Some adjustment of the base addition rates to produce pH conditions necessary for optimum reduction in metals concentrations can be anticipated, however, no significant increase in base addition rates would be anticipated for further pH adjustment because, at the bench test addition rates, the majority of the available acidity was neutralized and metals concentrations were generally within the range exhibited in the groundwater in the pit area monitoring wells.

7.1.3 Identification of Preferred Base Additives

7.1.3.1 Pit Water Treatment

On the basis of ease of handling, the preferred base amendment for pit water is NaOH. NaOH is indicated to be effective in reducing metals concentrations. It can be introduced to the pit by a system that would also be used for pit water volume reduction. Therefore, the adoption of NaOH for pit water pretreatment would reduce incremental treatment costs.

7.1.3.2 Neutralization of Waste Rock Backfill

Based on both cost and ease of handling, the preferred alternative for neutralization of waste rock appears to be slaked lime. This material could be spread over the surface of the backfill and mixed

concurrently with excavation and placement in the pit with little incremental change in earthwork costs. Slaked lime testing indicates that it is effective in neutralizing acidity and reducing concentrations of dissolved metals. Minor increases in addition rates to compensate for increases in the available acidity contained in the backfill, or to achieve an optimum pH condition would not be anticipated to significantly increase material costs.

If NaOH treatment of pit water is undertaken, high concentrations of sulfate can be anticipated following pit water treatment. Addition of excess slaked lime to the backfill could be employed as a means of reducing the sulfate concentration in residual pit water following treatment and volume reduction. Because of ease of application and low cost, sulfate reduction by this method would not substantially increase overall closure costs. Only 305 tons of lime would be required to neutralize the current pit water volume. At this addition rate, sulfate would be substantially reduced.

7.1.4 Pit Water Volume Reduction

The use of a land application area external to the open pit will result in incremental closure costs associated with engineering design, permitting, earthworks and equipment. The rates of solution loss associated with an in-pit spray evaporation system area anticipated to be at least as great as those that can be achieved with a land application area. Therefore, there appears to be no benefit associated with development of an external land application area.

7.2 Main Pit Closure Sequence

The following sections describe the proposed pit closure sequence. Estimated costs associated with these activities are summarized in Table 7.1

7.2.1 Pit Water Pretreatment

Prior to commencement of volume reduction, pretreatment of the pit water to a pH near 4.0 with NaOH is recommended. Ferric iron is a powerful and fast acting oxidant whose presence will result in the potential for accelerated oxidation of sulfides. Maintenance of a pH level that controls the solubility of ferric iron will reduce the rate of ongoing oxidation and consequent releases of acidity and metals.

Oxidation could be further controlled by introducing oxygen scavenging compounds such as sodium sulfite to the pit water. It is anticipated that small amounts of oxygen scavengers would be needed.

The NaOH (and if necessary, sodium sulfite) could be introduced to the pit through the spray evaporation system with addition of a venturi system to draw the base additive into a pumped water stream. The spray evaporation system is discussed below.

7.2.2 Pit Water Volume Reduction

Operation of the in-pit volume reduction system is anticipated to require approximately 8 months to reduce the current pit water volume to that required to fill the void space in the backfill. The system is anticipated to consist of a stainless steel diesel powered pump, a suction intake supported by a float and anchor, a distribution pipe placed around the periphery of the main pit and a series of spray nozzles that are directed toward the pit walls.

The formation of precipitates in the pipe and nozzle system is anticipated during volume reduction, therefore, the system should be constructed in a manner such that periodic maintenance is possible.

The system can be modified for introduction of treatment solution by placing a venturi feed system in the distribution line. The NaOH could then be transferred directly from a storage container (tanker trailer) to the pit water return line, minimizing risks associated with handling.

7.2.2 Final Pit Water Treatment

Following pit water volume reduction, final treatment of the residual pit water to produce acceptable water quality could be undertaken. If the pH is maintained near 4.0 during volume reduction, the additional NaOH requirements will be limited as the majority of the acidity in the pit water will have been neutralized.

7.2.3 Control of Sulfate and Salt Precipitation

The pit water contains approximately 2,400 mg/l sulfate. During volume reduction, the salt content of the pit water can be anticipated to increase without the addition of calcium to cause gypsum precipitation. Excess salt in the pit water will adversely impact pipes and spray nozzles through the formation of precipitates, and could potentially impact rates of evaporation.

Periodic addition of slaked lime is proposed as a means introducing calcium to the system to maintain low sulfate concentrations and reduce salt buildup. A small reactor tank or mixing vessel with a pressure bleed line from the spray evaporation system could be used to mix slaked lime with

pit water. The lime could then be returned in batches to the pit. Lime addition would be periodically undertaken to maintain a sulfate concentration of less than 4000 mg/l.

Assuming that a tank suitable for use as a mixing vessel is available on site, the costs to place and operate this system would not significantly increase pit water management costs. The addition of slaked lime to the pit water would reduce the required volume of NaOH and the associated costs for its acquisition.

7.2.4 Waste Rock Backfill Amendment

The backfill will continue to generate acidity until treatment and disposal within the pit water is completed. The available acidity in the backfill may increase, therefore, prior to backfill, available acidity in the waste rock should be reevaluated by a small scale leach test. Analysis of the sulfate concentration in the treated pit water could be undertaken prior to backfill to determine if the addition of excess lime to the fill could be used to precipitate gypsum and reduce sulfate concentration in the residual pit water.

7.2.5 Pit Backfill

To minimize the potential for the development of seeps through the closure cover, and subsequent damage to the clay cover over the backfill, placement of the drainage cut at a minimum elevation of 405 feet is recommended. The proposed configuration of the pit following backfill and cover placement will consist of a central drainageway constructed at minimal grade through the longitudinal axis of the pit. Exposed sulfide bearing pit wall rock will be covered with clay borrow material placed at a 3H:1V slope against the pit walls. The approximate configuration of the pit following cover placement is shown on Figure 5.1.

As stated above, the potential exists for the development of seeps during high water level conditions. Should seeps develop, the placement of additional fill material would be necessary to maintain the integrity of the clay cover and eliminate surface discharges.

Table 2.1
Summary of Selected Constituents
in Recent Pit Water Samples

Analyte	3/15/95 Sample	6/30/95 Sample
pH	5.9	7.2 *
Cond (uS)	4300	4420
Ag	nd	nd
Al	0.589	14.6
Ba	nd	0.043
Ca	58.2	66.7
Cd	0.9347	1.151
Cr	nd	nd
Cu	51	24.9
Fe	0.727	57.5
K	11.3	10.4
Mg	15.2	18.8
Mn	4.58	5.67
Na	631	572
Ni	0.292	0.33
Zn	11.8	15.5
Hg	0.00173	nd
As	nd	nd
Pb	nd	0.035
Se	1.34	1.346
Alk (mg/l)	16.2	nd
Cl (mg/l)	359	208
Sulfate (mg/l)	1990	2390
TDS (mg/l)	2550	3070

Notes
All metals are total concentration in mg/l
* In error, estimated pH is near 3.5

Table 4.1
Pit Water Treatment Tests

Treatment	TSP	NaOH	CaOH	Kiln Dust
Analyses				
Al	u	0.08	u	u
As	0.002	u	u	u
Ba	u	0.01	0.009	0.041
Cd	0.216	0.213	u	0.65
Ca	54.6	77.2	279	262
Cu	0.42	3.55	1.32	2.53
Fe	0.17	0.48	0.09	5.09
Pb	u	u	u	u
Mn	3.88	5.22	0.04	5.41
Ni	0.26	0.07	0.11	0.28
Se	1.03	1.07	0.71	1.06
Ag	u	u	u	u
Zn	3.63	0.41	0.14	10.2
Acidity	75	u	u	40
Alkalinity				
Bicarb	15	30	u	15
Carb	u	20	40	u
Hydrox	u	u	101	u
Total Alkalinity	15	50	141	15
pH	6	8.6	11.1	6.5
Phosphorous	17.3	nt	nt	nt
TDS	2770	2980	2800	3260
Sulfate	2100	2000	1700	2500

u indicates undetected
nt indicates not tested

Table 4.2
Waste Rock Neutralization Tests

Treatment	TSP	NaOH	CaOH	Kiln Dust
Analyses				
Al	10.3	13.6	26.1	5.52
As	0.02	0.02	0.5	0.38
Ba	0.896	1.19	1.7	1.54
Cd	0.017	0.041	0.076	u
Ca	103	252	489	576
Cu	0.49	1.66	3.38	0.38
Fe	23.2	44.4	99.7	19.8
Pb	0.25	0.25	0.46	0.28
Mn	3.24	6.24	5.75	1.3
Ni	0.59	0.14	0.28	0.03
Se	0.36	0.49	0.18	0.27
Ag	0.012	0.031	0.016	0.022
Zn	8.51	16	22.6	1.75
Acidity	80	80	195	u
Alkalinity				
Bicarb	236	15	u	392
Carb	u	u	u	u
Hydrox	u	u	u	u
Total Alkalinity	236	15	u	392
Conductivity	48000	57000	5980	8240
pH	7.6	6.3	5.5	4.1
TDS	52300	67200	6560	8360
Sulfate	35300	45900	3900	3500

u indicates undetected

TABLE 5.1
OBSERVED FLUCTUATIONS IN LOCAL WATER LEVELS
FOR THE FOUR-YEAR MONITORING PERIOD ENDING IN MARCH, 1995

Well	Minimum (ft msl)	Maximum (ft msl)	Mean (ft msl)	Standard Deviation (ft)
A3	433.5	443.0	437.9	3.022
GW-1	381.2	389.1	384.9	1.775
GW-2	390.9	404.2	398.0	2.840

TABLE 5.2

SUMMARY OF MAIN PIT AREA MONITOR WELL DATA

	WELL GW-1				WELL GW-2				WELL A-3			
CONSTITUENT (MG/L)	MAX	MIN	AVG	ST. DEV	MAX	MIN	AVG	ST. DEV	MAX	MIN	AVG	ST. DEV
Al	84.00	2.24	25.86	26.02	29.90	2.05	11.61	9.21	71.00	0.24	11.56	21.84
As	0.01	0.00	0.00	0.00	0.04	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Ba	0.92	0.09	0.33	0.25	0.78	0.08	0.30	0.22	0.53	0.10	0.18	0.11
Cd	0.04	0.00	0.01	0.01	0.12	0.00	0.04	0.04	0.01	0.00	0.00	0.00
Ca	17.00	1.60	4.46	3.71	22.70	1.43	14.00	8.03	4.00	0.00	0.78	1.39
Cu	1.37	0.05	0.38	0.38	1.07	0.07	0.41	0.31	1.00	0.02	0.16	0.26
Fe	238.00	4.70	70.02	72.63	94.60	12.10	41.36	25.33	128.00	0.43	23.20	39.02
Pb	0.06	0.00	0.03	0.02	0.46	0.03	0.12	0.12	0.08	0.00	0.01	0.02
Mn	1.57	0.10	0.58	0.49	0.70	0.08	0.33	0.18	3.00	0.01	0.50	1.02
Ni	0.04	0.01	0.02	0.01	0.18	0.01	0.05	0.05	0.15	0.01	0.04	0.04
Se	0.01	0.00	0.00	0.00	0.03	0.00	0.01	0.01	0.02	0.00	0.00	0.00
Ag	0.02	0.01	0.01	0.00	0.07	0.01	0.01	0.02	0.01	0.01	0.01	0.00
Zn	1.72	0.04	0.25	0.41	3.83	0.11	1.47	1.16	0.38	0.01	0.09	0.12

TABLE 6.1

ESTIMATED BASE MATERIAL REQUIREMENTS FOR BACKFILL

Material	Quantity Required (tons)	Cost/Ton (delivered)	Total Cost
Slaked Lime	7,280	$25.00	$182,000
Kiln Dust	13,000	$19.60	$254,800
TSP	11,700	$800	$9,360,000
NaOH	3,432	$540	$1,853,300

TABLE 6.2
ESTIMATED MATERIAL REQUIREMENTS
FOR TREATMENT OF PIT WATER

Material	Quantity Required (tons)	Cost/Ton (delivered)	Total Cost
Slaked Lime	305	$25.00	$7,600
Kiln Dust	1800	$19.60	$35,600
TSP	122	$800	$97,700
NaOH	37	$540	$19,800

Table 7.1
Estimated Costs for Pit Water Volume Reduction,
Pit Water Treatment and Backfill Neutralization

Activity	Task		Estimated
Volume Reduction			
	Pump Acquisition		$25,000
	Piping		$10,000
	Energy		$12,000
		Subtotal	$47,000
Pit Water Treatment			
	Materials (NaOH and lime) (See Note 2)		$27,400
	Application (See Note 3)		$2,000
		Subtotal	$29,400
Backfill Neutralization			
	Materials (Slaked Lime)		$182,000
	Application (Grading)		$7,000
		Subtotal	$189,000
		Total	$265,400

Notes
1) Cost do not include earthworks for placement in pit.
2) Includes pre- and final treatment, sulfate reduction
3) Incremental cost for venturi on spray evaporation system

LEGEND:

APPROXIMATE POST CLOSURE SURFACE CONTOUR

WASTE ROCK BACKFILL ELEVATION (395' MSL)

ESTIMATED POST CLOSURE POTENTIOMETRIC SURFACE CONTOUR (INTERMEDIATE OR AVERAGE WATER LEVEL FOR CONFINED FLOW CONDITION)

N

100 50 0 100

SCALE IN FEET

PREPARED FOR:

NEVADA GOLDFIELDS, INC.
Barite Hill

PREPARED BY:

SRK
STEFFEN ROBERTSON & KIRSTEN (U.S.)
Consulting Engineers & Scientists

BY	DATE
RD	11/95

TITLE:

POST CLOSURE
PIT CONFIGURATION

SCALE: AS SHOWN

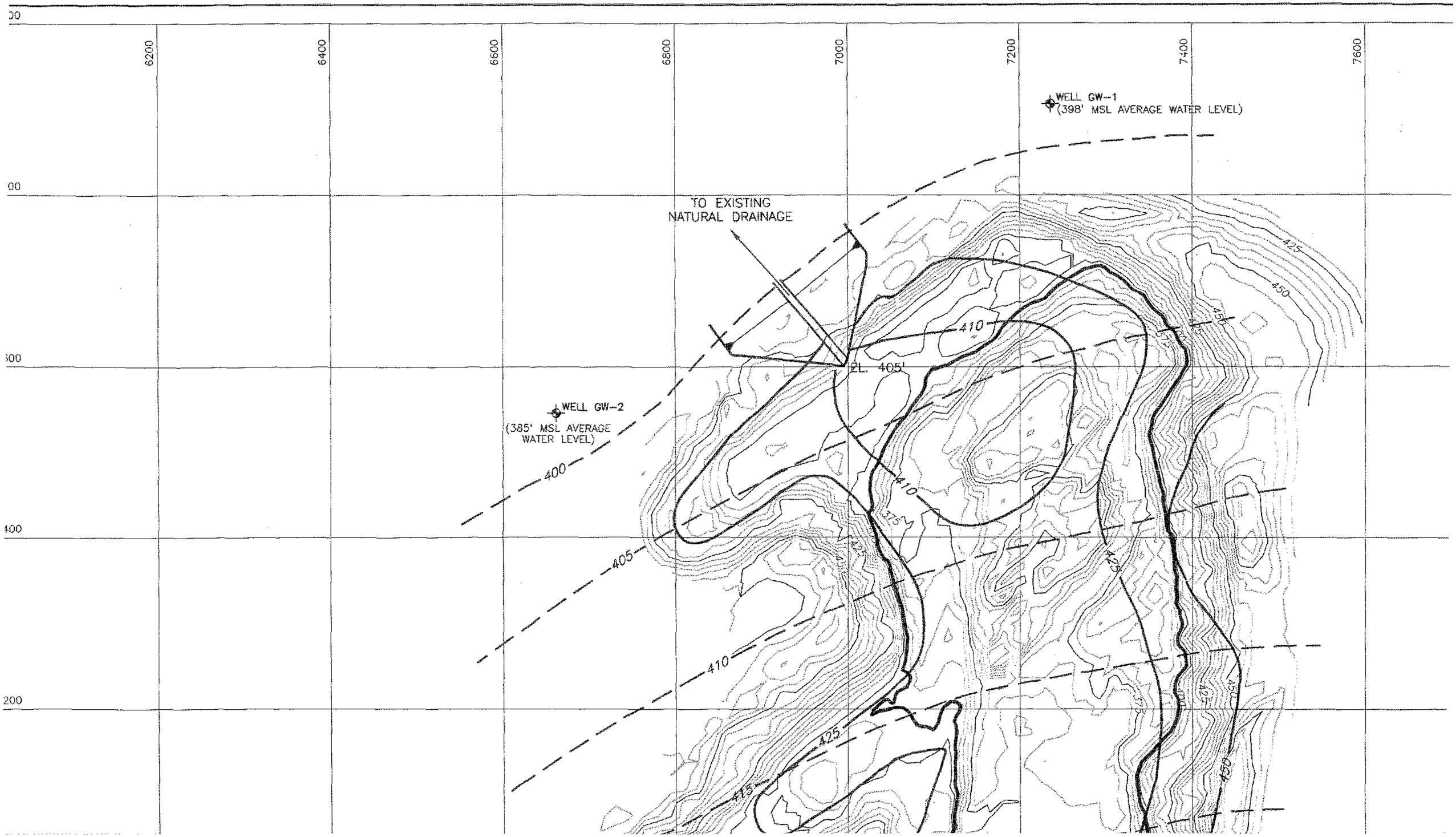
DRAWING No.:

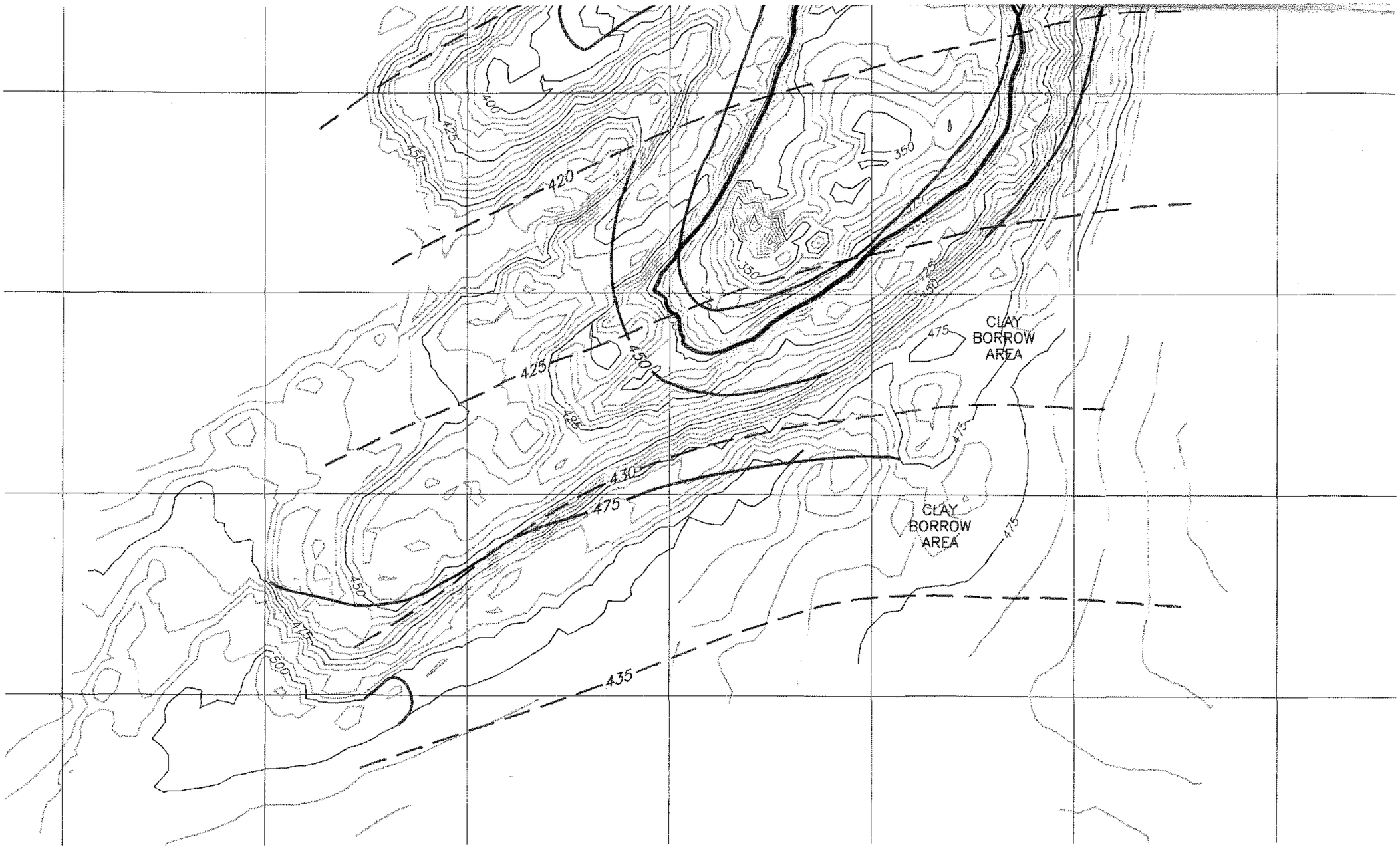
FIGURE 5.1

PROJECT No.: 14115.02

A
REVISION

REFERENCE					
			DESIGNED	GM	11/95
			DRAWN	PMW	11/95
			CHECKED	GM	11/95
			APPROVED	GM	11/95
			APPROVED		


6200
6400
6600
6800
7000
7200
7400
7600
00
00
500
400
200
WELL GW-1
(398' MSL AVERAGE WATER LEVEL)
TO EXISTING
NATURAL DRAINAGE
EL. 405'
WELL GW-2
(385' MSL AVERAGE
WATER LEVEL)
400
405
410
415
425
450


420
425
430
435
450
475
400
350
CLAY
BORROW
AREA
CLAY
BORROW
AREA

APPENDIX A
PIT WATER QUALITY DATA

Davis & Floyd, Inc.

Laboratory Analysis Report

Work Order # 95-03-165

Received: 03/15/95 03/30/95 09:36:56

Test Description	Units	01 MAIN PIT	02 MAIN PIT DUP
GROUNDWATER ELEVATION	Feet Above MSL	NA	NA
pH (FIELD ANALYSIS)	pH units	5.9	5.9
SPECIFIC CONDUCTANCE (FLD)	micromhos/cm	4300	4300
TEMPERATURE	Degrees C	16	16
SILVER (TOTAL)	mg/l	< 0.010	< 0.010
ALUMINUM (TOTAL)	mg/l	0.589	0.609
BARIUM (TOTAL)	mg/l	< 0.020	< 0.020
CALCIUM (TOTAL)	mg/l	58.2	58.7
CADMIUM (TOTAL)	mg/l	0.9347	0.9369
CHROMIUM (TOTAL)	mg/l	< 0.010	< 0.010
COPPER (TOTAL)	mg/l	51.0	51.4
COPPER (DISSOLVED)	mg/l	48.9	48.9
IRON (TOTAL)	mg/l	0.727	0.783
POTASSIUM (TOTAL)	mg/l	11.3	11.3
MAGNESIUM (TOTAL)	mg/l	15.2	15.3
MANGANESE (TOTAL)	mg/l	4.58	4.58
SODIUM (TOTAL)	mg/l	631.	639.
NICKEL (TOTAL)	mg/l	0.292	0.291
ZINC (TOTAL)	mg/l	11.8	11.9
MERCURY (TOTAL)	mg/l	0.00173	0.00173
ARSENIC (TOTAL)	mg/l	< 0.0050	< 0.0050
LEAD (TOTAL)	mg/l	< 0.020 X	< 0.020 X
SELENIUM (TOTAL)	mg/l	1.34	1.33
ORGANIC CARBON TOTAL	mg/l	64.1	66.7
ALKALINITY BICARBONATE	mg/l	16.2	11.7

A1

Davis & Floyd, Inc.

Laboratory Analysis Report

Received: 03/15/95 03/30/95 09:36:56

Work Order # 95-03-165

Continued From Above

Test Description	Units	01 MAIN PIT	02 MAIN PIT DUP
CHLORIDE	mg/l	359	357
SULFATE	mg/l	1990	1870
AMMONIA NITROGEN	mg/l	90.8	92.8
NITRITE NITROGEN	mg/l	0.336	0.314
NITRATE NITROGEN	mg/l	11.0	10.7
CYANIDE (TOTAL)	mg/l	38.0	39.8
DISSOLVED SOLIDS TOTAL	mg/l	2550	2580

A2

Received: 03/15/95 03/30/95 09:36:56

NEVADA GOLDFIELDS, INC.

NOTES:

X = INDICATES A MATRIX INTERFERENCE WHICH MAY REQUIRE A DILUTION OR WHICH PREVENTS THE REPORTING OF A RESULT. DETECTION LIMITS HAVE BEEN ADJUSTED WHERE APPLICABLE.

A3

Davis & Floyd, Inc.

Laboratory Analysis Report

Page 1

Work Order # 95-03-165

Received: 03/15/95

03/30/95 09:36:56

REPORT NEVADA GOLDFIELDS, INC.
TO P.O. BOX 1530
McCORMICK, SC 29835

PREPARED DAVIS & FLOYD, INC.
BY P.O. DRAWER 428
GREENWOOD, SC 29648

CERTIFIED BY

JOHN MCCORD

ATTEN JEAN WHISNANT

PHONE (803)-229-5211

WORK ID JOB NO. 7561.00
P.O. # N/A
TAKEN DAVIS & FLOYD, INC
TYPE SURFACE H2O
NUMBER OF SAMPLES 2

Comments:
WE ARE PLEASED TO PROVIDE THIS CERTIFIED REPORT OF ANALYSES. FEEL FREE TO TELEPHONE IF FURTHER EXPLANATION IS REQUIRED. UNLESS OTHER ARRANGEMENTS HAVE BEEN MADE, SAMPLES WILL BE DISPOSED OF OR RETURNED 14 DAYS FROM THE DATE OF THIS REPORT.

SAMPLE IDENTIFICATION	DATE COLLECTED
01 MAIN PIT	03/14/95 11:05:00
02 MAIN PIT DUP	03/14/95 11:05:00

A4

Davis & Floyd, Inc.

Laboratory Analysis Report

Page 2

Work Order # 95-06-212

Received: 06/30/95 07/14/95 10:55:28

Test Description	Units	01 MAIN PIT
GROUNDWATER ELEVATION	Feet Above MSL	NA
pH (FIELD ANALYSIS)	pH units	7.2
SPECIFIC CONDUCTANCE (FLD)	microsmhos/cm	4420
TEMPERATURE	Degrees C	25
SILVER (TOTAL)	mg/l	< 0.010
ALUMINUM (TOTAL)	mg/l	14.6
BARIUM (TOTAL)	mg/l	0.043
CALCIUM (TOTAL)	mg/l	66.7
CADMIUM (TOTAL)	mg/l	1.151
CHROMIUM (TOTAL)	mg/l	< 0.010
COPPER (TOTAL)	mg/l	24.9
COPPER (DISSOLVED)	mg/l	24.7
IRON (TOTAL)	mg/l	57.5
POTASSIUM (TOTAL)	mg/l	10.4
MAGNESIUM (TOTAL)	mg/l	18.8
MANGANESE (TOTAL)	mg/l	5.27
SODIUM (TOTAL)	mg/l	572
NICKEL (TOTAL)	mg/l	0.330
ZINC (TOTAL)	mg/l	15.5
MERCURY (TOTAL)	mg/l	< 0.00020
ARSENIC (TOTAL)	mg/l	< 0.0200X
LEAD (TOTAL)	mg/l	0.0350
SELENIUM (TOTAL)	mg/l	1.346
ORGANIC CARBON TOTAL	mg/l	38.8
ALKALINITY BICARBONATE	mg/l	< 1.0

A5

Davis & Floyd, Inc.

Laboratory Analysis Report

Page 1
Received: 06/30/95 07/14/95 10:55:28

Work Order # 95-06-312
Continued From Above

Test Description	Units	01 MAIN PIT
CHLORIDE	mg/l	209
SULFATE	mg/l	2390
AMMONIA NITROGEN	mg/l	94.5
NITRITE NITROGEN	mg/l	< 0.050
NITRATE NITROGEN	mg/l	1.15
CYANIDE (TOTAL)	mg/l	3.66
DISSOLVED SOLIDS TOTAL	mg/l	3070

A6

Davis & Floyd, Inc.

Laboratory Analysis Report

Page 4

Work Order # 95-06-312

Received: 06/30/95 07/14/95 10:55:28

NEVADA GOLDFIELDS, INC.

NOTES:

X - INDICATES A MATRIX INTERFERENCE WHICH MAY REQUIRE A DILUTION OR WHICH PREVENTS THE REPORTING OF A RESULT. DETECTION LIMITS HAVE BEEN ADJUSTED WHERE APPLICABLE.

A7

4506311, 4506312

DAVIS & FLOYD

Chain of Custody Form

Page __ of __

816 East Durst Street, Greenwood, S.C. 29649 · Phone (803)229-5211 Fax (803)229-7119

PROJ. NO.: 756100

PROJECT NAME: Nevada Goldfields

SAMPLERS NAME/AFFILIATION:(PRINTED): John McMahan

SAMPLE NO.	DATE	GRAB	TIME	COMP	TIME ON	TIME OFF	SAMPLE DESCRIPTION	NO. OF BOTTLES	1 1000ml P	2 1000 ml P	3 125ml G	4 250ml P	5 1 Gal P	6 1000ml P	7 125ml P	8	9	10	11	12	13	14	15	SAMPLE TYPE	POTENTIAL HAZARD
	6-30-95	X	1030				GW-1	7	1	1	1	1	1	1	1									GW	
		X	1146				GW-3	7	1	1	1	1	1	1	1									GW	
		X	1253				P	7	1	1	1	1	1	1	1									GW	
		X	1331				K	7	1	1	1	1	1	1	1									GW	
		X	1357				J	7	1	1	1	1	1	1	1									GW	
		X	1503				I	7	1	1	1	1	1	1	1									GW	
		X	1615				H	7	1	1	1	1	1	1	1									GW	
		X	145				H Dup	7	1	1	1	1	1	1	1									GW	
		X	1653				Main Pit	7	1	1	1	1	1	1	1									GW	

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)	RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
John L. McMahan II	6-30-95 0916				

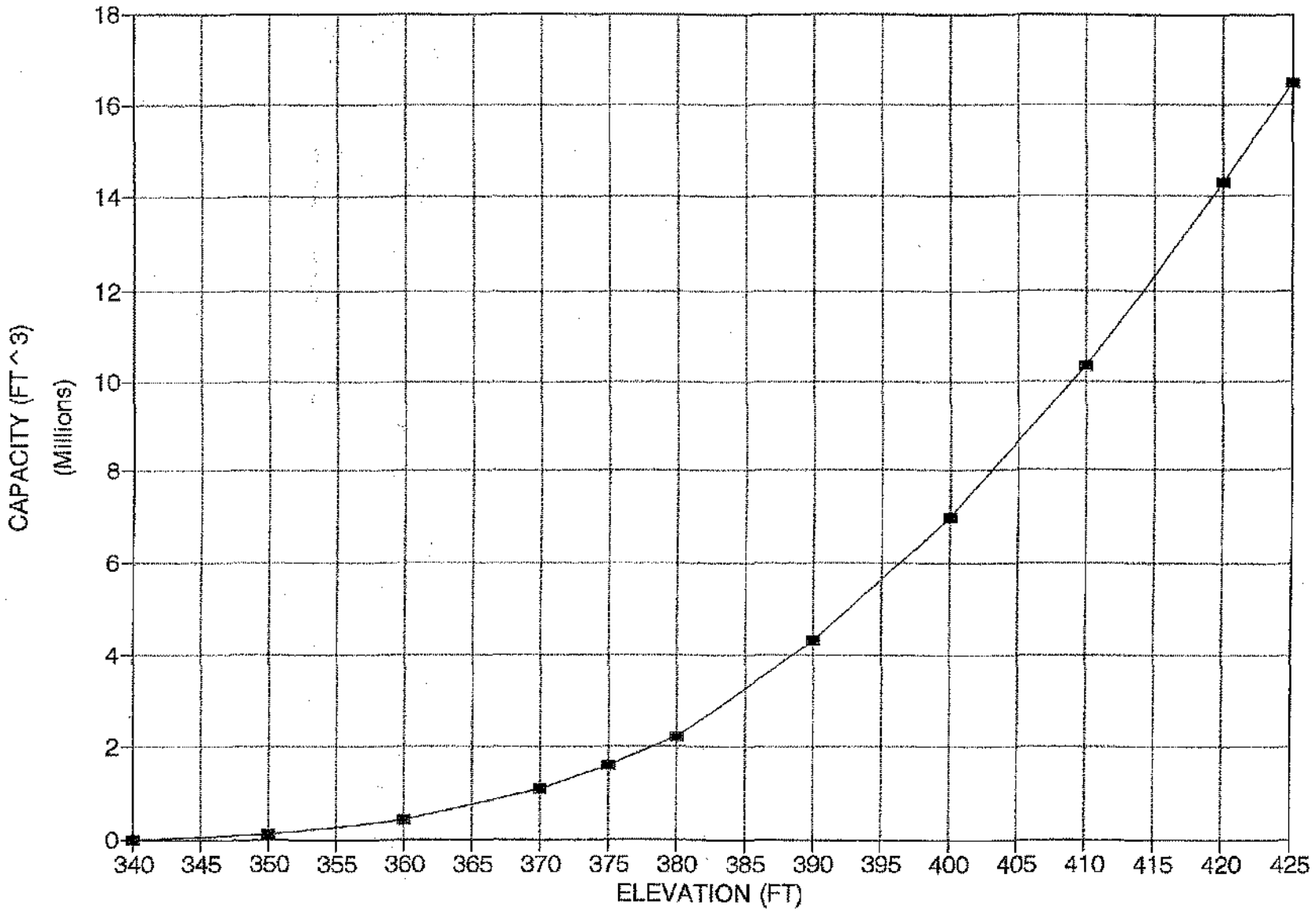
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED FOR LAB BY: (SIGNATURE)	DATE / TIME	CLIENT CONTACT:
		Dacryus Cagell	6-30-95 8:16	RESULTS SENT TO: / DATE:

DW-DRINKING WATER · GW-GROUND WATER · WW-WASTE WATER · RC-RCRA · HW-HAZARDOUS WATER · SW-SURFACE WATER · SD-SOLID · IM-IMPINGER SOLUTION · AB-ABSORBENT TUBE · F -FILTERS

07/20/95 12:20 ☎803443 2187 NEVADA GOLDFIELD 008

APPENDIX B
MAIN PIT HEIGHT VS CAPACITY RELATIONSHIP

BARITE HILL MAIN PIT
PIT HEIGHT-CAPACITY RELATIONSHIP



APPENDIX C
LABORATORY TEST DATA

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6823-04*
Client Sample ID: *14115-P-CaOH*
Client Project ID:
ACZ Report ID: *RG14541*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/15/95 00:00*
Date Received: *8/16/95*
Date Reported: *9/8/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP		U	mg/L	0.06	0.3	9/6/95	rd
Arsenic, total	M206.2 GFAA		U	mg/L	0.001	0.006	9/7/95	sh
Barium, total	M200.7 ICP	0.009	B	mg/L	0.006	0.02	9/6/95	rd
Cadmium, total	M200.7 ICP		U	mg/L	0.006	0.03	9/6/95	rd
Calcium, total	M200.7 ICP	279.0		mg/L	0.4	2	9/6/95	rd
Copper, total	M200.7 ICP	1.32		mg/L	0.02	0.1	9/6/95	rd
Iron, total	M200.7 ICP	0.09	B	mg/L	0.02	0.1	9/6/95	rd
Lead, total	M200.7 ICP		U	mg/L	0.04	0.2	9/6/95	rd
Manganese, total	M200.7 ICP	0.04	B	mg/L	0.01	0.05	9/6/95	rd
Nickel, total	M200.7 ICP	0.11		mg/L	0.02	0.1	9/6/95	rd
Selenium, total	SM 3500-Se C, AA-Hydride	0.71		mg/L	0.04	0.2	8/22/95	rs
Silver, total	M200.7 ICP		U	mg/L	0.01	0.05	9/6/95	rd
Zinc, total	M200.7 ICP	0.14		mg/L	0.02	0.1	9/6/95	rd

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						8/29/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						8/29/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1		U	mg/L	2	10	8/17/95	kh
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3			U	mg/L	2	10	8/24/95	kh
Carbonate as CaCO3		40		mg/L	2	10	8/24/95	kh
Hydroxide as CaCO3		101		mg/L	2	10	8/24/95	kh
Total Alkalinity		141		mg/L	2	10	8/24/95	kh
Lab Filtration	***						8/17/95	kh
pH (lab)	M150.1 - Electrometric	11.1		units	0.1	0.1	8/17/95	kh
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	2800		mg/L	10	20	8/18/95	ko
Sulfate	M375.3 - Gravimetric	1700		mg/L	100	200	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Hakumehl for RVP

Vice President of Operations: Ralph Poulsen

C1

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6823-01*
Client Sample ID: *14115-P-TSP*
Client Project ID:
ACZ Report ID: *RG14538*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/15/95 00:00*
Date Received: *8/16/95*
Date Reported: *9/8/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP		U	mg/L	0.06	0.3	9/6/95	rd
Arsenic, total	M206.2 GFAA	0.002	B	mg/L	0.001	0.006	9/7/95	sh
Barium, total	M200.7 ICP		U	mg/L	0.006	0.02	9/6/95	rd
Cadmium, total	M200.7 ICP	0.216		mg/L	0.006	0.03	9/6/95	rd
Calcium, total	M200.7 ICP	54.6		mg/L	0.4	2	9/6/95	rd
Copper, total	M200.7 ICP	0.42		mg/L	0.02	0.1	9/6/95	rd
Iron, total	M200.7 ICP	0.17		mg/L	0.02	0.1	9/6/95	rd
Lead, total	M200.7 ICP		U	mg/L	0.04	0.2	9/6/95	rd
Manganese, total	M200.7 ICP	3.88		mg/L	0.01	0.05	9/6/95	rd
Nickel, total	M200.7 ICP	0.26		mg/L	0.02	0.1	9/6/95	rd
Selenium, total	SM 3500-Se C, AA-Hydride	1.03		mg/L	0.04	0.2	8/22/95	rs
Silver, total	M200.7 ICP		U	mg/L	0.01	0.05	9/6/95	rd
Zinc, total	M200.7 ICP	3.63		mg/L	0.02	0.1	9/6/95	rd

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	*M3015 ICP*						*8/29/95*	*jw*
Total Metals Digestion	M3015 Metals Digestion(GFAA)						8/29/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	75		mg/L	2	10	8/17/95	kh
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		15		mg/L	2	10	8/24/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/24/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/24/95	kh
Total Alkalinity		15		mg/L	2	10	8/24/95	kh
Lab Filtration	***						8/17/95	kh
pH (lab)	M150.1 - Electrometric	6.0		units	0.1	0.1	8/17/95	kh
Phosphorus, total	M365.1-Automated Ascorbic Acid (dige	17.30		mg/L	0.05	0.3	8/19/95	ss
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	2770		mg/L	10	20	8/18/95	ko
Sulfate	M375.3 - Gravimetric	2100		mg/L	100	200	8/21/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL.
B = Analyte concentration detected at a value between MDL and PQL.
PQL = Practical Quantitation Limit

S. Halcumb for RVP
Vice President of Operations: Ralph Poulsen

C2

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6823-03*
Client Sample ID: *14115-P-NaOH*
Client Project ID:
ACZ Report ID: *RG14540*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/15/95 00:00*
Date Received: *8/16/95*
Date Reported: *9/8/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP	0.08	B	mg/L	0.06	0.3	9/6/95	rd
Arsenic, total	M206.2 GFAA		U	mg/L	0.001	0.006	9/7/95	sh
Barium, total	M200.7 ICP	0.010	B	mg/L	0.006	0.02	9/6/95	rd
Cadmium, total	M200.7 ICP	0.213		mg/L	0.006	0.03	9/6/95	rd
Calcium, total	M200.7 ICP	77.2		mg/L	0.4	2	9/6/95	rd
Copper, total	M200.7 ICP	3.55		mg/L	0.02	0.1	9/6/95	rd
Iron, total	M200.7 ICP	0.48		mg/L	0.02	0.1	9/6/95	rd
Lead, total	M200.7 ICP		U	mg/L	0.04	0.2	9/6/95	rd
Manganese, total	M200.7 ICP	5.22		mg/L	0.01	0.05	9/6/95	rd
Nickel, total	M200.7 ICP	0.07	B	mg/L	0.02	0.1	9/6/95	rd
Selenium, total	SM 3500-Se C, AA-Hydride	1.07		mg/L	0.04	0.2	8/22/95	rs
Silver, total	M200.7 ICP		U	mg/L	0.01	0.05	9/6/95	rd
Zinc, total	M200.7 ICP	0.41		mg/L	0.02	0.1	9/6/95	rd

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						8/29/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						8/29/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1		U	mg/L	2	10	8/17/95	kh
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		30		mg/L	2	10	8/24/95	kh
Carbonate as CaCO3		20		mg/L	2	10	8/24/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/24/95	kh
Total Alkalinity		50		mg/L	2	10	8/24/95	kh
Lab Filtration	***						8/17/95	kh
pH (lab)	M150.1 - Electrometric	8.6		units	0.1	0.1	8/17/95	kh
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	2980		mg/L	10	20	8/18/95	ko
Sulfate	M375.3 - Gravimetric	2000		mg/L	100	200	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Halamek for RVP

Vice President of Operations: Ralph Poulsen

C3

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6877-04*
Client Sample ID: *14115-WR-KD*
Client Project ID: *COC 01592*
ACZ Report ID: *RG14890*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/18/95 00:00*
Date Received: *8/21/95*
Date Reported: *9/13/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP	5.52		mg/L	0.05	0.3	9/13/95	fp
Arsenic, total	M206.2 GFAA	0.38		mg/L	0.02	0.1	9/11/95	sh
Barium, total	M200.7 ICP	1.540		mg/L	0.005	0.02	9/13/95	fp
Cadmium, total	M200.7 ICP		U	mg/L	0.005	0.03	9/13/95	fp
Calcium, total	M200.7 ICP	576.0		mg/L	0.4	2	9/13/95	fp
Copper, total	M200.7 ICP	0.38		mg/L	0.02	0.09	9/13/95	fp
Iron, total	M200.7 ICP	19.80		mg/L	0.02	0.09	9/13/95	fp
Lead, total	M200.7 ICP	0.28		mg/L	0.04	0.2	9/13/95	fp
Manganese, total	M200.7 ICP	1.300		mg/L	0.009	0.05	9/13/95	fp
Nickel, total	M200.7 ICP	0.03	B	mg/L	0.02	0.09	9/13/95	fp
Selenium, total	SM 3500-Se C, AA-Hydride	0.27		mg/L	0.02	0.1	8/23/95	rs
Silver, total	M200.7 ICP	0.022	B	mg/L	0.009	0.05	9/13/95	fp
Zinc, total	M200.7 ICP	1.75		mg/L	0.02	0.09	9/13/95	fp

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						9/7/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						9/7/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1		U	mg/L	2	10	9/1/95	ko
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		392		mg/L	2	10	8/25/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/25/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/25/95	kh
Total Alkalinity		392		mg/L	2	10	8/25/95	kh
Conductivity @25C	M120.1 - Meter	8240		umhos/cm	1	10	9/13/95	jk
Lab Filtration	***						8/23/95	kh
pH (lab)	M150.1 - Electrometric	4.1		units	0.1	0.1	8/22/95	ko
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	8360		mg/L	10	20	8/22/95	kh
Sulfate	M375.3 - Gravimetric	3500		mg/L	100	200	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Habermehl for RVP

Vice President of Operations: Ralph Poulsen

C4

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6877-03*
Client Sample ID: *14115-WR-SL*
Client Project ID: *COC 01592*
ACZ Report ID: *RG14889*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/18/95 00:00*
Date Received: *8/21/95*
Date Reported: *9/13/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP	26.10		mg/L	0.05	0.3	9/13/95	fp
Arsenic, total	M206.2 GFAA	0.50		mg/L	0.02	0.1	9/11/95	sh
Barium, total	M200.7 ICP	1.700		mg/L	0.005	0.02	9/13/95	fp
Cadmium, total	M200.7 ICP	0.076		mg/L	0.005	0.03	9/13/95	fp
Calcium, total	M200.7 ICP	489.0		mg/L	0.4	2	9/13/95	fp
Copper, total	M200.7 ICP	3.38		mg/L	0.02	0.09	9/13/95	fp
Iron, total	M200.7 ICP	99.70		mg/L	0.02	0.09	9/13/95	fp
Lead, total	M200.7 ICP	0.46		mg/L	0.04	0.2	9/13/95	fp
Manganese, total	M200.7 ICP	5.750		mg/L	0.009	0.05	9/13/95	fp
Nickel, total	M200.7 ICP	0.28		mg/L	0.02	0.09	9/13/95	fp
Selenium, total	SM 3500-Se C, AA-Hydride	0.18		mg/L	0.02	0.1	8/23/95	rs
Silver, total	M200.7 ICP	0.016	B	mg/L	0.009	0.05	9/13/95	fp
Zinc, total	M200.7 ICP	22.60		mg/L	0.02	0.09	9/13/95	fp

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						9/7/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						9/7/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	195		mg/L	2	10	9/1/95	ko
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3			U	mg/L	2	10	8/25/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/25/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/25/95	kh
Total Alkalinity			U	mg/L	2	10	8/25/95	kh
Conductivity @25C	M120.1 - Meter	5980		umhos/cm	1	10	9/13/95	jk
Lab Filtration	***						8/23/95	kh
pH (lab)	M150.1 - Electrometric	5.5		units	0.1	0.1	8/22/95	ko
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	6560		mg/L	10	20	8/22/95	kh
Sulfate	M375.3 - Gravimetric	3900		mg/L	200	400	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Hakenschl for RVP

Vice President of Operations: Ralph Poulsen

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ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6877-02*
Client Sample ID: *14115-WR-NAOH*
Client Project ID: *COC 01592*
ACZ Report ID: *RG14888*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/18/95 00:00*
Date Received: *8/21/95*
Date Reported: *9/13/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP	13.60		mg/L	0.03	0.2	9/13/95	fp
Arsenic, total	M206.2 GFAA	0.02	B	mg/L	0.01	0.06	9/11/95	sh
Barium, total	M200.7 ICP	1.190		mg/L	0.003	0.01	9/13/95	fp
Cadmium, total	M200.7 ICP	0.041		mg/L	0.003	0.02	9/13/95	fp
Calcium, total	M200.7 ICP	252.0		mg/L	0.2	1	9/13/95	fp
Copper, total	M200.7 ICP	1.66		mg/L	0.01	0.05	9/13/95	fp
Iron, total	M200.7 ICP	44.40		mg/L	0.01	0.05	9/13/95	fp
Lead, total	M200.7 ICP	0.25		mg/L	0.02	0.1	9/13/95	fp
Manganese, total	M200.7 ICP	6.240		mg/L	0.005	0.03	9/13/95	fp
Nickel, total	M200.7 ICP	0.14		mg/L	0.01	0.05	9/13/95	fp
Selenium, total	SM 3500-Se C, AA-Hydride	0.49		mg/L	0.02	0.1	8/23/95	rs
Silver, total	M200.7 ICP	0.031		mg/L	0.005	0.03	9/13/95	fp
Zinc, total	M200.7 ICP	16.00		mg/L	0.01	0.05	9/13/95	fp

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						9/7/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						9/7/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	80		mg/L	2	10	9/1/95	ko
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		15		mg/L	2	10	8/25/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/25/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/25/95	kh
Total Alkalinity		15		mg/L	2	10	8/25/95	kh
Conductivity @25C	M120.1 - Meter	57000		umhos/cm	1	10	9/13/95	jk
Lab Filtration	***						8/23/95	kh
pH (lab)	M150.1 - Electrometric	6.3		units	0.1	0.1	8/22/95	ko
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	67200		mg/L	10	20	8/22/95	kh
Sulfate	M375.3 - Gravimetric	45900		mg/L	200	400	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Hakenmehl for RVP

Vice President of Operations: Ralph Poulsen

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ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6877-01*
Client Sample ID: *14115-WR-TSP*
Client Project ID: *COC 01592*
ACZ Report ID: *RG14887*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/18/95 00:00*
Date Received: *8/21/95*
Date Reported: *9/13/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP	10.30		mg/L	0.03	0.2	9/13/95	fp
Arsenic, total	M206.2 GFAA	0.02	B	mg/L	0.01	0.06	9/11/95	sh
Barium, total	M200.7 ICP	0.896		mg/L	0.003	0.01	9/13/95	fp
Cadmium, total	M200.7 ICP	0.017		mg/L	0.003	0.02	9/13/95	fp
Calcium, total	M200.7 ICP	103.0		mg/L	0.2	1	9/13/95	fp
Copper, total	M200.7 ICP	0.49		mg/L	0.01	0.05	9/13/95	fp
Iron, total	M200.7 ICP	23.20		mg/L	0.01	0.05	9/13/95	fp
Lead, total	M200.7 ICP	0.25		mg/L	0.02	0.1	9/13/95	fp
Manganese, total	M200.7 ICP	3.240		mg/L	0.005	0.03	9/13/95	fp
Nickel, total	M200.7 ICP	0.59		mg/L	0.01	0.05	9/13/95	fp
Selenium, total	SM 3500-Se C, AA-Hydride	0.36		mg/L	0.02	0.1	8/23/95	rs
Silver, total	M200.7 ICP	0.012	B	mg/L	0.005	0.03	9/13/95	fp
Zinc, total	M200.7 ICP	8.51		mg/L	0.01	0.05	9/13/95	fp

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						9/7/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						9/7/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	80		mg/L	2	10	9/1/95	ko
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		236		mg/L	2	10	8/25/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/25/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/25/95	kh
Total Alkalinity		236		mg/L	2	10	8/25/95	kh
Conductivity @25C	M120.1 - Meter	48000		umhos/cm	1	10	9/13/95	jk
Lab Filtration	***						8/23/95	kh
pH (lab)	M150.1 - Electrometric	7.6		units	0.1	0.1	8/22/95	ko
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	52300		mg/L	10	20	8/22/95	kh
Sulfate	M375.3 - Gravimetric	35300		mg/L	200	400	8/23/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

D. Habermehl for RVP

Vice President of Operations: Ralph Poulsen

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ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6823-02*
Client Sample ID: *14115-P-KD*
Client Project ID:
ACZ Report ID: *RG14539*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *8/15/95 00:00*
Date Received: *8/16/95*
Date Reported: *9/8/95*

Sample Matrix: *Waste Water*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum, total	M200.7 ICP		U	mg/L	0.06	0.3	9/6/95	rd
Arsenic, total	M206.2 GFAA		U	mg/L	0.001	0.006	9/7/95	sh
Barium, total	M200.7 ICP	0.041		mg/L	0.006	0.02	9/6/95	rd
Cadmium, total	M200.7 ICP	0.650		mg/L	0.006	0.03	9/6/95	rd
Calcium, total	M200.7 ICP	262.0		mg/L	0.4	2	9/6/95	rd
Copper, total	M200.7 ICP	2.53		mg/L	0.02	0.1	9/6/95	rd
Iron, total	M200.7 ICP	5.09		mg/L	0.02	0.1	9/6/95	rd
Lead, total	M200.7 ICP		U	mg/L	0.04	0.2	9/6/95	rd
Manganese, total	M200.7 ICP	5.41		mg/L	0.01	0.05	9/6/95	rd
Nickel, total	M200.7 ICP	0.28		mg/L	0.02	0.1	9/6/95	rd
Selenium, total	SM 3500-Se C, AA-Hydride	1.06		mg/L	0.08	0.4	8/22/95	rs
Silver, total	M200.7 ICP		U	mg/L	0.01	0.05	9/6/95	rd
Zinc, total	M200.7 ICP	10.20		mg/L	0.02	0.1	9/6/95	rd

Metals Prep

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Total Digestion	M3015 ICP						8/29/95	jw
Total Metals Digestion	M3015 Metals Digestion(GFAA)						8/29/95	jw

Wet Chemistry

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	40		mg/L	2	10	8/17/95	kh
Alkalinity as CaCO3	M310.1							
Bicarbonate as CaCO3		15		mg/L	2	10	8/24/95	kh
Carbonate as CaCO3			U	mg/L	2	10	8/24/95	kh
Hydroxide as CaCO3			U	mg/L	2	10	8/24/95	kh
Total Alkalinity		15		mg/L	2	10	8/24/95	kh
Lab Filtration	***						8/17/95	kh
pH (lab)	M150.1 - Electrometric	6.5		units	0.1	0.1	8/17/95	kh
Residue, Filterable (TDS) @180C	M160.1 - Gravimetric	3260		mg/L	10	20	8/18/95	ko
Sulfate	M375.3 - Gravimetric	2500		mg/L	100	200	8/21/95	jk

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

S. Haberneckl for RVP

Vice President of Operations: Ralph Poulsen

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ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6423-01*
Client Sample ID: *14115-GRR1*
Client Project ID: *14115*
ACZ Report ID: *RG12249*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *7/11/95 00:00*
Date Received: *7/12/95*
Date Reported: *7/31/95*

Sample Matrix: *Soil*

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Neutralization Potential as CaCO3	M600 2-78-054 3.	50.0		%	0.1	0.5	7/26/95	mc
Solids, Percent	CLPSOW390, PART F, D-98	79.2		%	0.1	0.5	7/26/95	mc

↳ 500 T/KT $CaCO_3$ Equiv

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

Ralph V. Poulsen

Vice President of Operations: Ralph Poulsen

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ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6423-02*
Client Sample ID: *14115SNX1*
Client Project ID: *14115*
ACZ Report ID: *RG12250*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *7/11/95 00:00*
Date Received: *7/12/95*
Date Reported: *7/31/95*

Sample Matrix: *Soil*

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Neutralization Potential as CaCO3	M600 2-78-054 3.	55.0		%	0.1	0.5	7/26/95	mc
Solids, Percent	CLPSOW390, PART F, D-98	49.2		%	0.1	0.5	7/26/95	mc

550 T/KT $CaCO_3$ E9

Inorganic Qualifiers (based on EPA CLP 3/90)
U = Analyte was analyzed for but not detected
B = Analyte concentration detected at a value between MDL and PQL
PQL = Practical Quantitation Limit

Ralph V. Poulsen
Vice President of Operations: Ralph Poulsen

C10

ACZ

Analytical Results

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487
(800) 334-5493

Lab Sample ID: *L6574-01*
Client Sample ID: *BH Pit-1*
Client Project ID: *Barite Hill, #14115*
ACZ Report ID: *RG12835*

Steffen Robertson And Kirsten
3232 S. Vance St. Suite 210
Lakewood, CO 80227
Gene Muller

Date Sampled: *7/25/95 00:00*
Date Received: *7/26/95*
Date Reported: *8/10/95*

Sample Matrix: *Surface Water*

Wet Chemistry

Parameter	EPA Method	Result	Quant. Units	MDL	PQL	Date	Analyst
Acidity as CaCO3	M305.1	447	mg/L	2	10	8/9/95	kh

From bulk pit water sample
Received July 1995

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL

B = Analyte concentration detected at a value between MDL and PQL

PQL = Practical Quantitation Limit

Ralph V. Poulsen

Vice President of Operations: Ralph Poulsen

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APPENDIX D
HYDROGEOLOGIC COMPUTATIONS

STEFFEN ROBERTSON & KIRSTEN Consulting Engineers & Scientists	PROJECT: Barite Hill	NO. 14115
	CALCULATED BY: KAP	DATE: 9/6/95
	CHECKED BY:	DATE:
	SHEET 1 OF 6	

Purpose: To estimate hydraulic properties of backfill material and rock mass. The values of hydraulic conductivity determined from this analysis will be used to estimate the hydraulic gradient that is likely to exist within the backfill material after mine closure.

Results: Hydraulic conductivity of the backfill material is likely to be similar to that of the surrounding rock mass and the hydraulic gradient within the backfill will probably be similar to the gradient within the rock. ~~Any~~ Estimates of water levels should not ~~assume~~ assume ~~any assumption~~ that the backfilled pit will act as a drain or barrier.

STEFFEN ROBERTSON & KIRSTEN Consulting Engineers & Scientists	PROJECT: Barite Hill	NO. 14115
	CALCULATED BY: KAP	DATE: 9/6/95
	CHECKED BY:	DATE:
	SHEET 1 OF 6	

Methodology:

I. Hydraulic Conductivity Values from Reports:

K_{upper} = 0.05 ft/day (WESTEC, 1992)

K_{middle} = 0.18 ft/day

K_{lower} = 0.019 to 0.09 ft/day

Based on reported values, the average K for the rock mass as a whole could range from 0.019 to 0.18. Waste rock texture is highly variable ranging from silt ~~the~~ to boulders. Due to poor sorting & fine-grained matrix, it would be prudent to estimate K on the low side of the range of hydraulic conductivities. K for waste rock could range from 0.02 to 2.0 ft/day. It may be similar to the weathered ~~upper~~ zone of the rock mass (ie - 0.05 ft/day).

STEFFEN ROBERTSON & KIRSTEN Consulting Engineers & Scientists	PROJECT: Barite Hill	NO. 14115
	CALCULATED BY: KAP	DATE: 9/6/95
	CHECKED BY:	DATE:
	SHEET 3 OF 6	

II. Estimate of Rock Mass Hydraulic Conductivity from Mine Inflow Rate

Conceptual Model:

Aquifer is infinite in areal extent and unconfined. A reported deep fracture at 180' msl suggests that ~~the~~ secondary permeability must be significant at that level. Water level data indicate that 420' msl would be ~~the~~ a reasonable estimate of initial water level. This would make the saturated thickness 240 ft.

The mine pit in the model is cylindrical. ~~which~~ Its radius and depth increase as mining progresses. The mine is dewatered with a single, fully-penetrating well located at the center of the pit. The pit expands at the same rate as the cone of depression in the water table. At the end of 2 years, the mine has a radius of 300 ft and a depth of 80 ft. A maximum inflow of 20 gpm occurs at this time. The drawdown at the pit boundary is 80 ft.

Drawdown at a radius of 300 ft can be estimated through the use of the Theis equation and a drawdown correction to adjust for the effects of dewatering on Transmissivity.

Summary of Assumptions:

$r = 300$ ft

$s' = 80$ ft (for unconfined aquifer)

$b = 240$ ft

$t = 730.5$ days

$S = 4 \times 10^{-3}$

$Q = 3850$ ft^3/day

$$s = \frac{s'(2b - s')}{2b}$$ (drawdown correction)

$= 66.67$ ft (for equivalent confined aquifer)

Theis Equation:

$$s = \frac{Q}{4\pi T}\int_u^\infty \frac{e^{-u}}{u}\,du = \frac{Q}{4\pi T} W(u)$$

where: $u = \dfrac{r^2 S}{4Tt}$

$W(u)$ is interpolated from Tables.

STEFFEN ROBERTSON & KIRSTEN Consulting Engineers & Scientists	PROJECT: Barite Hill	NO. 14115
	CALCULATED BY: KAP	DATE: 9/6/95
	CHECKED BY:	DATE:
	SHEET 5 OF 6	

Initial guess at $K = 0.2$; $T = 48$

$u \approx 0.003$; $W(u) = 5.23$

$S_{calc} \approx 33.4$ ft

$S_{obs} = 66.7$ ft

Second guess at $K = 0.09$; $T = 22$

$u \approx 0.006$; $W(u) = 4.54$

$S_{calc} \approx 64.4$ ft

$S_{obs} = 66.7$ ft close enough

Best estimate of K is about 0.09 ft/day, which is within the range of K from pump tests. Estimate of K for backfill is about 0.05 ft/day.

STEFFEN ROBERTSON & KIRSTEN Consulting Engineers & Scientists	PROJECT: Barite Hill	NO. 14115
	CALCULATED BY: KAP	DATE: 9/6/95
	CHECKED BY:	DATE:
	SHEET 6 OF 6	
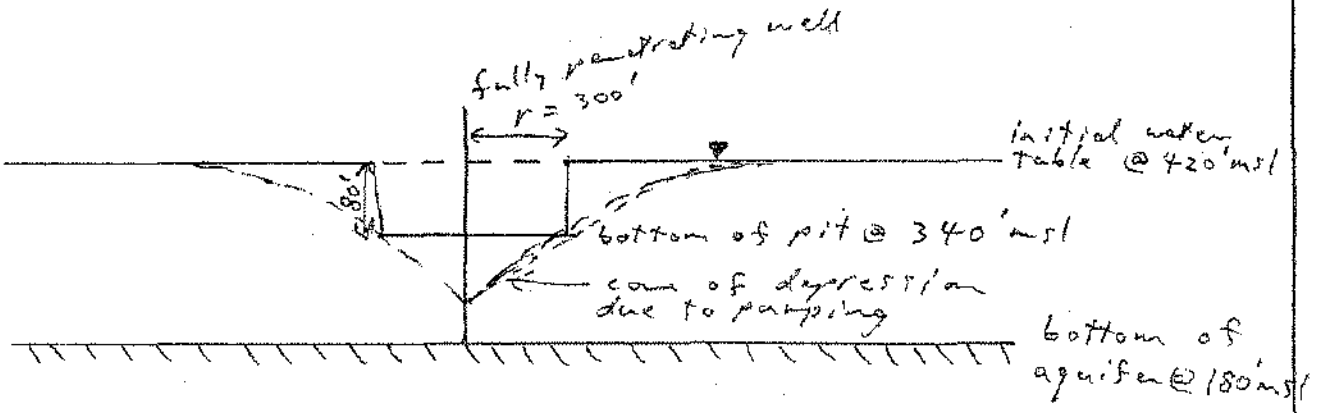
Diagram of Conceptual Model: