11.6 PROBABLE HYDROLOGIC CONSEQUENCES

This section provides a detailed assessment of the probable hydrologic consequences (PHC) of mining and reclamation activities at the Navajo Mine. The primary focus of the PHC is to predict the effects of proposed mining and reclamation activities on the prevailing hydrologic balance with respect to the quality and quantity of water in surface water and groundwater systems both during mining and after reclamation.

Disruption of the surface and geologic conditions and associated surface water and groundwater flow systems is necessary in order to extract the coal resource by surface mining. Surface coal mining and reclamation operations may affect the hydrologic balance in several ways, including:

- changing groundwater levels, recharge rates, and flow directions by removal of overburden and interburden materials and mining of the coal and by backfilling mine pits;
- exposing unweathered mineral surfaces in overburden and interburden to weathering processes during mining and backfilling operations;
- past placement of coal combustion by-product (CCB) materials in mine backfill;
- changing the quantity and quality of surface runoff and stream flows by construction of diversions, surface disturbance, sediment control structures, and construction and operation of best management practices (BMPs);
- altering surface topography and stream channels during mining and reclamation; and
- changing sediment loads and concentrations and flow rates within stream channels downstream of mining and thereby altering stream channel morphology.

The PHC is a process for identifying these potential changes in the hydrologic balance that may result from mining and reclamation. This PHC assessment builds on the geologic information, the baseline groundwater information, and the baseline surface water information contained in Chapters 5, 6, and 7 respectively. The baseline hydrologic information also identifies any water resource or water use that could be affected by the proposed mining and reclamation operation.

The PHC also identifies the appropriate preventive and mitigating measures to minimize the impacts to water resources and water uses. Regulations require the replacement of a water supply in use that is contaminated, diminished, interrupted, or destroyed by mining and reclamation activities. Alternate water supplies are identified in the PHC and Section 12.11, Hydrologic Reclamation Plan, to provide a suitable replacement for existing water uses that may impacted by mining and reclamation activities. The PHC lays the groundwork for the proposed monitoring plans.

Literature sources for this study include published and unpublished reports, papers, and data authored or developed by several state and federal natural resource management agencies. Reports published by private consultants and academic institutions were also used. Site-specific data were developed through drilling, monitor/piezometer well installations, and pump testing as described in Chapter 6. Additional data were obtained from past geological investigations, observations made by BHP Navajo Coal Company (BNCC) staff during the day-to-day operations of the mine, and surface water and groundwater monitoring performed in conjunction with historic and on-going mining and reclamation activities at Navajo Mine. The PHC also couples these data with detailed SEDCAD™ 4 (SEDCAD) modeling of surface flows and sediment yields, spoil and CCB leaching test results, and groundwater flow and chemical transport modeling in order to develop projections about potential hydrologic impacts of proposed mining and reclamation at Navajo Mine.

11.6.1 Summary of Probable Hydrologic Consequences

11.6.1.1 Groundwater Summary

Monitoring wells completed in the PCS and Fruitland Formation at Navajo Mine show that well yields are quite low and wells are typically pumped dry during sampling. The sampling also shows that the water quality in the PCS and Fruitland Formation is poor and generally not suitable for either livestock or domestic use (Appendix 6-G). Groundwater use in the vicinity of the Navajo Mine is limited in extent and is mostly derived from wells completed within surficial valley-fill deposits of Quaternary age, herein referred to as alluvium. An inventory of water wells and springs is included in Appendix 6-E. This inventory was extended several miles beyond the Navajo Mine permit boundary and includes wells completed in the alluvium of the Chaco River and the San Juan River. The inventory found no water supply wells completed in the Fruitland Formation or the Pictured Cliffs Sandstone (PCS) within or adjacent to the Navajo Mine permit area.

The inventory of wells and springs included in Appendix 6-E also identified a number of water wells completed within the alluvium of the San Juan River, the Chaco River, and Chaco tributaries including Pinabete Arroyo, Cottonwood Arroyo, and Chinde Arroyo. The water wells in the San Juan River alluvium are completed at varying depths and varying yields. Available water quality information provided in the Appendix 6-E Addendum shows that water quality in San Juan River alluvium is also quite variable with TDS concentrations above the United States Environmental Protection Agency (USEPA) drinking water use criterion in all wells sampled. Several water wells completed in the Chaco River alluvium are also shown in Appendix 6-E. Most of these wells are dug wells and the available water quality information shows variable water quality with TDS and sulfate concentrations often above published livestock use criteria and the USEPA secondary standards for drinking water use (Appendix 6.G, Table 6.G-2).

The water wells within the Navajo Mine lease completed in the alluvium of Pinabete and Cottonwood Arroyos support marginal stock water use, although the baseline TDS and sulfate concentrations exceed published guidelines for livestock use. The baseline fluoride concentrations fluctuate in the alluvial groundwater and are often above published guidelines for livestock use (Appendix 6-G).

Changes in groundwater flow and groundwater quality will occur as a result of mining and reclamation at Navajo Mine. During mining operations, all strata overlying the Fruitland coal seams are stripped to expose the coal for mining. Each successive open cut serves as a sink for groundwater causing drawdown of potentiometric heads in the adjacent coals. Some drawdown in the potentiometric heads in the underlying PCS may also occur, depending upon the baseline heads in the PCS relative to the base of the mine pit. Model simulations of the advance of proposed open pit mining in Area IV North show very limited extent of drawdown in the Fruitland Coals and underlying PCS as discussed in Section 11.6.2.4. Groundwater inflows to the mine pits in Area II and Area III have been too low to saturate or pond within the mine pit and are seldom observed as seeps along the highwall. The pit floors remain dry except on rare occasions when storm runoff is captured. The alluvium in the North Fork of Cottonwood Arroyo has been mined through in Area III, depleting the groundwater in the North Fork alluvium immediately up gradient and down gradient of the mine. Mining will not occur within the alluvium along the main stem of Cottonwood Arroyo. The advance of the mine pit in Area IV North will result in limited drawdown in the adjacent coal units and the underlying PCS but is not expected to result in a drawdown of groundwater levels in the alluvium within the main stem of Cottonwood Arroyo (Section 11.6.2.4).

As a result of mining and reclamation, the interbedded structure of the pre-mine Fruitland Formation is replaced with backfill spoil of overburden and interburden materials. As discussed in Section 11.6.2.4, the backfill spoil is more homogeneous and has a higher porosity and higher hydraulic conductivity than the pre-mine in-situ interbedded sedimentary deposits of the Fruitland Formation. Mining is also expected to result in higher recharge rates during and following reclamation as a result of removal of the badland topography that occurs over portions of the mine area and placement of topdressing materials within reclaimed areas that permit higher rates of infiltration and groundwater recharge relative to baseline conditions

Despite an increase in recharge rates, the rate of recharge will still be quite low and the time period required for water levels to recover to a near steady-state level in the mine backfill is estimated to be on the order of several centuries or longer unless there is an imported source of water that enhances recharge. One such imported source is irrigation seepage and return flows from the Navajo Agricultural Products Industry (NAPI) irrigation sites located adjacent to Areas I and II. The NAPI irrigation seepage water has resulted in re-saturation of the Bitsui Pit starting in the early 1980's while other backfilled pits that are not located near external sources of water have remained dry.

The mine spoil and CCB materials that are derived from the coal and overburden at Navajo Mine do not exhibit hazardous toxicity as demonstrated by the extraction procedure (EP) toxicity test results presented in Appendix 11-K. Although this toxicity procedure has been replaced by the TCLP test, the results are still a valid indication that the materials are non-hazardous. In addition, the characterization of overburden and interburden materials provided in Section 11.6.2.2 indicates that there is no widespread occurrence of potentially acid-forming overburden or interburden materials. The strata are mostly highly alkaline, although there are some limited locations where the acid-base potential values indicate potentially acid-forming material. However, the overburden and interburden materials that will be used to backfill the pit show a substantial net alkaline environment. The mining process for removal and backfilling of overburden and interburden materials provides sufficient blending and mixing of the strata so that acidic spoil water conditions will not occur within mine backfill. This conclusion is supported by the neutral to alkaline pH levels observed in the Bitsui spoil monitoring wells.

Characterization investigations conducted on mine spoil and CCB materials contained in Appendix 11-K together with analysis of groundwater samples from wells completed in mine spoil and in CCB materials show that TDS and sulfate concentrations are lower in saturated CCBs in comparison with saturated mine spoils. Arsenic, boron, fluoride, and selenium concentrations increased in fly ash leachate and also showed higher concentrations in CCB wells Bitsui-1 and Watson-4 in comparison with the concentrations in spoil wells. Other trace constituents were below detection limits in the majority of the samples from both CCB wells and spoil wells. The leaching tests, reported in Appendix 11-K, show that arsenic, boron, and fluoride are all attenuated in flow through mine spoil. Furthermore, arsenic and selenium were below detection limits in the spoil leaching tests reported in Appendix 11-VV and in all of the Bitsui spoil monitoring wells, including the well immediately down gradient of CCB material. Thus, both the leaching tests and the observations in the Bitsui backfill monitoring wells indicate that, if CCBs become saturated, the probable result is that concentrations of arsenic, boron, fluoride, and selenium may increase above the concentrations present in the water source that saturates the CCB materials.

Groundwater flow from the saturated CCB materials will evolve geochemically with changes in pH and redox conditions, chemical precipitation and coprecipitation, adsorption and dispersion. Under low redox conditions, sulfate reduction can be expected to precipitate sulfide metals that will reduce concentrations of sulfate and metals in groundwater transport. Concentrations of other constituents, such as arsenic, boron, fluoride, and selenium may also decrease as a result of geochemical processes. The attenuation of arsenic, boron, fluoride, and selenium concentrations is indicated by observations in the spoil monitoring wells located downgradient of saturated CCB materials in the Bitsui Pit. Furthermore, the monitoring data indicate that TDS and sulfate concentrations are not expected to increase in CCBs that become saturated with spoil water. As a result, the quality of groundwater that migrates from backfilled pits is not expected to measurably change due to the presence of CCB materials in mine backfill.

The concentrations of TDS, sulfate, boron, and manganese are expected to increase in the mine spoil water relative to the concentrations in the recharge water sources. Concentrations of boron in mine spoil are expected to remain below the livestock use criterion of 5 mg/l while the boron concentrations in CCB material exceed the livestock use criterion. TDS and sulfate concentrations in the baseline groundwater exceed drinking water use criteria and exceed published criteria for livestock use (Appendix 6.G, Table 6.G-2). Concentrations of other trace constituents are expected to remain below detection limits or comparable to the concentrations observed in the recharge water sources.

The constituent concentrations in mine spoil water will also vary with the chemistry of the water sources recharging the mine spoil. In Area I these sources include the No. 8 coal seam water with TDS concentrations ranging from 5,000 to 10,000 mg/l and seepage from adjacent NAPI irrigation plots with unknown TDS concentrations. Precipitation recharge rates are very low relative to the other sources of recharge at the Bitsui Pit and probably account for less than 1% spoil water present in this pit. In Areas II through IV, recharge from NAPI irrigation will be negligible and the primary sources of recharge of mine spoils include precipitation recharge with low TDS concentrations and inflows from the various coal units which show median TDS concentrations in baseline monitoring wells ranging from 13,400 mg/l at the No. 6 coal seam well KF84-18A to 2,770 mg/l at the No. 7 coal seam well KF84-20C. Some inflow from the PCS with high TDS concentrations may also occur in Areas II through IV but the inflow will cease once the hydraulic head in the backfill rises sufficiently to reverse the flow from the PCS to the Fruitland Formation.

Section 11.6.2.3.1 provides an assessment of potential transport of spoil water from the mine in Area I through the Fruitland Formation to its discharge location at formation subcrop beneath the alluvium of San Juan River. Based on estimates of groundwater flow velocities, the projected travel time from the mine to the formation subcrop is expected to be on the order of 290 years. Measurable changes in TDS and sulfate concentrations in the San Juan River alluvial groundwater at the Fruitland Formation subcrop are not expected to occur for the following reasons:

- Sulfate reduction in the coal is expected to attenuate transport of sulfate and TDS from spoil water. Sulfate reduction occurs in the coal when dissolved oxygen in the groundwater in the recharge area is depleted by biogeochemical process. The occurrence of sulfate reduction in the coal between the Bitsui Pit and San Juan River alluvium is indicated by the absence of sulfate in monitoring well and SJKF-2, SJKF-3, SJKF-4 and SJKF-5 and observations of apparent sulfate reduction in the coal at the Bitsui 2 monitoring well located adjacent to the Bitsui Pit. Sulfate reduction functions to not only reduce sulfate concentrations but also concentrations of metals that are precipitated as metal sulfides and concentrations of TDS due to the reduction in sulfate concentrations.
- Groundwater flow in the San Juan River alluvium is more than two orders of magnitude higher than groundwater flow estimated to be discharging to the alluvium from the Fruitland Formation.

When water levels in the mine backfill recover sufficiently, groundwater will migrate from the mine backfill vertically into the PCS and laterally toward potential discharge locations. These discharge locations include the Fruitland Formation subcrop at the San Juan River alluvium, the coal bed methane depressurization areas in the Fruitland Formation and PCS located east and northeast of the mine, the Fruitland Formation and PCS subcrop locations along the Cottonwood Arroyo valley, and Fruitland Formation and PCS outcrop locations to the west of Areas II and III. The discharge at the Fruitland Formation and PCS outcrop will be removed by evapotranspiration like it does under baseline conditions.

Groundwater flow and transport rates are extremely slow as demonstrated in Section 11.6.2.4. Modeling of mine water transport from Area IV North found that long-term post-reclamation TDS concentrations in the groundwater in the alluvium of Cottonwood Arroyo are expected to increase down gradient of the mine area. An increase in TDS concentrations of the magnitude predicted by the PHC assessment is not expected to materially impact the suitability of the alluvial groundwater for livestock use as indicated in Section 11.6.2.4. Furthermore, alluvial groundwater flows in Cottonwood Arroyo are extremely low and vary with space and time.

Baseline monitoring of the wells in the Cottonwood alluvium demonstrate groundwater in the alluvium is an unreliable supply, which limits its potential for livestock use.

The TDS concentrations in the alluvium of Cottonwood Arroyo down gradient of mining could increase by as much as 20% over a 500 year period following mining. These changes could impact water supply well QACW–2B (BIA No. 13R-28A) completed in the alluvium of Cottonwood Arroyo west of the permit area as shown on Exhibit 11-166. This is a dug well that has been used for stock water supply. It is not owned by BNCC but has been sampled by BNCC for baseline water quality and water levels. However, the quantity of water in the Cottonwood alluvium is limited and this well has limited saturated thickness and several other water monitoring wells in the Cottonwood alluvium are periodically dry. Mining activities are not expected to adversely impact any other developed water sources (Section 11.6.2.5).

BNCC has surface water rights on the San Juan River, New Mexico Office of State Engineer Permit 2838, which can be used to offset any adverse impacts to the State of New Mexico and present users. These rights will be maintained throughout the mining operation and a period thereafter, for retirement, if required to any affected San Juan Basin water users. For temporary impacts to water users, unseasonably dry conditions, or lack of potable water supply, BNCC provides water to local permittees in tanks for livestock use in areas around the lease, when requested. BNCC also provides the community potable water at two locations, one near the Navajo North facilities and the other near the Area III facilities. Permanent impacts to surface water users may be mitigated by the construction of impoundments incorporated into the post-mining landscape (Chapter 12 Sections 12.11 Hydrologic Reclamation Plan and 12.3.4.1 Permanent Impoundments).

11.6.1.2 Surface Water Summary

The surface water resources in the mine permit area and adjacent area are described in Chapter 7. Six named naturally ephemeral streams are directly affected by mining. These drain from east to west across the mine permit area and into the Chaco River, located west of the Navajo Mine permit area. Chinde Arroyo, located furthest north, has perennial flows derived from return flows from NAPI. Cottonwood Arroyo, located furthest to the south, exhibits intermittent flows from unused irrigation canal outflows and some irrigation return flows associated with NAPI. Chinde and Cottonwood have the largest drainage areas. The Chaco River is an ephemeral to intermittent drainage until its confluence with the drainage from Morgan Lake. Morgan Lake discharges continually, yielding perennial flows in the lower reaches of the Chaco River, which flows north into the San Juan River.

Sediment ponds and highwall containment ponds are described in Sections 11.5.4.2 and 11.5.4.4 of the PAP. Sediment ponds are located downgradient of mine related disturbance and treat surface water runoff from the mine for sediment. These ponds are sized to contain a 10-year 24-hour storm event at a minimum, and in many cases a 100-year 6-hour storm. Discharge from the sediment ponds may occur following events greater than the design storm. Discharges have been infrequent, as only one discharge was reported from nine outfalls in the period between 1 July 2008 and 30 June 2011 (USEPA 2011). Highwall containment ponds are constructed upgradient of mine pit areas to collect surface water runoff from watersheds upstream of the mine. The highwall containment ponds have the capabilities to contain a range of storm events, from the 2-year 6-hour event to the 100-year 6-hour event, dependent on the size of the upland watershed and the risk of pit flooding assumed by the mine. Design criteria are summarized in Appendix 11-II. The sediment ponds have been engineered and designs may be reviewed in the Chapter 11 Appendices and Exhibits. Exhibits 11-13B, 11-13C, 11-13D, 11-13E, 11-13E-1, and 11-13F map the impoundments within their watersheds while other exhibits document the designs and as-builts of each pond within the permit area. Tables 11-4, 11-5, and 11-6 include summaries of site impoundments.

Surface drainage from the mine permit area is contained until reclamation standards have been met and then will drain via the tributary channels into the Chaco River. Diversions have been constructed on the Chinde and Cottonwood Arroyos to enable flows in these Chaco tributaries to pass through the permit area. The flow in Neck Arroyo also passes through the mine permit area as the main Neck channel and most of its drainage area has not been and will not be affected by mining other than by the transportation corridors. Hosteen Wash, Barber Wash, and Lowe Arroyos have been interrupted by mining and no flow from these drainages passes through the mine permit area. Instead, flows are retained by check dams and containment structures located upstream of mining. The disturbed channel segments for these arroyos will be reclaimed and flows from these drainages will pass through the mine permit area after reclamation. Permanent impoundments with capacities of less than 10 acre feet will be constructed on the reclaimed mine, at or near pre-mining impoundments (Section 12.3.4.1 and Table 12.3.4-1), at locations with adequate watersheds to support the impoundment. Inlet and outlet structures will be designed to safely handle peak discharges of large events up to the 100-year 6-hour storm event. BNCC plans to ensure that water quality at permanent impoundments is suitable for the proposed use through sampling. Further discussion of permanent impoundment water quality may be reviewed in Section 11.6.4.

Bitsui Wash, located in the northern portion of Area I outside of the permanent program permit area, drains to the north into the San Juan River. Bitsui receives drainage from pre-law jurisdictional lands on the northern area of the mine lease and starting in the early 1980's irrigation return flow from NAPI. The Bitsui Wash does not receive drainage from the reclaimed areas or from sediment ponds within the Navajo Mine permit area, however the NAPI irrigation return flows contribute intermittent to perennial flows depending upon NAPI activities.

The Chaco River, which flows north into the San Juan River, drains an area of more than 4,000 square miles. Flow in the Chaco River is ephemeral except for the last 12.5 miles of the river, where perennial flow is the result of spillway overflows from Morgan Lake and discharge from the Four Corners Power Plant (FCPP). One other prominent surface water feature adjacent to the Navajo Mine is Morgan Lake, which is manmade and used as cooling water for FCPP. The San Juan River serves as the primary source of water for Morgan Lake. Water from Morgan Lake is also used by BNCC for mine operations.

Prior to mining and the construction of Morgan Lake, surface water use within the Navajo Mine permit area and adjacent area was limited to surface water captured in stock watering ponds, which were constructed to catch surface flows from some of the small tributary drainages. The location of stock watering ponds on and near the permit area is shown on Exhibit 10-3. Due to the unreliable nature of water supplies at stock watering ponds, and the temporary loss of some historical livestock impoundments, BNCC also provides water to local permittees when requested in permanent tanks for livestock use at locations around the lease. BNCC provides potable water from two stations located near the North Facility area and near Area III, but outside the mine lease, as a courtesy to neighboring landowners (Exhibit 11-168). Additional information on post-mining water sources is provided in the Hydrologic Reclamation Plan Section 12.11.

Almost all of the surface water use in the vicinity of the Navajo Mine is from the San Juan River. The largest use is for irrigation, which accounts for 78 percent of the water use in San Juan County while power generation and associated mining accounts for only about 10 percent of water use (Blanchard et al. 1993). Other than the San Juan River, surface water is not used for drinking or irrigation.

Surface water impacts associated with mining are related to water quantity, water quality, and water use. At a minimum, surface water runoff from the 10-year 24-hour storm is contained within mine site sediment ponds, and discharge may for storms exceeding the design storm event or designed impoundment storage capacity. Navajo Mine has permitted outfalls under a NPDES permit issued by the USEPA (Appendix 11-J). These outfalls will operate until reclamation standards are met and the area achieves bond release. Then containment structures are removed and surface runoff from precipitation events will drain to the Chaco River tributaries that cross the permit area. Under baseline conditions, these tributary channels carry very high concentrations of suspended solids and bed loads during storm runoff events. Sediment control measures, as outlined in Section 11.2.10, will prevent additional contributions of sediment to stream flow or to runoff outside the permit area during operations. Surface reclamation plans and associated modeling demonstrate that total suspended solids concentrations and sediment yields may be equivalent or less than pre-mining levels following reclamation.

Changes in peak flows due to the presence of upstream containment berms, diversions and highwall impoundments, coupled with retention of water within pits and down gradient sediment ponds will reduce peak flows and runoff volumes down gradient of the mine during operations. As areas are reclaimed, BNCC expects to see better retention of surface water runoff within the permit area compared with pre-mining conditions, due to lower slopes and the placement of topdressing materials with more permeable textures than occurred naturally pre-mine. Following successful reclamation and stabilization, flows should be comparable with pre-mining conditions with, perhaps, a slight decrease in peak flows and runoff volumes due to the improved infiltration following reclamation (Section 11.6.3).

Prior to mining and before the development of up gradient agricultural lands, surface flows in channels traversing the permit area were predominantly ephemeral. It is anticipated that post-mining flows will also be ephemeral, due to the limited precipitation regime coupled with marginal development of alluvium, unless flows from the upgradient NAPI generate seasonal or perennial flows. NAPI impacts have resulted in the perennial and intermittent flows in Chinde and Cottonwood respectively. Future development of NAPI may continue further east and south of existing development into the headwaters of Cottonwood, and south into the headwaters of the Brimhall and Hunters Wash. The expanded NAPI irrigation plots would be far removed from mining within Area III or Area IV North. The ephemeral surface flows are unpredictable and carry such high sediment loads that essentially no use is made of the water for agricultural or other purposes (Chapters 6 and 7). Stock watering ponds are the principal use of surface water on or near the permit area, and these are not located on the larger tributaries where pond embankments are susceptible to failure due to flash floods.

Surface water quality after mine reclamation is expected to support existing uses prior to mining as a result of the revegetation practices outlined in Section 12.6. As discussed in the previous subsection, the overburden and interburden materials that will be used to backfill the pit show a substantial net alkaline environment. An extensive program of sampling regraded spoils has been developed for Navajo Mine to ensure that the regraded spoils are suitable for revegetation and surface drainage reclamation. Water quality changes that could occur include increases in TDS, sulfate and iron as discussed in Appendix 11-K, Table 11-14f, and Section 11.6.3.

11.6.2 Assessment of Potential Groundwater Changes

The monitoring wells completed in the Fruitland Formation and in the PCS within the study area demonstrate that groundwater yields from the Fruitland Formation and the PCS, which underlies the Fruitland Formation at the Navajo Mine, are quite low and most monitoring wells are pumped dry during sampling. Furthermore, the water quality in the PCS and Fruitland Formation is poor and generally not suitable for either livestock or domestic use (Appendix 6-

G). An inventory of wells and springs is included in Appendix 6-E. The results show that there are no known water supply wells completed in the Fruitland Formation or the PCS within or adjacent to the Navajo Mine permit area. All of the water supply wells located within or adjacent to the Navajo Mine are completed within alluvium. There were two PCS wells located several miles east of the permit area that were identified in 1985 in the original Navajo Mine area well inventory by Billings and Associates, Inc (BAI) (1985). These wells will not be affected by mining due to the distance from the mine. The water quality in these wells is poor and unsuitable for use with total dissolved solids (TDS) concentrations above the New Mexico regulatory threshold for current or future use of 10,000 mg/l as referenced in 20.6.2.3101(A) New Mexico Administrative Code (NMAC) and 20.6.2.3103NMAC. Well No. 38 has been abandoned. Spring No. 56 was also reported to be issuing from the PCS at a location adjacent to the San Juan River alluvium. The TDS for this spring was 624 mg/l, which is acceptable for livestock use but exceeds the USEPA Drinking Water Criteria. This spring is located to the north and down gradient of Morgan Lake and may be the result of seepage from Morgan Lake as suggested by its location and the TDS of the water, which is considerably lower than the concentrations observed elsewhere in the PCS as described in Appendix 6-G.

There was one PCS well BAI #90 located several miles west east of BNCC coal lease Area V that was identified in 1985 in the original Navajo Mine area well inventory by Billings and Associates, Inc (1985). This well was described as a Gulf Oil Co. Shot hole with a well depth of 131 feet and no water quality or depth to water information provided. The other PCS well identified in Appendix 6-E is well 13-7-2. This well is located in Burnham several miles south of BNCC coal lease Area V. This was the original Burnham Chapter House well but was abandoned and replaced with a deeper well due to poor water quality and poor yield. The replacement well was also removed and water for the Burnham Chapter Hours is currently piped in from the Carson/Huerfano area to the east, where it is taken from the Ojo Alamo aquifer.

The inventory of wells and springs included in Appendix 6-E identified a number of water wells completed within the alluvium of the San Juan River, the Chaco River, and Chaco tributaries including Pinabete Arroyo, Cottonwood Arroyo, and Chinde Arroyo. The water wells in the San Juan River alluvium are completed at varying depths and have varying yields. Available water quality information provided in the Appendix 6-E Addendum shows that water quality in San

Juan River alluvium is quite variable with TDS concentrations ranging from 528 mg/l to 5,880 mg/l. These water quality results are consistent with the data reported by Thorn (1993), which found TDS concentrations ranging from 1,860 mg/l to 3,940 mg/l in four wells completed in the San Juan River alluvium. Several water wells completed in the Chaco River alluvium are shown in Appendix 6-E. Most of these wells are dug wells and the available water quality information shows variable TDS concentrations ranging from 1,950 mg/l to 3,110 mg/l. Limited groundwater quality baseline data for the Chaco River alluvium are also provided by Thorn (1993). The results show considerable variability in the alluvial water quality with TDS concentrations ranging from 742 to 11,900 mg/l, sulfate concentrations ranging from 350 to 6,600 mg/l, and fluoride concentrations ranging from 0.4 to 1.7 mg/l.

The water wells within the BNCC coal lease completed in the alluvium of Pinabete and Cottonwood Arroyos support marginal stock water use, although the baseline TDS and sulfate concentrations exceed published guidelines for livestock use (Lardy, G. and C. Stoltenow, 1999) The baseline fluoride concentrations fluctuate in the alluvial groundwater and are often above the published water quality criterion for livestock use and the USEPA drinking water use criterion (Appendix 6-G).

11.6.2.1 Observations During Previous Mining And Reclamation At Navajo Mine

The location of the pits previously mined or currently being mined at the Navajo Mine are shown on Exhibit 11-166. The Bitsui and Watson Pits were mined in the mid-1960s and backfilled in the 1970s before the promulgation of regulations under the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Some of the backfill in this area consisted of CCBs from the FCPP. CCBs were placed at discrete locations within the backfill and surrounded by and covered by overburden removed during mining of the coal. Approximate CCB placement locations within the Bitsui and Watson Pits are shown on Exhibit 11-167. CCB placement within these mine pits also preceded the NAPI irrigation activities which began at locations adjacent to the Bitsui Pit in the early 1980s. The NAPI irrigated plot that is closest to Bitsui Pit is shown on Exhibit 11-167. NAPI irrigation has had a significant influence on both nearby groundwater elevations and flow directions.

Since mining at the Navajo Mine started long before SMCRA became law, baseline hydrologic monitoring data generally does not exist for Area I and portions of Area II of the Navajo Mine. Nevertheless, the "GM-" monitoring wells shown on Exhibit 11-166 were installed during the period from 1975 to 1977 and provide baseline information for Areas III, IV, V, and portions of Area II. Many of the GM wells have been mined through or abandoned and additional monitoring wells were installed, most in 1983 and 1984. Monitoring wells were installed in 1998 and in 2007 for baseline characterization of Areas IV South and V.

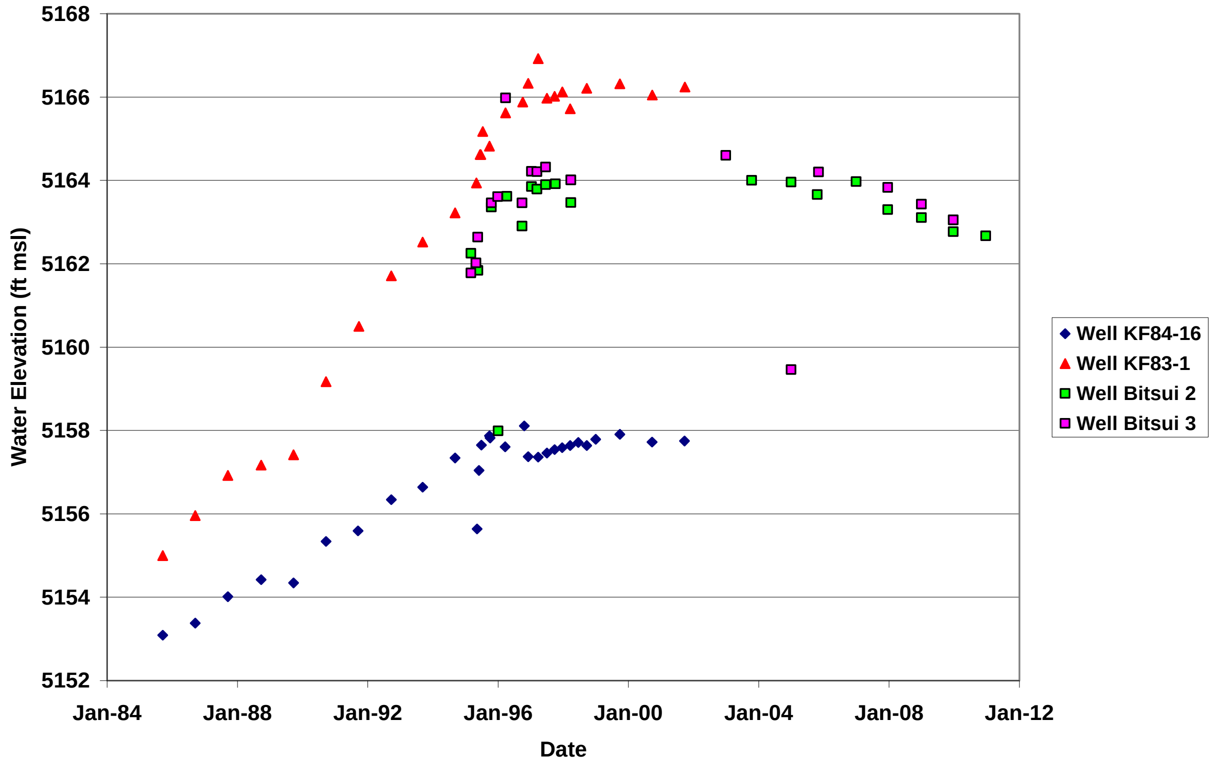
BNCC also collected groundwater data from historic CCB disposal on pre-law and interim lands (Supplemental Groundwater Study (SGS), Appendix 11-MM) to investigate possible impacts to groundwater from mine placement of CCBs at Navajo Mine. The Bitsui Pit is in the northeastern portion of the mine lease area, as shown on Exhibit 11-166. The Bitsui Pit location was selected for the study for the following reasons:

Unlike other CCB placement locations at the mine, the CCBs at the Bitsui Pit were expected to be largely saturated based on the close proximity to center pivot irrigation conducted by NAPI east of the coal lease, and the Bitsui Pit is closest to the San Juan River of all the backfilled pits at Navajo Mine.

The SGS, which was undertaken in 1995, was accomplished by installing six groundwater monitoring wells within mine backfill and CCB disposal areas in the Bitsui Pit. Other wells were installed during the mid-1990s to monitor backfill and CCB placement in locations not influenced by NAPI irrigation. Wells Watson-1 and Watson-4 were installed in the CCBs placed within the Watson Pit and wells Custer 2 and Custer 3 were installed in the CCBs placed in the Custer Pit to monitor the influence of Morgan Lake. Custer 1 was drilled in shallow Fruitland Formation sands west of Custer Pit Ramp 4 to monitor the influence of Morgan Lake. The new wells at the Bitsui, Watson and Custer Pits and No. 8 coal seam wells KF-84, KF83-1 and KF84-16 were monitored for static water levels and water quality on a quarterly basis from 1995 through 1998 and then annually. These wells are shown on Exhibit 11-167 along with other monitoring wells in the vicinity

Navajo Mine also monitored static water level (SWL) and collected water quality samples from several No. 8 seam coal wells in the vicinity of Bitsui Pit starting in 1985 and 1986. Time plots of water elevations measured in the nearest coal wells are provided in Figure 11-30. Over an 11-year period from 1985 to 1996, SWL in the No. 8 coal seam rose 11 feet in well KF83-1, which is near the southeast corner of the Bitsui Pit. During that same period of time, water levels rose 5 feet in well KF84-16, which is also completed in the No. 8 coal seam further east of Bitsui Pit as shown in Exhibit 11-167. The Bitsui-3 well is completed in the No. 8 coal seam east of the Bitsui Pit but west of the well KF84-16. The Bitsui-2 well is completed in the No. 8 coal seam approximately 300-feet north of the Bitsui Pit as shown on Exhibit 11-167. Water elevations initially increased in both the Bitsui-2 and -3 wells after they were installed in 1995. The water levels in these coal wells would have been drawn down considerably during mining at the Bitsui Pit but the magnitude of drawdown and recovery prior to installation of the wells is uncertain. Water elevations in all of these wells appear to have reached an equilibrium stage with relatively little change in water elevations since 1996, as indicated in Figure 11-30.

Figure 11-30. Water Elevations in Coal Monitoring Wells in the Vicinity of the Bitsui Pit



The rise in water levels is associated with NAPI irrigation and the No. 8 Coal recharging the Bitsui Pit. Observations of seepage from nearby NAPI irrigation emerging from the highwall at the northeast end of the Dodge Pit adjacent to and southwest of the backfilled Bitsui Pit support the conclusion that seepage from NAPI irrigation provides a source of the recharge water for the Bitsui Pit and the Dodge Pit. Also, the NAPI irrigation has produced return flows sufficient to maintain perennial flows in Bitsui Wash upstream of the mine and to provide a water source for the perennial pond located on a branch of Bitsui Wash and referred to as "NAPI Pond" on Exhibit 11-166. These sources of water from NAPI irrigation return flows are sufficient to migrate down gradient and saturate the backfilled Bitsui Pit.

Three geologic sections through selected monitoring well locations were prepared to examine groundwater conditions in three dimensions. These geologic sections along with the map showing the locations of the sections are provided Exhibit 11-167. Measured water levels in monitoring wells are shown on the sections.

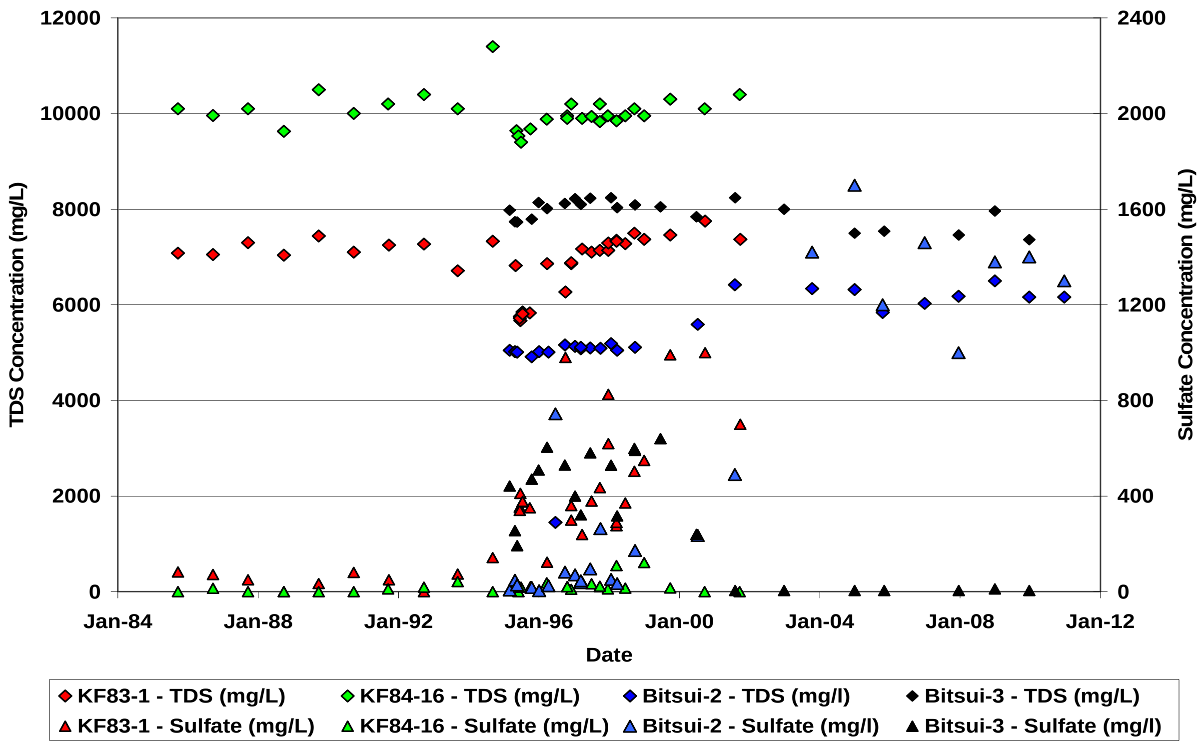
The water level measurements depicted in the geologic sections show minimal influence from Morgan Lake on the adjacent Custer Pit. The wells completed in the CCBs of the Custer Pit remained dry. Approximately one foot of saturation was observed in June 1989 at the No. 8 coal well KF83-2 located adjacent to the Custer Pit. Also, the Custer Pit and ramps remained dry during mining operations. The ten to twenty-five foot thick shale layer separating the bottom of the lowest mineable coal seam and the PCS (see Chapter 6) acts to isolate the mine pits from groundwater in the PCS. No noticeable upward seepage through the mine floor (shale layer) has been observed, even though, prior to backfilling, the mine pits in the vicinity of Morgan Lake were well below the potentiometric levels in the PCS as projected in Exhibit 11-166.

Saturated conditions developed within the backfill of the Dodge Pit as indicated by the water level rise in spoil well KF83-14. The water source for saturation of both the Dodge Pit and the Bitsui Pit is believed to be primarily from NAPI irrigation with perhaps very minor contribution from the PCS, although the dry conditions observed in the backfilled Custer Pit located closer to Morgan Lake indicates little influence from the relatively high potentiometric surface in the PCS near Morgan Lake.

Watson-1 well, completed in the CCBs at the Watson Pit, also remained dry. A couple of feet of saturation was present in the Watson-4 well, which may be the result of upward seepage from the PCS as recharge rates are extremely slow and the well is upgradient of the saturation in the Bitsui Pit and not near NAPI irrigation as shown Exhibit 11-167.

TDS and sulfate concentrations observed in monitoring wells completed in the No. 8 coal seam near the Bitsui Pit are plotted in Figure 11-31. The increase in sulfate in well KF83-1 corresponds with a decrease in alkalinity such that TDS concentrations did not change. TDS concentrations in wells KF84-16 and in Bitsui-3 show no consistent trends, although sulfate concentrations appeared to temporarily increase in both of these wells in the mid-1990's.

Figure 11-31. Time Series of TDS and Sulfate in Coal Wells Located Near the Bitsui Pit



The increase in sulfate started in 1995 in well KF83-1 and was above 400 mg/l when Bitsui-3 was first sampled in 1996. The sulfate in these wells is thought to be due to migration of spoil water from the adjacent Bitsui Pit. Spoil water migration may have been enhanced by frequent purging and sampling of these wells, which increases gradients toward the monitoring well with corresponding increases in flow velocities in the fractured (cleated) coal. Well KF84-16 is located about 1,400 feet to the east of the Bitsui Pit and has much higher TDS concentrations in comparison with coal wells KF83-1 and Bitsui-3, which are located close to the Bitsui Pit. This is consistent with the baseline characterization, which found that TDS concentrations in the coals increased with depth and distance from the outcrop. The decline in sulfate in wells KF83-1 and Bitsui-3 may be related to a reduction in gradients and perhaps due to attenuation by sulfate reduction. Sulfate reduction likely accounts for the absence of sulfate in the coals located further from recharge areas.

Sulfate and TDS both increased in the coal well Bitsui-2, although the magnitude of the TDS increase was less than the magnitude of the sulfate increase. The sulfate and TDS increased at Bitsui-2 and not at Bitsui-3, KF84-16 and KF83-1 because of the closer proximity of Bitsui-2 to the mine spoil and the local direction of ground water flow to the northeast towards Bitusi-2 (Exhibit 11-167). Sulfate concentrations within the background coal wells between the mine and the San Juan River alluvium are very low (median <10 mg/L) and is typical for coal aquifers beyond the recharge areas (Table 11-14g). The sulfate concentrations associated with mine spoil wells are significantly higher compared to coal wells. The average of the median sulfate concentrations in the Bitsui Pit spoil monitoring wells was 7,593 mg/L, with median concentrations ranging from 8,900 mg/L at the Bitsui-4 spoil monitoring well to 5,030 mg/L at the Bitsui-5 spoil monitor well (Table 11-14g). Also, the recent sulfate concentration at the coal monitor well Bitsui-2 is significantly higher than the concentrations at the baseline coal monitoring wells, but not as high as concentrations at the spoil monitor wells (Table 11-14g).

The increase in sulfate in well Bitsui-2 started in 1995 reaching a maximum in year 2004. Sulfate concentrations in this well have fluctuated since year 2004 but have centered around 1,400 mg/l. While the leveling off of sulfate concentrations suggests breakthrough of a sulfate plume, the sulfate concentrations in this well are about 27 percent of the median value of approximately 5,115 mg/l measured in the nearest spoil monitoring well Bitsui-5. The lower and relatively steady concentrations of sulfate measured in coal monitor well Bitsui-2 samples can be related to dispersion and bacterially mediated sulfate reduction and subsequent metal sulfide precipitation resulting in an overall removal of dissolved sulfur species.

Sulfate reduction was found to explain the large reduction in sulfate concentrations in groundwater transport from mine spoil through a coal seam at the West Decker surface coal mine in Montana (Clark, 1995). The geochemical process postulated to explain the observations included bacterial reduction of sulfate utilizing coal as a source of organic matter, reverse ion exchange of sodium for calcium and magnesium ions with transport through the coal, and precipitation of calcium and magnesium carbonates and sulfide metals. These same processes could also explain the observations in the coal at the Bitsui-2 well located down gradient of the Bitsui Pit.

Ion exchange, carbonate formation and sulfate reduction are processes that can explain the observed data trends. These reactions are all reversible and limited within a given area. As a plume migrates the reactions will take place primarily at the leading edge or front of the plume while equilibrium will be approached for these processes behind the front, assuming the source water does not change. These biogeochemical reactions will result in an overall reduction in the observed breakthrough of specific constituents and assuming the source is finite will result in a breakthrough consisting of concentrations lower than those observed at the source.

Bacterially mediated sulfate reduction in groundwater systems is a well known and documented process (Freeze and Cherry, 1979; Drever, 1988; Schwarzenbach et al., 1993; Clark, 1995; Stumm and Morgan, 1996; Clark and Fritz, 1997; Benner et al., 2002; Doshi, 2006; Appelo and Postma, 2007; Praharaj and Fortin, 2008). Overall bacterially mediated sulfate reduction mass action can be described as follows:

$$SO_4^{2-} + 2C_{organic} + 2H_2O = H_2S + 2HCO_3^-$$

The produced hydrogen sulfide is then involved in chemical reaction with metals (Me) resulting in precipitation:

$$H_2S + Me^{+2} \rightarrow MeS + 2H^+$$

Metals that readily form metal sulfide precipitates include cadmium, copper, iron, lead, manganese, mercury, nickel, and zinc. Other metals including arsenic, antimony, and molybdenum can form complex sulfide minerals (Doshi, 2006) and manganese, iron, nickel, copper, zinc, cadmium, mercury, and lead may also be co-precipitation with other metal sulfides (Doshi, 2006). Bacterially mediated sulfate reduction also consumes acidity by generating bicarbonate as a product which in turn raises the pH. The increased pH facilitates the precipitation of metal sulfides (Gadd, 2004).

The sulfide concentrations in the Bitsui-2 monitor well samples vary significantly from non-detect to over 60 mg/l supporting a dynamic system of sulfate reduction and sulfide removal. Additionally, the Bitsui-2 iron and manganese concentrations are several orders of magnitude lower than the concentrations observed in the Bitsui spoil wells. This observation supports the removal of sulfide generated from sulfate reduction as iron and manganese sulfides. Also, the pH values at Bitsui-2 have been maintained at approximately 8.13 on average since October

2003; while the incoming spoil water is lower with median values at spoil monitoring wells Bitsui-4, Bitsui-5, and Bitsui-6 ranging from 6.8 to 7.50, indicating an increase in pH that supports the reduction of sulfate.

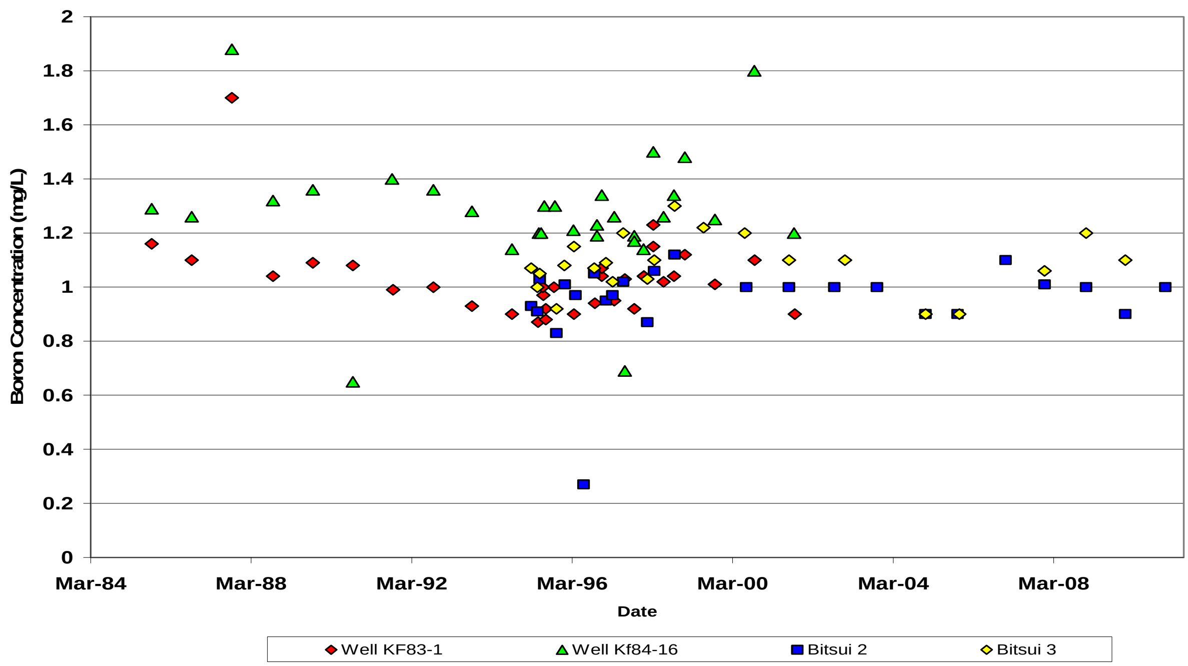
Baseline concentrations of dissolved iron and manganese concentrations in upgradient No. 8 coal seam monitor wells are low with median concentrations ranging from less than 0.05 to less than 0.5 and from 0.008 to 0.38 mg/L, respectively (Appendix 6.G Table 6.G-9). Spoil monitor wells show higher concentrations of dissolved iron and manganese while the dissolved iron and manganese concentrations at Bitsui-2 are much lower (Table 11-14g). The migration of high sulfate water from the spoil does not indicate transport of iron and manganese from the spoil water. Also, the bicarbonate values in the Bitsui-2 well appear to be decreasing. Calcium concentrations are high in the spoil water but remain low in the Bitsui-2 well (Table11-14g). The high bicarbonate values result in saturation with respect to calcite causing calcite precipitation in order to reach equilibrium. This prevents the increase in calcium concentrations in spoil water transport through the coal and reduces the bicarbonate concentrations.

Bacterially mediated sulfate reduction rates are dependent on sulfate concentrations, amount of available organic carbon and temperature (Benner et al., 2002; Appelo and Postma, 2007; Praharaj and Fortin, 2008). The sulfate concentrations at the Bitsui-2 monitor well have sustained values equal to or greater than 1,000 mg/l or 10 milli-moles (mM) since October 2003. This well is also completed in coal which provides the source of organic carbon necessary for bacterial mediated sulfate reduction. The high sulfate concentrations and large pool of organic carbon result in high sulfate reduction rates (Benner et al., 2002; Appelo and Postma, 2007; Praharaj and Fortin, 2008). The highest rates found in the literature are on the order of 0.92 mM/day which are noted as being achievable under laboratory conditions at sulfate concentrations above 2 mM (Appelo and Postma, 2007). Doshi (2006) also reports sulfate reduction rates between 0.553 mM/day and 1.052 mM/day in laboratory scale bioreactors. However, use of laboratory sulfate reduction rates in transport modeling results in no sulfate reaching the Bitsui-2 well from the Bitsui Pit. Since field conditions are not as favorable as the laboratory experiments, a more realistic reduction rate of 0.11 mM/day was observed in the field (Benner et al., 2002).

A study of geochemical processes in groundwater impacted by coal mine water showed that bacterially mediated sulfate reduction decreased sulfate concentrations from 1,100 mg/l to less than 100 mg/l (Clark, 1995). Clark (1995) also found simultaneously decreasing bicarbonate values from approximately 3,000 mg/l to less than 2,400 mg/l as a result of saturation with respect to calcite and subsequent calcite precipitation. While Clark (1995) does not present a sulfate reduction rate, a rate can be back calculated from the data provided. Using the reduced amount of sulfate (~1,000 mg/l) and the approximate time for sulfate reduction in observation wells of 50 to 228 days, the sulfate reduction rate is estimated to range between 0.21 to 0.046 mM/day similar to those reported by Benner et al (2002). The sulfate reduction rates from field studies have been used to provide bounds for sulfate reduction in the calibration of the sulfate transport model developed in Section 11.6.2.3.1.

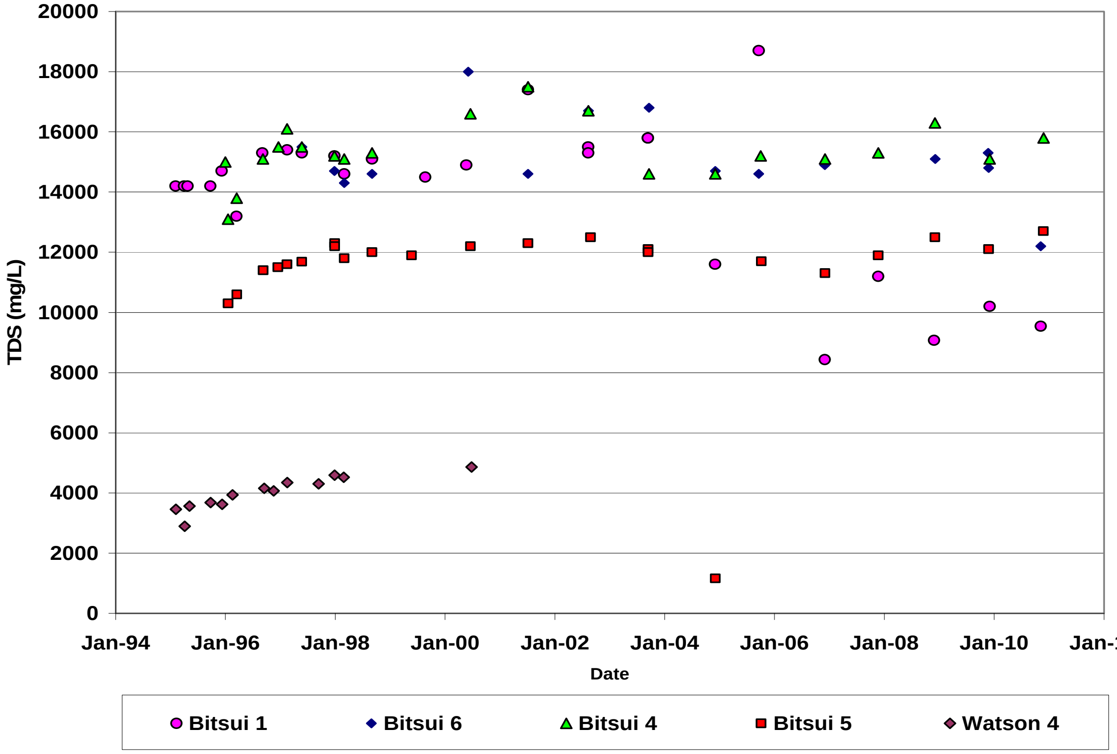
Finally, boron, a constituent at elevated concentrations in CCB leachate, shows no concentration change in the coal wells located near the Bitsui Pit as shown in Figure 11-32. Very high concentrations of boron and extremely high concentrations of sulfate may be an indicator of CCB leachate. However, high sulfate concentrations are also associated with spoil materials and sulfate alone does not identify CCB leachate. The use of TDS, boron and sulfate together provide identification of the source. Although boron is more conservative at the pH values observed in the coal groundwater, sulfate was used for modeling transport of mine water because of the larger difference between downgradient coal background and spoil water concentrations compared to boron. The lack of elevated boron concentrations in coal wells KF83-1 and Bitsui-2 indicate that backfill, rather than CCBs, is the cause of increased sulfate concentrations.

Figure 11-32. Time Series of Boron Concentrations in Coal Wells Located Near the Bitsui Pit



The results of time series plots of TDS, sulfate/chloride, and boron concentrations from the Bitsui backfill monitoring wells and the Watson-4 CCB well are provided in Figures 11-33, 11-34, and 11-35, respectively. The results show similar TDS concentrations in the CCB monitoring well Bitsui-1 and in mine backfill wells Bitsui-4 and Bitsui-6 but lower TDS concentrations in backfill monitoring well Bitsui-5. The Bitsui-5 well has lower concentrations of sulfate and higher concentrations of chloride in comparison with the spoil wells Bitsui 4 and Bitsui-6 as shown in Figure 11-33. These differences may partly be explained by the proximity to water recharge sources. Bitsui-5 is closer to the down gradient coal and may have initially received more recharge of low sulfate and higher chloride water from the down gradient coal. With water level recovery in the backfill, the sulfate concentrations have increased and the chloride concentrations have declined in well Bitsui-5 and are starting to approach the concentrations observed in wells Bitsui-4 and Bitsui-6. Wells Bitsui-4 and Bitsui-6 are completed in the Bitsui Pit mine backfill approximately 280 feet and 170 feet, respectively, north of CCB monitoring well Bitsui-1 as shown in Exhibit 11-167. Water elevations in these three wells show a very slight gradient to the north, estimated at 0.0025 ft/ft between Bitsui-1 and Bitsui-4. The Bitsui-6 well is completed in the mine spoils at a location approximately 33 feet from an identified CCB backfill placement location.

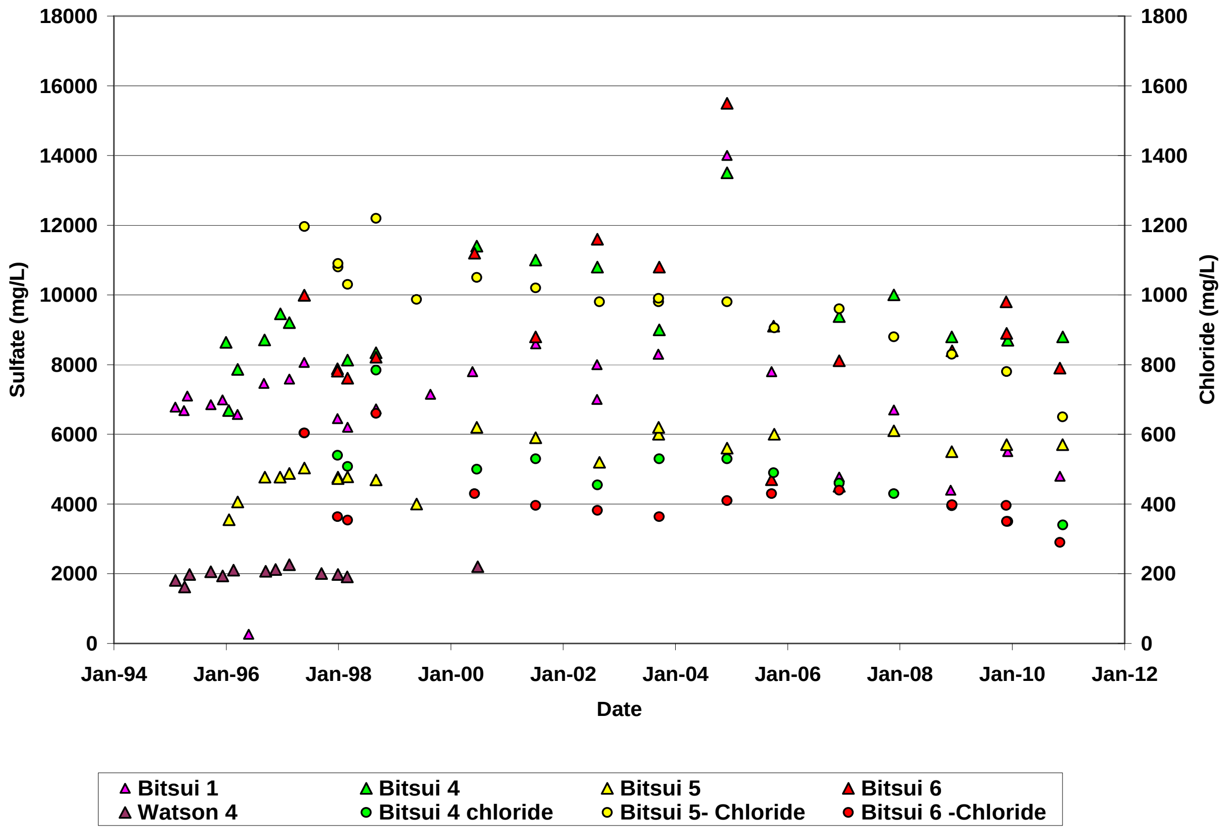
Figure 11-33. TDS Concentrations in Bitsui and Watson Wells



The lowest TDS concentrations were observed in the Watson-4 well, which can be used to characterize leachate from CCB disposal at a location that is not influenced by NAPI irrigation, spoil water, or pit inflows from the coals. The relatively low TDS observed in the Watson-4 CCB well demonstrates that CCBs are not a source for the relatively high TDS observed in spoil monitoring wells Bitsui-4 and Bitsui-6.

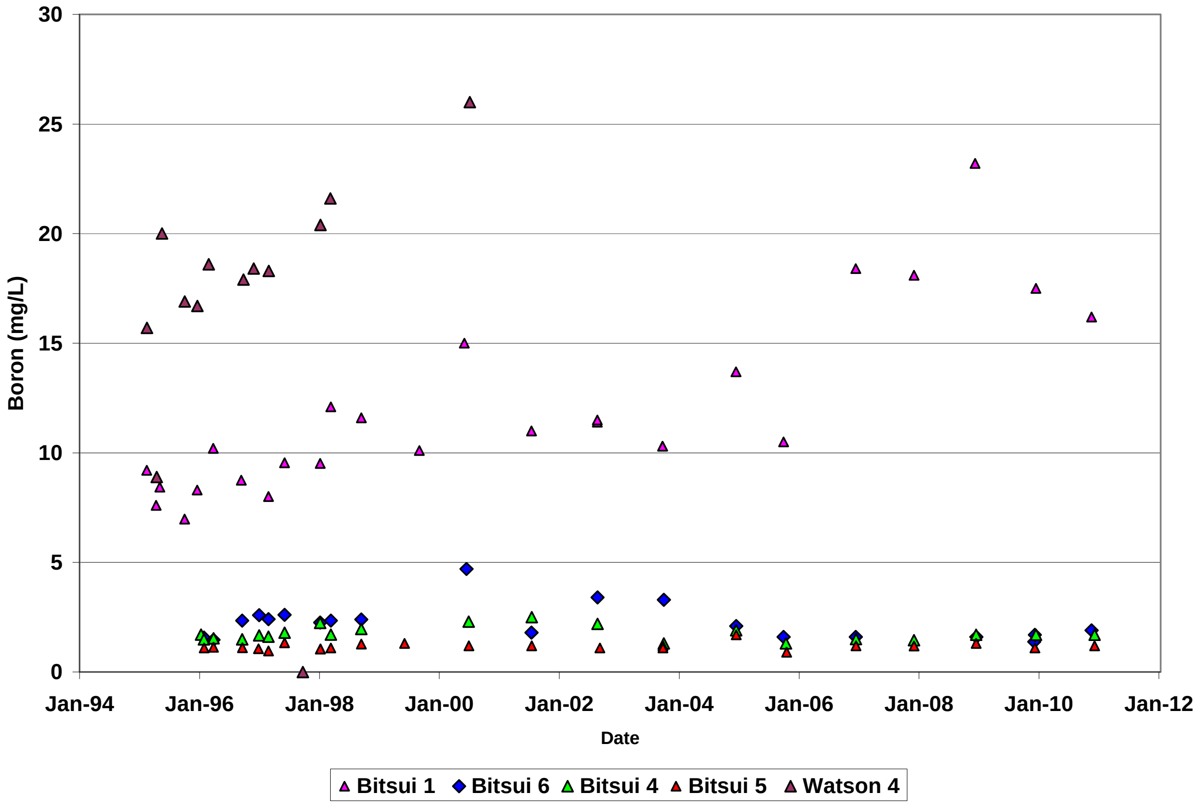
The sulfate concentration plots in Figure 11-34 show highest levels in the mine backfill wells Bitsui-4, and Bitsui-6 and slightly lower levels in the CCB well Bitsui-1 and in spoil well Bitsui-5. The sulfate concentrations observed in the Watson-4 well are much lower than the concentrations observed in the backfill wells, but are higher than the concentrations observed in the nearby coal wells.

Figure 11-34. Sulfate and Chloride Concentrations in Bitsui and Watson Wells



The boron concentrations plotted in Figure 11-35 show highest levels in the Watson-4 CCB well, which can be used to characterize leachate from CCBs at a location that is not influenced by NAPI irrigation or pit inflows from the coals. The boron concentrations in the Bitsui-1 CCB well are significantly higher than in the other backfill wells and in the coal wells (Figure 11-32), but lower than the concentrations observed in the Watson-4 CCB well. On the other hand, the sulfate in Bitsui-1 was similar to the sulfate in the backfill spoil wells. This suggests that mine spoil water is the source of the water in the Bitsui-1 CCB well. The boron concentrations in the mine spoil wells Bitsui-4, and Bitsui-5 are similar to the concentrations observed in the coals and do not show any influence from CCBs. The boron concentrations observed in well Bitsui-6 are slightly higher than the concentration observed in Bitsui-4, and Bitsui-5, indicating possible influence of groundwater from the CCBs located approximately 33 feet south of this backfill monitoring well.

Figure 11-35. Boron Concentrations in Bitsui and Watson Wells



The sulfate, TDS, and boron concentrations are higher in the Bitsui spoil wells in comparison with the concentrations observed from mine spoil leached with surface water and with coal water as presented in Table 11-14c. The higher concentrations in the Bitsui spoils in comparison with the leaching tests may be due to higher concentrations in the NAPI irrigation source water after it has leached the overburden materials between the irrigation site and the Bitsui Pit or it may be due to chemical evolution within the mine spoil linked to ion exchange and precipitation. Calcium and sulfate concentrations increase in spoil leachate from the dissolution of gypsum. Precipitation of calcite and ion exchange of calcium for sodium results in a larger increase in sulfate and a smaller increase in calcium. As shown in Table 11-14a, the calcium concentrations are lower and sodium and sulfate concentrations are higher in spoil wells Bitsui-4, Bitsui-5, and Bitsui-6 in comparison with concentrations observed from mine spoil leached with coal water as presented in Table 11-14b. These results suggest that ion exchange and precipitation in mine spoil permit sulfate concentrations to increase above gypsum solubility limits and above observations from short-term leaching tests.

Table 11-14a also provides a comparison of concentrations in spoil wells, CCB wells and potentially affected coal wells with the median baseline concentrations observed in Fruitland coal wells at the mine site and with median baseline concentrations observed in No. 8 coal wells down dip and down gradient near the subcrop with the San Juan River alluvium. The observations for downgradient coal wells SJKF#2, SJKF#3 and SJKF#4 wells are considered to be representative of baseline conditions in the coal because the samples were obtained in 1984 at the time that groundwater levels were just beginning to recover from the drawdown influence from mining as shown in the water level plots in adjacent coals wells KF83-1 and KF84-16 (Figure 11-30). The sample obtained in 1984 from downgradient coal well SJKF#5 is also considered to be representative of baseline conditions for the same reason. This well, however, is shown as a potentially affected coal well in Table 11-14a because it is much closer to the mine backfill and could be potentially affected at some time in the future.

Median concentrations are summarized in Table 11-14a along with the number of analyses available for each constituent, including field splits that are used for calculating the median at each well. Less than detection results are entered at 1/2 the detection limit for calculating the median concentration. When the calculated median is found to be at one half the value of a detection limit, the detection limit is shown as the median if it is lower than any detected result.

The baseline concentrations of TDS, calcium, and sodium in wells KF84-18a and KF84-18b were comparable with the concentrations observed in spoil wells, while the baseline concentrations for sulfate and boron were lower. The TDS, calcium, and sodium concentrations in the spoil wells are also lower than the concentrations observed in two of the three down gradient baseline coal wells. Sulfate concentrations in the spoil wells are higher than the baseline sulfate concentrations observed in coal wells. Boron concentrations in spoil wells Bitsui-4 and Bitsui-5 are comparable with the baseline boron concentrations in the down gradient coal wells. As discussed previously, the boron in spoil well Bitsui-6 is higher, due to influence from CCB placement immediately upgradient of this well. Bitsui-1, which is completed in the CCBs at this location, exhibits higher boron concentrations and lower sulfate concentrations in comparison with spoil well Bitsui-6.

Table 11-14a.
Concentrations for Selected Constituents in Navajo Mine Monitoring Wells

Location	Well	TDS (mg/L)		SO4 (mg/L)		Ca (mg/L)		Na (mg/L)		B (mg/L)	
		n	median	n	median	n	median	n	median	n	median
Baseline Fruitland Coals within coal lease (median concentrations From Table 6.G-9)	KF2007-01	5	3460	5	740	5	3.2	5	1180	5	0.33
	KF98-02	6	3130	6	107	8	6.9	6	1210	6	0.40
	KF84-18a	26	13400	26	5.5	26	157	26	4640	26	0.72
	KF84-18b	25	9300	25	<10	25	114	25	3380	25	0.73
	KF84-20A	26	7260	26	<10	26	18.4	26	2690	26	0.55
	KF84-20C	23	2770	23	7	23	9.6	23	1040	21	0.42
	KF84-21a	30	8375	30	63	30	13.3	30	3080	30	0.61
	KF84-21a	1	8505	1	184	1	14.6	1	2858	1	0.63
	KF84-22a	22	4650	22	2140	22	15.3	22	1600	22	0.27
	KF84-22b	26	6115	26	<10	26	45	26	2210	25	0.39
	KF84-22d	1	8610	1	<10	1	27.4	1	2866	1	0.50
	KF84-22e	2	8155	2	24.5	2	35.6	2	2803	2	0.51
	Median		7708		16		17		2747		0.51
Baseline Coal downgradient (median)	SJKF#2	1	43035	1	<10	1	515	1	13456	1	1.23
	SJKF#3	1	50810	1	<10	1	700	1	15632	1	1.43
	SJKF#4	1	7370	1	<10	1	27	1	2642	1	1.57
	Median		43035		<10		515		13456		1.43
Mine spoil (median)	Bitsui-4	20	15150	20	8900	20	290	20	4630	20	1.69
	Bitsui-5	21	11800	23	5030	23	59.5	23	3870	23	1.11
	Bitsui-6	20	14850	20	8850	20	368	20	4270	20	2.07
CCB wells (median)	Bitsui-1	25	14600	26	6995	26	75.3	26	4845	25	10.5
	Watson-4	13	4070	13	2010	13	703	13	510	13	18.3
Potentially Affected Coal Wells (median)	Bitsui-2	26	5145	26	165	26	6.21	26	2072	26	0.99
	Bitsui-3	17	7960	21	317	21	22.4	21	3130	21	1.07
	KF83-1	41	7100	41	340	41	19.4	41	2620	41	1.01
	KF84	26	7760	27	3860	27	48	27	2520	27	1.3
	KF84-16	32	9955	32	15.5	32	38.2	32	3835	32	1.26
	SJKF#5	1	4470	1	<10	1	5.57	1	1668	1	1.23

* All wells are shown on Exhibit 11-166 except for KF2007-1 and KF98-02 which are shown on Appendix 6-G Exhibit 6-G-1

** In the case of 2 values the median is averaging the data

Table 11-14b.

Selective Results of Batch Leach Tests

Comparison of leaching water (surface water from Chinde Arroyo and groundwater from Coal seam #4-6) and leachate water produced (Data from IT Corporation Leach Report, Appendix 11-K, Tables 27.B13 through 27B.29)

(Concentrations in milligrams per liter).

Water Source	PH	TDS	Ca	Na	Cl	SO4	Fe	Mn	B	F	Se	As	Cd
Surface Water from Chinde Arroyo	7.8	1,900	230	280	15	1,200	0.45	0.08	0.31	1.0	<0.001	<0.001	<0.001
Surface Water Leachate:													
Spoils S-4	7.8	4,600	640	850	43	2,700	0.06	0.7	<0.5	0.6	0.20	0.002	<0.001
Spoils S-5	8.2	3,500	320	750	27	2,300	0.02	0.26	<0.5	0.9	0.018	0.002	<0.001
Fly Ash	12.2	2,000	290	380	16	590	0.02	0.02	1.0	1.9	0.09	0.009	<0.001
Bottom Ash	8.5	2,000	260	330	22	940	0.03	0.07	<0.5	0.9	0.046	<0.001	<0.001
CCB w/ S-4	7.7	5,300	670	850	37	3,200	0.02	1.4	<0.5	1.0	0.018	<0.003	<0.001
CCB w/ S-5	8.1	4,500	550	800	29	3,000	0.08	0.39	<0.5	1.8	0.010	<0.003	<0.001
Groundwater from coal seams 4-6 (Composite #4)	8.2	9,800	140	3,500	5,200	120	0.15	0.03	0.53	0.3	0.011	0.015	0.001
Groundwater Leachate:													
Spoils S-4	7.8	12,000	730	3,200	5,500	2,700	0.06	0.7	<0.5	0.5	0.20	0.002	<0.001
Spoils S-5	8.2	11,000	530	3,200	5,600	2,300	0.02	0.26	<0.5	0.6	0.018	0.002	<0.001
Fly Ash	12	10,000	520	3,000	5,600	320	0.02	0.02	6.2	3.1	0.22	0.017	<0.001
Bottom Ash	8.5	8,700	170	3,500	5,500	170	0.03	0.07	0.6	0.7	0.020	<0.001	<0.001
CCB w/ S-4	7.9	12,000	790	3,100	5,700	2,000	0.04	1.3	<0.5	0.9	0.016	0.009	<0.001
CCB w/ S-5	7.9	12,000	740	3,700	5,600	2,000	0.09	0.64	0.9	1.3	0.009	0.008	<0.001

The potentially affected coal wells are all located adjacent to the pre-SMCRA mined locations within Area 1 as shown on Exhibit 11-167. KF84 is located adjacent to the Custer Pit while the other potentially affected coal wells in Table 11-14a are down gradient of the Bitsui Pit. The TDS, calcium, and sodium concentrations in these wells are generally consistent with the corresponding baseline concentrations in the coals while the sulfate and boron concentrations are slightly higher (see Table 11-14a).

Outside of these groundwater level and water quality changes that have been observed in the coals adjacent to the Bitsui Pit, the only other groundwater change that has been observed at the Navajo Mine is the drawdown in water levels in several of the coal wells adjacent to mining within Area II and Area III. The 2006-07 Navajo Mine Hydrology Report (BNCC, 2009) shows declines in water levels in No. 8 coal seam well KF84-18b and No 7 coal seam wells KF84-20C and KF84-22b. Water levels have fluctuated in the No. 8 coal seam well KF84-18b but this well has been dry or has had insufficient water for sampling for most of the monitoring events since year 2003. Water levels in several of the other coal seam wells listed in Table 11-14a have been dry or have insufficient water for sampling since year 2001, these include wells KF84-20C, KF84-22b, KF84-18a, KF84-20B, KF84-20A, and KF84-21A.

Although drawdown effects have been observed prior to year 2002 in several of the baseline coal monitoring wells listed in Table 11-14a, the water quality monitoring through year 2001 at these wells has been selected to represent baseline water quality. There could be no influence from the mine on water quality of these wells because the hydraulic gradients at these well locations would have been toward the mine pit after the start of mining. These baseline coal wells are at locations that are quite distant from NAPI plots and results are not affected by NAPI irrigation unlike the monitoring wells near the Bitsui Pit. The water quality in these wells after reclamation can be compared with the baseline quality to identify any changes that might be due to mining.

During mining operations, all strata overlying the Fruitland coal seams are stripped to expose the coal for mining. Each successive open cut serves as a sink for groundwater causing drawdown of potentiometric levels in the adjacent coals and the underlying PCS. The potential impact of mining activities on groundwater quantity was addressed in Chapter 6. In that analysis, a three dimensional model was used to evaluate hydrologic consequences due to stress propagation from pit advance. The analysis showed that the stress propagation resulted in minimal impacts to the hydraulic regime as drawdown of only two to three feet were computed near the mine area for the coal seams and interbedded lithologic units of the Fruitland Formation. The effects of mining on the water bearing strata decrease by orders of magnitude within a few miles of the mine area (Appendix 6-D).

Average inflow to the entire mine area was estimated to be approximately 239 acre-feet per year over a model simulation time of 12 years. Observations during actual mining have shown that these model estimates of mine inflow were too high. Groundwater inflows to the mine pits in Area II and Area III have rarely been sufficient to be observed as seeps along the highwall. The pit floors remain dry except on rare occasions when storm runoff is captured. It appears that any groundwater flow to the mine pits from the Fruitland Formation is consumed by evaporation from the highwall. Also, no noticeable upward seepage through the pit floor or significant disruption of the mine floor (shale layer) has been observed in the mine pits.

11.6.2.2 Groundwater Impacts due to CCB Placement and Mine Spoil

The mine spoils are the non coal overburden and interburden materials of the Fruitland Formation that are removed to allow access to the coals and then placed within the mined pit to achieve approximate original contour. The overburden and interburden is generally comprised of fine to medium grained sandstones, siltstones, sandy and silty claystones, carbonaceous claystones, and bentonitic claystones, although the mostly tan or gray shale dominates. The clays are commonly highly expansive and are believed to be smectites. The potential to form acidic material from the oxidation of sulfur is not common and pH values are typically highly alkaline (pH > 8.0). Removal and backfilling of overburden and interburden materials provides for adequate blending and mixing of overburden materials ensuring that potential acid forming materials are blended with neutralizing materials such that acidic water will not occur within the mine spoil. This conclusion is supported by laboratory results of acid-base accounting of mine spoil samples, which shows average total sulfur acid base potential of approximately 19.0

tons/kilotons and by the neutral to alkaline pH levels observed in the Bitsui backfill monitoring wells. The laboratory results of the spoil samples were analyzed as part of Navajo Mine's root-zone monitoring program, and provided annually to OSM in the root-zone sampling reports

Between 1971 and 2008, BNCC placed CCBs from FCPP in mined out pits or ramps at Navajo Mine. BNCC does not have any current operational plans to place CCB materials in the mine backfill for future reclamation within the permit boundary. Historic placement locations are primarily within Area I with limited placement in Area II. As discussed in Section 11.6.2.1, the SGS (Appendix 11-MM) was implemented to assess possible impacts to groundwater from historic mine placement of CCBs at Navajo Mine. BNCC has also completed detailed studies of the constituents leached from CCBs and mine spoil for the PHC determination. The results of these studies are provided in Appendix 11-K. Spoil and CCBs do not exhibit hazardous toxicity as demonstrated by the EP toxicity tests results in Appendix 11-K. Leaching tests and physical and chemical testing were also performed as described in Appendix 11-K to quantify the interactions between the CCBs, the mine spoils, the coals and the groundwater in the coals. These results show that, except for boron, CCBs and spoil material have similar leaching concentrations. A subsequent spoil testing program was also completed in year 2008 to generate additional information on spoil properties and leaching characteristics of mine spoil. These testing results are presented in Appendix 11-VV and are used to support the PHC assessment for proposed spoil placement as mine backfill within Area IV North at Navajo Mine.

Parameter concentrations (mg/kg) of a solid matrix of CCB and of spoil disposed of at Navajo Mine are presented in Tables 11-14c and 11-14d (taken from the Appendix 11-K, Tables 27-B3 and 27-B4). The only notable parameter differences with the spoil is that fly ash has elevated concentrations of boron, and slightly higher concentrations of selenium and barium. For the remainder of the trace metals, the concentrations of spoil, fly ash, and bottom ash are similar. Both bottom ash and fly ash have lower concentrations of sulfate, sodium, and calcium when compared to spoil.

Per USEPA's 1993 final regulatory determination CCB materials (fly ash, bottom ash, boiler slag, and flue gas emission control waste) are exempt from regulation as a hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA, 58 FR 42466, 9 Aug 1993). Solid samples of fly ash, bottom ash, and spoil were subjected to the Extraction Procedure (EP) Toxicity Test and the extract from this procedure was subsequently analyzed for a suite of metals and general chemistry. The results (Appendix 11-K, Table 27.B11) were all below the limits for EP toxicity used to classify a material as toxic.

Table 11-14b is a comparison of surface and groundwater concentrations before and after they have been leached through different mixtures of spoil and CCB. The data presented in Table 11-14b was selectively extracted from data tables contained in Appendix 11-K. Several general relationships are evident from Table 11-14b for both groundwater and surface water as follows.

1. Surface water and groundwater leached through fly ash or bottom ash had lower TDS than when leached through spoil and is similar to the original concentration of the pre-leach water.
2. In general, the leachates produced do not widely differ from that of coal seam groundwater. TDS concentrations in the leachate have increased (except for bottom ash, which had a lower TDS than the groundwater) due to increases in sulfate, calcium, and chloride concentrations. However, the increased TDS concentration is small in comparison to the concentration of the coal groundwater.
3. Trace constituent concentrations are similar for all the leachates produced, with the exception of fly ash alone, which showed increases in arsenic, boron, and fluoride and selenium concentrations.
4. Spoil serves to attenuate arsenic, boron, and fluoride when concentrations are slightly elevated in fly ash leachate, in baseline surface water and in baseline coal seam water.
5. The iron concentration in both surface water and groundwater decreased following leaching through spoil, CCB, or a mixture of the two. Manganese concentrations increased in both surface and groundwater leaching of mine spoil but not in leaching of fly ash or bottom ash.
6. Selenium concentrations in surface water and groundwater leached through a mixture of CCB and spoil are similar to the selenium concentrations in leachate produced by spoil alone. Boron concentrations in groundwater leached through a mixture of CCB and spoil are similar to the original concentration of the groundwater. Boron

concentrations declined in surface water leached through a mixture of CCB and spoil. Fluoride concentrations also declined in surface water leached through spoil.

Table 11-14c

Coal Combustion By-product (CCB) Analysis Summary

(Table 27-B3, Appendix K)

PARAMETER	UNIT	CCB	
		FLY ASH (No sludge)	BOTTOM ASH
Acidity(1)	mg/kg $CaCO_3$	<100(3)	397
Alkalinity(1)	mg/kg $CaCO_3$	11,577	2,976
Chloride	mg/kg	100	124
Cyanide	mg/kg	0.20	0.22
Fluoride	mg/kg	176	81
Nitrate(1)	mg/kg No_3-N	<1	2
pH		NA(2)	NA
Phenolics	mg/kg	1.29	1.36
Residue:			
Filterable @ 180 ^{0} C	mg/kg	NA	NA
Specific Conductance @ 25 ^{0} C	µmhos/cm	NA	NA
Sulfate(1)	mg/kg SO_4^{-2}	1,667	<100
Metals:			
Aluminum	mg/kg	6,600	2,000
Arsenic	mg/kg	11	0.38
Barium	mg/kg	850	420
Boron	mg/kg	160	10
Cadmium	mg/kg	0.4	<0.1
Calcium	mg/kg	12,000	3,000
Chromium	mg/kg	5	<1
Cobalt	mg/kg	2	1
Copper	mg/kg	0.063	0.023
Iron	mg/kg	5,300	2,100
Lead	mg/kg	26	<1
Magnesium	mg/kg	530	150
Manganese	mg/kg	99	32
Mercury	mg/kg	0.2	<0.1
Molybdenum	mg/kg	<6	<6
Nickel	mg/kg	2	<1
Potassium	mg/kg	162	44
Selenium	mg/kg	6.5	<2(4)
Silver	mg/kg	<0.2	<0.2
Sodium	mg/kg	430	84
Zinc	mg/kg	13	5

(1) Water leachable.
(2) NA – not analyzed.
(3) < - Less than.
(4) Higher detection limits due to matrix interference.

Table 11-14d

Spoils and Overburden Analysis Summary

(Table 27-B4 Appendix K)

PARAMETER	UNIT	S–1	S–2	S–3	S–4	S-5	D-1	D-2
Acidity(1)	mg/kg $CaCO_3$	399	299	197	399	298	399	398
Alkalinity(1)	mg/kg $CaCO_3$	3,293	3,693	3,945	3,593	3,777	7,186	3,877
Chloride(1)	mg/kg	250	150	246	200	248	399	149
Cyanide	mg/kg	0.17	1.18	0.20	0.25	0.20	0.08	0.20
Fluoride	mg/kg	471	463	420	575	503	403	332
Nitrate(1)	mg/kg NO_3-N	29	16	12	20	24	15	20
pH		NA(2)	NA	NA	NA	NA	NA	NA
Phenolics	mg/kg	1.09	1.19	1.09	1.18	1.05	0.90	1.98
Residue:								
Filterable @ 180 ^{0} C	mg/kg	NA	NA	NA	NA	NA	NA	NA
Specific Conductance @ 25 ^{0} C	µmhos/cm	NA	NA	NA	NA	NA	NA	NA
Sulfate	mg/kg SO_4^{-2}	8,982	7,236	6,410	12,724	6,610	1,946	3,529
Metals:								
Aluminum	mg/kg	8,100	7,400	5,500	6,600	6,600	9,200	6,200
Arsenic	mg/kg	6.5	6.0	36	17	4.3	4.5	4.6
Barium	mg/kg	180	42	130	520	150	110	120
Boron	mg/kg	9	8	4	<3(3)	4	<3	<3
Cadmium	mg/kg	1.0	0.9	1.1	0.9	0.8	1.1	0.9
Calcium	mg/kg	16,000	17,000	7,9000	9,500	27,000	14,000	11,000
Chromium	mg/kg	3	3	2	3	3	6	6
Cobalt	mg/kg	7	7	8	7	9	7	6
Copper	mg/kg	11	6	6	15	9	10	0.143
Iron	mg/kg	14,000	13,000	39,000	27,000	14,000	20,000	18,000
Lead	mg/kg	35	32	58	35	32	42	72
Magnesium	mg/kg	2,900	3,100	2,300	2,100	2,900	4,100	6,200
Manganese	mg/kg	200	200	360	190	470	350	250
Mercury	mg/kg	<0.1	<0.1	0.2	0.8	<0.1	0.2	0.2
Molybdenum	mg/kg	<6	<6	<6	<6	<6	<6	<6
Nickel	mg/kg	10	9	13	10	13	10	9
Potassium	mg/kg	1,100	1,400	906	1,200	1,400	903	801
Selenium	mg/kg	<1(4)	<2(4)	<2(4)	<2(4)	<2(4)	<1(4)	<1(4)
Silver	mg/kg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Sodium	mg/kg	2,600	2,700	2,700	3,500	2,700	2,900	1,400
Zinc	mg/kg	66	63	58	71	69	63	56

(1) Water leachable.
(2) NA – not analyzed.
(3) < - Less than.
(4) Higher detection limits due to matrix interference.

These leaching test results together with the data collected from the SGS that were presented in Section 11.6.2.1 show that some increase in TDS concentrations would be expected in mine spoil water in comparison with the TDS concentrations in the original source of water (i.e. groundwater or surface water). The leaching tests indicate that the increase in TDS is due primarily to increases in calcium, sodium, and sulfate while the field monitoring results from the SGS indicate that the increase in TDS is due primarily to increases in sodium and sulfate. Apparently, precipitation of calcite allows sulfate to increase above gypsum solubility limits accounting for the increase in sulfate and decrease in calcium in saturated mine spoils in comparison with leaching test results. The groundwater monitoring data from the Navajo Mine show that baseline groundwater in the coals is very saline. TDS levels have remained at or near baseline concentrations in the potentially affected coal seam wells located near the backfilled mine pits as discussed in Section 11.6.2.1.

The leach study, as well as the data from the SGS, shows that TDS and sulfate concentrations are lower in saturated CCBs in comparison with mine spoils when the source of saturation is surface water or groundwater. Also, TDS and sulfate concentrations do not increase in CCBs that become saturated with spoil water. Arsenic, boron, fluoride, and selenium concentrations increased in fly ash leachate and also showed higher concentrations in CCB wells Bitsui-1 and Watson-4 in comparison with the concentrations in spoil wells (see Table 11-14e). Selenium concentrations in the CCB wells were below the livestock criterion of 0.05 mg/l. Boron and fluoride in the CCB wells were above the relevant livestock criteria of 5 mg/l and 2 mg/l, respectively (Appendix 6.G, Table 6.G-2). Arsenic concentrations in the CCB wells were about an order of magnitude lower that the relevant livestock criteria of 0.2 mg/l for surface water in the Navajo Nation (Navajo Nation Environmental Protection Agency Water Quality Program, 2008). Other trace constituents were also below detection limits in the majority of the samples from both CCB and spoil wells and are not listed in Table 11-14e.

Table 11-14e

Trace Constituent Concentrations in Spoil and CCB Wells

Location	Well	As (mg/L)		B (mg/L)		Fe diss (mg/L)		Mn diss (mg/L)		F (mg/L)		NO3-N (mg/L)		Se (mg/L)	
		n	median	n	median	n	median	n	median	n	median	n	median	n	median
Mine spoil (median)	Bitsui-4	20	0.0025	20	1.69	20	0.51	20	3.650	20	0.30	3	0.330	20	0.0025
	Bitsui-5	24	0.0025	23	1.11	23	0.11	23	0.108	23	1.00	2	0.050	23	0.0025
	Bitsui-6	20	0.0025	20	2.07	20	0.345	20	4.560	20	0.29	4	0.090	20	0.0025
CCB wells (median)	Bitsui-1	24	0.0210	25	10.5	25	0.100	25	0.200	26	2.25	5	1.400	25	0.0060
	Watson-4	12	0.0048	13	18.3	12	0.175	13	0.010	13	3.86	5	0.050	13	0.0120
Potentially Affected Coal Wells (median)	Bitsui-2	25	0.0025	26	0.99	26	<0.03	26	<0.01	26	1.7	5	0.5	26	<0.0025
	Bitsui-3	20	0.0025	21	1.07	21	0.06	21	<0.01	20	1.02	4	1.1	21	<0.0025
	KF83-1	22	0.0025	41	1.01	40	0.14	41	<0.02	41	1.07	11	0.03	39	<0.0025
	KF84	17	0.0025	27	1.3	26	0.13	27	0.14	27	2.7	2	0.085	27	<0.0025
	KF84-16	18	0.0025	32	1.26	32	0.14	32	0.05	32	0.69	6	0.11	31	<0.0025
	SJKF#5	1	0.0010	1	1.23	1	0.036	1	0.17	1	2.07	1	-	1	<0.001

The arsenic, boron, and fluoride concentrations in spoil well Bitsui-6 located immediately down gradient of CCB well Bitsui-1 confirm the leaching tests results which found that spoil attenuates or reduces the concentrations of arsenic, boron, and fluoride. The CCB and spoil well monitoring results in Table 11-14e also indicate likely attenuation of selenium in saturated mine spoils. Attenuation of metals in mine spoil occurs as a result of adsorption associated with the high cation-exchange-capacity (CEC) of mine spoils and geochemical precipitation and co-precipitation. Also, when groundwater containing low sulfate levels interacts with the spoil, sulfate concentrations increase. Laboratory data suggest that colloidal hydroxides are formed when the spoils and water interact. This geochemical interaction and mixing facilitates the adsorption and precipitation of metals, thus reducing their concentrations. The attenuation data from the leach study (Appendix 11-K) also shows that the concentrations of many parameters would be reduced after contact with the coal seam. While cation-exchange and precipitation reactions are finite and reversible processes the source of metals is also a finite process and cation-exchange and sulfide precipitation is expected to significantly reduce metals concentrations in down gradient groundwater.

Sulfate reduction resulting in metal sulfide precipitation results in highly insoluble precipitates (Drever, 1998). The sulfide precipitates will remain in mineral form unless sufficient oxygen is provided to the system. Given the very low recharge and groundwater flow rates at the site the release of metals trapped as sulfides is unlikely and should act as a relatively permanent sink within the system. Additionally, given the large source of sulfate within the system, observed sulfate reduction to sulfide, and the finite source of metals the natural attenuation of metals due to metal sulfide precipitation is likely to reduce metal concentrations down gradient.

The cation-exchange process will only reverse if there is a significant geochemical change in the inflowing water source. One such difference that could cause the release of metals would be a lowering in pH. The lowering of pH increases the hydronium ion concentration and competes for exchange sites with cations. However, as shown in the leachate testing the pH remains neutral to slightly alkaline and the inflowing coal groundwater is very alkaline with a pH of approximately 9. This indicates that over time the groundwater will increase in pH to a value similar to the inflowing groundwater at a pH of 9 and not result in the displacement of metals from exchange sites. Additionally, the metals that are attenuated by cation-exchange would require higher concentrations of other metals or the presence of newly incorporated metals with a greater exchange site affinity to displace those metals on the exchange sites. Thus, the total number of exchange sites and the amount of the finite source will determine whether or not the metals will breakthrough. Once the source is depleted some metals may desorb over time to equilibrate with the new incoming water chemistry while a portion of the metals will remain at the exchange sites resulting in overall reduction and attenuation over time leading to lower trailing concentrations rather than a breakthrough of high metals concentrations.

Mine spoil does not appear to be a source for selenium as concentrations were below the 0.005 mg/l detection limit in the groundwater samples obtained from the three spoil monitoring wells Bitsui-4, Bitsui-5 and Bitsui-6. On the other hand, mine spoil does appear to be a source for manganese, which increased in spoil leachate and also showed higher concentrations in spoil wells in comparison with CCB wells as shown Table 11-14e and with baseline coal wells as shown in Appendix 6-G Table 6.G-9. The concentrations of other constituents in the spoil water are comparable to the concentrations in the baseline groundwater in the PCS and Fruitland coals.

The water quality in the mine spoils and in the baseline groundwater are both poor and chloride, sulfate, and TDS concentrations exceed relevant criteria for drinking water and livestock use (Appendix 6.G, Table 6-G-2). Based on the Table 11-14e results, the arsenic, boron, fluoride, and selenium concentrations in the mine spoils are expected to meet livestock use criteria (Appendix 6-G). The fluoride concentrations fluctuate in the baseline groundwater and are often above the relevant criteria for livestock and drinking water use (Appendix 6.G, Table 6-G-2).

Additional leaching tests were performed on Navajo Mine spoils to support the PHC assessment for proposed spoil placement as mine backfill within Area IV North at Navajo Mine. These testing results are presented in Appendix 11-VV These leaching tests included 18-hour batch leaching tests of composite mine spoils performed in accordance with the USEPA Synthetic Precipitation Leaching Procedure (SPLP, SW-846 Method 1312) and with the Synthetic Groundwater Leaching Procedure (SGLP). Also, 45-day leaching tests were included along with the standard 18-hour leaching procedure, in order to assess any changes associated with longer exposure to the leachant.

Composite spoil samples were obtained from Navajo Mine Area III in accordance with the regraded spoil sampling plan (Chapter 12 Section 12.3.1). A composite sample of coal seam water was comprised of equal proportions of water extracted from the No. 8 coal seam well KF2007-01 and from the No. 3 coal seam well KF98-02, located within Area IV. Two duplicate samples of the composite coal water were obtained and analysis results are presented in Table 11-14f as "Initial Coal Water Sample" and "Initial Coal Water DUP."

Synthetic precipitation was prepared in the laboratory and used as a surrogate for field site precipitation that could percolate through the spoil backfill and provide recharge to groundwater and potentially surface water discharge. The prepared solution is highly purified water with strong solvating properties. The water quality is presented in Table 11-14f under the heading "Initial Synthetic Precipitation".

The composite spoil was leached in duplicate (18-hr tests) with coal well water (Spoil Leachate 1 and Spoil Leachate 1 DUP; a test in which spoil is exposed to coal water for 45 days according to the long-term leaching procedure described above (Spoil 45-Day). Finally, an 18-hour leaching test of spoil was performed using the synthetic leaching fluid described in the SPLP (Spoil SPLP).

The leaching test results indicate that the pH of leachate using the expected field site materials and waters remains neutral to alkaline, indicating that low pH values that are typically responsible for enhanced trace metals transport will not exist with the mine backfill at the Navajo Mine. This finding is supported by data collected and conclusions reported for site wide geologic and hydrologic conditions. The synthetic precipitation leaching solution started with an initial pH of 5.0 and increased to a pH value of 7.5 for the spoil 18-hour batch samples, indicating the buffering influence of these materials to slightly alkaline conditions. An initial flush of salts, principally calcium and sulfate, occurs with leaching of these spoil along with detectable concentrations of some metals and trace constituents as indicated in Table 11-14f.

Fluoride was at a concentration of 2.4 mg/l in the background composite coal groundwater sample used in the leaching test. However, fluoride concentrations are attenuated in mine spoils as demonstrated by the leaching test results of mine spoil, which showed fluoride concentrations dropping from the concentration of 2.4 mg/l in the composite coal water used for leaching to concentrations of 1.6 and 1.5 mg/l in the in 18-hour and 45-day spoil leachates, respectively.

Thus, if spoil water does saturate CCB, the probable result is that concentrations of arsenic, boron, fluoride, and selenium may increase in the CCB material but these concentrations should decrease due to attenuation as this water migrates through the spoil, as supported by observed field and laboratory leachate data. TDS and sulfate concentrations are not expected to increase in CCBs that become saturated with spoil water. The concentrations of sulfate, sodium, TDS, boron, and manganese are expected to increase in spoils that become saturated with surface water infiltration or groundwater. Sulfate concentrations are likely to increase in the coal seam water adjacent to the mine pit as shown in Figure 11-31 for the coal wells adjacent to the Bitsui Pit. TDS would also increase in the coals adjacent to the mine pit but by less than the increase in sulfate as demonstrated in Figure 11-31.

Table 11-14f

Batch Leaching Test Results

Analyte (mg/L)	USEPA Drinking Water Criteria	Aquatic & Wildlife Habitat (Acute)[1]	Aquatic & Wildlife Habitat (Chronic)[1]	Livestock (LW)[1]	Initial Coal Water Sample	Initial Coal Water DUP	Initial Synthetic Precipitation	Spoil SPLP	Spoil 45-Day	Spoil Leachate	Spoil Leachate Dup
Al[3]		0.750 mg/L	0.87 mg/L	NCNS	0.13	0.14	0.056	< 0.05	0.38	0.29	0.3
Sb	0.0056				<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067
As	0.01	0.340 mg/L D	0.150 mg/L D	0.200 mg/L	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015
Ba	1	NCNS	NCNS	NCNS	0.093	0.088		0.07	0.079	0.25	0.2
Be	0.004				< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
HCO_3					1300	1200		33	960	1000	1000
B	0.63	NCNS	NCNS	5.0 mg/L D	0.31	0.29		0.084	0.36	0.44	0.45
Cd[2]	0.005	0.005	0.0005	0.05 mg/L	<< 0.00051	<< 0.00051	<< 0.00051	<< 0.00051	<< 0.00051	< 0.006, 0.00087*	<< 0.00051
Ca					3.4	3.3	0.27	150	56	64	69
CO_3					260	300	< 7	14	< 7	< 7	< 7
Cl	250				710	700		1.5	600	610	610
Cr (III + VI)[4]	0.1	1.2	0.156	1.0 mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Co		NCNS	NCNS	1.0 mg/L D	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cu	1.3	0.032	0.019	0.5 mg/L D	< 0.005	< 0.005	< 0.005	< 0.005	0.053	< 0.005	< 0.005
F	2	NCNS	NCNS	NCNS	2.4	2.5	0.0067	0.54	1.5	1.6	1.6
Fe	0.3				0.067	0.073	< 0.05	< 0.05	< 0.05	0.17	0.18
Pb	0.015	0.171	0.007	0.100 mg/L	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011
Li					< 0.1	< 0.1	< 0.1	< 0.1	0.11	0.1	0.1
Mg					1.3	1.2		15	12	13	13
Mn	0.05[3]				< 0.01	< 0.01	< 0.01	0.19	0.098	0.11	0.1
Hg	0.002	0.0024 mg/L	0.000001 mg/L	NCNS	<< 0.00005	<< 0.00005	<< 0.00005	<< 0.00005	<< 0.00005	< 0.00024, 0.0001*	< 0.0002, 0.00008*
Mo		NCNS	NCNS	NCNS	0.012	< 0.01	< 0.01	< 0.01	0.015	0.014	0.014
Ni	0.61	1.011	0.112	NCNS	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
pH (standard units)	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	9	8.9	5	7.5	8	8	7.9
K					11	10	< 1	7	14	14	14
Se	0.05	0.033 mg/L	0.002 mg/L	0.05 mg/L	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026
Ag	0.035	0.0154	NCNS	NCNS	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Na					1200	1100	5.7	150	1200	1200	1200
SO_4	250				300	260	3.4	670	930	970	990
Tl	0.0017	0.700 mg/L D	0.150 mg/L D	NCNS	<< 0.011	<< 0.011	<< 0.011	<< 0.011	< 0.4, 0.014*	<< 0.011	<< 0.011
TDS	500				3100	3000	28	1200	3500	3500	3600
V		NCNS	NCNS	0.100 mg/L D	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	5	0.253	0.255	25 mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0095

[1] Navajo Nation Water Quality Program, **2007**, Navajo Nation Surface Water Quality (NN SWQ) Standards.
[2]Hardness dependent criteria in NN SWQ Standards 2007 calculated based on median hardness for Chinde Arroyo of 248.5 mg/L as CaCO3
[3] pH 6.5 – 9
[4]Hardness dependent criteria in NN SWQ Standards 2007 for Cr(III) only
<< Reported value is less than the MDL
*Above MDL, but below PQL
D – Dissolved; NCNS – no current Navajo standard

11.6.2.3 Potential Migration of Spoil and CCB Leachate in Groundwater From Current Mining and Reclamation Operations

As discussed, re-saturation of a portion of mine spoil within the Bitsui and Dodge pits has occurred over a period of about 25 years due to the contribution of seepage flow from adjacent NAPI irrigation. The Doby Pit is also located adjacent to NAPI irrigation plots. However, BNCC installed the Doby French drain adjacent to the Doby highwall to intercept seepage from the NAPI irrigation plots in order to curtail the resaturation of the Doby Pit. A backfill monitoring well, Doby-1-BF, was completed in the Doby Pit to monitor the rate of re-saturation of the Doby Pit and to assess the effectiveness of the Doby French Drain. The well has been monitored annually since September 2002 and has been dry during every monitoring event.

The rate of re-saturation is expected to be extremely slow at the other mine pits at Navajo Mine. This conclusion is based on the following:

- Groundwater modeling described in Section 11.6.2.4.1 found that resaturation of the backfilled pit within Area IV North will be very slow and will take several centuries or longer to approach steady state post-mining levels.
- Groundwater in the coal monitoring wells KF84-18a and KF84-18b located adjacent to the backfilled Yazzie Pit have remained nearly dry, indicating little or no water level recovery in the backfill.
- Well Doby-1-BF installed in the Doby Pit backfill has remained dry over the period from to 2002 to 2010. The Doby well was installed to assess the effectiveness of the Doby French Drain at intercepting seepage from the adjacent NAPI plots. These results demonstrate that the French Drain was effective and captured seepage from nearby NAPI irrigation. These results also show that without the NAPI seepage influence, the rate of re-saturation of mine backfill will be extremely slow.

The Yazzie Pit is the only pit at Navajo Mine, other than the mine pits within Area I, which is located near a potential source of water in Chinde Arroyo and the Chinde Diversion that could re-saturate the backfill more quickly than the extremely slow rates predicted for the Area IV North mine backfill in Section 11.6.2.4.1. A gain-loss evaluation of Chinde Arroyo and the

Chinde Diversion found that there was water loss within Segment 3, the uppermost segment of the Chide Diversion (see Appendix 11-OO). The Chinde Diversion routes flow around the Yazzie Pit. The uppermost segment routes flow to the north along the east side of the Yazzie Pit. It then bends to the west and flows between the backfilled Yazzie and Doby Pits. Chinde Arroyo at the point of the diversion was originally an ephemeral stream but now exhibits perennial flow due to irrigation return flows and seepage along with occasional flows caused by discharge from the Navajo Indian Irrigation Project (NIIP) Ojo Amarillo canal and storm runoff events.

According to the Chinde Wash Surface Water Gain/Loss report (Appendix 11-OO), the water loss within Reach 3 of the Chinde Diversion is largely the result of evapotranspiration losses from the wetlands and salt cedar thickets that exist at the head of the diversion and to a lesser extent the result of seepage from the diversion that can be seen in the Yazzie highwall immediately below this wetland area at the head of the diversion. Although most of this seepage from the Chinde Diversion is currently lost to evaporation, it is likely that a portion of the seepage enters the Yazzie Pit backfill. This seepage contribution could increase the rate of re-saturation of the backfill in the Yazzie Pit, although rates of re-saturation should be slower than was observed for the Bitsui Pit because the seepage contribution is thought to be relatively small based on the following:

- both the Yazzie and Doby Pits, located adjacent to the Chinde Diversion, remained dry during mining and reclamation operations,
- the Doby-1-BF monitoring well installed in the backfill of the Doby Pit adjacent to the Chinde Diversion has remained dry, and
- little recovery of groundwater levels has been observed in coal wells KF84-18a and KF84-18b located adjacent to the Yazzie Pit.

Potentiometric surface maps for the Fruitland coal units (Exhibits 6-2 through 6-5 and Exhibits 6.G-2 and 6.G-3) all show general gradients toward the east in the direction of the dip of the coal and toward the northeast in the direction of the subcrop of the Fruitland Formation with the San Juan River alluvium. Both groundwater modeling and water level measurements from the network of monitor/piezometer wells installed by BNCC also indicate local gradients in the Fruitland coals toward Cottonwood and Pinabete Arroyos within Areas III and IV as shown in

Exhibits 6.G-2 and 6.G-3. Potentiometric gradients were found to be quite flat across Area III while the coal units within and adjacent to Area II were dry or nearly dry.

11.6.2.3.1 Area I Groundwater Migration

Based on the potentiometric surface for the No. 8 coal, the discharge locations for the re-saturated mine spoil within Area I are projected to be:

- the subcrop of the No. 8 coal and the Fruitland Formation beneath the alluvium of San Juan River Valley to the northeast of Area I and
- down dip in the No. 8 coal Seam toward the drawdown influences of nearby coal bed methane wells (Exhibit 11-166).

The subcrop of the No. 8 coal seam and the Fruitland Formation beneath the alluvium in the San Juan River Valley occurs at elevations below the water levels in the coal seam to the south. The San Juan River alluvium, herein, refers to the unconsolidated Quaternary deposits of alluvium and Pleistocene outwash materials. The characteristics of the deposit varies but is largely comprised of either a gravel or sand matrix containing varying combinations of boulders, cobbles, pebbles, and silt. The approximate location for the coal subcrop is depicted in Exhibit 11-166. The approximate extent of the San Juan River alluvium along the Fruitland Formation subcrop is also mapped out in this exhibit. This subcrop location along the alluvium of the San Juan River is thought to be the primary discharge location for groundwater in the No. 8 coal and in the undifferentiated Fruitland Formation.

Discharge from the coal seam may also occur as leakage into the units above or below the coal. Although the potential rate of leakage through the shale, mudstone, and siltstones which overlie and underlie the coal seam is very low, the area of contact above and below the coal is sufficiently large that the potential discharge via leakage can be significant. However, the higher predicted potentiometric elevations in the PCS in the vicinity of Morgan Lake, as depicted in Exhibit 11-166, are predicted to limit or preclude vertical downward leakage into the PCS from the coal and the mine backfill and may even provide a source of water for recharging the backfill. Upward vertical gradients will diminish as water levels rise in the pit backfill.

However, it is expected that gradient reversal will be limited to locations more distant from Morgan Lake such that little spoil water within Area 1 will enter the PCS. Lateral groundwater flow is expected to occur from the saturated mine backfill in the direction toward the subcrop in both the No. 8 coal and in the undifferentiated Fruitland Formation.

A groundwater transport model was applied to assess the potential impact of mine spoil and CCB placement within Area 1 on the water quality in the down gradient coal seam and on the water quality in the alluvium of the San Juan River valley. This model represents a simplification of the groundwater flow system. Estimates of hydraulic variables and physical relationships used for the model are based on presently available data. For the purpose of this evaluation, it is assumed that the primary path for groundwater flow from the mine spoil will be through the coal in a north-north east direction toward the coal formation subcrop in the San Juan River alluvial aquifer (see Figure 11-24). Some groundwater flow will also occur through the undifferentiated Fruitland Formation but the rate and magnitude of this flow is expected to be lower than in the coal due to the lower hydraulic conductivity and higher porosity of the undifferentiated Fruitland Formation relative to the coal.

A steady-state MODFLOW model of groundwater flow through the coal was set up to support the groundwater transport modeling. The MT3DMS model was applied in conjunction with the steady state MODFLOW model to simulate advection, dispersion/diffusion, and sulfate reduction in order to estimate transport through the coal to the subcrop location along the San Juan River alluvium. The mass transport parameters for dispersion and decay (sulfate reduction) were estimated based on calibration to the sulfate breakthrough concentrations observed in the down gradient coal well Bitsui-2. Sulfate decay rates estimated from model calibration were found to be at the lower bound of the estimated decay rates reported in the literature (Benner et al., 2002; Appelo and Postma, 2007; Doshi, 2006; and Praharaj and Fortin, 2008).

As shown from Figure 11-24, the most northern portion of the mine area, where spoils have been placed, is the Bitsui Pit located more than 5,000 feet from the coal subcrop with the San Juan River alluvial aquifer. Saturation within the Bitsui Pit extends for a distance of approximately 2,000 feet perpendicular to the estimated direction of flow as depicted in Figure 11-24. The water elevation in the Bitsui Pit backfill is estimated at 5,164 feet based on water level measurements in the Bitsui backfill wells. The water elevations in these wells have been within about 1-foot of this estimate over the period from 2001 through 2010. The 5,164 elevation was specified as a constant head in the along the south boundary of the MODFLOW model domain shown in Figure 11-24. Head levels in the coal beneath the San Juan River alluvium along the northern boundary of the MODEFLOW model domain shown in Figure 11-24 were estimated based on the heads in the alluvium. These alluvial heads were estimated to vary linearly from the San Juan River elevation of 5,087 feet at the west end to the river elevation of 5,132 at the east end of the specified head boundary. No flow model boundaries were specified on the west and east sides of the MODFLOW model domain shown in Figure 11-24. The boundary on the west side extends to the approximate outcrop of the coal and beyond limits of saturation in the backfill. The no flow boundary on the east side was set at a sufficient distance from the Bitsui Pit to have minimal influence on the dispersion calculations. The model mass balance difference is approximately 1%, indicating insignificant mass contribution from beyond the east and west boundaries.

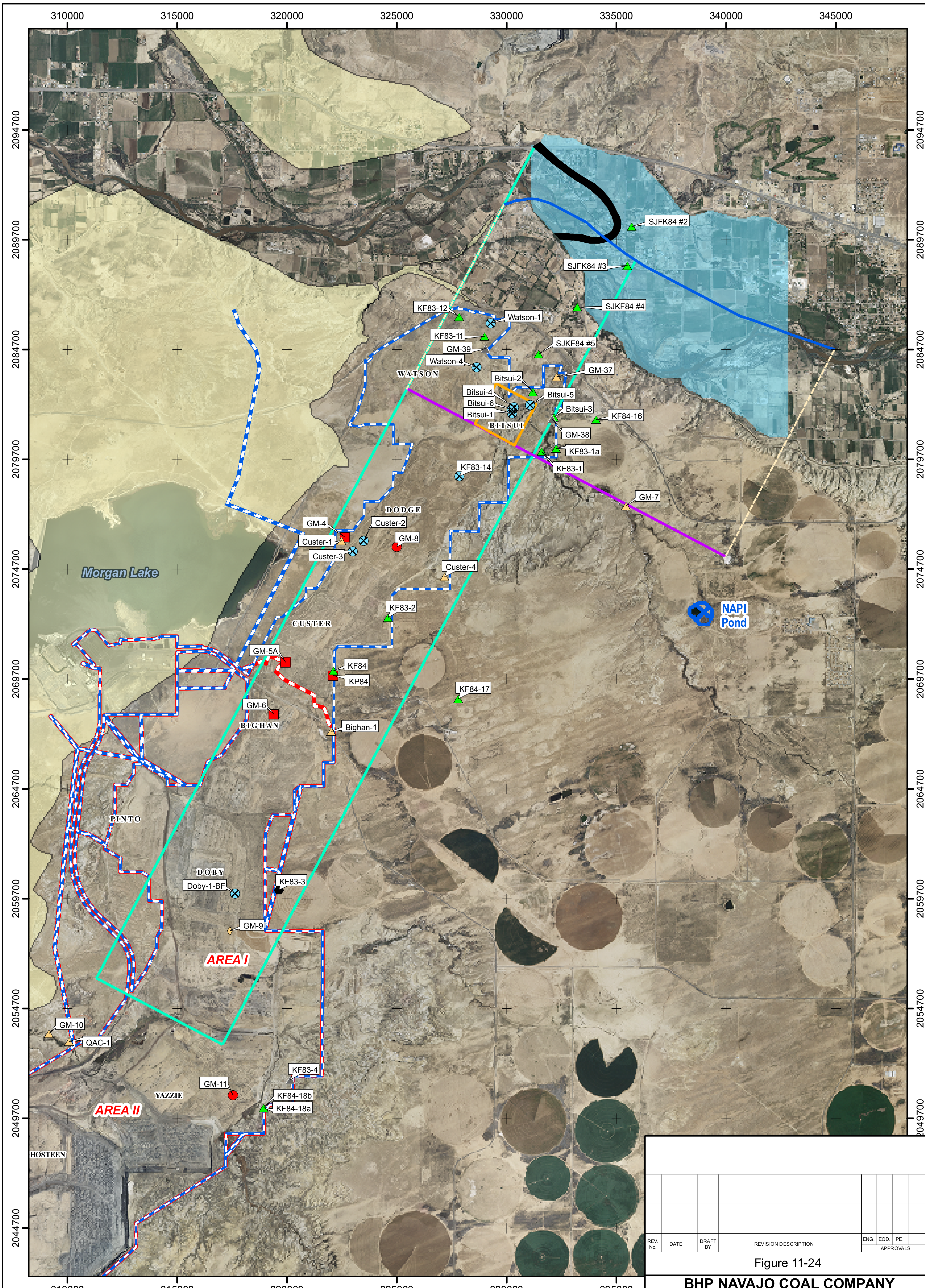
A summary of hydraulic conductivity estimates for the Fruitland Formation coal seams is provided in Table 6-1 (Chapter 6). A hydraulic conductivity of 0.08 feet per day from this table is considered a reasonably conservative estimate for the No. 8 coal based on the test results for wells SJKF84 #3, SJKF84 #4 and SJKF84 #5 located in the coal down gradient of the Bitsui Pit. The porosity of coal seams is primarily associated with cleating and small scale fracturing of the coal. Porosity estimates ranging from 0.02 to 0.007 were obtained for the Fruitland Formation coals from tests conducted for the Western Cretaceous Coal Seam Project (Mavor et al., 1992). An estimate of coal porosity of 0.01 was used for modeling. This estimate also appears to match the rate of transport from the Bitsui Pit to well Bitsui-2 and has been used in the model calibration and simulations.

Sorption of sulfate was assumed to be near zero and was not included in the transport model. The longitudinal dispersivity value of 10 feet was estimated from model calibration using well Bitsui-2 located approximately 300 feet from the Bitsui Pit. Lateral dispersivity was estimated as 0.1 x longitudinal and vertical dispersivity was estimated at 0.01 x longitudinal dispersivity.

These are standard dispersivity factors used in transport modeling (Gelhar et al, 1992). The model calibration is not very sensitive to the dispersivity values.

The source concentration of sulfate in the Bitsui Pit was assumed to be constant after resaturation of the Bitsui Pit. A sulfate source concentration of 7,000 mg/l was estimated based on the average of the median sulfate concentrations in backfill wells Bitsui-4 and Bitsui-5, the two backfill wells nearest the Bitsui-2 well.

Sulfate reduction in nature can be described by a second order decay rate that is dependent on both the carbon source and sulfate concentration. However since the aquifer matrix is comprised of coal, the carbon source is considered fixed and the sulfate reduction can be modeled as a pseudo first-order decay rate. The sulfate reduction rate is represented in the MT3DMS model using a first-order decay equation assuming a pseudo first-order process with a constant decay rate throughout the coal unit. The sulfate reduction decay rate of 3x 10^{-4} day^{-1} was estimated by model calibration to the sulfate breakthrough in well Bitsui-2. A comparison of the sulfate concentrations observed at the Bitsui-2 coal well with the predicted sulfate breakthrough curve from the calibrated model is provided in Figure 11-36. The calibrated sulfate reduction decay rate determined by model calibration is near the lower bound of sulfate reduction values found in the literature, including the study of sulfate reduction in coals down gradient of mine spoilt (Clark, 1995). Using data from Clark (1995) for sulfate reduction in groundwater down gradient of mine spoil at the West Decker Mine in Montana, sulfate decay rates were estimated to range from 3 x 10^{-3} day^{-1} to 6 x 10^{-4} day^{-1}.



REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQD.	PE.
				APPROVALS		

Figure 11-24

BHP NAVAJO COAL COMPANY

bhpbilliton

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Navajo Mine Permit

Area I Groundwater Models

PREPARED BY: MD	DRAWN BY: MD	PAPER SIZE: 11"x17"
APPROVED BY: APO	DATE: 04/16/2011	

Data Source:
Aerial Photography (San Juan County) 2009
* NMBMMR RM-19 Beaumont 1998

N

1:48,000

Projection Information:
State Plane New Mexico West
North American Datum 1927
FIPS 3003
feet

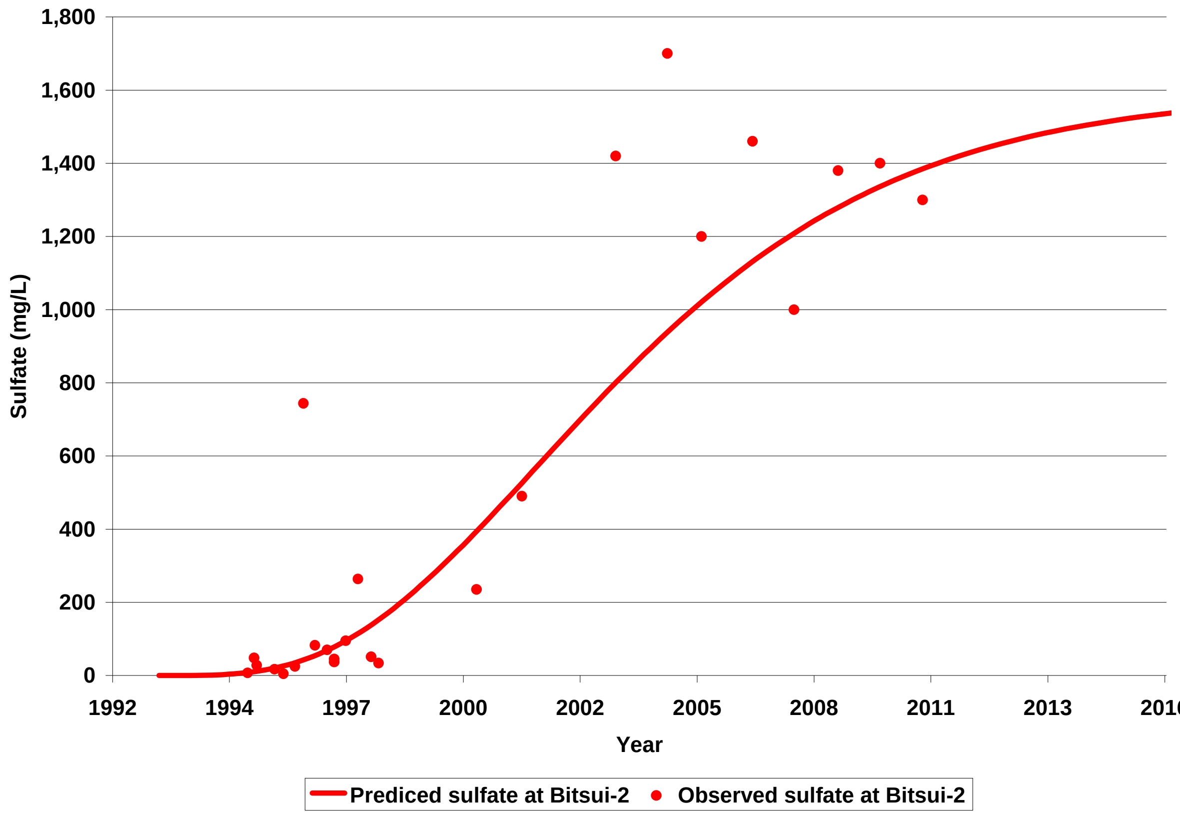
Feet
0 2,200 4,400 8,800

Bitsui Transport Model:
- Specified Head Boundary
- Constant Head Boundary
- No Flow Boundary
- Bitsui Pit Source
- Max Mine Water Flow Projection
- San Juan Alluvium above Fruitland Formation Outcrop
- Approximate Coal Subcrop*

- BNCC Lease Area
- BNCC Permit Area
- Pictured Cliffs Formation (Kpc)
- NAPI Pond
- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- Well, Coal No. 2, Existing
- No 3. Coal Monitoring Well

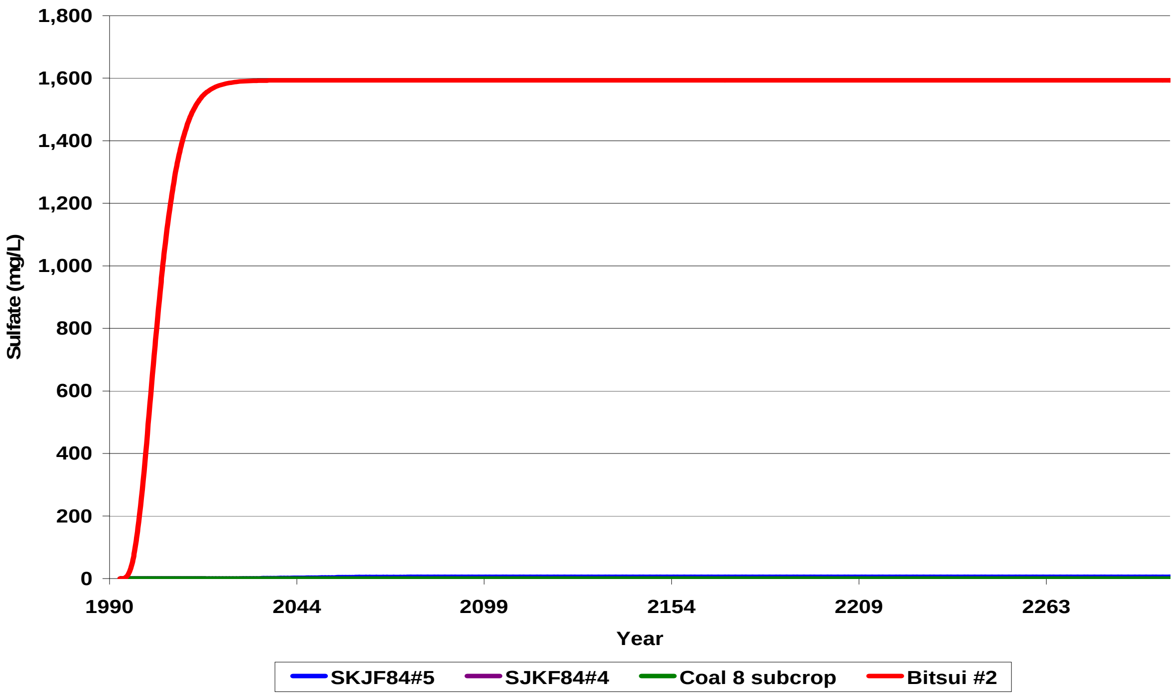
- Well, Coal No. 4, Existing
- No 6. Coal Monitoring Well
- No 7. Coal Monitoring Well
- No 8. Coal Monitoring Well
- Fruitland Well or Nested Wells
- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Backfill Monitoring Well

Figure 11-36. Predicted Sulfate Concentrations at well Bitsui-2



The model predicts sulfate concentrations over time anywhere in the model domain. Prediction points were established at the Bitsui-2 well located down gradient of the Bitsui Pit, at well SJKF84#5, at SJKF84#4 and at the coal subcrop on the model boundary. These prediction locations are shown on Figure 11-24. Predicted sulfate concentrations for the specified prediction points are plotted in Figure 11-37. These results show that sulfate concentrations in the Bitsui-2 well approach a steady state value of about 1,600 mg/l assuming that source concentrations remain at 7,000 mg/l. These results also show that steady state sulfate concentrations remain below the 10 mg/l detection limit at the down gradient coal wells SJKF84#5 and SJKF84#4 and at the coal subcrop with the alluvium at the model boundary.

Figure 11-37. Model Predicted Sulfate Concentrations at Specified Prediction Points



A sensitivity analysis was performed for longitudinal dispersivities and sulfate decay coefficients. These results found that the predicted sulfate results are not sensitive to the dispersivity but the results are sensitive to the sulfate reduction rate. Figure 11-38 shows the sensitivity of sulfate concentrations to changes in sulfate decay rate at Bitsui-2. Figure 11-39 shows the modeled sulfate concentrations at SKJF84 #5 at the corresponding sulfate decay rates.

Although the lower rates of sulfate reduction in the sensitivity analysis appear to fit the earlier sulfate data for well Bitsui 2, the higher rates of sulfate reduction in the sensitivity analysis fit the more recent sulfate data for well Bitsui-2. The sulfate reduction decay rate of 3x 10^{-4} day^{-1} provided the best fit to the last 5 years of data using the sum of squares of residuals as a measure of goodness of fit. The fit was almost as good with the sulfate reduction decay rate of 2.8x 10^{-4} day^{-1}. As shown in Figure 11-39, the sulfate breakthrough rate at well SJKF84#5 remains below 15 mg/L for any sulfate reduction rate that provides a reasonable comparison with the sulfate observations at the Bitsui-2 well as shown in Figure 11-38. With the first-order sulfate decay model, sulfate concentrations reach a steady concentration following break through as shown in Figure 11-37 provided the source concentrations remain steady. Continued monitoring of sulfate concentrations in the Bitsui-2 coal well and the Bitsui 5 spoil well will serve to further verify the sulfate decay model and rate and the assumption of constant source concentrations and permit, if warranted, any modifications to the model predictions.

The modeling results with all reasonable bounds of sulfate decay rates indicate that there will be no sulfate transport from the mine spoil to the coal subcrop along the San Juan River valley. Also, as a result of sulfate reduction, TDS levels are also not expected to increase in the coal water at the subcrop with the alluvium. Sulfate reduction is expected to continue to occur in the saturated coal between the Bitsui Pit and the subcrop of the coal at the San Juan River alluvium. Although sulfate reduction does not occur in the oxygenated groundwater shallow coals in recharge areas, sulfate reduction would occur if sulfate were present in the anoxic groundwater in the coal near the regional discharge areas along the San Juan River Valley. Sulfate is not present in the coal at the regional discharge areas as demonstrated by the SJKF wells, which show sulfate at less than detection. Sulfate ~~has~~ been removed from the groundwater flow system by sulfate reduction up gradient of the discharge areas.

Although the TDS concentrations did increase in the Bitsui-2 well as indicated in Figure 11-31, this increase is less than the increase in sulfate concentrations. Alkalinity and chloride concentrations actually decreased in this well with the transport of water from the mine spoils through the coal. While there is not a direct 1:1 relationship between increases in sulfate and TDS concentrations carbonate precipitation is expected to continue prevent an increase in alkalinity, and thereby largely limit any increase in TDS to the increase in sulfate concentrations. Carbonate precipitation is expected to occur as long as alkalinity levels in the groundwater remain relatively high and the spoil water continues to provide a source of calcium and magnesium for groundwater transport in the coal downgradient of the spoil. Thus, sulfate reduction under the anoxic groundwater between the Bitsui Pit and the San Juan River alluvium is expected to attenuate the transport of TDS and sulfate from mine spoil such that negligible changes in TDS and sulfate concentrations at the coal subcrop are expected over the long-term.

Figure 11-38. Predicted Sensitivity of Sulfate Concentration to Sulfate Decay Rate at Bitsui #2

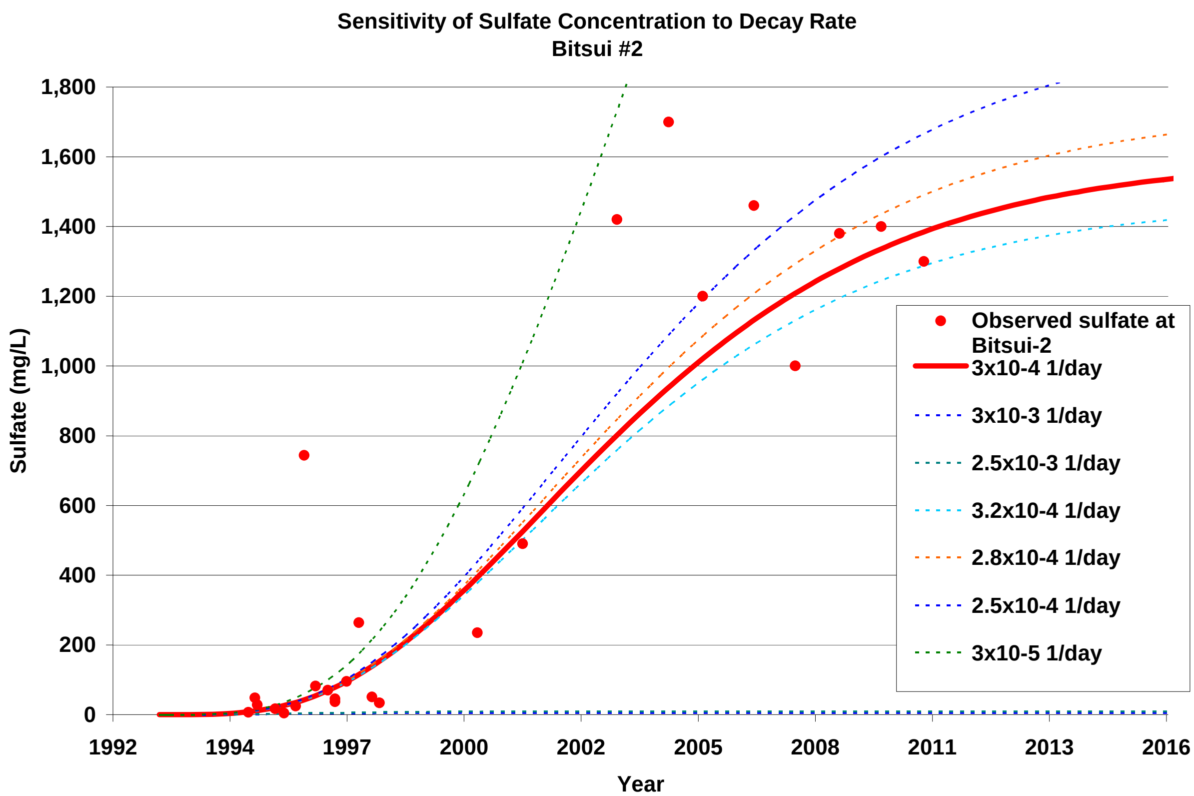
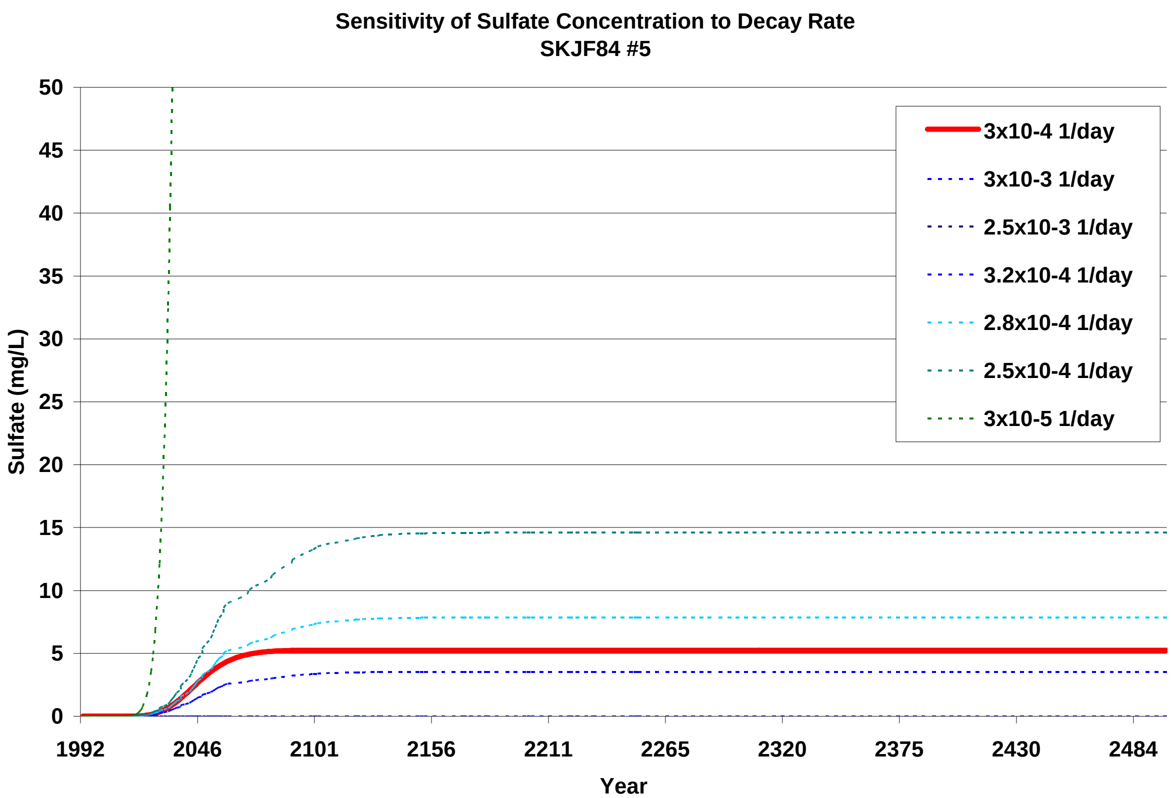


Figure 11-39. Predicted Sensitivity of Sulfate Concentration to Sulfate Decay Rate at SKJF84 #5



Some groundwater transport will also occur through the undifferentiated Fruitland Formation as suggested by Cross Section A-A' in Exhibit 11-167. The undifferentiated Fruitland formation is comprised of interbedded sequences of shales, carbonaceous shales, sandstones, mudstones, claystones, and coal stringers. While carbon sources and reducing environments are present in the undifferentiated Fruitland formation due to the carbonaceous shales and coal stringers, sulfate reduction rates could be lower than in the coal. On the other hand, the rate of groundwater flow is expected to be lower through the undifferentiated Fruitland due to the lower hydraulic conductivity expected for these interbedded sequences of shales, carbonaceous shales, sandstones, mudstones, claystones, and coal stringers in comparison with the coal. Furthermore, groundwater velocities in the undifferentiated Fruitland Formation will be lower because the overall porosity is expected to be higher than in the coal. Thus, even if sulfate reduction rates are lower in the undifferentiated Fruitland formation, transport times are expected to be longer, allowing more time for sulfate reduction.

A simple calculation of flow velocities and transport times has been performed to demonstrate the likely differences that can be expected based on the expected differences in effective porosity. The effective porosity of the coal was estimated to be approximately 1% based on both the literature for the Fruitland coals and the transport model calibrations. The effective porosity in the undifferentiated Fruitland will vary with materials in the Fruitland Formation and is lower in the clays and shales than in the sandstones even though clay has higher porosity than sandstone. Effective porosity can be determined for the specific yield of the material. Johnson (1967) provides a comprehensive review of specific yields for sedimentary materials. The specific yield decreases with the particle size of the sediments. The specific yields were reported to range from 10% to 32% for unconsolidated sands. Johnson (1967) provides a specific yield estimate of 10% for tight and partially cemented sandstones. Johnson (1967) provides average specific yield estimate of 3% for clays and 8% for silts. The effective porosity of coal stringers may be higher than 1% effective porosity estimated for the No. 8 coal, particularly if the shallower stringers are more weathered. Typically, higher porosity is usually present in the shallow coals in the San Juan Basin (Questa Engineering Corporation, 2000). Based on these results an overall porosity of the undifferentiated Fruitland is likely to be on the order of 5% or higher.

An elevation difference of 63 feet is calculated for the water elevation of 5,164 feet measured in the Bitsui Pit and the water elevation of 5,101 feet estimate in the alluvium at the coal subcrop. The distance between the Bitsui Pit and the coal subcrop is approximately 7,300 feet resulting in an average hydraulic gradient between the Bitsui Pit and the groundwater at the coal subcrop of 0.0086 ft/ft.

The average groundwater velocity between the Bitsui Pit and the coal subcrop can be estimated using the following equation:

$$v = kI/ N_e$$

where:

v = Velocity of groundwater in the Fruitland Formation (feet per day).

N_e = Effective porosity (dimensionless)

K = Hydraulic conductivity (feet per day)

I = Hydraulic Gradient (dimensionless)

Thus, based on the porosity and hydraulic conductivity for the coal, the groundwater velocity is estimated to be 0.069 feet per day and it would take 290 years for water from the mine pit to flow the 7,300 foot distance through the coal from the Bitsui Pit to the coal subcrop with the San Juan River alluvial aquifer. The groundwater velocity in the undifferentiated Fruitland Formation is expected to be at least 5 times lower based on an estimated effective porosity of 5%. Also, the hydraulic conductivity of the undifferentiated Fruitland Formation is expected to be lower based on the extent of shale and claystone within the unit and the observations from mining and exploration drilling that the coals in the Fruitland will typically yield some water while very little water will flow from the undifferentiated Fruitland.

Even if the TDS and sulfate were to increase in the Fruitland Formation at the coal subcrop several hundred years from now, it is unlikely that it would result in a significant increase in the alluvial groundwater due to the much higher flow rates in the alluvial groundwater relative to the flow in the Fruitland Formation. A groundwater mixing calculation has been performed to provide upper bound estimates for the magnitude of the potential increase in TDS concentrations in the San Juan River alluvium. The lateral extent of the Navajo Mine perpendicular to the direction of flow toward the Fruitland Formation subcrop at the San Juan River alluvium is estimated at approximately 6,500 feet as indicated by the mine water flow projection shown in Figure 11-24. The maximum volume of groundwater from the reclaimed mine that can discharge to the San Juan River alluvium can be estimated using the following equation:

$$Q = k\ I.\ L.\ M$$

where:

Q = Estimated discharge of potentially mine-affected groundwater to the San Juan River alluvial aquifer (ft^3/day)

K = Hydraulic conductivity of the Fruitland Formation, which is assumed to be 0.08 ft/day based on the hydraulic conductivity of the coal

I = Hydraulic gradient from the Navajo Mine to the Fruitland Formation subcrop, which is conservatively estimated to be 0.01 ft/ft

L = Lateral extent of the mine normal to the general direction of flow in the coal seam = 6,500 ft

M = Estimated average saturated thickness of the Fruitland Formation between the Bitsui Pit and the San Juan River alluvium estimated to be on the order of 50 to 60 feet as suggested by Cross Section A-A' in Exhibit 11-167.

Assuming a gradient of 0.01 ft/ft based on measurements at the Bitsui Pit and a hydraulic conductivity of 0.08 feet per day for both the coal and the undifferentiated Fruitland Formation, the discharge to the San Juan River alluvium (Q) is estimated as:

$$Q = [0.08 \text{ feet per day}] \cdot [0.01] \cdot [6{,}500 \text{ ft}] \cdot [60 \text{ ft}]$$

$$Q = 312 \text{ feet}^3/\text{day}$$

This is likely the upper bound estimate as the hydraulic conductivity of 0.08 ft/day is considered to be upper bound estimate for combined coal and undifferentiated Fruitland Formation. The results of these calculations, nonetheless, demonstrate that the annual production of mine-affected groundwater that could reach to the San Juan River alluvium is small when compared to the flow in the San Juan River alluvium as discussed below.

The thickness of the San Juan River alluvial deposits varies. Depths of San Juan River alluvial wells reported in Appendix 6E-Addendum 12-D-A ranged from 7 feet (~~BAI~~# 154 USGS boring SJ-4) to 110 feet (~~BAI~~#3 David R. Knoll well) . The saturated thickness in these wells ranged from 0 feet (~~BAI~~# 3) to 25 feet (~~BAI~~# 8 and ~~BAI~~#148) with a median of 15 feet, although both water depths and well depths are not given for many wells. Also, the thickness of the alluvium at a given location may not correspond precisely with the depth of the alluvial well. A conceptual model of the San Juan River and the floodplain alluvium is presented in a report by the United States Department of Energy (2009) for the Shiprock Uranium Mill Tailings Site. This report lists the San Juan River as the major source of groundwater in the alluvial aquifer with less significant sources of alluvial water which include infiltration and recharge of precipitation on the floodplain and discharge of bedrock groundwater to the alluvium. There is also considerable mixing of river water and alluvial groundwater. This occurs seasonally as well as with distance along the length of the river with river water recharging the groundwater system near the downstream end of a pool and then discharging back to the river near the downstream end of the riffle (United States Department of Energy, 2009).

A hydraulic conductivity of the San Juan River alluvium of 85 feet per day was found to provide the best overall estimate for the alluvial aquifer based on a series of groundwater model calibration runs with a uniform hydraulic conductivity (United States Department of Energy, 2009). Hydraulic gradients in the alluvium vary across the floodplain but are approximately the same as the valley gradient. The valley gradient of 0.0034 ft/ft was measured for the San Juan River valley along the Fruitland Formation subcrop as depicted in Exhibit 11-166. An average width of the alluvium of 6,851 feet was estimated by dividing the mapped area of the San Juan River alluvium in Exhibit 11-166 by the length of the valley segment. Using a hydraulic gradient of 0.0034 ft/ft, a valley width of 6,851 feet, a hydraulic conductivity of 85 feet per day, and a saturated thickness of 15 feet, the average flow in the alluvial aquifer is estimated as:

$$Q = [85 \text{ feet per day}] \cdot [0.0034] \cdot [6{,}851 \text{ ft}] \cdot [15 \text{ ft}]$$

$$Q = 29{,}413 \text{ ft}^3/\text{day}.$$

Thus, the ratio of the groundwater discharge from the Fruitland Formation to the alluvium across the maximum mine water flow projection to the groundwater flow in the San Juan River Alluvium is:

$$\text{Ratio} = 312/29{,}413 = 0.0106$$

The existing water quality in the San Juan River alluvial aquifer is quite variable as indicated by the available water quality data from San Juan River alluvial wells provided in Appendix 6-E. TDS, sulfate concentrations, and fluoride concentrations for these wells are provided in Table 11-14g, along with water quality data for San Juan River alluvial well G-7 provided by Thorn (1993). Thorn's report also provides information on boron concentrations in the alluvial groundwater. Table 11-14g provides a comparison of water quality data for San Juan River alluvium, for the baseline coal wells and for the wells in the Bitsui Pit.

The baseline No. 8 coal well SJKF #4 is located closest to the coal subcrop as shown in Exhibit 11-166. The TDS concentration of 7,370 mg/l observed in the SJKF #4 well is considered to be representative of the TDS in the coal water reaching the San Juan River alluvial aquifer, although TDS concentrations in excess of 40,000 mg/l have been observed at wells SJKF #2 and SJKF #3 located further down dip. The TDS concentration observed in this well is higher than TDS concentration of 6,160 mg/l observed in the Bitsui-2 well in years 2009 and 2010 so that there would need to be a considerable increase in TDS concentrations along the entire groundwater transport path from the Bitsui Pit to the subcrop in order for mine water transport to increase the TDS loadings to the San Jun River alluvium.

Based on the dilution ratio of 0.01, a TDS increase from the 6,160 mg/l observed in the Bitsui-2 well to 10,370 mg/l across the entire transport zone would result in a TDS increase in the San Juan River alluvium of only 30 mg/L. If TDS concentrations in the coal across the entire transport zone from the Bitsui Pit to the coal at the subcrop were to increase from the 7,370 mg/l observed in the SJKF #4 well to the maximum concentration of 18,000 mg/l observed in all the Bitsui Pit spoil monitoring results, the TDS increase in the San Juan River alluvium could be as high as 106 mg/L. These are considered to be hypothetical worst case estimates for the following reasons:

- They are based on an assumption of no attenuation in sulfate and TDS concentrations in transport from the mine spoil to the coal subcrop. This is highly unlikely and inconsistent with observations from monitoring wells located within the Bitsui Pit and in the coal down gradient of the Bitsui Pit and the predictions that have been developed based on calibrating a sulfate transport model with these data

- The baseline TDS concentrations at the coal subcrop were assumed to be at the lowest observed concentration of 7,370 mg/l observed in the SJKF #4 well. The TDS in some of the baseline coal water reaching the San Juan River alluvium is likely to be much higher, perhaps approaching concentrations in excess of 40,000 mg/l as observed at wells SJKF #2 and SJKF #3. Consequently, the incremental increase in TDS concentrations in the coal water entering the San Juan River alluvium may be much lower than assumed by the calculations.

A 30 mg/l or 106 mg/L change in alluvial concentrations is far below the natural variation observed in the San Juan River alluvial wells as represented by the standard deviation calculated from the alluvial well results presented in Table 11-14g.

Table 11-14g

Water Quality of the San Juan River Alluvium in Comparison with Mine Spoil Water and Coal Water

Location	Well	TDS*** (mg/L)	SO4 (mg/L)	Ca (mg/L)	HCO3 (mg/L)	B (mg/L)	Fe (mg/L)	Mn (mg/L)
Baseline Coal	SJKF#2	43,035	<10	515	944	1.23	0.008	2.93
	SJKF#3	50,810	<10	700	673	1.43	0.018	0.71
	SJKF#4	7,370	<10	27	3,232	1.57	0.018	0.11
	Composite #4*	9,800	120	140	na	0.53	0.15	0.03
Mine spoil (median)	Bitsui-4	15150	8900	290	1751	1.69	0.51	3.650
	Bitsui-5	11800	5030	59.5	3030	1.11	0.11	0.108
	Bitsui-6	14850	8850	368	1344	2.07	0.345	4.558
	mean	13,933	7,593	239	2,042	1.62	0.322	2.772
Bitsui-2 (median years 1995- 2010)		5,145	165	6.2	3233	0.99	<0.03	<0.01
Bitsui-2 (Year 2010)		6,160	1,300	8.0	1,500	1.00	0.050	0.010
San Juan River Alluvial Aquifer	G-7**	3,940	1,700	25	207	0.32	14.0	1.20
	BIA# 147	842	310	na	na	na	na	na
	BIA# 148	528	174	na	na	na	na	na
	BIA# 150	5,880	3,600	na	na	na	na	na
	BIA# 151	2,140	1,300	na	na	na	na	na
	BIA# 152	2,140	1,300	na	na	na	na	na
	BIA# 45	1,270	456	na	na	na	na	na
	Average	2,391	1,263			0.32		0.02
Standard Deviation		1,766	1,095			na		na

*Composite #4 from Coal No 4 and 6 in Table 11-14b

**Data from Thorne (1993)

***TDS based on rresidual at 180°C.

See Tables 11-14a and 11-14e for number of samples in median calculation for the Bitsui Wells

Table 11-14g also provides a comparison of the TDS, sulfate, boron, and manganese concentrations in the San Juan River alluvial groundwater with the concentrations in the Bitsui Pit, in the Bitsui-2 coal well located immediately down gradient of the Bitsui Pit and in the baseline coal water samples.

As discussed earlier, potentiometric surface maps for the Fruitland coal units (Exhibits 6-2 through 6-5 and Exhibits 6.G-2 and 6.G-3) all show general gradients toward the east. Thus, some of the groundwater flowing through Area I mine spoils may not discharge along the San Juan River valley but rather will flow down dip in response to coal depressurization from coal bed methane extraction. For display purposes, approximate locations of coal bed methane wells near the Navajo Mine have been included on Exhibit 11-166.

The data and associated modeling calculations all show that water in the backfill within Area I at the Navajo Mine will not measurably affect the water quality in the San Juan River alluvial groundwater.

11.6.2.3.2 Area II Groundwater Migration

All of Area II coal seams were found to be mostly dry, with minor saturation along the eastern lease boundary. Coal wells KF84-18a and KF84-18b, located near the Yazzie Pit highwall, have been dry or have had limited saturation throughout mining and following mine backfilling. Thus, little groundwater inflow to the backfilled Area II mine pits is expected from the coals adjacent to the highwall. Water sources that could potentially saturate the backfilled mine pits within Area II include precipitation recharge and water flowing in the Chinde Arroyo. Recharge rates are extremely low based on the studies by Stone (1987) and the dry conditions in the Fruitland Formation within Area II prior to mining.

The Chinde Diversion routes flows in Chinde Arroyo around the Yazzie Pit. Chinde Arroyo was originally an ephemeral stream but now exhibits perennial flow due to NAPI irrigation. It is likely that a small portion of the flow in Chinde Diversion seeps into the Yazzie backfill. This seepage contribution is believed to be small because saturation has not been observed in the backfill in the Doby Pit. While the Doby French drain intercepts seepage from NAPI irrigation it does not intercept seepage from the segment of the Chinde Diversion that is adjacent to the Doby Pit. Nevertheless, the potential seepage from the Chinde Diversion is an additional source of water could increase the rate and level of re-saturation of the backfill in the Yazzie Pit and in the Doby Pit.

The potentiometric elevations in the PCS within Area II (Exhibit 11-166) are projected to be at or near the base of the mine pits. As the mine spoils begin to saturate over the long-term, the buildup of heads in the mine spoil will increase the rate of vertical flow to the PCS. A build up of head in the mine backfill would also result in lateral flow into the adjacent Fruitland Formation. Thus, transport directions for mine spoil water would be vertical downward into the

PCS and laterally down dip in the Fruitland Formation. Lateral flow through the Fruitland Formation will flow down dip to the east in the direction of coal depressurization from coal bed methane extraction or will flow to the northeast toward the Fruitland Formation subcrop beneath the alluvium of San Juan River valley. This component of flow and transport has been addressed in the Area I assessment in Section 11.6.2.3.1.

Lateral flow through the PCS within Area II is expected to be generally toward the northeast as indicated by the potentiometric surface provided in Exhibit 11-166. There could also be a component of flow west toward the PCS outcrop located east of the Chaco River. Groundwater flow rates through the PCS would be very low due to the very low hydraulic conductivity of the PCS. Any discharge along the PCS outcrop to the west of Area II would be removed by evapotranspiration. Based on pre-mine observations along the PCS outcrop adjacent to Areas III and IV North, flow rates in the PCS are expected to be insufficient to sustain flow at a seep. PCS water may also flow vertically downward into the Lewis Shale as was found in groundwater studies performed within lease Areas IV North and South and V.

11.6.2.3.3 Area III Groundwater Migration

In the southern part of Area III, all of the coal seams, but the No. 8 coal seam, were found to be saturated. As discussed in Chapter 6, the lower coal units (No. 2, No 3) pinch out just north of Area III. Discharge locations for the Fruitland coal seams within Area III include:

- the outcrop locations along the Cottonwood Arroyo valley to the south and the Chaco River valley to the west,
- down dip toward the center of the San Juan Basin where the groundwater flow joins the regional flow to the northeast toward the subcrop at the San Juan River alluvium and the coal bed methane depressurization areas, and
- into the PCS and Lewis Shale via vertical flow from the Fruitland Formation.

Groundwater flow rates through the Fruitland coals within Area III are believed to be extremely low because of the low hydraulic conductivities of the coal and the relatively flat potentiometric gradients.

For a long period following mining within Area III gradients will be toward the mine backfill. As the mine spoils begin to saturate over the long-term, the buildup of heads in the mine spoil will increase reversing the gradients with respect to the mine spoils. Based on model estimates of Area IV North it could take as long as 80 years for gradient reversal to occur. Transport directions for mine spoil water at that time would be laterally down dip in the Fruitland Formation, laterally toward the outcrop areas to the south and west of Area III and vertically into the PCS. Lateral flow from the mine spoils through the Fruitland Formation and PCS will be very low due to the low hydraulic conductivity of these units as indicated by the test results in Appendix 6-G and due to the relatively flat gradients that can be expected based on pre-mine conditions. Most discharge to the PCS and Fruitland Formation outcrops to the south and west of Area III is expected to be removed by evapotranspiration, although a portion of this groundwater flow could reach the Cottonwood Arroyo alluvium.

11.6.2.4 Potential Groundwater Impacts from Proposed Mining and Reclamation within Area IV North

BNCC is proposing to conduct surface coal mining and reclamation activities within a 704 acre mining block in Area IV North of its coal lease with the Navajo Nation. The No. 8 coal seam extends over a little more than half of the proposed mine area. Perched groundwater appears to occur in the No. 8 and No. 7 coal seams as indicated in Figure 6.G-4 in Appendix 6-G. Groundwater encountered during mining within Area IV North will be quite small based on observations from exploration drilling within Area IV North and on observations at Area III mining which found that groundwater in the coals and overburden was insufficient to sustain pit inflows during mining. Instead, any groundwater observed as seepage along the face of the highwall was removed by evaporation and did not pool within the mine pit.

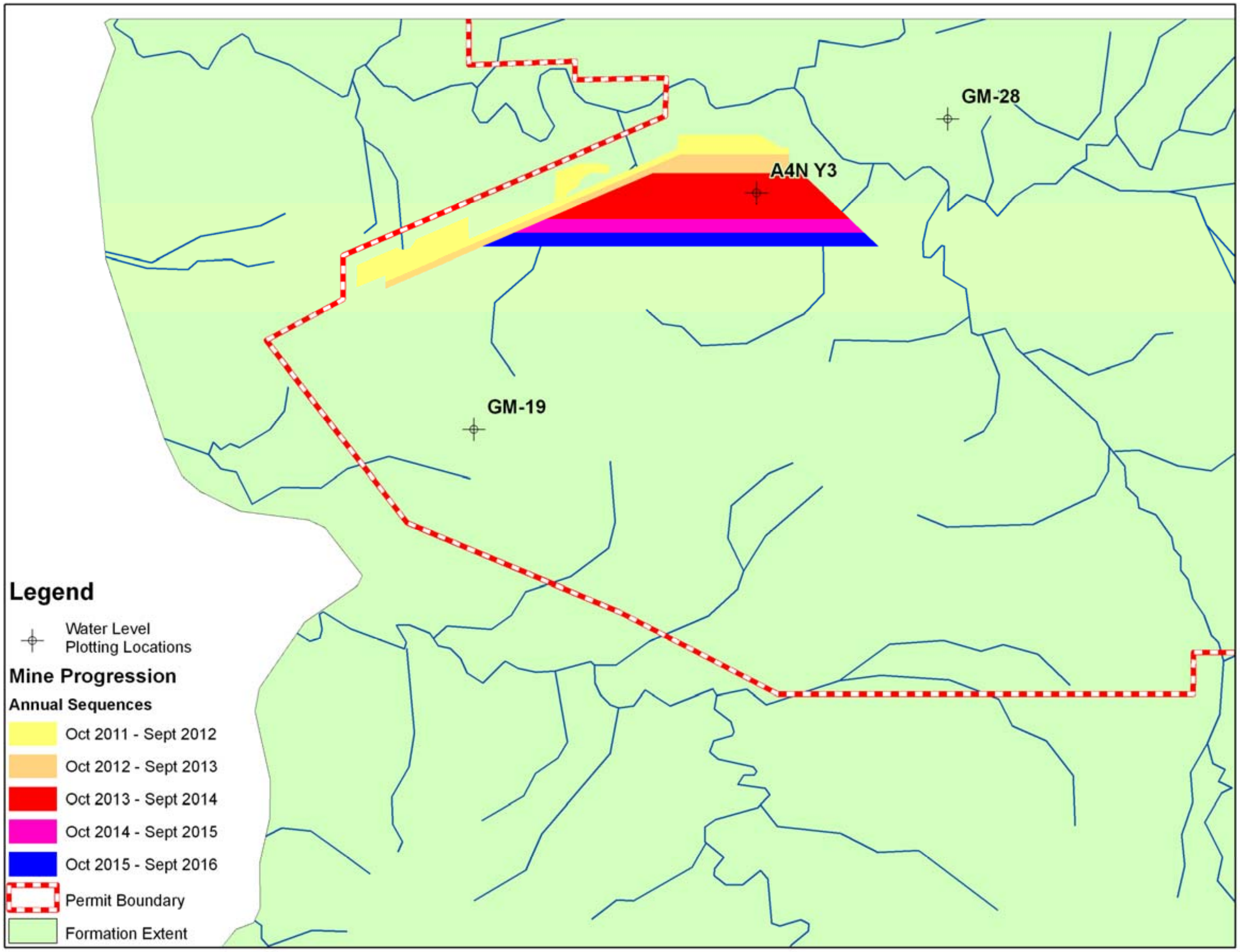
The calibrated steady-state groundwater model of Areas IV North and South and V of the BNCC's coal lease was used to provide a better understanding of the likely short-term and long-term groundwater changes that are expected to occur within and adjacent to proposed mining (Appendix 11-WW). Figure 11-40 shows the groundwater model domain and the location for proposed mining within Area IV North. As with any model of a complex physical system, the groundwater model has limitations and uncertainties. Simplifying assumptions must be made to model the complex hydrogeologic system. In particular, the hydrogeologic units within the model domain have been represented as homogeneous and isotropic. Geologic environments are never homogeneous and isotropic. However, such assumptions are required because it is not possible to define hydraulic conductivities, specific storage, specific yield, porosity, and other properties spatially within all the hydrogeologic units within the model domain.

Although model calibration produces a non unique solution, the calibration was constrained such that the calibrated model parameters and recharge estimates were consistent with the measurements at the site and relevant estimates from the literature. The hydrogeologic unit within the model domain that is believed to include the greatest uncertainty in the model simulations is the alluvium within the valleys of Cottonwood, Pinabete, and Brimhall. Part of this uncertainty is due to the difficulties in delineating the extent and depth of alluvium and representing that delineation by the finite element mesh. Also, the baseline information shows that the groundwater within the alluvium is not at steady state as is assumed in the calibration of the steady state model. Groundwater flows, groundwater levels and groundwater recharge within the alluvium varies seasonally and from year to year. Perched conditions also occur within some segments of the alluvium as indicated by the well nest adjacent to Pinabete Arroyo. All of these conditions add to the uncertainty in the predictions within the alluvium based on the calibrated steady-state groundwater model.

Despite these limitations, the model provides a better understanding of the hydrogeologic system and the nature of the changes in the system that might occur as a result of mining and reclamation. The model predictions are essentially scientific hypotheses that will be re-examined as mining and reclamation proceed. The model provides a useful tool for evaluating the possible extent and magnitude of changes in the hydrogeologic system that might occur in response to proposed mining and reclamation. The model is also useful in identifying the time frames that might be associated with these changes. These results provide better insight into the locations and frequency of monitoring that can be used to confirm or modify the PHC predictions.

Groundwater flow in the Fruitland coals and in the underlying PCS in the area of proposed mining is north toward Cottonwood Arroyo as indicated in Figures 6.G-1 through 6.G-3 in Appendix 6-G. However, the rate of groundwater flow from bedrock units to the alluvium along Cottonwood Arroyo is known to be very low because the alluvium is only marginally saturated. Cottonwood alluvial well QACW-2 located west of the permit area was often dry during baseline monitoring and Cottonwood alluvial well QACW-1 was dry throughout the baseline monitoring from 1989 through 1998.

Figure 11-40. Mining Block Sequences for Proposed Mining in Area IV North



Groundwater was observed during baseline monitoring at well GM-17 completed in the alluvium of North Fork of Cottonwood Arroyo. In the limited areas where partial saturation of the alluvium occurs, groundwater flows are too low to support base flow in the channel at any time. The limited saturation found within the Cottonwood alluvium is recharge from direct precipitation, from ephemeral surface water flows in Cottonwood Arroyo and from periodic discharges of excess flows from the NIIP Ojo Amarillo canal into the North Fork of Cottonwood Arroyo.

One of the primary hydrogeologic changes to occur as a result of mining is the removal of the coal, the interbedded shales, and the sandstone strata, resulting in more homogeneous and isotropic conditions within the mine backfill. When broken up during mining, the overburden and interburden material placed in the mine pit as backfill have higher porosity and hydraulic conductivity than the pre-mine in-situ interbedded sedimentary deposits of the Fruitland Formation. Laboratory measurements of pre-mine overburden core indicate porosity values of about 0.35 while porosity of mine spoils is on the order of 0.4. These laboratory porosity measurements are consistent with the long-term swell factor of 12% estimated based on experience in mining the same formation at the Navajo Mine. The higher porosity will result in higher hydraulic conductivity in comparison with the pre-mine interburden and overburden material.

Horizontal hydraulic conductivity values of pre-mine overburden and interburden strata are expected to be in the range from 8.63×10^{-3} ft/day to 2.8×10^{-5} ft/day based on regional information from Kaiser et al. (1994) and Frenzel (1983). The hydraulic conductivity estimates from laboratory measurements of two pre-mine overburden samples from the Navajo Mine are also within this range (Physical Testing Laboratory Data provided in Appendix 11-K). A horizontal hydraulic conductivity of 5.0×10^{-4} ft/day was used for unweathered interburden and overburden materials in the calibrated model.

A hydraulic conductivity value of 5.63×10^{-2} ft/day has been used in the post-reclamation model for the mine spoils in the backfill below 10 ft of the final reclaimed surface at Area IV North. This estimate of hydraulic conductivity for mine spoils was between the average of 1.13×10^{-2}

ft/day estimated from laboratory tests on five mine spoil samples from the Navajo Mine (Physical Testing Laboratory Data provided in Appendix 11-K) and the estimate of 2.27 x 10^{-1} ft/day obtained by Rehm et al. (1980) from the geometric mean of 40 hydraulic conductivity values measured for mine spoils in the Northern Great Plains. A hydraulic conductivity value of 5.63 x 10^{-1} ft/day has been used to represent the model layer for the upper 10 ft within the mine backfill, which will be comprised of weathered spoil and topdressing material.

Hydraulic parameters for mine backfill and topdressing materials that were used for modeling post-reclamation conditions are summarized in Table 11-14h. Given some degree of uncertainty in the ultimate hydraulic conductivity of Navajo Mine spoil materials, the value selected for steady-state modeling was considered to be a reasonable upper bound for the hydraulic conductivity of the spoils over the long term. This value is approximately 5 times higher than the average of the laboratory measurements on representative spoil samples, 10 times higher than the model calibrated hydraulic conductivity of the weathered overburden and 100 times higher than the model calibrated hydraulic conductivity of the unweathered interburden material. The hydraulic conductivity of 1.13 x 10^{-2} ft/day estimated from laboratory tests on Navajo Mine spoils was considered to be a reasonable lower-bound estimate for hydraulic conductivity of mine spoils and was used to represent mine spoils in the transient model. This lower-bound estimate provides more conservative estimates of the water recovery rates in mine spoils.

Another primary hydrogeologic change that is expected to occur as a result of mining in Area IV North is the removal of the badland surfaces that cover much of the proposed mine area and the establishment of reclaimed surface conditions that provide for more groundwater recharge. The recharge rate estimates used for modeling post-reclamation conditions are also summarized in Table 11-14h. Lower slopes and placement of topdressing materials within reclaimed areas are expected to result in higher recharge for reclaimed surfaces compared to the relatively steep slope badland surfaces that currently exist within the proposed Area IV North mine area. The pre-mine recharge rate for this area averages only about 0.0069 in/year based on the estimates from Stone (1987) that were assigned to these pre-mine surfaces based on slope categories.

Table 11-14h.

Recharge Rates and Hydraulic Properties of Mine Spoils for Groundwater Modeling

Surface characterization	Recharge range[1] (in/yr)	Mean recharge[1] (in/yr)	Modeled recharge (in/yr)
Reclaimed areas	0.01 to 0.23	0.04	
Reclaimed depression areas		0.16	
Reclaimed areas-transient			0.1
Reclaimed areas-steady state			0.04
Alluvium- pre-mine and reclaimed	0.09		0.09
Pre-mine surfaces (excluding alluvial terraces)	0.002 to 0.04		0.002 to 0.03

Reclamation materials	Porosity (%)	Ksat (cm/sec)	Ksat (ft/day)
Surface mine spoils (L1)	40.6	2.0E-04	5.6E-01
Mine spoils < L1	40.6	2.0E-05	5.6E-02
Geometric mean of mine spoils in northern Great Plains (Rehm et al. 1980)		8.0E-05	2.3E-01
Lab tests of Navajo Mine spoil samples	40.6	4.0E-06	1.1E-02

[1] Estimates from Stone (1987)
L1- Uppermost layer in model
Ksat - Saturated hydraulic conductivity

For steady-state modeling, the recharge rate of 0.04 in/year measured by Stone (1987) for upland flats was assumed to be a reasonable estimate of recharge rate over the long term following reclamation. This recharge rate is more than five times the average pre-mine rate and reflects the improved surface and soil conditions resulting from mine reclamation. An even higher recharge rate of 0.10 in/year was used for mine spoils in the transient modeling until final reclamation, after which the long-term recharge rate of 0.04 in/year was used for reclaimed areas in the transient model. This recharge rate of 0.10 in/year represents an average rate for the mine backfill in various stages of reclamation and is based on the average between Stone's estimate of 0.16 in/year for depressions during mine reclamation and the 0.04 in/year for final reclamation.

11.6.2.4.1 Water Level Drawdown and Recovery

The open mine pit acts as a drain for drawdown of any groundwater in the overburden/interburden, in the coal seams, and in the underlying PCS. Model simulations of the advance of proposed open pit mining in Area IV North have been performed to provide estimates of drawdown and recovery in the Fruitland coals and in the PCS during mining and reclamation.

These simulations were performed for the proposed annual mining block sequences as depicted in Figure 11-40.

The estimated 5 foot drawdown contour in the No. 8 coal seam in Year 2016 at the completion of proposed mining is provided in Figure 11-41. The corresponding 5 foot drawdown contour in the No. 3 coal in Year 2016 is provided in Figure 11-42. Based on the very limited extent of drawdown in the coal units, surface mining in Area IV North is not expected to result in a drawdown in water levels or depletion of water in the alluvium of Cottonwood Arroyo.

There will also be some depressurization of the PCS below the mine pit. Figure 11-43 shows the estimated 5 foot drawdown contour in the PCS in Year 2016 at the completion of proposed mining in Area IV North. The layer of shale separating the bottom of the lowest coal seam and the PCS serves to restrict groundwater inflow from the PCS during mining. The thickness of shale layer between the No. 2 coal and the PCS averages about 8.7 feet over the Area IV North mine block but is absent in some places. This variation in the shale thickness has been included in the groundwater model and the associated estimates of drawdown within the PCS. Artesian pressures in the PCS occur in the eastern portion of the Area IV North mine block where the shale thickness separating the coal from the PCS is greater. Likewise, the drawdown in the PCS is dampened, particularly in these locations where the shale thickness is greater.

The groundwater model was also applied to simulate the rate of recovery of water levels in mine backfill and the drawdown and recovery of potentiometric levels in the PCS and in the Fruitland coals adjacent to the mining block. The water level drawdown and recovery plots for point A4N Y3, located within the proposed Area IV North mine area, is shown on Figure 11-44. This point was selected at a location where the mine is deeper and the No. 8 coal is present. Also, at this location the shale separating the coal from the PCS is projected to be 15.3 feet thick based on the geologic model.

The plot shows the large downward gradients that occur from the No. 8 coal seam to the PCS. With advance of mining to this location in Year 3, the drawdown level in the Fruitland coals is essentially the base of the mine pit at an elevation of about 5,203 feet. Drawdown in the underlying PCS at the same location is damped. Maximum drawdown is less than 17 feet, occurring approximately 30 years following the start of mining. Upward gradients from the PCS to the mine backfill occur until about 85 years after the start of mining. After that time, the recovery in the backfill is sufficient that gradients are vertically downward from the backfill to the PCS.

Figure 11-41. Drawdown in the No. 8 Coal under Proposed Mining in Area IV North

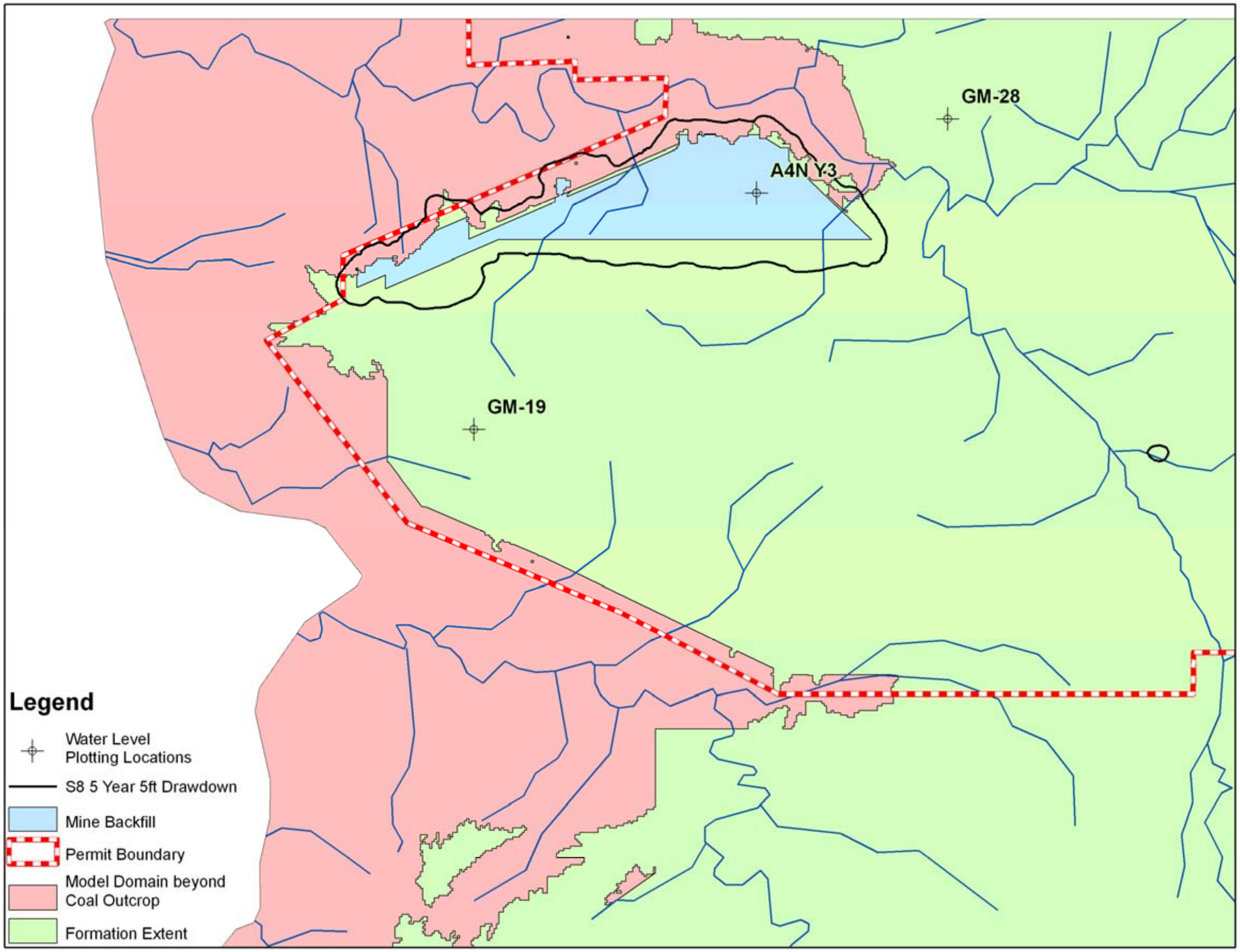


Figure 11-42. Drawdown in the No. 3 Coal under Proposed Mining in Area IV North

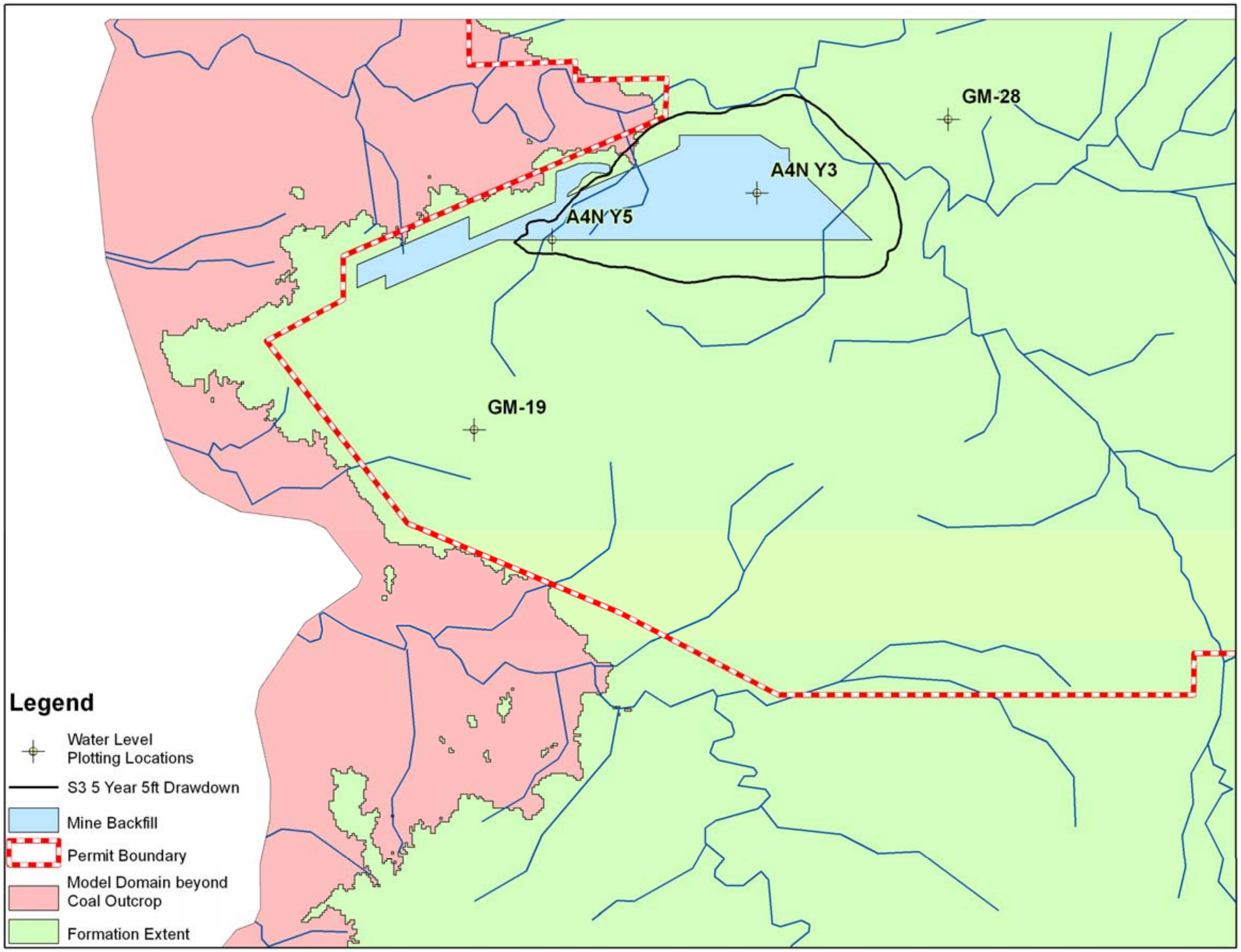


Figure 11-43. Drawdown in the PCS under Proposed Mining in Area IV North

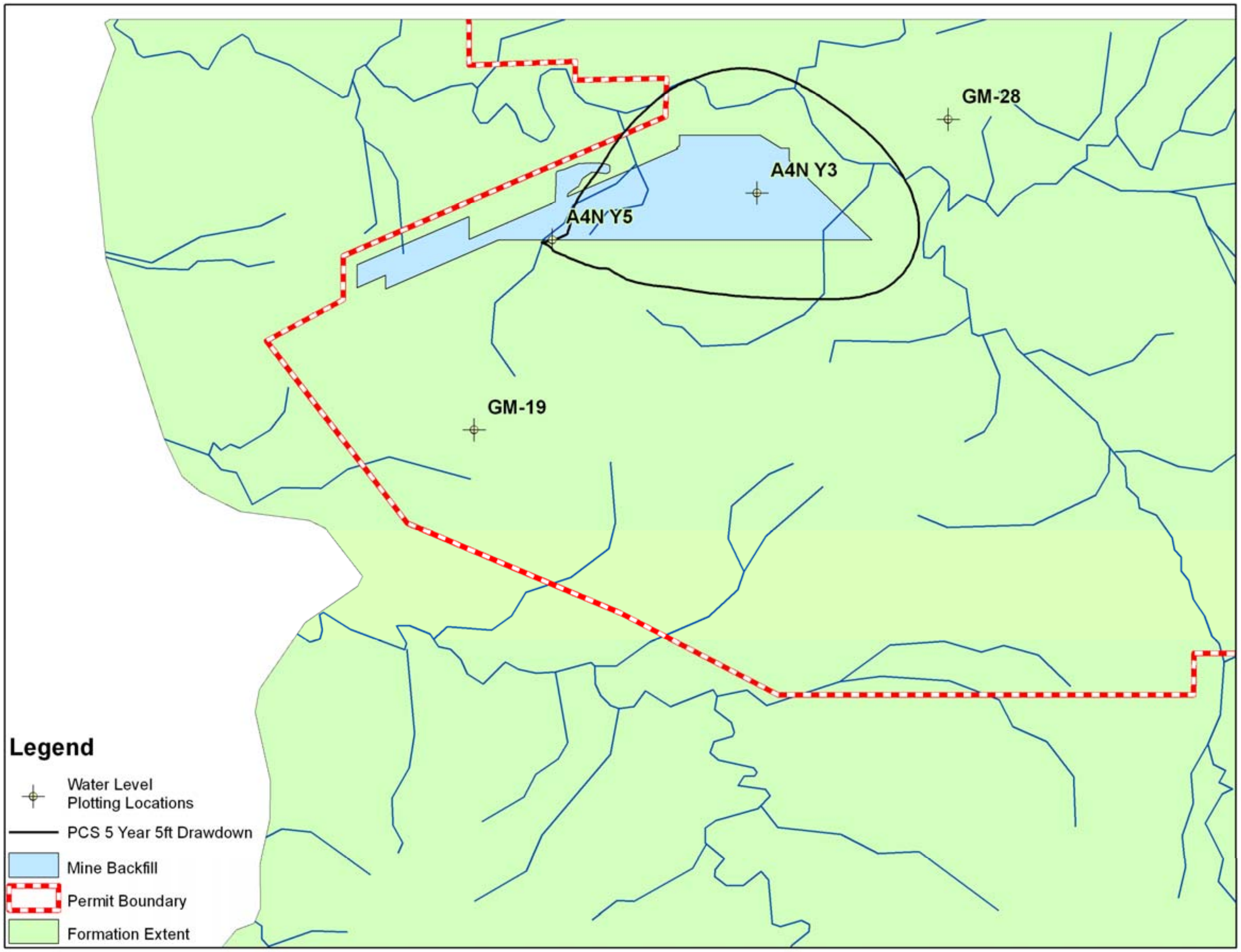
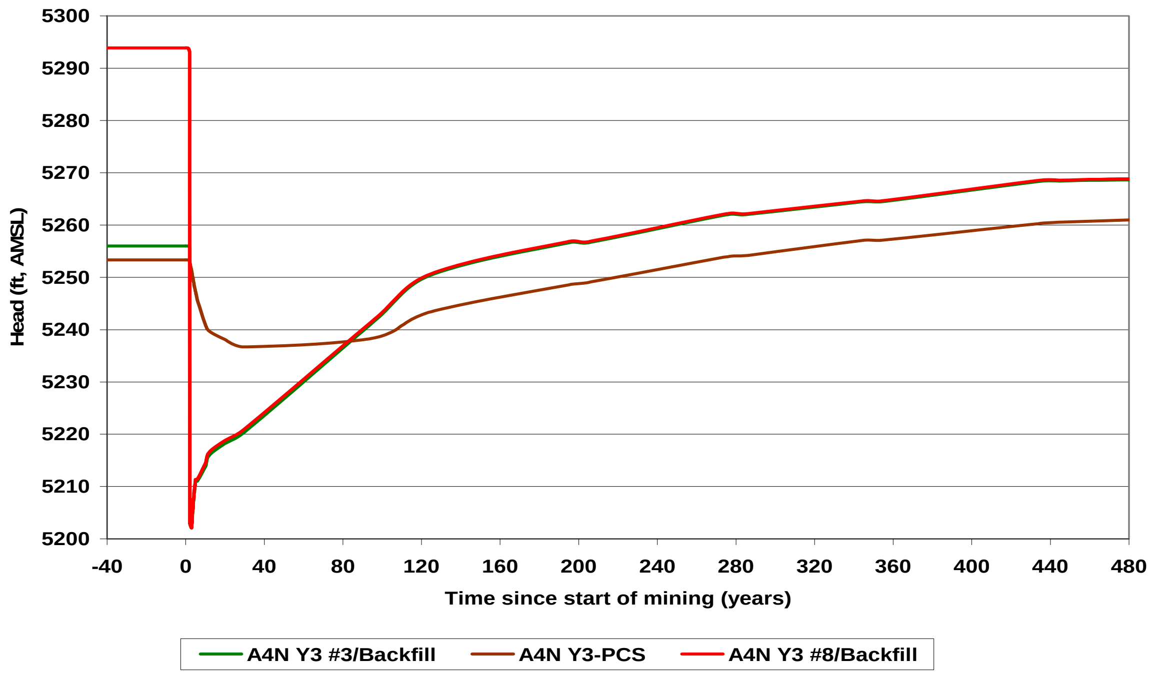


Figure 11-44. Drawdown and Recovery in the PCS and Backfill with Area IV North Mining



The transient model simulations show that it takes over 400 years for recovery of water levels to approach steady-state conditions in the PCS and in the mine backfill. It is possible that actual recovery rates may be slightly faster than the estimates shown in these figures if the recharge rates are higher than the estimates used for modeling. However, it is more likely that recovery rates will be slower than estimated as recharge rates for post-mining may be lower than estimated herein and closer to the pre-mine rates. As discussed previously, the recharge rates used to represent conditions for long-term reclamation were more than five times the average recharge rate for the mine area prior to mining and are believed to be upper-bound estimates based on the recharge measurements by Stone (1987).

The results in Figure 11-44 also show that final steady-state water level in the mine backfill is considerably lower than the pre-mine level of perched groundwater in the No. 8 coal. On the other hand, the final steady-state water level in the mine backfill is higher than the pre-mine potentiometric level in the No. 3 coal at this location. Likewise, the final steady-state water level in the PCS is higher than the pre-mine potentiometric level in the PCS at this location. The heads in the mine spoil are much more uniform with depth, although the vertically downward head gradient between the mine backfill and the PCS is greater than the vertically downward head gradient between the No. 3 coal and the PCS prior to mining. The higher vertical downward gradients and the higher potentiometric levels mean that the vertical downward flows are higher under steady state conditions following mining. The increase in the rate of vertical flow into the PCS from the post-reclamation backfill in Area IV North occurs in response to the increase in the recharge rate that was applied to the reclaimed surface for post-reclamation conditions. As indicated in Table 11-14h, the average recharge rate of 0.04 in/year for post-reclamation conditions within the Area IV North Mine Area is more than five times the average pre-mine recharge rate of 0.0069 in/year estimated based on predominance of badland surfaces at the proposed mine area.

Figure 11-40 shows locations selected as prediction points for presenting water level drawdown and recovery results from modeling, including the A4N Y3 location that was previously discussed. The other two locations correspond with the locations of the now abandoned PCS wells, GM-19 and GM-28. The drawdown and recovery results for the GM-19 and GM-28 locations are provided in Figures 11-45 and 11-46, respectively. These results show very little change in the potentiometric level or head in the No. 8 coal seam, the No. 3 coal seam or in the PCS during and following mining at these locations within the permit area.

These results together with the estimated 5-foot drawdown contour maps at the end of mining in year 2016 show that the hydrogeologic effects of proposed mining within Area IV North are localized and occur over a long time period. The long-term change resulting from the removal of the interbedded coal, shales, mudstones, and sandstone strata and replacement with a relatively homogeneous and isotropic mine backfill will be an increase in the rate of vertical flow into the PCS from the mine backfill compared with the vertical flow into the PCS from the Fruitland formation prior to mining.

The model simulated steady-state post mining potentiometric surface in the PCS is provided in Figure 11-47. This surface is similar to the pre-mining PCS potentiometric surface in Appendix 6-G Figure 6.G-1 except for the localized increase in the heads in the PCS below the mine backfill within Area IV North. The higher head in the PCS below the mine backfill is due to the higher heads at the base of the mine backfill. Very little change in heads is predicted at locations away from mine backfill, including at the former PCS wells GM-19 and GM-28, located within the permit area at distances of about 3,500 and 3,000 feet from the Area IV North mine pit. This localized increase in heads in the PCS results in an increase in gradients toward the northwest and toward the northeast as depict in Figure 11-47.

Figure 11-45. Drawdown and Recovery in the PCS, the No. 3 Coal and the No. 8 Coal at GM-19

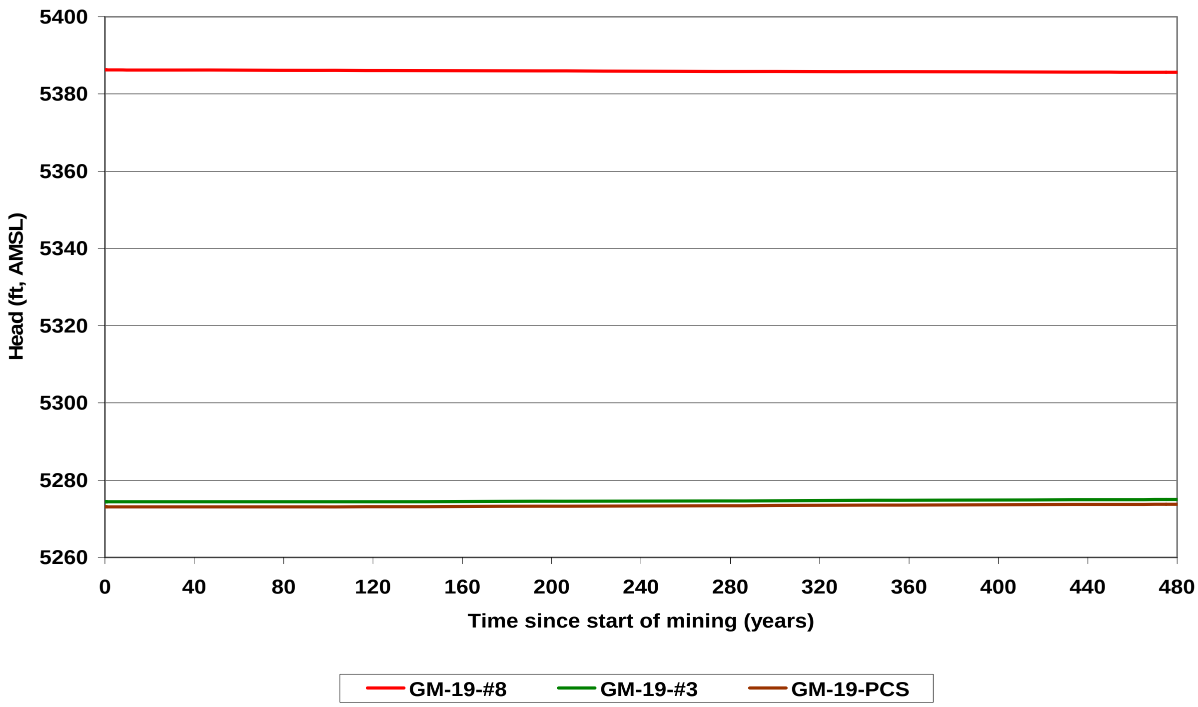
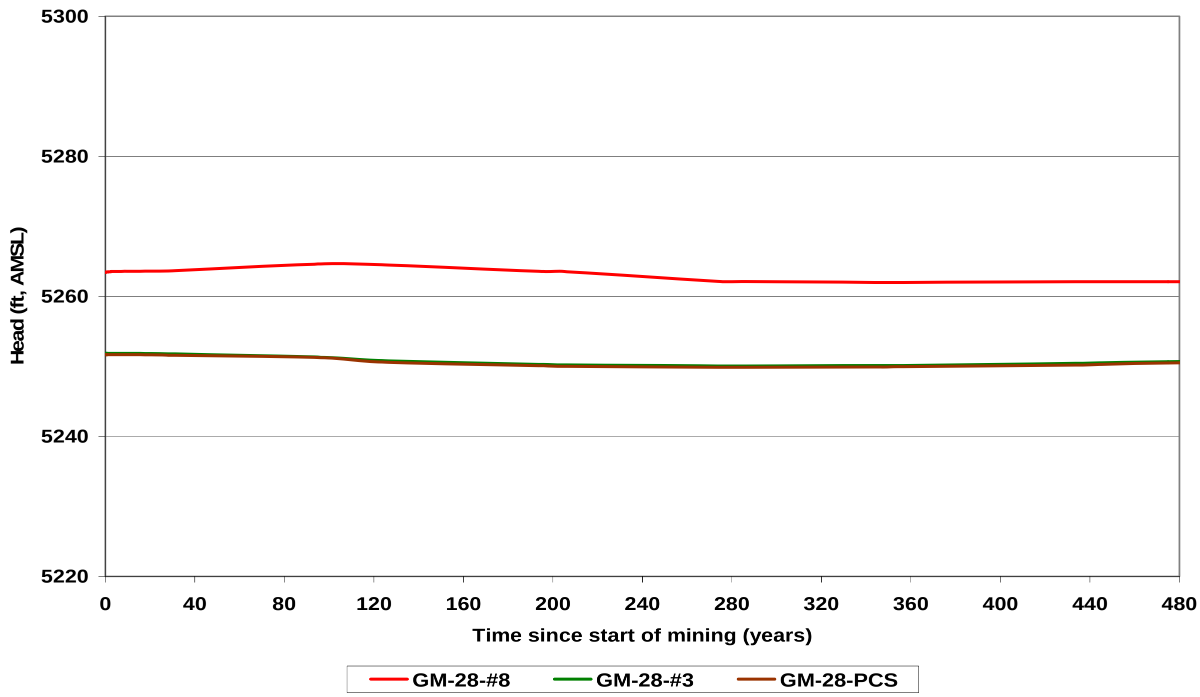


Figure 11-46. Drawdown and Recovery in the PCS, the No. 3 Coal and the No. 8 Coal at GM-28



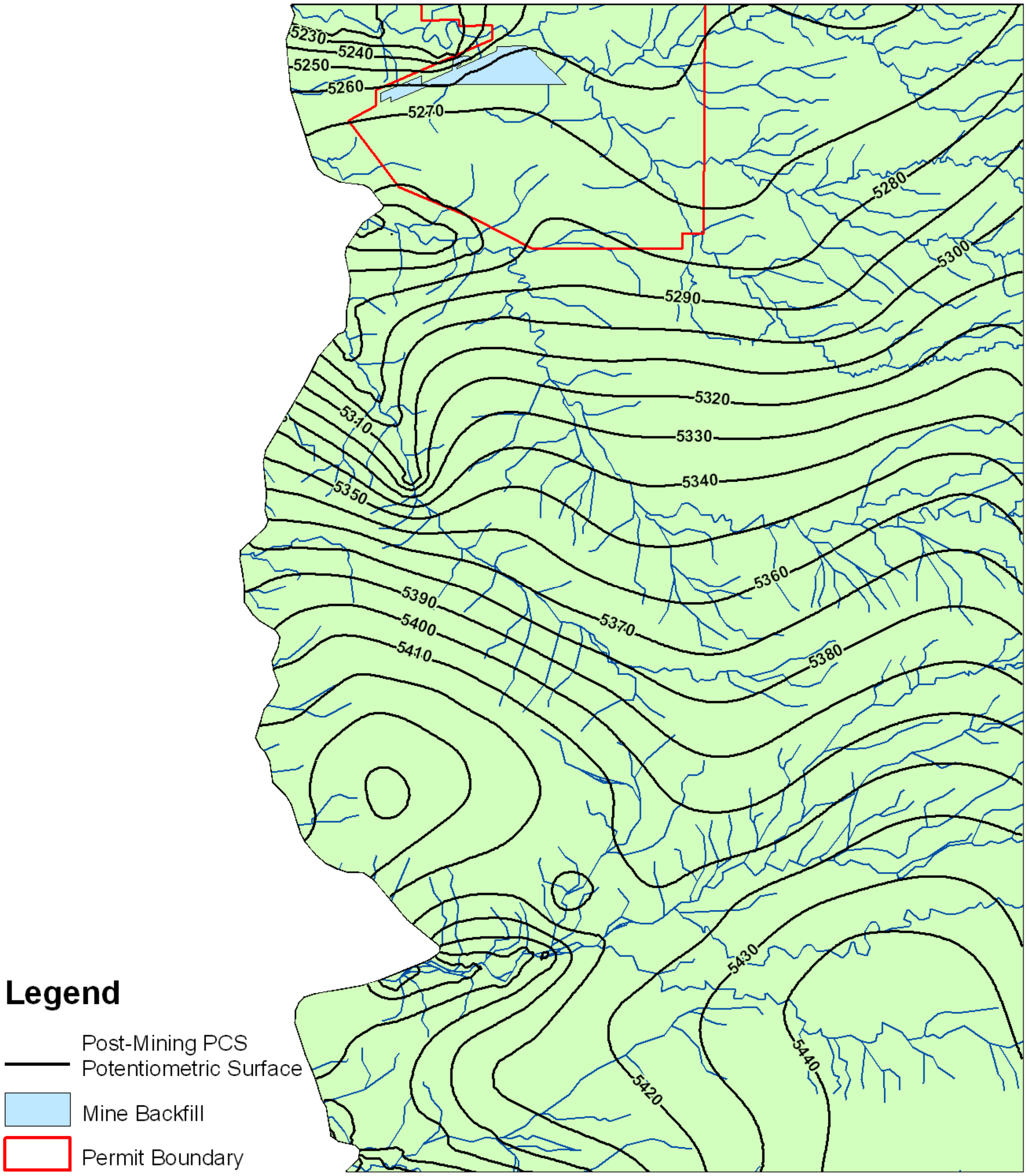
11.6.2.4.2 <u>Potential Impacts to Alluvial Groundwater Flow</u>

In both the pre-mining and post-reclamation groundwater flow models, there is a component of groundwater flow from Area IV North toward the alluvium within the topographic low along Cottonwood Arroyo. The increase in the post-reclamation recharge rate within the mine areas also increases the rate of the groundwater flow in the alluvium. The model estimates for the steady-state post-reclamation alluvial groundwater flow at the mouth of Cottonwood Arroyo is 4.58 gallons per minute (gpm) compared to the pre-mine alluvial groundwater flow estimate of 4.3 gpm.

However, the estimated increase in flow is not expected to measurably change the potential well yield from the alluvium for several reasons. First, the pre-mine groundwater flow in the Cottonwood alluvium was often insufficient to sustain water supply at alluvial wells. During baseline monitoring of the Cottonwood alluvium, well QACW-1 was dry and well QACW-2 was often dry. Water was observed in well QACW-2B during many of the monitoring events but the saturated thickness was limited to a few feet. Furthermore, actual groundwater flows in the alluvium are variable in space and time and a modeled steady state flow of 4.3 gpm does not translate into a reliable water supply of 4.3 gpm. Likewise, an estimated increase in the steady state flow by 0.3 gpm does not imply that this increase would be available as a reliable water supply at alluvial wells. Finally, groundwater recovery to the post-mining steady state conditions with the slight increase in groundwater flow is estimated to take more than 400 years.

The road crossings of Cottonwood Arroyo are not expected to affect the groundwater in the Cottonwood alluvium. The alluvium in the North Fork of Cottonwood has been mined through in Area III. Thus, the groundwater in the alluvium of the North Fork Cottonwood has most likely been depleted immediately up gradient and down gradient of the mine. The loss of alluvial groundwater flow from the North Fork may result in a decrease in groundwater flow in the Cottonwood alluvium below the confluence with the North Fork. The alluvium along the main stem of Cottonwood will not be mined through and advance of the pit in Area IV North and drawdown in the coal units and the PCS are not expected to significantly affect groundwater levels in the alluvium of Cottonwood Arroyo.

Figure 11-47. PCS Steady-State Post-Mining Potentiometric Surface



11.6.2.4.3 Potential Groundwater Quality Changes

Groundwater quality changes beyond the active mine area at Area IV North will be minimal during mining and reclamation operations. During active mining, hydraulic gradients, and groundwater flow directions in the Fruitland Formation and in the underlying PCS will be toward the mine pits and backfill areas. Thus, it is expected that there will be little change in the quality of groundwater beyond the limits of the mine pit and mine backfill during mining and reclamation operations.

The water quality in the mine backfill materials will evolve as these materials begin to resaturate with recharge from precipitation and groundwater inflows from the adjacent Fruitland Formation coal seams and from the underlying PCS. Upward flow into the mine backfill from the PCS will be relatively low and will cease once saturation levels in the backfill rise sufficiently to reverse directions of flow after about 85 years following the start of mining. Dissolved solids present in the pore water of mine overburden and interburden materials (spoil) that are used to backfill the pit may be concentrated by evaporation during mining. There may also be some enhanced weathering of the minerals within the newly fractured and broken interburden strata that are removed during mining of the coals and placed within the mine backfill. The characteristics of the overburden and interburden strata within Area IV North were determined from an extensive drilling, coring, and testing program described in Chapter 5.

It is expected that TDS and sulfate concentrations will increase in the Area IV North mine spoil relative to the baseline concentrations in the Fruitland Formation coals based on both spoil leaching tests results and the water quality analysis of spoil water samples taken from the Bitsui Pit as presented in Section 11.6.2.2. Concentrations of boron and manganese may also increase but other trace constituents are expected to remain below detection limits or comparable to the concentrations observed in the baseline coal water.

The TDS concentrations are lower in the Fruitland coals in the vicinity of Area IV North in comparison with the baseline TDS concentrations further north in the vicinity of Areas I and II. The groundwater leaching test results presented in Table 11-14b showed TDS concentrations of

11,000 and 12,000 mg/L in leachate generated from two spoil samples using composite coal groundwater samples from Area II wells KF84-18a and KF84-18b with a TDS concentration of 9,800 mg/L. A comparable TDS concentration of 11,850 mg/l was observed in spoil water in the Bitsui Pit at well Bitsui-5. This well is most representative of concentrations from spoil only in the Bitsui Pit because it is not located near or down gradient of any CCB placement locations.

The water sources for leaching of mine spoil in the Bitsui Pit in Area I include the No. 8 coal water with TDS concentrations ranging from 5,000 to 10,000 mg/L, seepage from the PCS and from adjacent NAPI irrigation plots with unknown TDS concentrations and some precipitation recharge with low TDS concentrations. The water sources for recharge of the Area IV North mine spoils include:

- inflows from the various coal units with average TDS concentrations of approximately 3,000 mg/l as found for the composite coal sample used in the leaching test results presented in Table 11-14f;
- precipitation recharge with TDS concentrations of approximately 1,200 mg/l based on the SPLP leaching test results presented in Table 11-14f; and
- upward flow from the PCS with average TDS concentrations in the range from 7,800 to 9,200 mg/l based on samples obtained from nearby PCS well GM-19 (Appendix 6-G Table 6.G-14).

Inflow from the PCS is estimated to be very low and temporary so that backfill recharge over the long-term is expected to be primarily from the coals and from precipitation recharge. Since the TDS concentrations are lower in the coal water at Area IV North in comparison with the coals near the Bitsui Pit, the TDS concentrations in the spoil water in Area IV North should also be lower than the concentrations observed at the Bitsui spoils or in the Table 11-14b spoil leaching test results. Nevertheless, there is likely to be some increase in TDS concentrations within the Area IV mine spoil water relative to the baseline TDS in the Fruitland Formation at this location.

The spoil leaching test results presented in Table 11-14f using coal water representative of Area IV North may be viewed as a lower bound estimate for the TDS in spoil water in Area IV North. These results indicate that TDS and sulfate concentrations in the spoil water may increase by about 500 mg/l and 900 mg/L, respectively above the corresponding concentrations in the coal. The TDS and sulfate concentrations in the spoil water at the Area IV North mine may be higher than these leaching test results due to calcite precipitation and ion exchange which results in increased sulfate and sodium concentrations and decreased calcium concentrations in saturated mine spoils in comparison with leaching test results. While the TDS observed in the spoil well Bitsui-5 was within the limits of the TDS in Table 11-14b for the two spoil leaching tests performed using the composite coal groundwater, the sulfate concentrations in Bitsui-5 were about two times the concentrations observed in the spoil leaching tests. For this PHC analysis, the TDS concentrations in the Bitsui-5 well were used as an upper bound estimate for the post-mine TDS concentrations in the mine spoils in Area IV North.

Table 11-14i provides a range of concentrations for constituents of concern that might be expected in Area IV North mine spoils based on leaching tests and water quality monitoring at spoil well Bitsui-5. These results show TDS and sulfate to be the primary constituents of concern with respect to spoil leachate. Arsenic and selenium were below detection in the spoil water sample and in most of the leaching test results. Fluoride is lower in the spoil water than in the coals and is attenuated in flow through mine spoil. Boron and manganese concentrations are elevated in mine spoil but concentrations are below criteria for livestock use.

Table 11-14i.

Estimated Source Concentrations in Mine Spoils

Constituent	Area IV North coal water[1]	Estimated Source Concentrations in Mine Spoils (mg/L)			
		Spoil Well Bitsui #5	SPLP of Area III Spoil	Area III Spoil leached with Area IV N coal water	S-4 Spoil leached with Area II coal water
Arsenic	<0.015	<0.005	<0.015	<0.015	0.002
Boron	0.31	1.11	0.084	0.45	<0.5
Calcium	3.4	60	150	67	730
Manganese	<0.01	0.108	0.19	0.11	0.70
Fluoride	2.4	1.0	0.54	1.6	0.50
Sodium	1200	3870	150	1200	3200
Selenium	<0.026	<0.005	<0.026	<0.026	0.2
Sulfate	300	5,030	670	980	2700
TDS	3100	11,850	1200	3550	12000

[1]Determined from Initial Coal Water results in Table 11-14f for composite sample of No. 8 and No 3 Coal wells

SPLP= Synthetic Precipitation Leaching Procedure

Consequently, TDS was selected for transport modeling simulations using a lower bound source concentration of 3,550 mg/l and an upper bound TDS concentration of 11,850 mg/l. TDS was assumed to behave conservatively, that is with no attenuation due to adsorption or chemical transformation. Sulfate was not modeled. Based on the observations at the spoil well Bitsui-5, sulfate concentrations are expected to comprise about 43% of the TDS. The results of leaching tests using coal water as summarized in Table 11-14i indicate sulfate fraction of TDS of 23% and 28% while the SPLP results indicate a sulfate fraction of about 56% of the TDS. For lateral transport from the mine spoil to the Cottonwood alluvium sulfate may be assumed to vary with TDS concentrations based on the sulfate-TDS ratio in the mine spoil source Sulfate reduction is not likely to occur to a measurable degree in the shallow groundwater and the transport of TDS and sulfate may be expected to behave conservatively. The estimate of sulfate comprising 43% of the TDS is based on actual spoil water data from the Bitsui Pit and is believed to be the best estimate for the ratio of sulfate to TDS in spoil water transport. However, the ratio could vary from this estimate as indicated by the leaching test results. However, it may not be appropriate to assume that sulfate concentrations in groundwater transport from the mine spoils through the coals will vary directly with the modeled changes in TDS concentrations because sulfate and TDS may not behave conservatively due to sulfate reduction.

The FEFLOW™ software used for groundwater flow modeling includes features that simulate both conservative and reactive transport. The FEFLOW™ transport routines were applied to simulate the transport of TDS from the Area IV North mine spoil. The chemical transport model was applied to the steady-state post-reclamation groundwater flow conditions to provide predictions of long-term post-reclamation TDS transport from the mine spoil in Area IV North.

The transport model solves advection-dispersion-adsorption equations for constituent transport processes in groundwater flow. Several transport scenarios were performed to evaluate the sensitivity of transport results to changes in groundwater flow parameters. Transport sensitivity scenarios specified the upper bound TDS source concentration of 11,850 mg/l that remained constant throughout the 500-year transport modeling period. An addition sensitivity scenario assuming the lower bound TDS source concentration of 3,550 mg/l was run with the most likely configuration of groundwater flow parameters (Scenario 5).

The 500-year transport simulations were performed using the post-mine steady-state groundwater flow conditions as the initial condition for transport modeling. A 500-year simulation period was considered reasonable for modeling the fate and transport from a constant TDS source concentration in the backfill. After 500 years it is expected that the source concentrations in the mine backfill will decline as groundwater flows through the mine backfill and flushes salts that may have been concentrated in the mine spoils as a result of weathering and evaporation during mining and backfilling operations. Table 11-14j summarizes the flow parameters varied in the transport sensitivity runs. Scenarios 4 and 5 in Table 11-14j represent the most likely case of post-mining groundwater flow parameters and the upper and lower bounds of source concentration, respectively (Appendix 11-WW).

Table 11-14j.

Summary of Transport Model Sensitivity Runs

Transport Scenario	Source Concentration (mg/l)	Backfill Recharge Rate (in/yr)	Backfill Hydraulic Conductivity (ft/d)	Specific Storage (1/ft)	Coal Specific Yield (fraction)
1	11,500	0.04	0.056	$1x10^{-4}$	.2
2	11,500	pre-mine	0.56	$3.8x10^{-6}$ Coal: $2.8x10^{-5}$	.2
3	11,500	0.04	0.56	$3.8x10^{-6}$ Coal: $2.8x10^{-5}$	0.005
4	11,500	0.04	0.056	$3.8x10^{-6}$ Coal: $2.8x10^{-5}$	0.005
5	3,550	0.04	0.056	$3.8x10^{-6}$ Coal: $2.8x10^{-5}$	0.005

Natural background concentrations were not included in the transport modeling for several reasons:

- the natural background concentrations in all the geologic strata represented by layers in the model is variable and cannot be defined over the entire model domain;
- the natural background concentrations in the alluvium varies not only spatially but also with time and would be difficult to adequately simulate in the transport model; and
- the objective of the transport modeling is to clearly depict the direction and rate of transport of TDS from the mine spoils, which may be difficult to identify with the variability in natural background TDS concentrations in all the geologic strata.

Nevertheless, the natural background concentrations in the alluvium have been considered in the subsequent interpretations drawn from the transport modeling results.

FEFLOW™ transport modeling results are presented for the following selected model layers:

- L1 - corresponding with the alluvium, with the upper 10 ft of soil and overburden in unmined areas and with the upper 10 ft of backfill and topdressing materials in reclaimed areas;
- L4 - corresponding with the No. 8 coal seam in unmined areas and the same elevation as the No. 8 coal in the mine backfill;

- L20 - corresponding with the No. 3 coal seam in unmined areas and same elevation as the No. 3 coal seam in the mine backfill areas;
- L28 - corresponding with the PCS throughout the model domain.

The results of the simulations at the end of the 500-year simulation period for L1 are presented in Figures 11-48 through 11-52 for each of model transport sensitivity scenarios listed in Table 11-14j. The results of all scenario runs for the upper bound TDS source concentration of 11,850 mg/l show that concentrations greater than 5,000 mg/l do not extend very far from the mine spoil. The primary horizontal direction of TDS migration from the mine spoil in L1 is toward the alluvium and topographic lows along Cottonwood Arroyo. Elevated TDS concentrations extend down gradient within the alluvium of Cottonwood Arroyo but are less than 1,000 mg/l near the mouth of Cottonwood.

The L28 simulation results for TDS transport in the PCS are presented in Figures 11-53 through 11-57 for each of model transport sensitivity scenarios listed in Table 11-14j.. These results show that the primary direction for TDS transport from the mine spoils is vertically into the PCS. Thus, the primary direction for spoil water migration is into a water-bearing zone that has TDS concentrations similar to, if not higher than, the TDS levels expected for spoil water. The results for the upper bound TDS source concentrations show that the TDS concentrations in the PCS directly below the mine spoils are generally within the range from 5,000 to 10,000 mg/L. The higher TDS concentrations occur where the shale separating the backfill from the PCS is the thinnest or absent. Groundwater flow and TDS transport in the PCS in the vicinity of the Area IV North mine is predominantly laterally toward the alluvium and topographic low along Cottonwood Arroyo. TDS transport in the PCS to the north and east is limited as shown in these figures.

The simulation results at the end of the 500 year simulation period for the No. 8 coal (L4) are presented in Figures 11-58 and 11-62, respectively, for the scenarios listed in Table 11-14j. Likewise, the No. 3 coal (L20) results at the end of the 500 year simulation period are presented in Figures 11-63 and 11-67. These results show groundwater flow and TDS transport from the mine spoil to the north toward the Fruitland Formation outcrop along Cottonwood Arroyo.

Lateral transport to the northeast in the No. 8 coal is restricted due to the lower heads in the mine backfill relative to the heads in the No. 8 coal prior to mining. Lateral transport in the No. 3 coal is also restricted despite the higher heads in the backfill relative to the heads in the No. 3 coal prior to mining. TDS transport in the No. 3 coal is restricted due to the lower permeability of the No. 3 coal relative to the No. 8 coal.

Figure 11-48. Scenario 1 TDS Transport in the L1 after 500-years with Constant Source of 11,850 mg/l

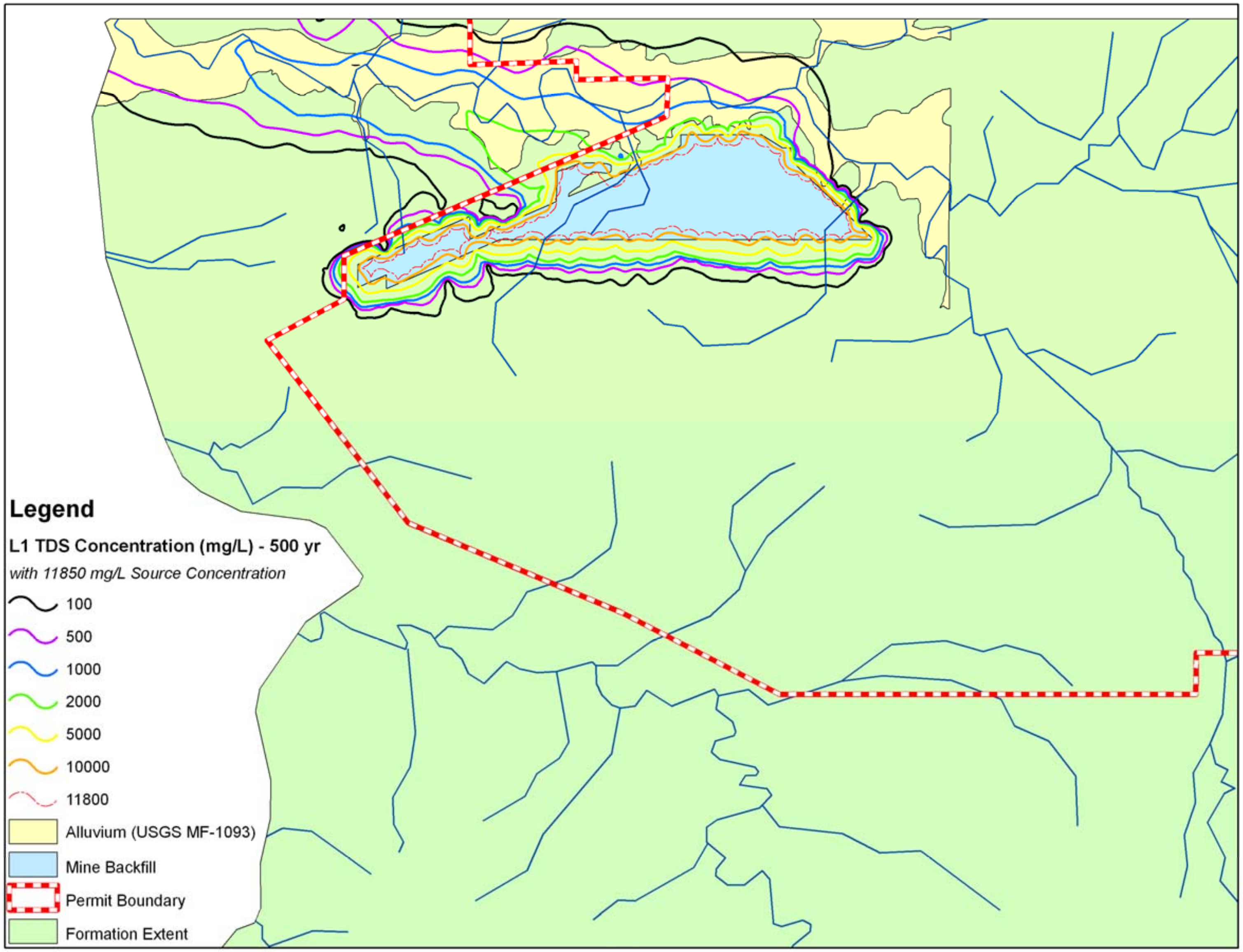


Figure 11-49. Scenario 2 TDS Transport in the L1 after 500-years with Constant Source of 11,850 mg/l

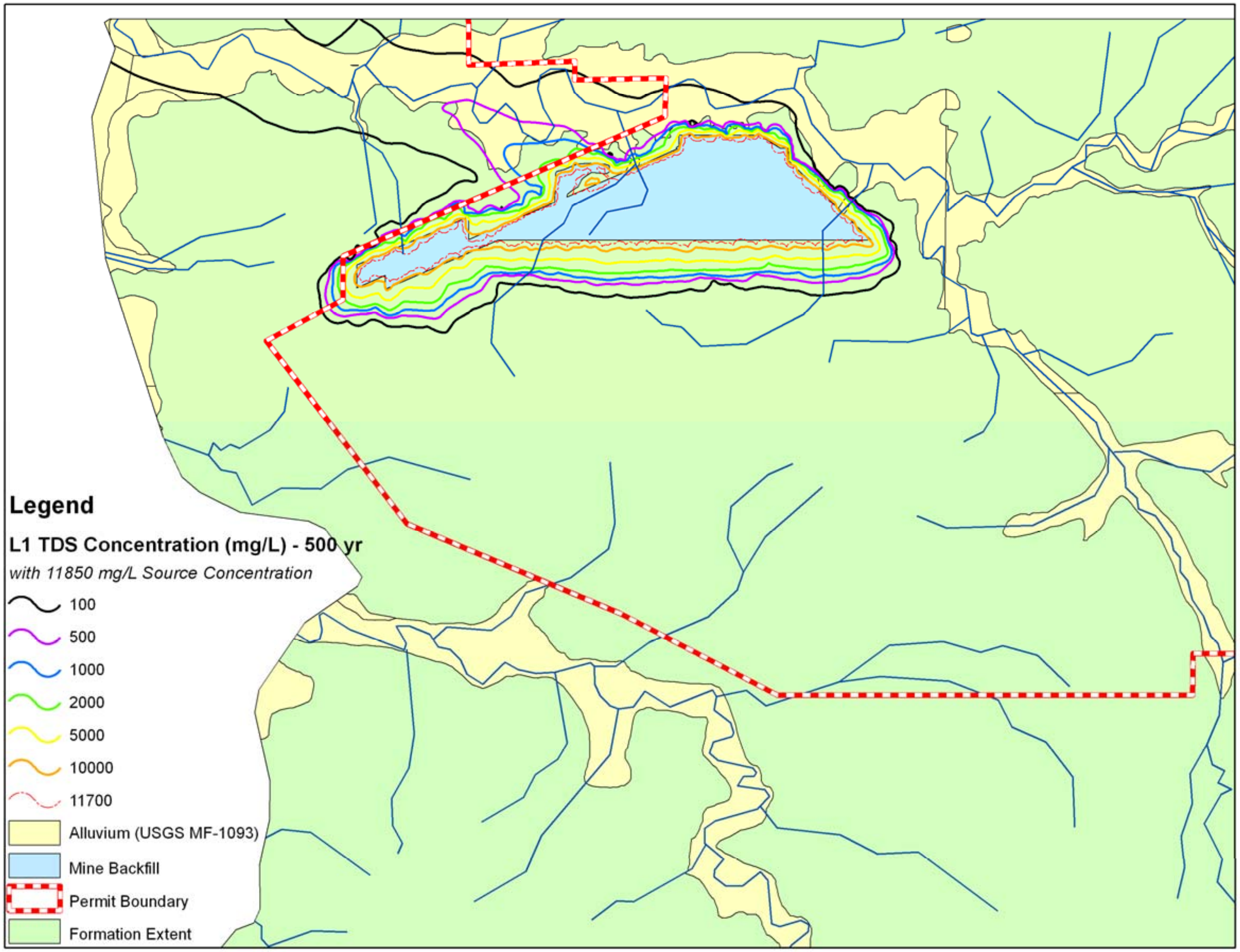


Figure 11-50. Scenario 3 TDS Transport in the L1 after 500-years with Constant Source of 11,850 mg/l

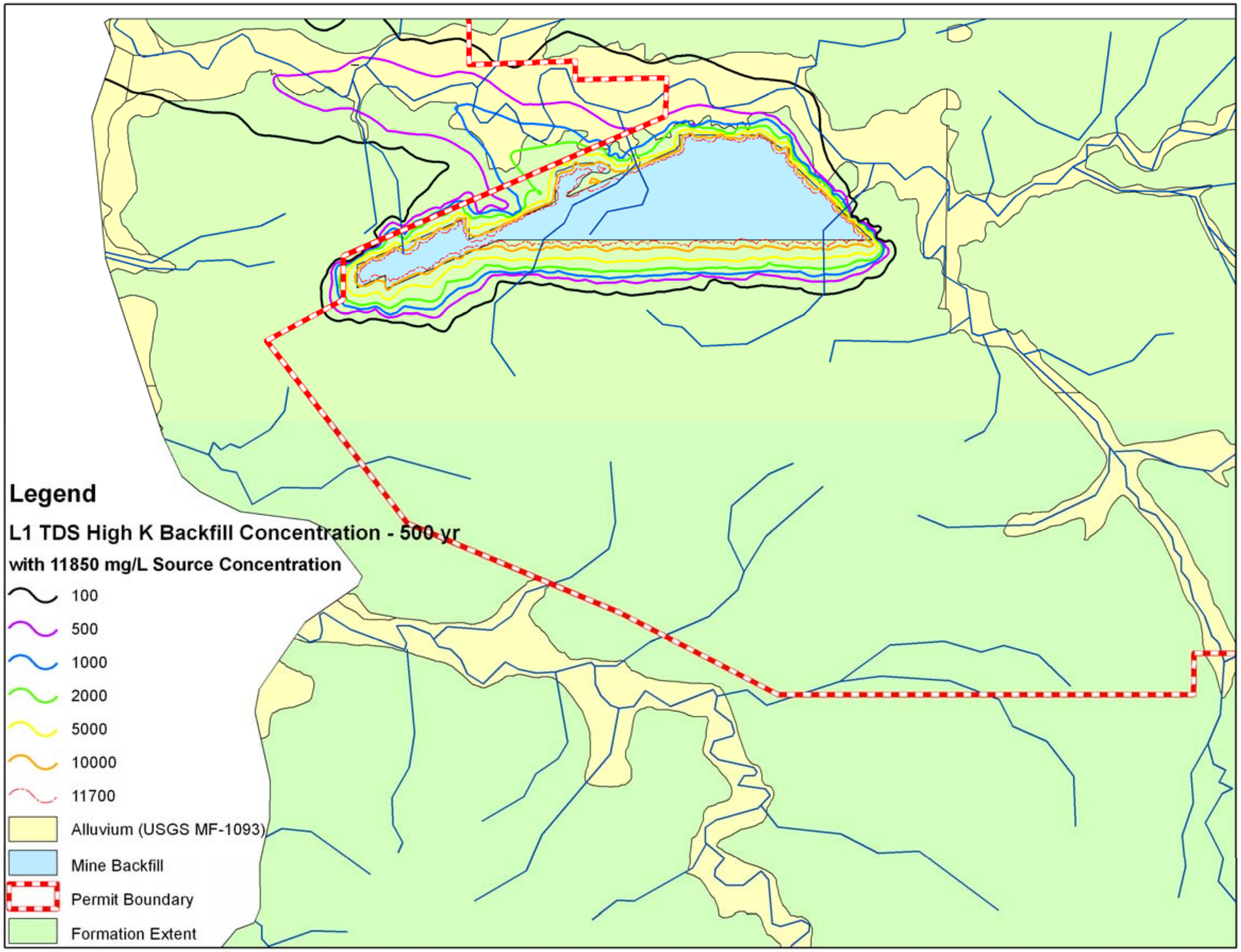


Figure 11-51. Scenario 4 TDS Transport in the L1 after 500-years with Constant Source of 11,850 mg/l

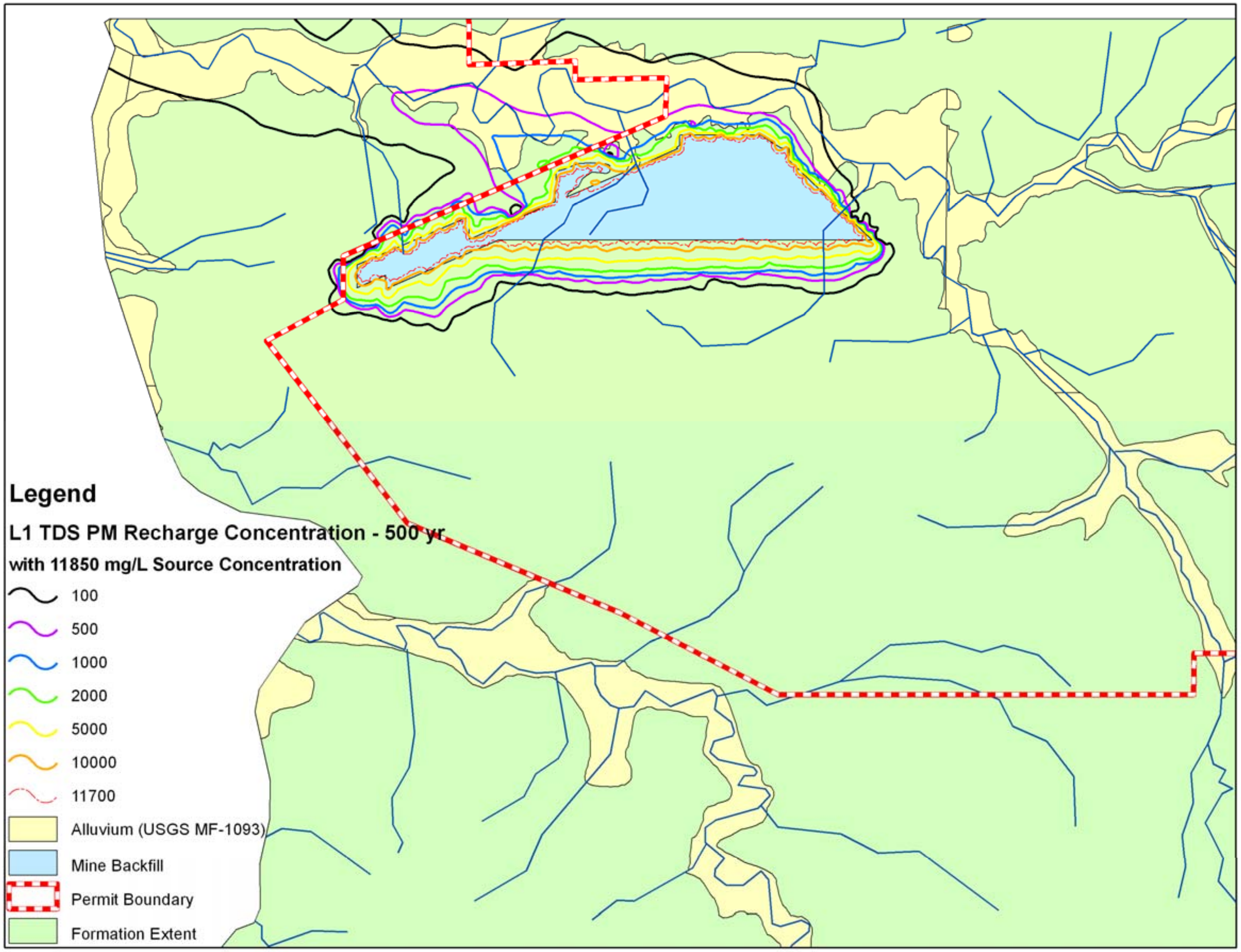


Figure 11-52. Scenario 5 TDS Transport in the L1 after 500-years with Constant Source of 3,550 mg/l

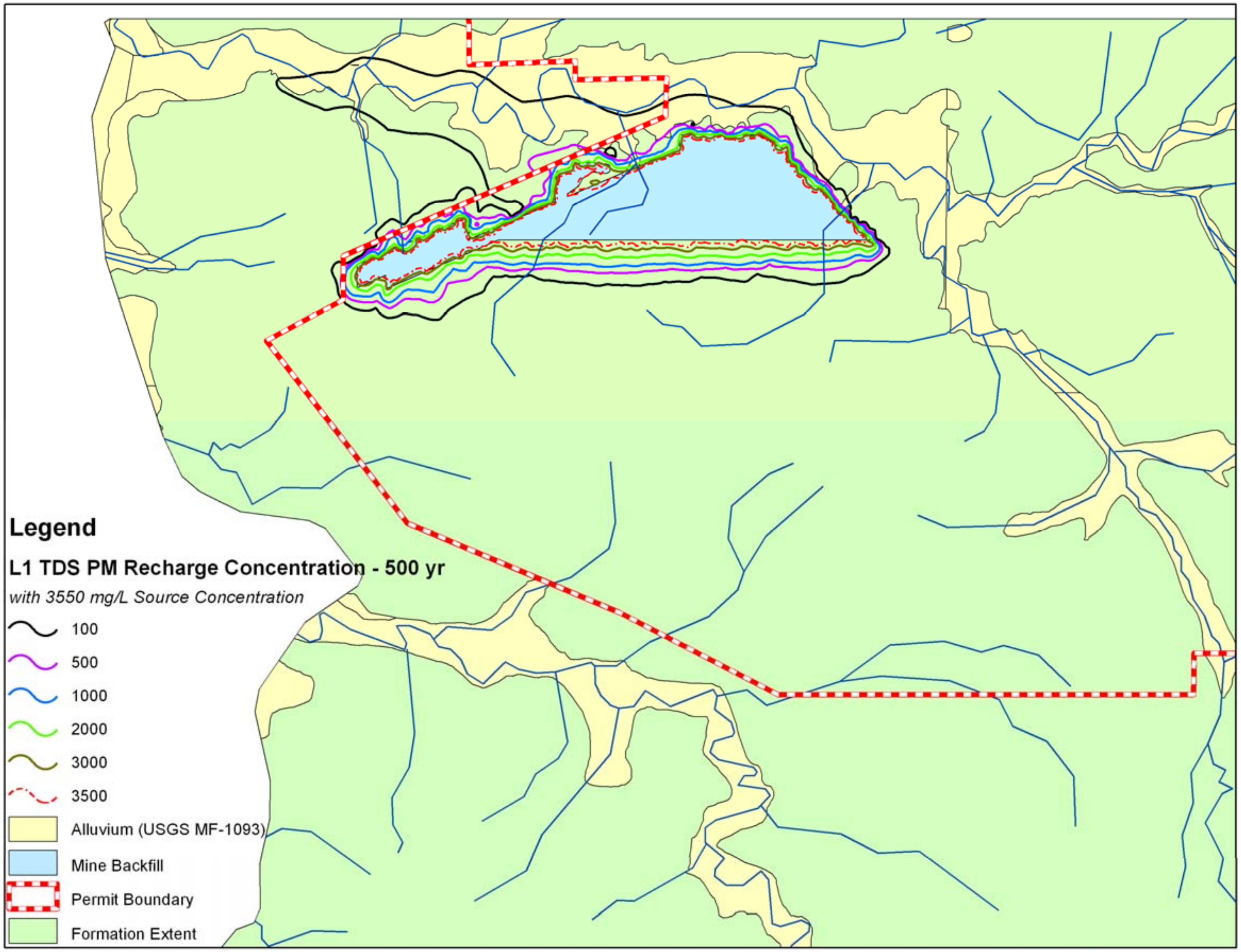


Figure 11-53. Scenario 1 TDS Transport in the PCS after 500-years with Constant Source of 11,850 mg/l

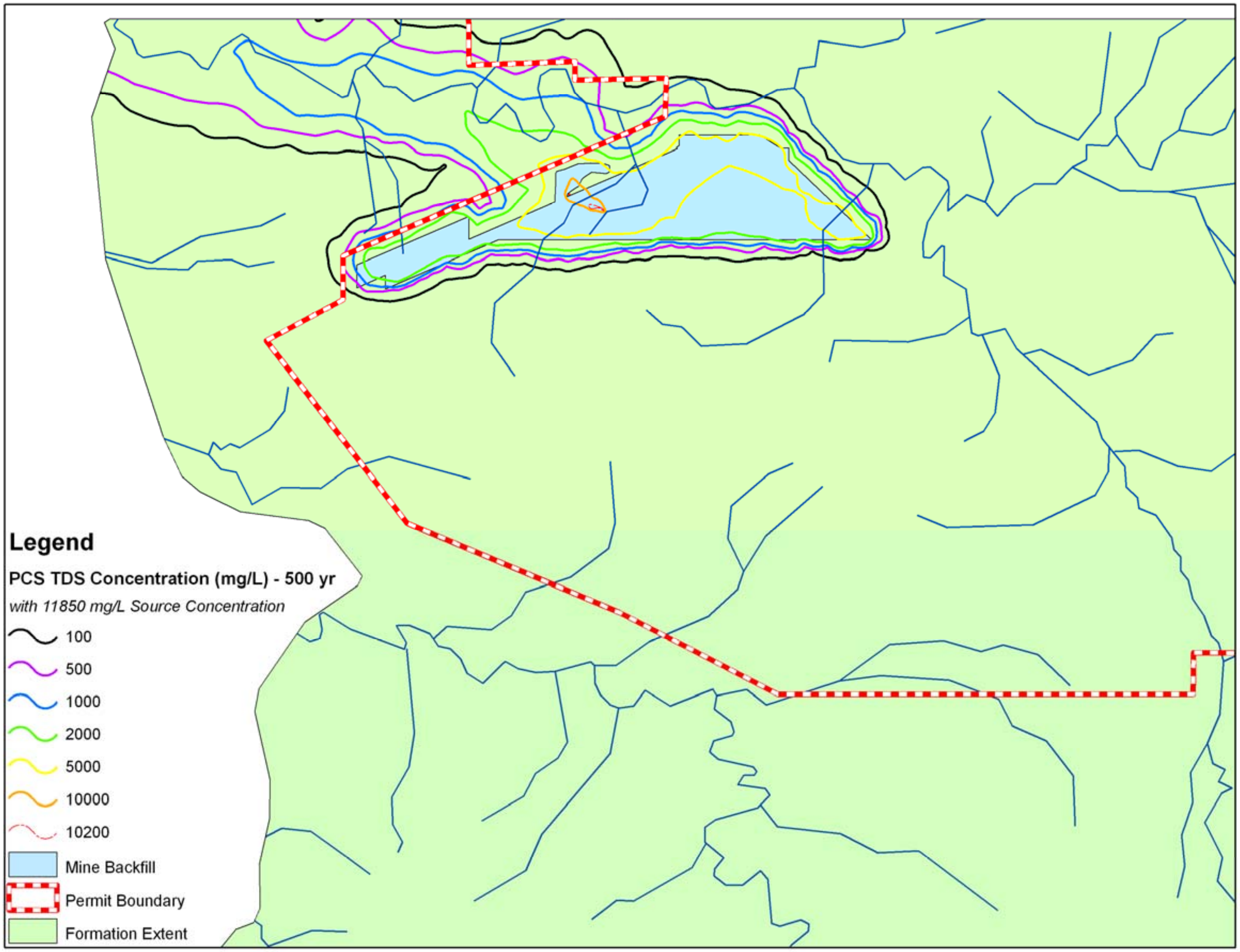


Figure 11-54. Scenario 2 TDS Transport in the PCS after 500-years with Constant Source of 11,850 mg/l

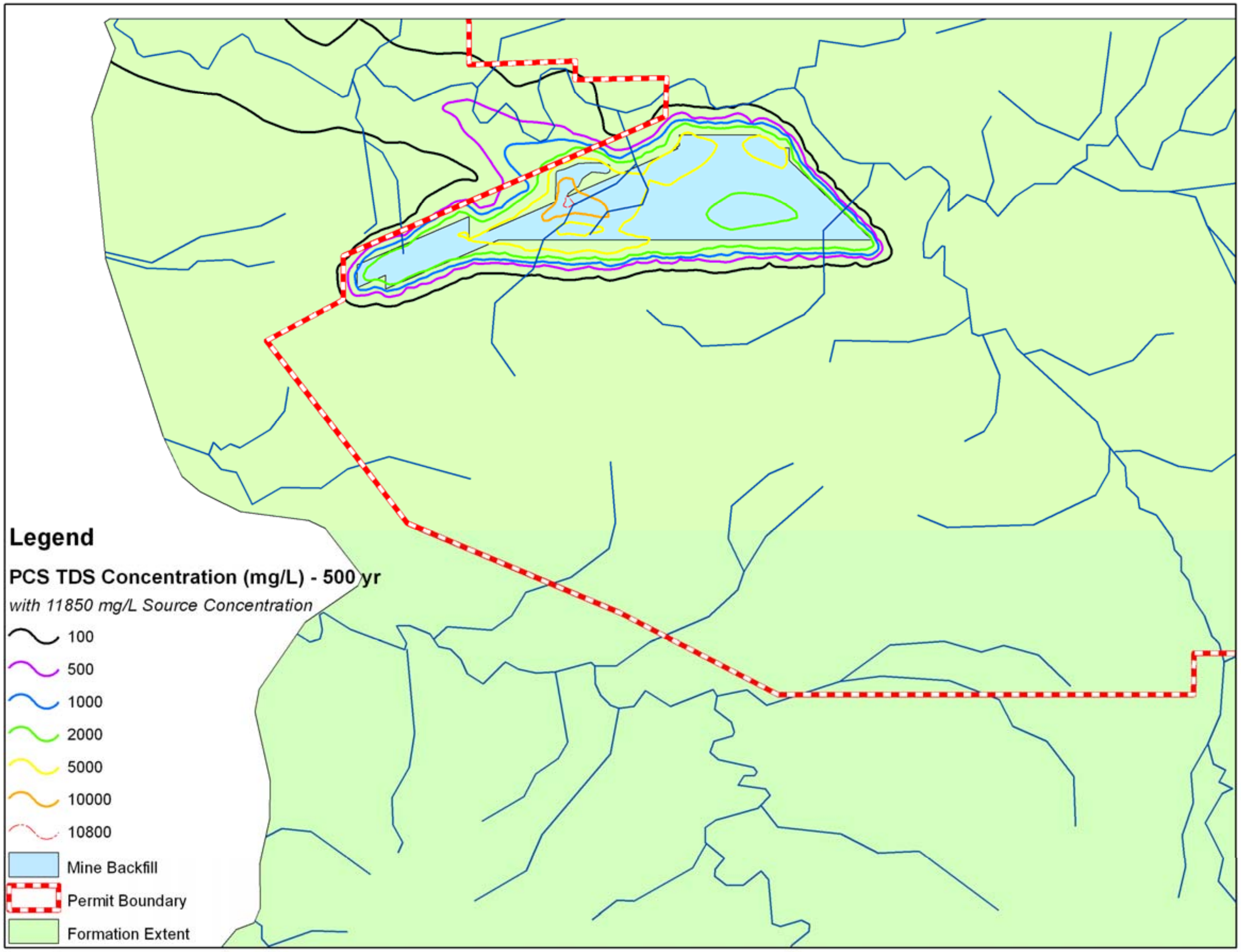


Figure 11-55. Scenario 3 TDS Transport in the PCS after 500-years with Constant Source of 11,850 mg/l

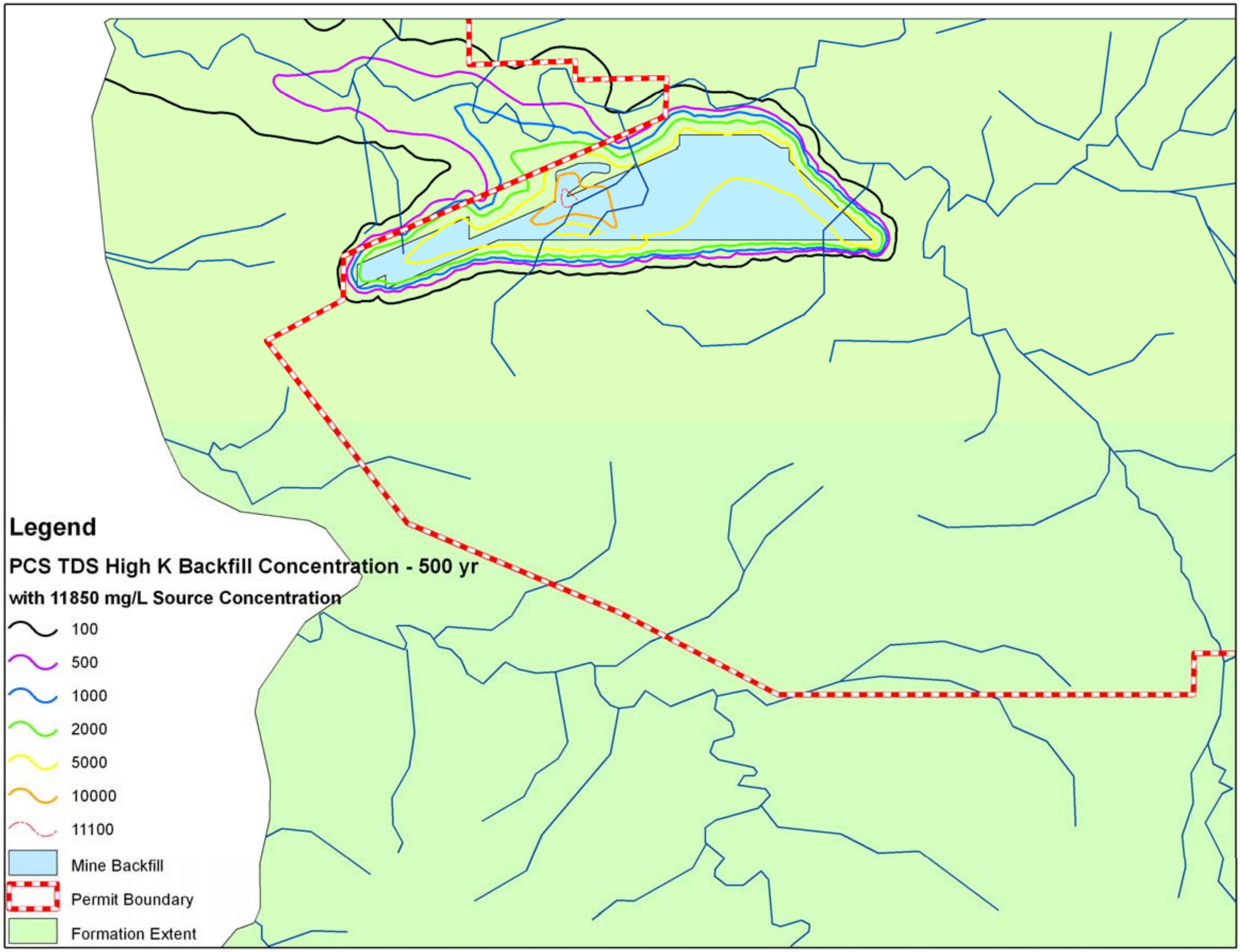


Figure 11-56. Scenario 4 TDS Transport in the PCS after 500-years with Constant Source of 11,850 mg/l

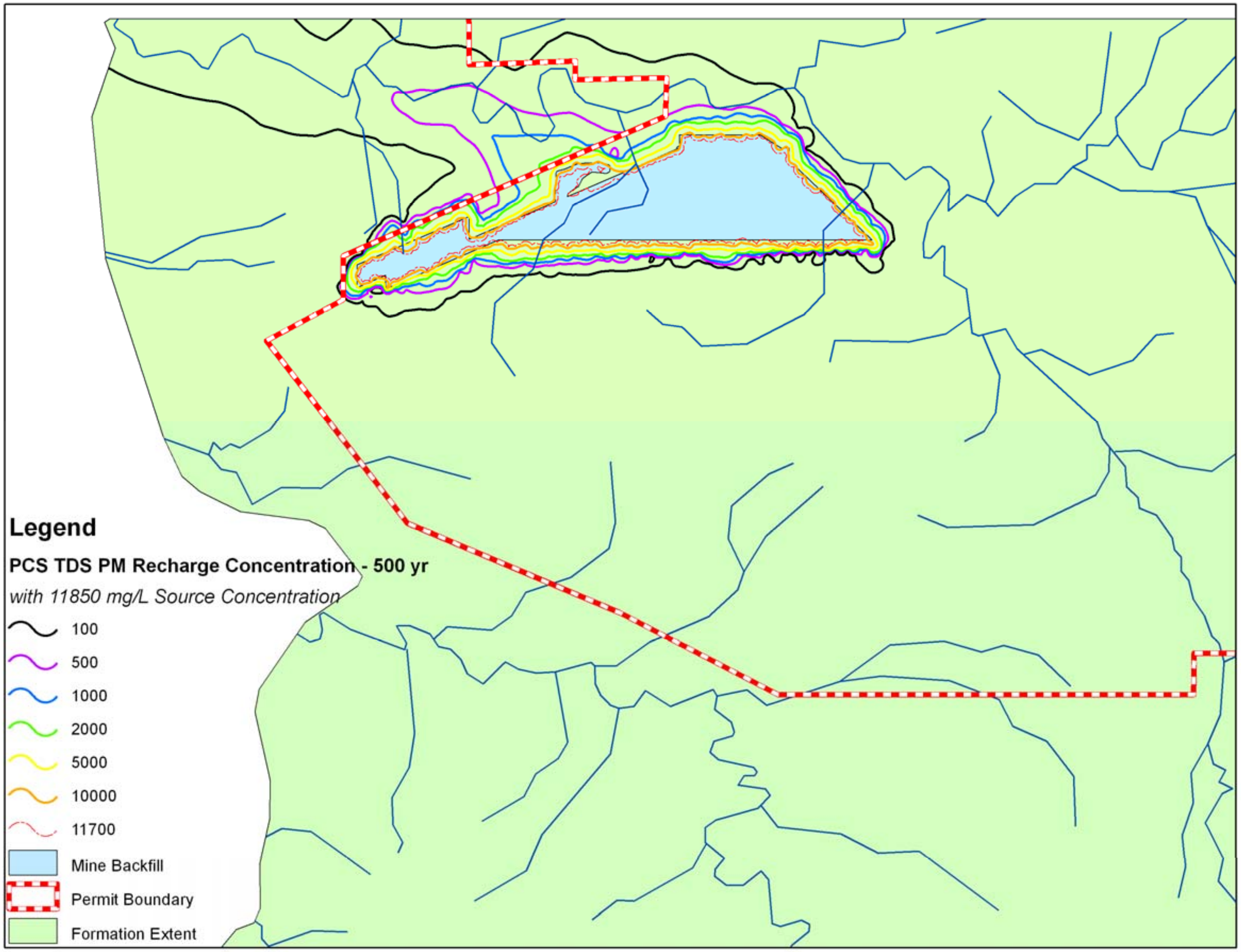


Figure 11-57. Scenario 5 TDS Transport in the PCS after 500-years with Constant Source of 3,550 mg/l

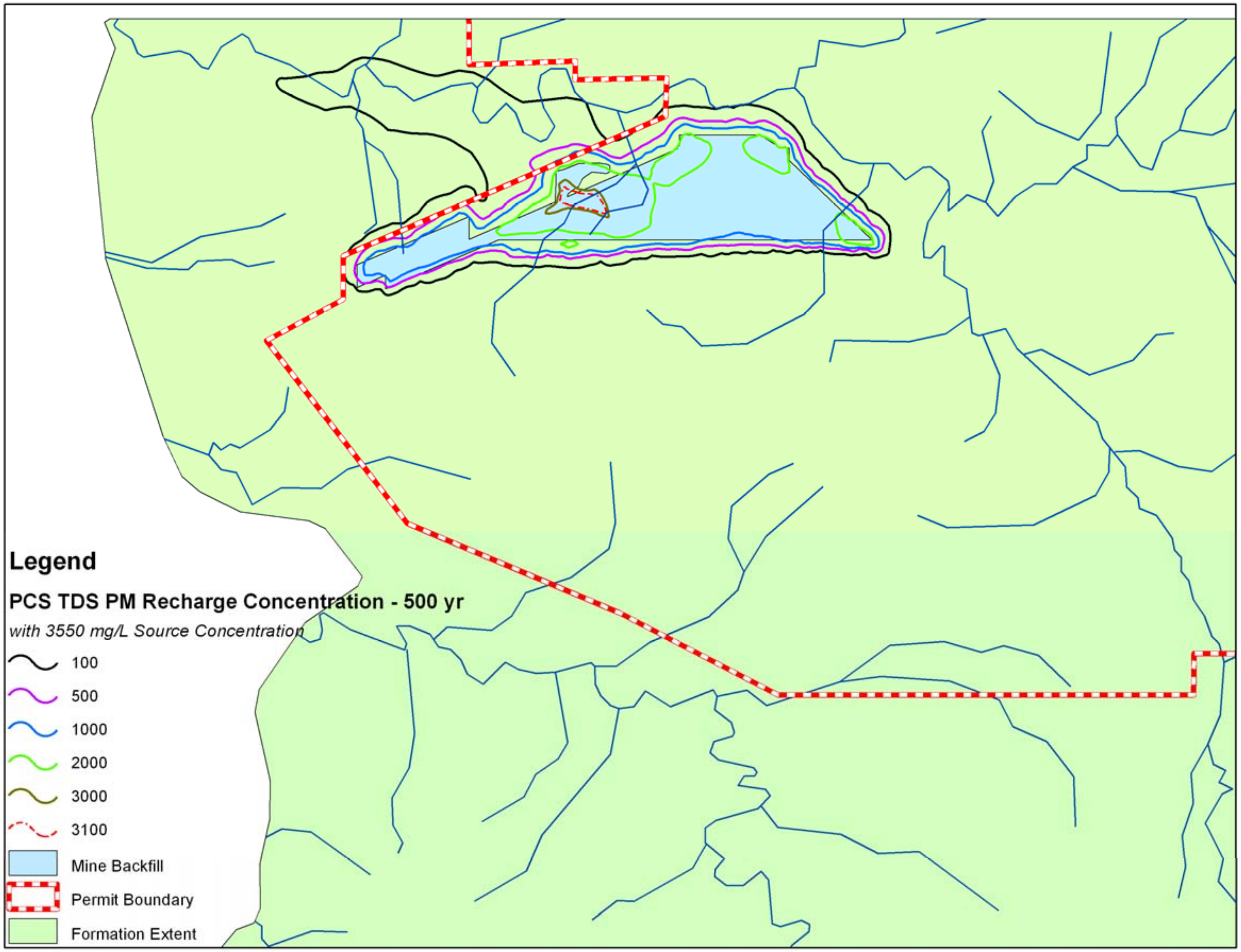


Figure 11-58. Scenario 1 TDS Transport in the No. 8 Coal after 500-years with Constant Source of 11,850 mg/l

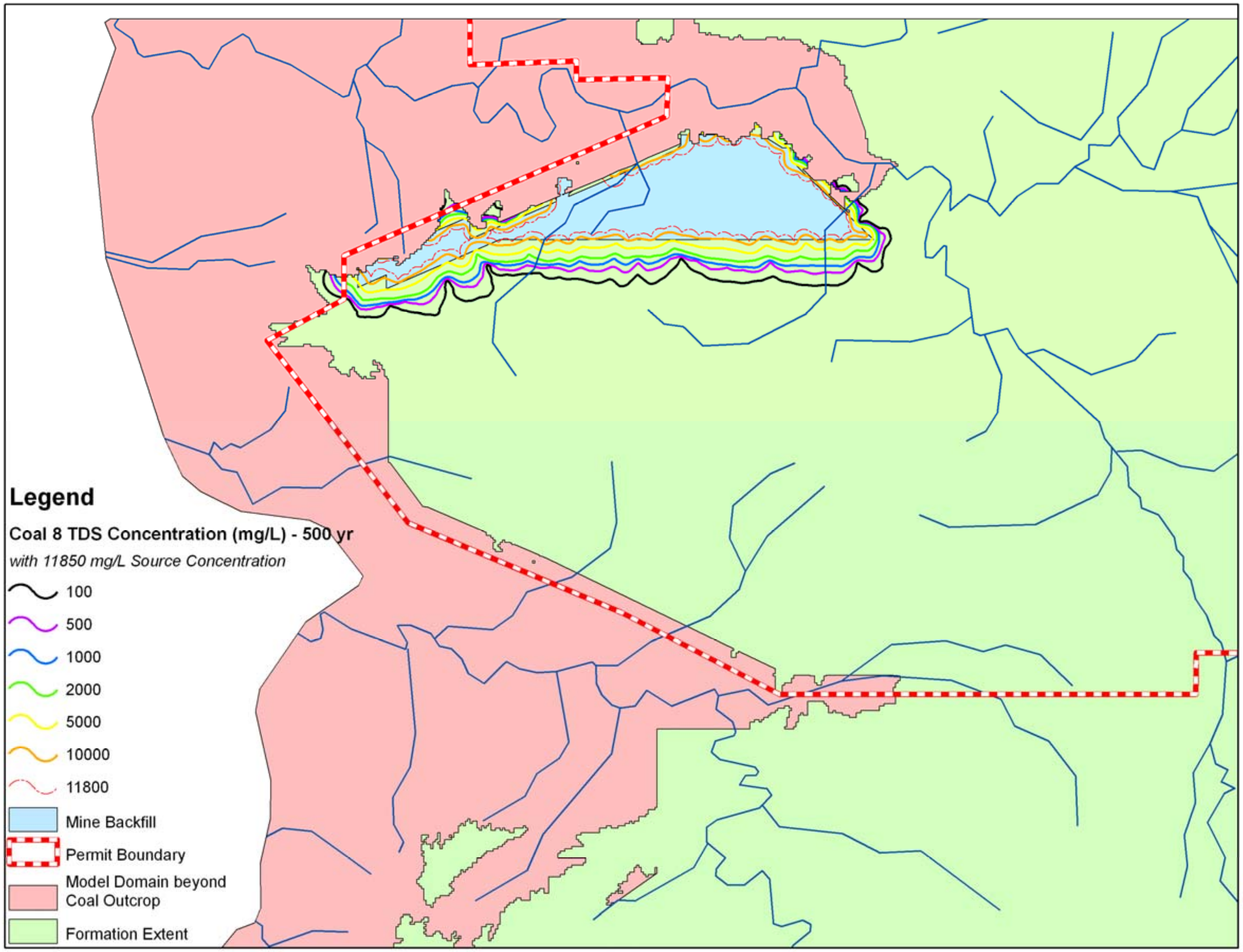


Figure 11-59. Scenario 2 TDS Transport in the No. 8 Coal after 500-years with Constant Source of 11,850 mg/l

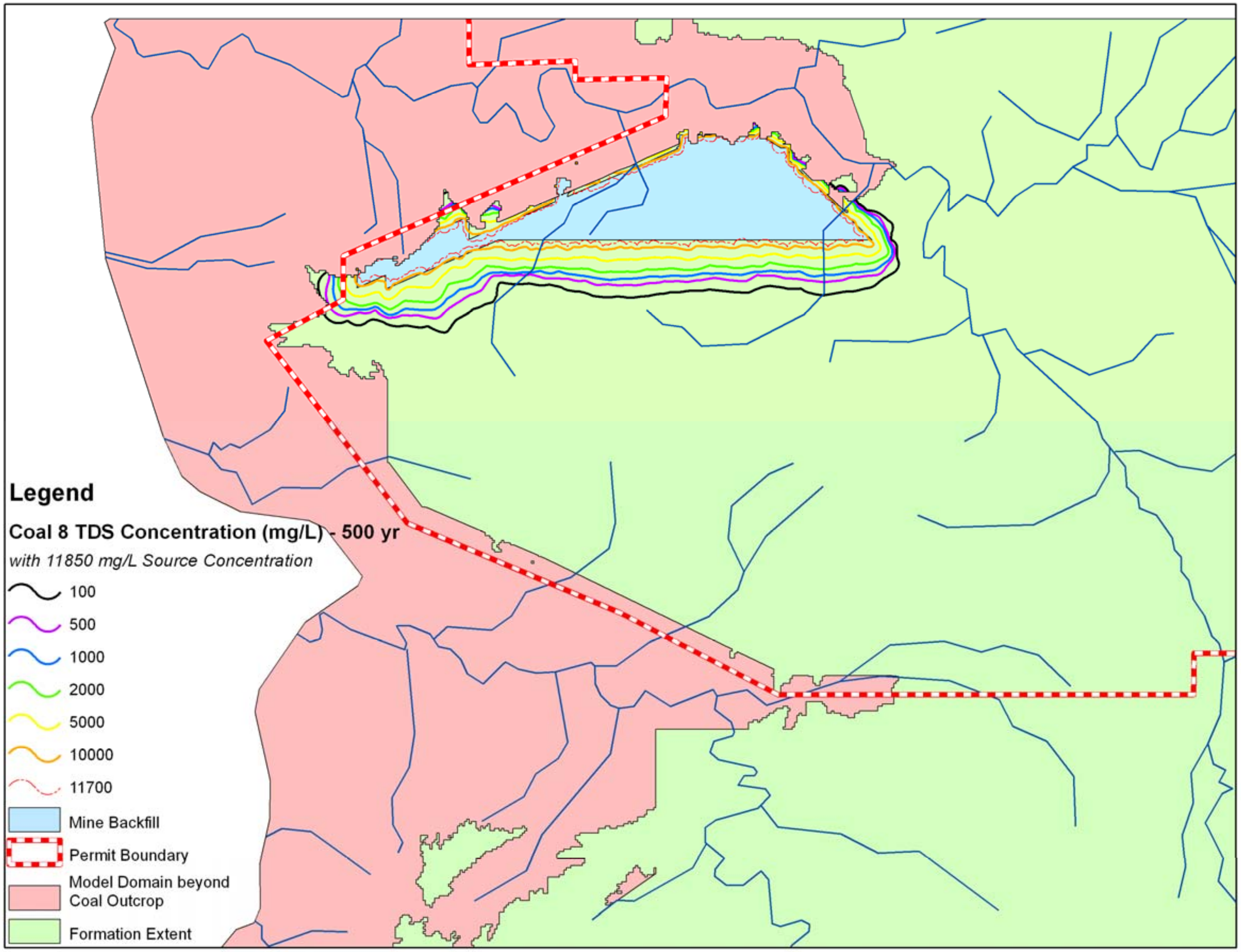


Figure 11-60. Scenario 3 TDS Transport in the No. 8 Coal after 500-years with Constant Source of 11,850 mg/l

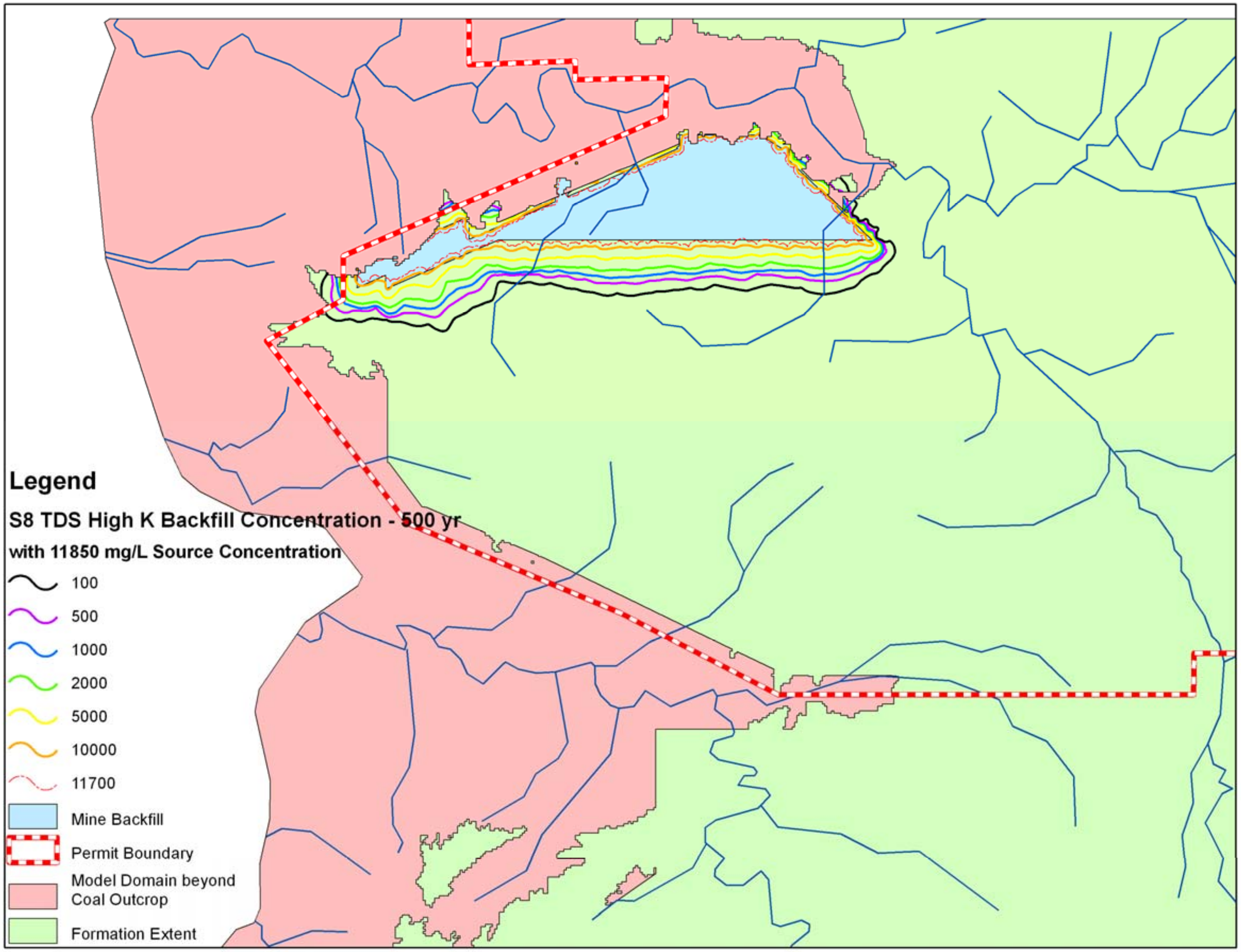


Figure 11-61. Scenario 4 TDS Transport in the No. 8 Coal after 500-years with Constant Source of 11,850 mg/l

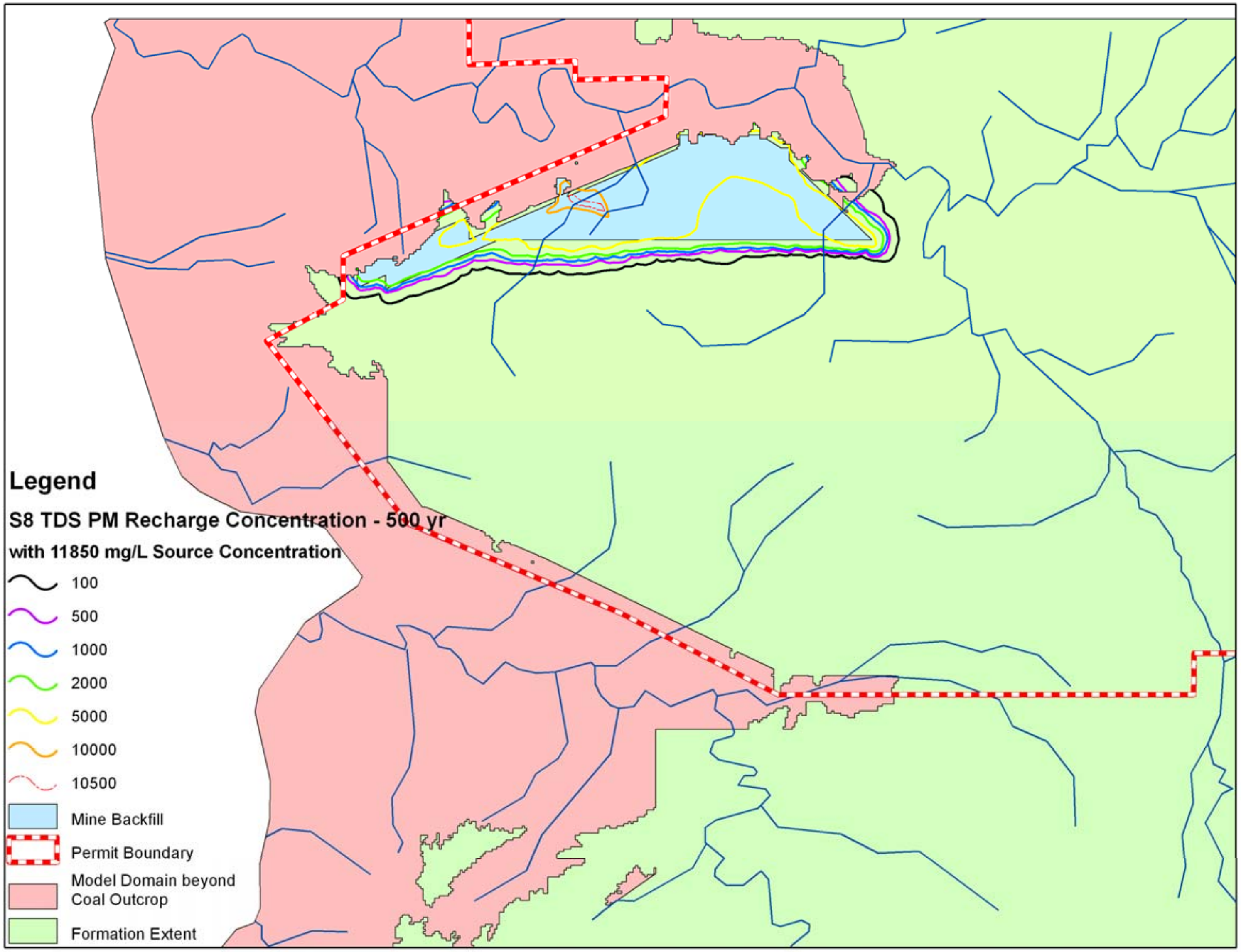


Figure 11-62. Scenario 5 TDS Transport in the No. 8 Coal after 500-years with Constant Source of 3,550 mg/l

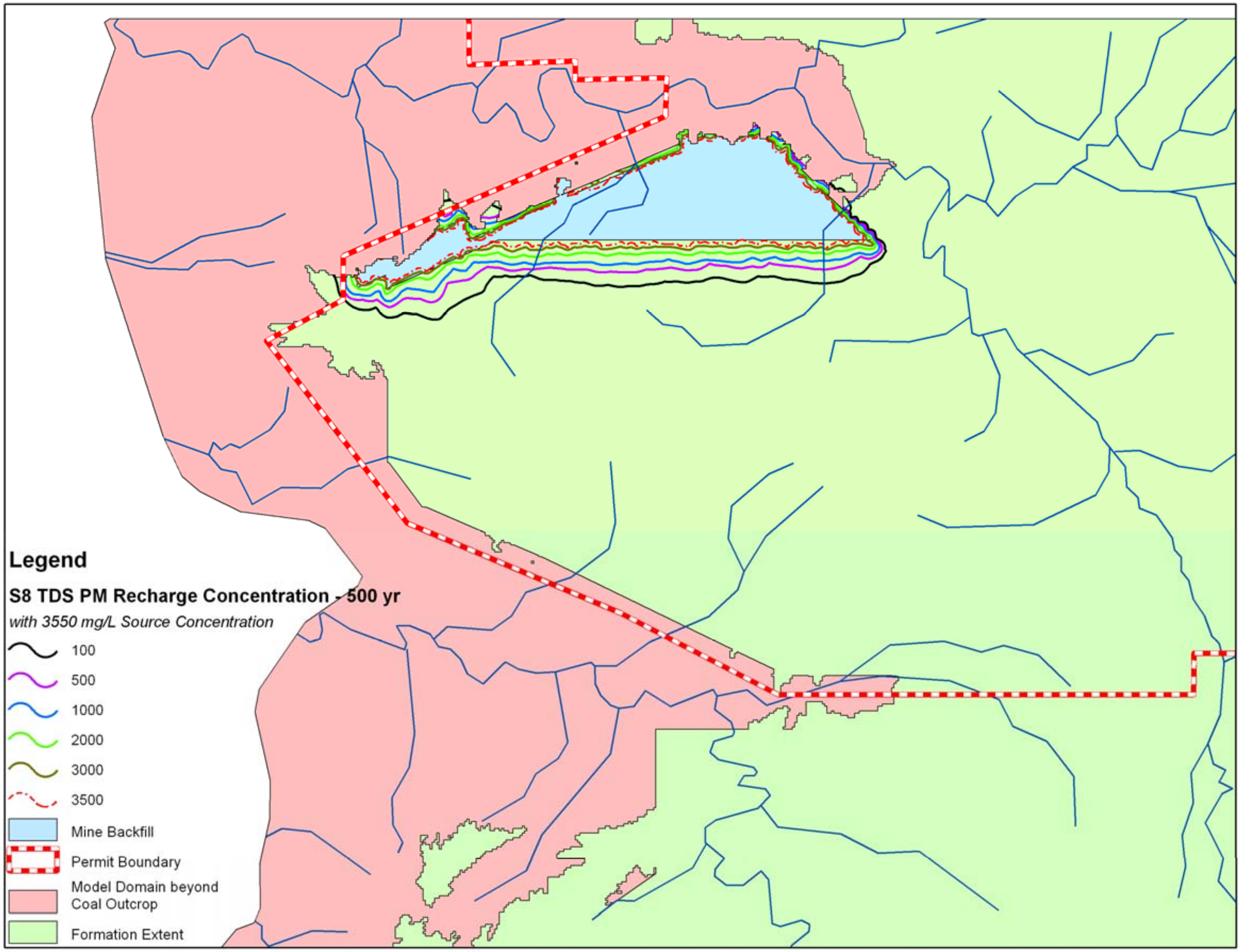


Figure 11-63. Scenario 1 TDS Transport in the No. 3 Coal after 500-years with Constant Source of 11,850 mg/l

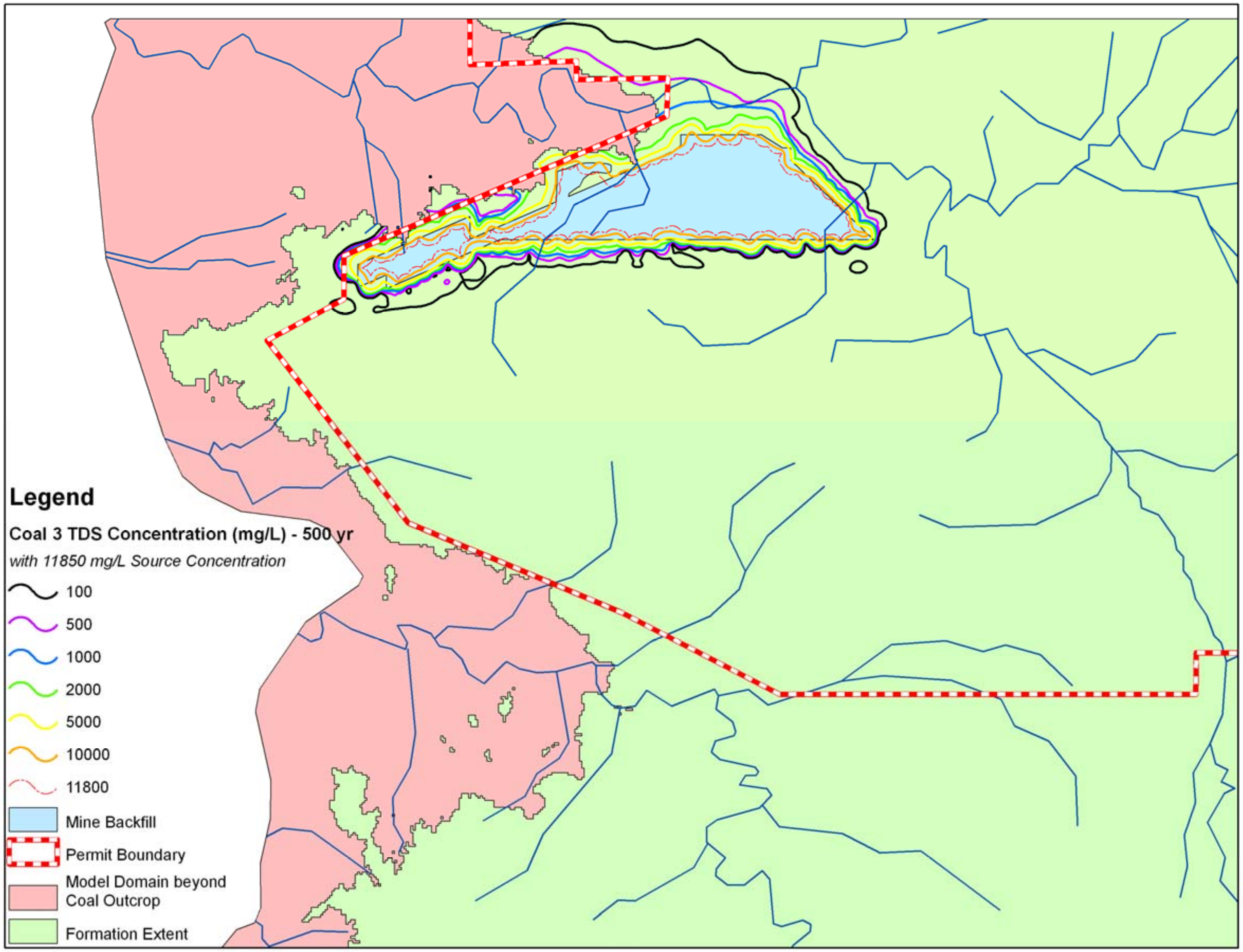


Figure 11-64. Scenario 2 TDS Transport in the No. 3 Coal after 500-years with Constant Source of 11,850 mg/l

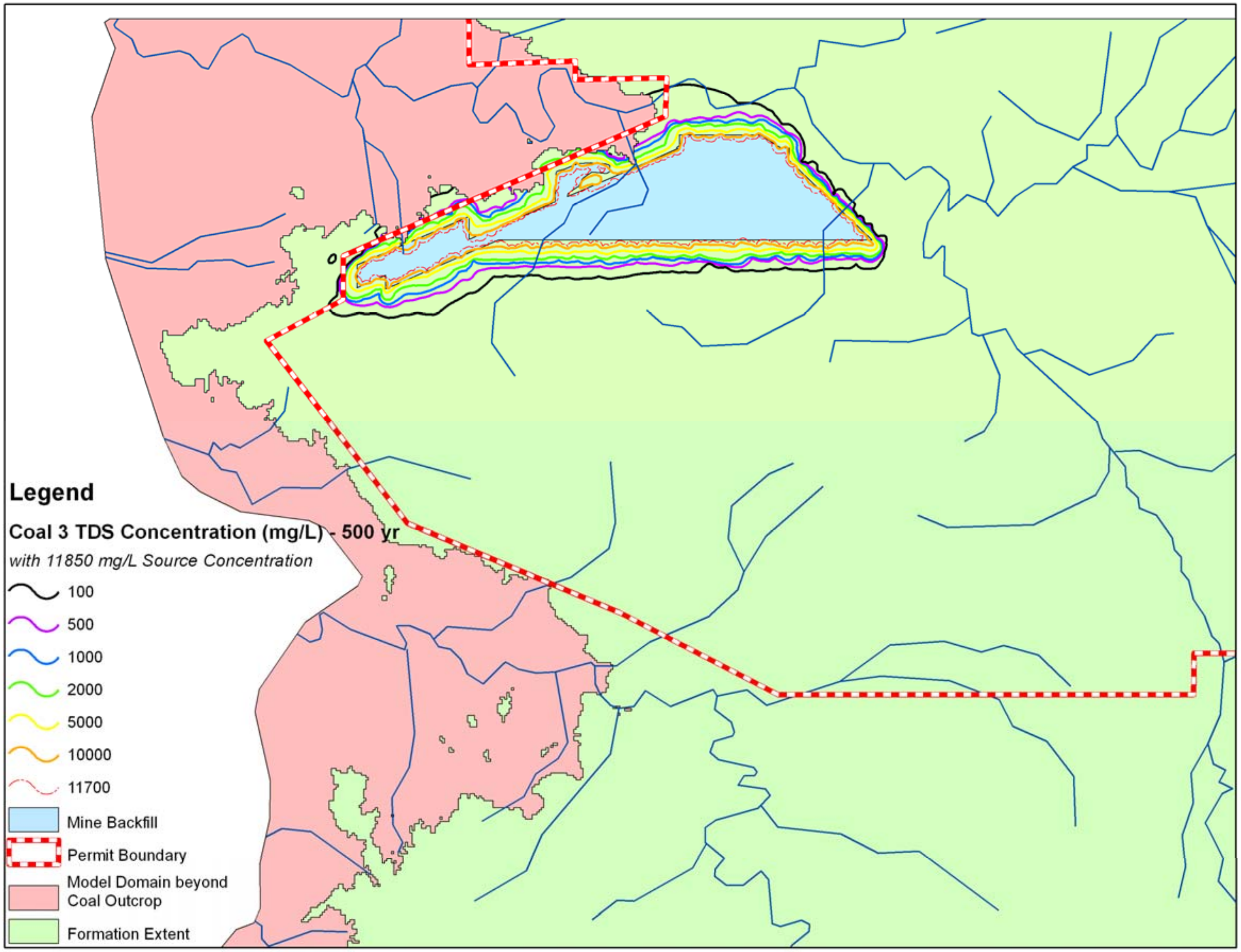


Figure 11-65. Scenario 3 TDS Transport in the No. 3 Coal after 500-years with Constant Source of 11,850 mg/l

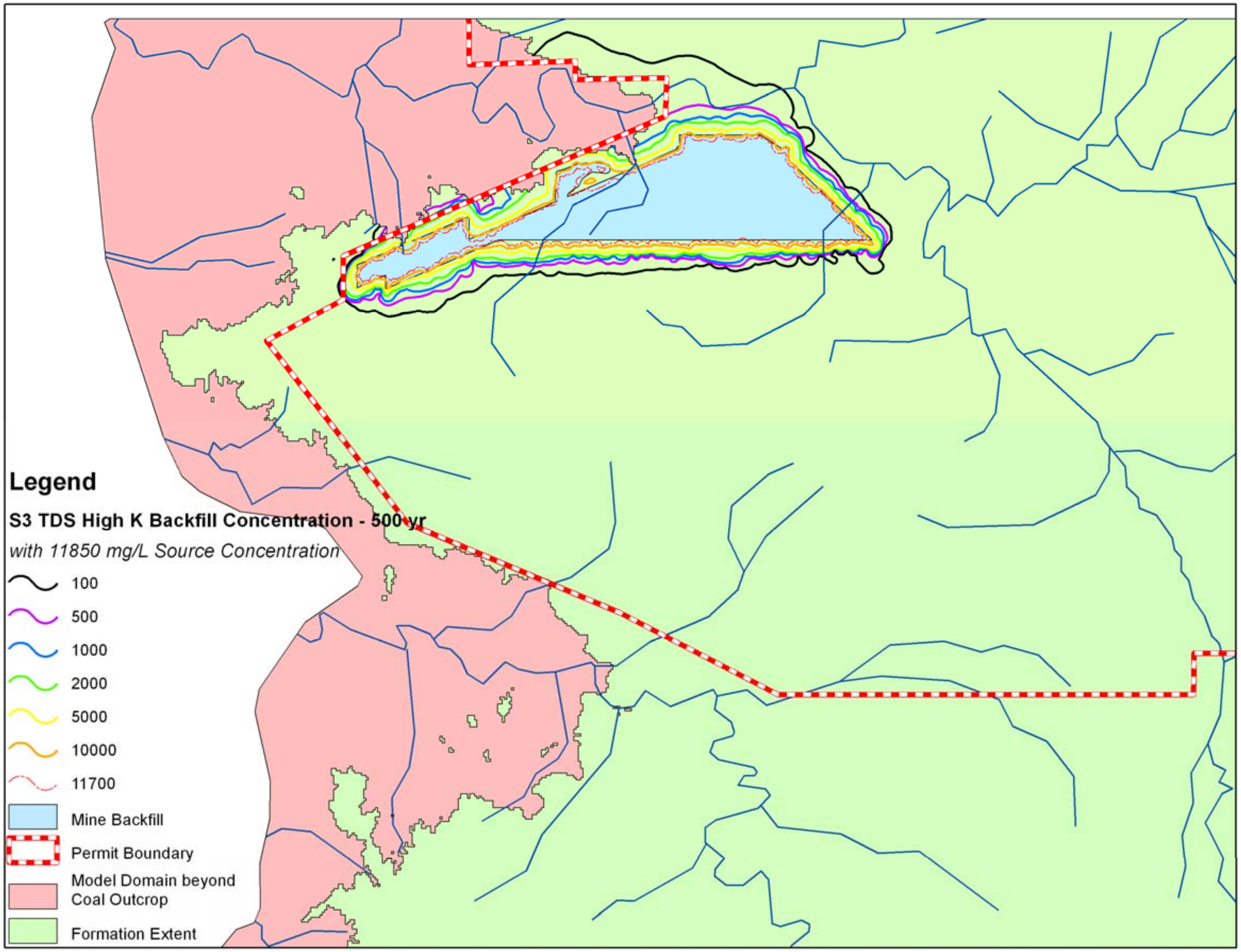


Figure 11-66. Scenario 4 TDS Transport in the No. 3 Coal after 500-years with Constant Source of 11,850 mg/l

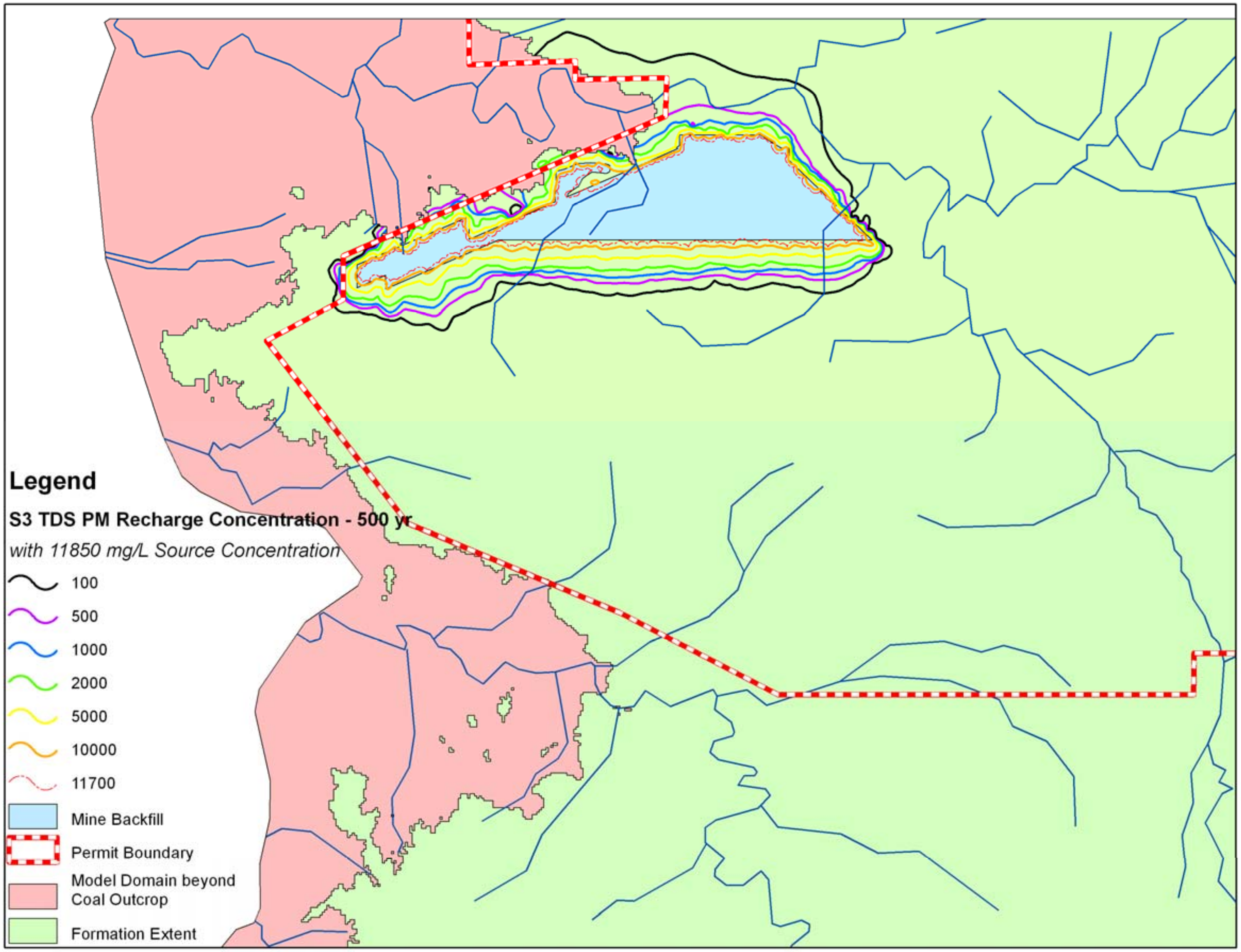
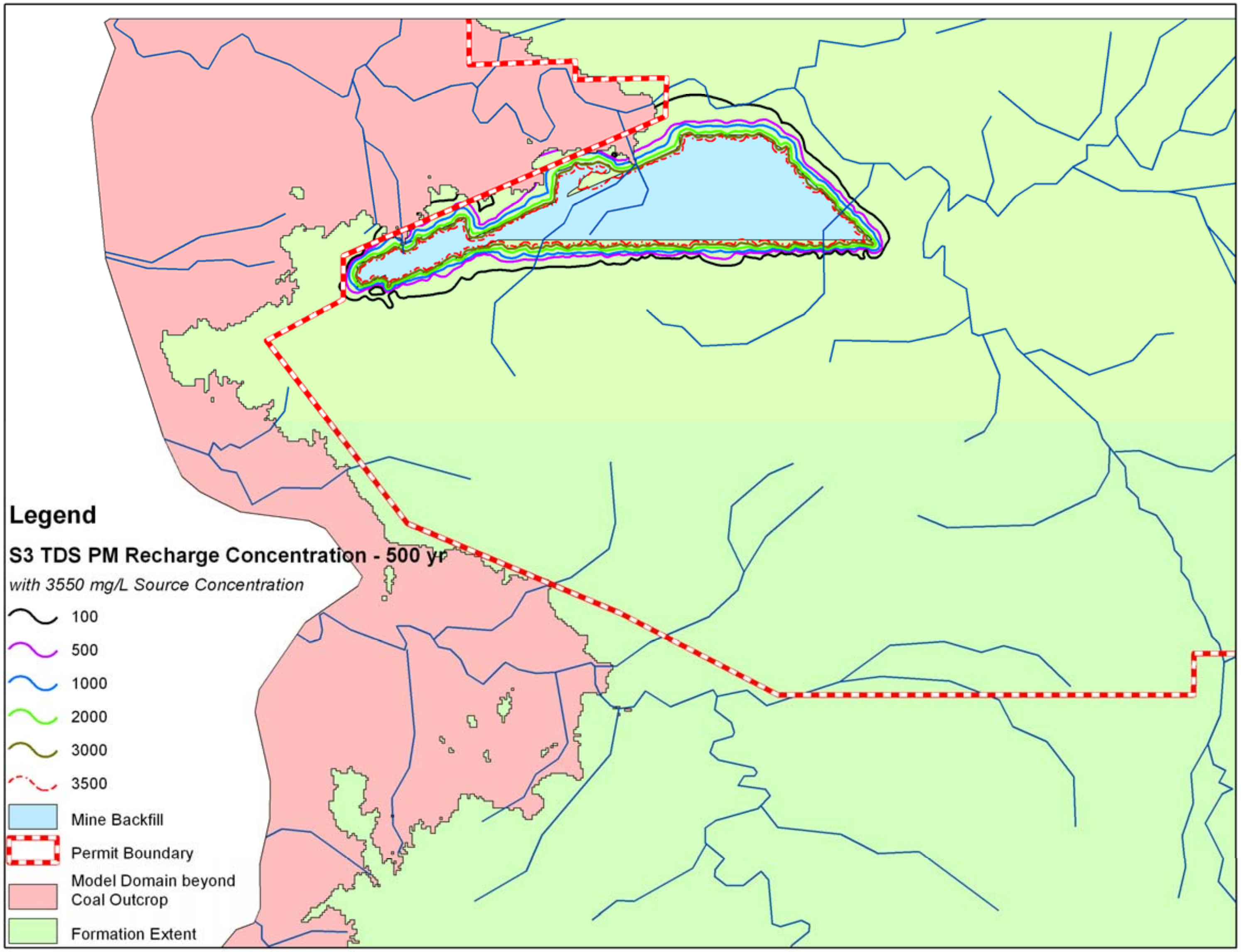


Figure 11-67. Scenario 5 TDS Transport in the No. 3 Coal after 500-years with Constant Source of 3,550 mg/l



The transport modeling simulations show that lateral migration of groundwater flow and constituents from the mine spoil within Area IV North is largely toward the alluvium and the topographic lows along Cottonwood Arroyo. However, there is also a large vertical component of flow and constituent migration from the mine spoils to the PCS, where the baseline TDS concentrations may be similar to or higher than the TDS concentrations in mine spoil.

The steady-state pre-mine calibrated model and the steady-state post-reclamation model were used to provide estimates of groundwater flow in the alluvium at the mouth of Cottonwood Arroyo, where the Cottonwood alluvium meets the Chaco River alluvium. Table 11-14k provides the model predictions of pre-mine and post-reclamation steady-state groundwater flow in the alluvium at the mouth of Cottonwood Arroyo. The increase in the steady state groundwater flow under post-reclamation conditions occurs as the result of the higher recharge rate estimated for post-reclamation conditions. Table 11-14k also provides the modeled TDS concentrations in the alluvium at the mouth of Cottonwood Arroyo after 500 years based on the transport simulations for each of the model scenarios listed in Table 11-14j.

Table 11-14k.

Modeled Result for Alluvium at Mouth of Cottonwood

	Post-mine model flow	**Pre-mine model flow**
Flow (ft^3/day)	**882**	**827**
Scenario from Table 11-14j	**Post-mine 500-yr concentration (mg/l)**	
1	**860**	
2	**160**	
3	**340**	
4	**210**	
5	**64**	

The results of the transport modeling scenarios shown in Figures 11-48 through 11-67 and in Table 11-14k indicate that modeled post-mining concentration of TDS from mine backfill along the Cottonwood Arroyo drainage is most sensitive to the TDS source concentration in mine spoil water (Scenarios 4 and 5), to the specific storage and specific yield of the Fruitland Formation coals and interburden (Scenarios 1 and 3), and to the recharge in the mine backfill (Scenarios 2 and 3). The results also show that modeled TDS migration from the mine backfill is relatively insensitive to the hydraulic conductivity of the backfill (Scenarios 3 and 4).

It should also be noted that the modeled post-reclamation TDS concentrations do not include any contribution of TDS to the alluvial and PCS groundwater from outside the mine area. Transport modeling was performed to assess the fate of mine spoil water. Based on the calibrated groundwater model, it is expected that spoil water from Area IV North will disperse laterally and vertically but that a major component of flow and transport will be toward the alluvium within the topographic low along valley of Cottonwood Arroyo, where it will mix with groundwater flow in the Cottonwood alluvium. Transport modeling has also demonstrated the large vertical component of groundwater flow and constituents from the mine backfill flow vertically to the PCS, where it will mix with groundwater in the PCS. Based on the calibrated groundwater model, it is expected that the major component of groundwater in PCS beneath the Area IV North mine spoils will also be toward the head dependent boundary at the topographic low along valley of Cottonwood Arroyo with smaller components for flow vertically into the Lewis Shale and laterally to the northeast in the direction of regional discharge along the San Juan River valley. Although the model assumes no flow in the PCS along the west boundary, it is likely that there will also be components of flow in both the PCS and the Fruitland laterally toward the west, where the flow is discharged by evapotranspiration along the formation outcrop. This loss of water by evapotranspiration along the outcrop is not simulated by the model and likely results in some overestimation of the components of flow toward the head dependent boundary at the topographic low along valley of Cottonwood Arroyo.

Mixing calculations were performed using post-reclamation modeled concentrations together with actual background concentrations to arrive at better estimates of the post-reclamation groundwater concentrations in the alluvium at the mouth of Cottonwood Arroyo for each of the transport model scenarios. The estimates in Table 11-14l of the post-reclamation concentrations in the alluvium at the mouth of Cottonwood Arroyo were obtained by adding the estimated pre-mine constituent mass flux in the Cottonwood alluvium to the model-predicted post-reclamation constituent mass flux in the alluvium at the mouth of Cottonwood Arroyo, and dividing by the predicted post-reclamation groundwater flow in the alluvium at the mouth of Cottonwood

Arroyo. These mixing calculations are expected to slightly overestimate the post-mine concentrations because the baseline mass flux includes the pre-mine mass flux contribution from all areas including the mine area. Thus, the calculated post-mine TDS concentration in the Cottonwood alluvium includes both the TDS contribution from the mine spoils along with the pre-mine TDS contribution from the Fruitland Formation for the mine area.

The median TDS concentration of 3,015 mg/L obtained from baseline monitoring of Cottonwood alluvial well QACW-2B located in the Cottonwood alluvium west and down gradient of the Permit Area was used to estimate the pre-mine constituent mass flux in the Cottonwood alluvium. The Table 11-14l estimates of post-mine TDS concentrations in the alluvium at the mouth of Cottonwood Arroyo were used to estimate the constituent mass flux in the alluvium at the mouth of Cottonwood Arroyo associated from the Area IV North mine spoil for each of the transport model scenarios.

Comparisons of the estimated post-reclamation concentrations in the alluvium at the mouth of Cottonwood with the baseline estimates in Table 11-14l show that the estimated changes in TDS concentrations in alluvium at the mouth of Cottonwood range from a decrease of 124 mg/l in Scenario 5 to an increase of 672 mg/l in Scenario 1. Scenarios 3 and 4 represent the most likely case of flow parameters and the most conservative case of source concentration. Based on Scenarios 3 and 4, the post-reclamation TDS concentration is predicted to increase over baseline estimates by 152 mg/l and by 22 mg/l, respectively. These predicted changes in TDS concentrations are well below the normal variability in TDS concentrations in the Cottonwood Alluvium as indicated by median absolute deviation of 330 mg/l determined from 32 baseline samples from well QACW-2B

Table 11-14l.

Estimated Post-Reclamation TDS in Cottonwood Alluvium

	Flow (ft^3/day)	TDS (mg/l)	mass flux (kg/day)
Pre mine estimates	**827**	**3015**	**70.61**
Mine contribution (Scenario 1)	**882**	**860**	**21.48**
Mine contribution (Scenario 2)	**882**	**160**	**4.00**
Mine contribution (Scenario 3)	**882**	**340**	**8.49**
Mine contribution (Scenario 4)	**882**	**210**	**5.24**
Mine contribution (Scenario 5)	**882**	**64**	**1.60**
Estimated Cottonwood Alluvium (Scenario 1)	**882**	**3687**	**92.08**
Estimated Cottonwood Alluvium (Scenario 2)	**882**	**2987**	**74.60**
Estimated Cottonwood Alluvium (Scenario 3)	**882**	**3167**	**79.10**
Estimated Cottonwood Alluvium (Scenario 4)	**882**	**3037**	**75.85**
Estimated Cottonwood Alluvium (Scenario 5)	**882**	**2891**	**72.20**

Based on these results, changes in long-term post-reclamation TDS concentrations in the groundwater in the alluvium of Cottonwood Arroyo down gradient of the mine area may be expected. Worst-case estimates based on upper bound source concentrations indicated TDS concentration increases on the order of 22% while the simulation results with the lower bound source concentrations for mine spoil (Scenario 5) indicate a decrease in TDS concentrations in the Cottonwood alluvium near the mouth of Cottonwood Arroyo. The results for Scenarios 3 and 4 are based on upper bound source concentrations and the most likely values for backfill recharge and specific storage and specific yield. These results provide estimates of TDS concentration increases in the range from about 1 % ~~of~~ 5%.

An increase in TDS concentrations of the magnitude predicted by this PHC assessment is not expected to materially impact the suitability of the alluvial groundwater for livestock use because the Cottonwood alluvium is an unreliable supply for stock water and the quality is a poor source for livestock supply due to high baseline TDS and sulfate concentrations. The median baseline TDS concentration at well QACW-2B was 3,015 mg/l, which is slightly above the livestock suitability criteria of 3,000 mg/L recommended by Lardy, G., C. Stoltenow, and R. Johnson, 2008 (Appendix 6.G, Table 6.G-2). The median baseline TDS concentration of 15,210 well GM-17 is far above the livestock suitability criterion while the median baseline TDS concentration in well QACW-2 was 2,305 mg/l, which is more suitable for livestock use but this well was often dry. Furthermore, the median baseline sulfate concentrations in all of the Cottonwood alluvial wells was well above the livestock suitability criteria of 1,000 mg/L recommended by Lardy, G., C. Stoltenow, and R. Johnson, 2008 (Appendix 6.G, Table 6.G-2). Finally, the alluvial groundwater flows in Cottonwood are extremely low and vary with space and time. Water levels obtained during baseline monitoring of the wells in the Cottonwood alluvium demonstrates groundwater in the alluvium is an unreliable supply as wells were often dry or had very limited saturated thickness, which limits its potential for livestock use.

In summary, the mine spoils are expected to have higher concentrations of TDS and sulfate than the pre-mine Fruitland Formation coals. Concentrations of boron and manganese may also increase in the spoils but are unlikely to exceed livestock use criteria. Estimates from mixing calculations indicated TDS concentrations in the Cottonwood alluvium are likely to increase over the long-term but not sufficiently to materially impact potential groundwater use.

11.6.2.4.4 Uncertainty and Error in Model Predictions

The constrained model calibration lends greater confidence in using the model results for prediction. Nevertheless, the 3-dimensional, multilayer saturated-unsaturated flow model is a simplified representation of a complex physical system. In essence all models are wrong. Nevertheless, the calibrated model is useful and helps provide a better understanding of the likely short-term and long-term groundwater changes that are expected to occur within and adjacent to proposed mining. The usefulness of the model must be considered in the context of the uncertainty in the model predictions and the consequences of making decisions based on erroneous model predictions. In the context of a PHC assessment, performance monitoring is used to adjust and modify model predictions over time so that adaptive measures can be taken to prevent material damage to the hydrologic balance

The US Army Corps of Engineers (1999) "Engineering and Design Manual-Groundwater Hydrology" (EM 1110-2-1421) describe five approaches for dealing with uncertainty in model execution and interpretation of results. The first two, best estimate and worst case estimates are single value results that need to be used to some extent due to the large number of inputs and parameters required by complex models. However, these approaches do not lend much assurance as to the uncertainty of accuracy of the model predictions. Nevertheless, the uncertainty in using the best estimates is reduced by constrained model calibration. This PHC has relied on the third and forth approaches for the more sensitive model parameters in order to assessing model prediction error and model uncertainty:

- Best Estimate with sensitivity analysis adjustments and
- Bracketed ranges

The bracketed range is used to assess the uncertainty in the predictions of TDS transport in mine spoil. Best estimate with sensitivity analysis adjustments has been used to assess the uncertainty in the calibrated steady state model and to characterize the uncertainty in model parameters required for prediction, including the reclamation recharge rate, the backfill hydraulic conductivity, and the values for specific storage and specific yield.

These results indicate that the extent of drawdown of potentiometric levels in the Fruitland coals and in the PCS is limited, although the extent is sensitive to the actual specific storage in the coals and in the PCS. Nevertheless, the rate and extent of drawdown has limited adverse impact to existing or future use and is primarily of concern with respect to the potential for induced drawdown of water levels in the Cottonwood alluvium.

The primary water quality concern is the potential for long-term increases in the concentrations of TDS and sulfate in the alluvial groundwater in Cottonwood Arroyo downgradient of mining. Estimates of changes in TDS concentrations from model predictions using bracketed ranges and best estimates with sensitivity analysis and from mixing calculations adjustments indicate that TDS concentrations in the Cottonwood alluvium are likely to increase over the long-term. The predicted magnitude of change is sensitive to the estimate of TDS concentrations in the mine spoil, the values for specific storage and specific yield, and the estimate for the reclamation recharge rate but is likely to be well within the normal baseline variability in TDS concentrations in the Cottonwood alluvium.

While the model predictions are useful in identifying the direction of groundwater flow, the likely magnitude of change and the time frames might be associated with these changes, the model predictions are hypotheses that will need to be re-examined as mining and reclamation proceed. Consequently, monitoring will be performed and used to reduce the uncertainty in model predictions over time so that appropriate mitigation could be implemented, if required. It is anticipated that a monitoring well would be installed in the mine backfill within Area IV North after backfilling reclamation of a significant portion of the mine pit. Monitoring of this well would provide information on the actual TDS concentrations that develop within the mine spoil water. Likewise, it is anticipated that Cottonwood alluvial well QACW-2B or comparable alluvial well would be monitored and that a monitoring well would be installed in the Fruitland Formation well between the mine backfill in Area IV North and the Cottonwood alluvium. Monitoring of water levels and TDS concentrations in these wells would provide information on drawdown, recovery, and water quality that can be used to adjust and modify the PHC model predictions if monitoring indicates significant change in the assumptions from which the model predictions were derived.

11.6.2.5 Assessment of Impact on Adjacent Groundwater Users

Wells and springs located on or near the permit area are shown on Figure 6E-1 in Appendix 6-E. Wells and springs which could potentially be impacted by mining are located to the west, east, and north of the permit area. Wells and springs located to the south of the permit area cannot be impacted as the groundwater flow directions in the Fruitland Formation and the PCS are toward the northeast with localized flow toward the west near the mouth of the Cottonwood Arroyo. This includes the alluvial wells W-343, W-0345, W-0345, W-0346 and W-0348 located along Pinabete Arroyo 0348 (Figure 6-E-1 in Appendix 6-E) as proposed mining and reclamation will not affect the Pinabete Arroyo drainage or the Pinabete alluvial groundwater.

Wells and springs are evaluated on a case by case basis to assess whether the quantity or quality of the water supply to the well could potentially be affected. Starting from the south, and moving counterclockwise, well #70 is identified by BAI as an alluvial well located within the Permit Area, but this well could not be found. Furthermore, there is no alluvium at the well location identified by BAI in the original Appendix 6-E. Consequently, it is believed that the well does not exist and there is no alluvial groundwater at the identified well location that could be affected by proposed mining. Likewise, springs #52, #53, #13R-104 and S-0127 and wells W-0148, W-0686 and #46 are located far to the east and topographically upgradient of the permit area. The springs derive water from sources stratigraphically above the Fruitland Formation that will not be affected by mining. Well #46 is identified as a 9-foot deep hand dug alluvial well. The well is located next to a crop circle and is more than 4.5 miles from the mine. The alluvium at this location is up gradient of mining and will not be impacted by mining. The completion interval for Well W-0148 is not identified but it is also located adjacent to a crop circle. Likewise the completion zone for Well W-00686 is not identified but both wells are located well beyond the portion of the Fruitland Formation that could potentially impacted by mining.

Wells #38 and #44 are PCS water wells located nearly six miles east of Area III in Township 27N, Range 15W. These wells will not be affected by mining due to the distance from the mine. Well No. 38 was shown to have a total depth of 1,505 feet and completed in both the PCS and the Cliff House Sandstone. The depth of water in the well was listed at 470 feet below ground surface (bgs) and the water quality was poor with a TDS of 18,300 mg/l, a specific conductance of 28,900 uS/cm, and a chloride concentration of 11,000 mg/l. Nearby, Well No. 44 is shown to be completed in the PCS at a total depth of 804 feet. The depth of water was listed at 475 feet bgs and the quality was poor with a specific conductance of 25,600 uS/cm and a chloride concentration of 9,160 mg/l. The yield of this well was reported at 2-3 gpm. Poor water quality in the PCS has caused No. 38 to be abandoned and No. 44 to be classified unfit for human consumption.

Wells No. 51 and 41 (Township 28N, Range 15W), are several miles east of the permit boundary, and both have been abandoned. One mile north is W-0147, a Navajo stock well for which there is no information.

The Navajo spring S-0767 is located more than 1.5 miles east of the reclaimed Doby Pit and downgradient of NAPI irrigation. Hydrologic influences from NAPI are substantially more likely than impacts from the mining operation. Two miles northeast of the spring is W-0146, a stock well, which is over 3 miles east and upgradient of the Bighan Pit. It is also located among several NAPI crop circles. The stock well W-0313 is located approximately 3 miles northeast of the permit area and over one mile southeast and upgradient of the reclaimed Bitsui Pit. The screen interval for this well is not identified.

Four non-BNCC wells with associated beneficial uses (Wells No. W-0603, the Wesleyan Navajo Mission alluvial well, W-0593, and 146) have been indentified in Township 29N, Range 15W at locations between the Bitsui Pit pre-law mining area and the San Juan River. Wells north of the San Juan River are not considered, as the San Juan River acts as an aquifer discharge point in this vicinity (Chapter 6). Well W-063 is a stock well with a windmill, for which there is no completion information. The Wesleyan Navajo Mission well (Well No. 147) is 19 feet deep and completed in the alluvium of the San Juan River. Well W-0593 is a stock well with a windmill, which may be the same as Well No. 146, an alluvial well, approximately 28 feet deep. Ownership and usage is unknown, but the well appears to be attached to a windmill. The quality and quantity of the groundwater in the San Juan River alluvium that supplies water for this well will not be affected by mining at Navajo Mine as demonstrated in 11.6.2.3.1.

Springs No. 54 and 56 are owned by the Navajo Nation. These springs are located within 2,000 feet of the pre-law Watson Pit. It is unknown whether the springs are currently flowing. Spring No. 56 was reported to be issuing from the PCS at a location adjacent to the San Juan River alluvium. The TDS was reported at 624 mg/l which is acceptable for livestock use but exceeds the USEPA Drinking Water Criteria. This spring is located to the north and downgradient of Morgan Lake. This spring is located more than 2 miles northeast of BNCC's Navajo Mine North Facilities Area. It is unlikely that this spring could be affected by mining because Morgan Lake, which is the likely source of water for this spring, lies between the North Facilities Area and the spring. Spring No. 54 issues from a terrace. The TDS was reported at 703 mg/l which is acceptable for livestock use but exceeds the USEPA Drinking Water Criteria. This spring does not appear to derive its water source from the Fruitland Formation because TDS concentrations are more than one order of magnitude lower than the TDS concentrations observed in Fruitland Formation wells located within several miles of this spring. Uses reported for both springs include domestic, stock, and/or irrigation.

The RA French well and other wells completed in the alluvium to the north west of the pre-law Watson and Bitsui Pits obtain water the San Juan River alluvium and will not be affected by mining at Navajo Mine as demonstrated in 11.6.2.3.1. Well G5 is an alluvial well located downgradient of Morgan Lake, and more than three miles from the lease boundary. This well and the nearby Little Geyser Spring (G9) are heavily influenced by the perennial flows from Morgan Lake, and from periodic recharge from flows along Chaco.

There are three stock wells west of the South Barber, Mason, and Neck Arroyo area on the Chaco River: W-0520, W-0519, and W-0342. W-0519 is an alluvial well with a depth of 16 feet. There is no depth information on the other two wells. Well W-00645 located along the Chaco River west of Areas III is identified as a dug livestock watering well and thus is likely completed in the alluvium of the Chaco River. The well depth is not indicated. It is unlikely that these Chaco alluvial wells will be affected by proposed mining. Water quality information for the Chaco River alluvium from Myers and Villanueva (1986) and Thorn (1993) show a general increase in TDS and sulfate concentrations in the downstream direction. Myers and Villanueva (1986) found TDS concentrations ranging from 877 mg/L to 8,440 mg/L while the results provided by Thorn (1993) show considerable variability in the alluvial water quality with TDS concentrations ranging from 742 to 11,900 mg/l. Water within the Chaco River alluvium at all wells is unsuitable for drinking water use based on the USEPA secondary drinking water standards due to elevated levels of TDS and sulfate. The incremental change in flow and water quality in the Cottonwood alluvium from proposed mining is unlikely to result in measurable change the flow and TDS concentrations in the Chaco River alluvium, given the natural variability in flow and water quality in the Chaco River alluvium and the much greater drainage area and alluvial groundwater flow along the Chaco valley relative to the Cottonwood and Lowe tributaries from Area III and IV.

Well W-0618 (#35) in the alluvium of Cottonwood Arroyo west of the permit area is a collapsed well located near alluvial monitoring well QACW-2, which has usually been dry during baseline monitoring. QACW–2B (#126) completed in the alluvium of Cottonwood Arroyo west of the permit area is a dug well that has been used for stock water supply and is not owned by BNCC.

This well is shown on both Figure 6E-1 sheet 2 and Exhibit 11-166 and appears to correspond with BIA well No. 13-R-28A in the permit file at the Navajo Nation, Water Resource Management office in Fort Defiance, Arizona. The TDS concentrations in the alluvium of Cottonwood Arroyo down gradient of mining are expected to increase following proposed mining within Area IV North. The groundwater modeling performed for the PHC assessment indicates that it could be many decades if not several centuries after mining and reclamation for any measurable increase in TDS concentration to develop along within the Cottonwood Alluvium downgradient of mining. The magnitude of any increase cannot be accurately predicted but is expected to be within the range of variation in TDS concentrations observed during baseline monitoring at well QACW-2B. The Cottonwood alluvium is currently a poor source of livestock water supply due to TDS and sulfate concentrations above limits recommended for livestock use. Furthermore, the quantity of water in the Cottonwood alluvium is limited and several of the baseline water monitoring wells in the alluvium were often dry.

There are four alluvial wells along the Chaco River south of the confluence with Cottonwood Arroyo. Well 13-15-4 is 11 feet deep. No use is specified. It appears to be downgradient of the confluence of the Pinabete Arroyo with the Chaco River. It is only 1.5 miles from the permit area, but with the local groundwater gradient, is most likely to be influenced by the Chaco River. Well 45 is 8 feet deep, but further south and upgradient of the Pinabete-Chaco confluence. It is more than 2 miles west or northwest of the Navajo Mine lease boundary. There is no information about the depth of the other two alluvial wells, 13-AW (13T-513) (#58) and W-0691, but they are two miles west of Area IV South. These wells identified along the Chaco River south and upgradient of the confluence with Cottonwood Arroyo will not be affected as they are not hydrologically connected with the groundwater that could be affected by proposed mining within Area III and IV North. Thus, within the permit area and adjacent area the only water supply well~~s~~ or spring~~s~~ could be potentially affected by previous or proposed mining at Navajo Mine is well QACW–2B completed in the alluvium of Cottonwood Arroyo west of the permit area.

BNCC has water rights on the San Juan River, New Mexico Office of State Engineer Permit 2838, which can be used to offset any adverse impacts to the State of New Mexico and present users. These rights will be maintained throughout the mining operation and a period thereafter, for retirement, if required to any affected San Juan Basin water users. For temporary impacts to surface water users, BNCC may provide water to local permittees in tanks for livestock use in areas around the lease. Permanent impacts to surface water users may be mitigated by the construction of impoundments incorporated into the post-mining landscape (Chapter 12 Sections 12.11 Hydrologic Reclamation Plan and 12.3.4.1 Permanent Impoundments).

11.6.3 <u>Assessment of Potential Surface Water Changes During Mining and Reclamation Operations</u>

Minimization of impacts to the hydrologic balance are focused on reducing the disturbance footprint to the extent practical, limiting the amount of upgradient water commingled with disturbed area drainage, utilizing BMPs to limit migration of sediment during storm events, and containment or treatment of flows downgradient of the mine site. Hydrologic water management is integrated into mine planning. Stream buffer zones have been demarcated to limit disturbance in channel reaches unaffected by mining. Temporary diversions have been constructed to route upgradient flows around active mining pits into downgradient natural channels, when possible. In other situations, upgradient impoundments have been established to contain upstream water runoff.

There will be periods when precipitation runoff from the drainages that normally flowed across the areas intersected by mining will not make it to the Chaco River during operations, but will either be intercepted by the mine pit or captured in temporary pit protection ponds (highwall impoundments) located up gradient of mining. Precipitation runoff collected in the pit or in the pit protection ponds may be utilized for dust suppression, other mine needs, or will naturally diminish from evaporation, and seepage. Once reclamation is completed within the mining area, precipitation runoff from these reclaimed areas will flow through channels in the reconstructed topography and then to the Chaco River. Precipitation runoff from reclaimed areas may be reduced somewhat from pre-mine levels due to any of the following factors: lower slopes, enhanced vegetative growth, engineered traditional or geomorphic drainage designs, and the use of sediment-control BMPs that operate to retain water in the reclaimed areas reducing storm-water runoff to the channels.

There is a direct relationship between the maximum peak flows and total runoff volume and sediment yield; the management of water flow through the site during operations is designed to reduce peak sediment concentrations through the use of storm water management plans and the containment of sediment associated with storm flows. Post-reclamation water management is focused towards establishment of a stable post-mine topography enhanced by vegetative stabilization which will decrease storm water runoff and sediment yield. The post-mine topography is designed to replicate the approximate original contour.

The probable hydrologic consequences analysis was developed with the support of site-specific data and modeling. Surface water and sediment modeling was performed using SEDCAD to model peak flows, yield and sediment concentrations. Key assumptions on soil and cover were derived from soil and vegetation mapping at the site (Tables 11-15, 11-16, 11-16A, 11-16B, 11-16C, and 11-16D).

11.6.3.1 Stream Buffer Zone Protection

Six major tributaries to the Chaco River have been identified within the Navajo Mine permit area and are discussed in Chapter 7 Section 7.2, and shown on Exhibits 7-3, 7-4, and 7-4C. The six drainages are: Chinde Arroyo, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, and Cottonwood Arroyo. Mining or support activities are projected to occur in all the listed drainages. Mining will not occur in the Neck Arroyo, however, transportation roads and facilities are present.

Diversions are employed to route water around the mining area to minimize impacts to the hydrologic balance. North, in Area I, the Doby North and Dodge diversions route water away from the pit. Further south in Area II, the Chinde and Hosteen diversions are employed. Area III diversions include the North Fork of Cottonwood Arroyo (Section 11.5.5.3).

Those areas identified as stream buffer zones (Exhibits 11-9 through 11-11) outside the approved mining disturbance (see Chapter 12, Exhibits 12-1, 12-2, and 12-3 for scheduled mining disturbance) will not be disturbed by surface mining activities (30 CFR 816.57(b)) and will be marked as described in Section 11.1.1. The remaining drainages will not be marked since none of the sub-watersheds within the identified drainages meet the definition of buffer zone stream.

11.6.3.2 Water Quality Effects during Operations

Potential surface water quality changes that could occur during mining and reclamation operations include the generation of additional sediment. BMPs at the site include the use of perimeter berms and containment features. Topdressing and regolith stockpiles are protected by berms to minimize migration of solids into undisturbed areas. Typical berm cross-sections are shown in Figure 11-9. The coal stockpiles will be partially enclosed and surrounded by containment berms to minimize migration of coal fines (Figure 11-7), and divert surface runoff into either directly into a sediment pond or into a ditch or channel that leads to a sediment pond. In areas subject to containment berms, such as topdressing stockpiles, berms will be able to contain the runoff from a 10-year 6-hour (10-yr 6-hr) storm. See Section 11.5.4.5 for further discussion on containment berms.

An anomalous discharge occurred on 12/31/2010 from outfall 002 of NPDES Permit NN0028193, located downgradient of coal storage, coal preparation, and facilities area runoff following winter weather of snow and fog. There had been 0.37 inches of precipitation in Farmington, NM on December 29, 2010, additional precipitation of 0.11 inches on December 30, 2010, with high temperatures just above freezing at 33°F. The effluent had a pH of 8.0, a TDS of 1790 mg/L, dissolved arsenic of 0.0013 mg/L, dissolved boron of 2.6 mg/L, total recoverable iron of 0.88 mg/L, total recoverable manganese of 0.193 mg/L, dissolved and total selenium of 0.002 mg/L, sulfate of 1000 mg/L and TSS of 142 mg/L. All reported parameters were within discharge limits for the permit except for the TSS, which exceeded the daily maximum limit of 70 mg/L. There had not been any discharges from this site or any of the other active outfalls (9 total) since July 1, 2008 (USEPA 2011).

When runoff does occur, the newly exposed overburden, interburden, and coals and mine spoils may result in increases in TDS, sulfate, iron, and manganese in surface runoff from these disturbed areas. The analyses of overburden and interburden materials presented in Tables 5-2, Tables 11-14, 11-14b, 11-14c, and Appendix 11-K show that these materials are not acid forming. The water quality of newly exposed strata and mine spoils is best characterized by the SPLP test results for Navajo Mine spoils Table 11-14f. The spoil leachate results presented in Table 11-14f describe TDS and sulfate concentrations of 1,200 mg/l and 670 mg/l, respectively. These concentrations are above the median concentrations observed in surface water baseline samples but are well below the highest concentrations observed in the baseline surface water quality samples (Table 7-7). Surface runoff from disturbed areas will be retained by BMPs and is unlikely to reach the downgradient tributaries to Chaco or the Chaco River itself except during extreme precipitation events that exceed the design requirements of the structures. Some historic selenium analyses had minimum detection limits higher than the standard, but future detection limits of 0.001 mg/l should accommodate better interpretations of data. Trace constituents in SPLP spoil leachate are below detection limits except for fluoride, boron, and barium. These parameters are well below their corresponding Navajo Nation livestock and wildlife use criteria (NNEPA WQP, 2008). Manganese was also detected, but has no livestock and wildlife use criterion (Table 11-14f).

There is the potential for increases in salinity in water that might be flushed from sediment ponds and containment berms during large storm events that produce spillway overflows. However, any increased salinity in water from ponds or berms is unlikely to produce a measurable change in the salinity of flows in tributaries to the Chaco River due to dilution from high flows in the drainages during the storm events.

Motor fuel storage and equipment maintenance will be provided at the industrial facilities areas shown on Exhibits 11-9 through 11-11. Nevertheless, equipment repair may on occasion, need to be performed within the active mining or reclamation areas. BNCC maintains and implements a Spill Prevention, Control, and Countermeasure (SPCC) plan that identifies areas of risk, specifies appropriate controls for bulk storage areas, identifies control strategies for managing a spill, should it occur, and lists procedures for safely disposing of any contaminated materials.

Appendix 11-HH includes hydrologic data for the land farm used to treat materials contaminated with petroleum hydrocarbons.

Federal and state or tribal water quality standards will be met during surface coal mining and reclamation operations at the applicable compliance point, whether that is the furthest down gradient sediment pond or the permit boundary. This is achieved through the use of perimeter berms and sediment ponds to contain or treat runoff within the permit area. The Navajo Nation Environmental Protection Agency (NNEPA) has designated uses, Fish Consumption (FC), Secondary Human Contact (ScHC), Aquatic and Wildlife Habitat (A&WHbt), and Livestock Watering (LW), for all Waters of the Navajo Nation (NNEPA WQP, 2008), which includes drainages within the Navajo Mine permit area. There are no other higher levels of designated use for surface water resources within the Navajo Mine permit area.

Permanent impoundments, discussed in Chapter 12 Section 12.3.4.1, will meet the requirements of 30 CFR 816.49(b). The permanent impoundments will suitable for the post-mining land use and will not results in a diminution of the surface water quality or quantity to the adjacent water users. Prior to final bond release, BNCC will demonstrate compliance with applicable surface water quality criteria.

In conclusion, the water and sediment control measures, as outlined in Section 11.5.4, not only prevent additional contributions of sediment but also serve to contain mine water that may have higher concentrations of TDS and sulfate than in the baseline flow in the tributaries to Chaco or in the Chaco River. Thus, these measures also serve to minimize potential changes in water quality of receiving streams outside the permit area.

11.6.3.3 Runoff and Erosion during Mining and Reclamation Operations

Mining and reclamation operations are designed to minimize impacts to undisturbed upland flows through the mining operation and to contain or treat all sediment-laden waters that have interacted with disturbed area runoff. BNCC has engineered the mine plan and supporting facilities to limit effects to the hydrologic balance and surface water quality. Sediment ponds have been constructed downgradient of mining operation disturbances to store or treat and release stormwater runoff. A summary of site sediment ponds is compiled on Table 11-5, with references to permit design information. Additionally, upland flows are routed around mining pits through diversions or impounded in highwall impoundments. Typically these features are located east or south of the mining area.

Diversions associated with Area I include Doby North and Dodge. Further south in Area II are the Chinde and Hosteen diversions. Area III diversions include the North Fork of Cottonwood (Exhibits 11-13E).

Appendix 11-N provides conceptual engineering design data. Designs for the Chinde Diversion crossing are found in Appendix 11-JJ. Engineering designs for the North Fork Cottonwood Diversion are found in Exhibits 11-74, -74A through 74E. The diversion designs are described in Appendix 11-QQ.

Highwall impoundments have also been designed and constructed to prevent water from entering active mining pits. Locations are shown on Exhibits 11-13B through 11-13E. Appendix 11-II includes pre-approved designs as highwall impoundments that do not require approval prior to construction. As-built information is submitted and retained in Appendix 11-II. Highwall impoundment design includes a hazard assessment to ensure the safety of the miners and structures within the pit (Table 11-7). Impoundments are designed to contain the 2-yr 6-hr storm at a minimum, and the 100-yr 6-hr storm whenever possible. It should be noted that water from highwall impoundments will never leave the permit area as surface discharge, as discharged water will be intercepted by the pits. A number of upland ponds protecting the various mine areas are included in Table 11-7.

The PHC analysis includes a characterization and evaluation of reclaimed channels and surface topography. The post-mining topography has been engineered to be stable over time, through the reclamation and establishment of a final surface configuration which includes drainages. From a hydrologic perspective, the post-mining topography is evaluated on the basis of adequate drainage density.

Drainage density is an integrated measure of drainage basin morphology. Drainage density is the length of stream channels per unit area within a drainage basin. The restoration of post-mine drainage networks within the range of pre-mine drainage densities and configurations or regional norms will ensure that pre-mine conditions are achieved.

Drainage densities are calculated by measuring the total stream length in miles and dividing that length by the drainage area in square miles. Pre-mining and post-mining stream lengths were measured for the total drainage area of each stream as well as the area within the lease boundary only. U.S.G.S. 7.5 minute quadrangles were used to determine the pre-mining drainage densities. Post-mining drainage densities were determined from the 1:6000 scale final surface configuration topography maps provided in Chapter 12.

Peak flow, runoff volume, sediment yield, and peak sediment concentrations were predicted for both pre- and post-mine drainages for Chinde Arroyo, Hosteen Wash, Barber Wash, South Barber Drainage, Neck Arroyo, Lowe Arroyo, and Cottonwood Arroyo and the tributaries to the Chaco River that are projected to be disturbed. These estimates were developed using the SEDCAD modeling technique as described in Chapter 7. Pre-mine and undisturbed runoff curve numbers were developed from the soil cover complexes within each drainage. For areas disturbed by mining, an analysis of the available topdressing types and quantities was made to determine an appropriate curve number (Tables 11-15 and 11-16 through 11-16d). This analysis indicated that, as a whole, the available topdressing material has a curve number close to that of the Shiprock Soil Complex "Sk" in Tables 11-15 and 11-16 through 11-16d. The curve number of reclaimed areas was based on this soil type.

The Chinde Arroyo and Cottonwood Arroyo are also impacted by the activities of the NAPI located hydraulically up gradient from the mine. These impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. The impacts are similar to both streams with the exception that the Chinde is a perennial stream.

TABLE 11-15
TOPDRESSING TYPES AND QUANTITIES (1)

Soil Mapping Unit Symbol	Soil Mapping Units	Percent of Map Unit (3)	Soil volume (cubic yards)					Title of SCS Soil Survey (4)	Hydrologic Group
			Area I	Area II	Area III	Area IV North	Total		
Ba	Badland	-	0	0	0	0	0		
Bb (2)	Bacobi and	39	37,061	20,523	201,579	342,305	601,468	1	C
	Monierco soils	61	57,967	32,101	315,290	535,401	940,759	2	D
Bc	Blancot	-	0	0	664,484	0	664,484	2	B
Bh	Blancot, very hard	-	0	0	307,680	0	307,680	2	B
Fa	Faro and Persayo Soils	-	8,024	83,158	0	161,922	253,104	2	D/D
Gr	Grieta	-	0	0	0	69,104	69,104	3	B
Jc	Jocity -Gilco	-	503,634	183,596	481,270	1,525,313	2,693,813	3	B/B
Jh	Jocity, very hard	-	0	0	103,722	46,339	150,061	3	B
Ma	Mack	-	0	0	1,433,038	176,992	1,610,030	5	C
Mn	Mayqueen	-	295,981	55,176	0	23,851	375,008	2	B
Ms	Mayqueen -Shiprock	-	421,971	341,951	614,672	333,565	1,712,159	2	B
Mv	Mayqueen -Shiprock, very hard	-	85,805	0	61,024	0	146,829	2	B
Na	Nakai	-	0	0	0	53,010	53,010	4	B
Nt	Natrargids	-	0	6,628	0	0	6,628	2	D
Nv	Natrargids, overblown	-	2,159	82,861	97,028	218,490	400,538	2	D
Ra	Razito	-	599,753	521,804	458,595	311,260	1,891,412	5	A
Rh	Razito. very hard	-	73,893	0	21,089	196,707	291,689	5	A
Rl	Redlands Variant	-	19,683	33,505	945,193	331,678	1,330,059	5	B
Rv	Redlands Variant, very hard	-	0	0	105,452	61,901	167,353	5	B
Sc	Shiprock	-	192,636	540,865	868,130	160,006	1,761,637	2	B
Sh	Shiprock, very hard	-	22,430	21,812	67,523	143,239	255,004	2	B
Sl	Shiprock -Blancot	-	278,724	0	23,813	0	302,537	2	B/B
Sv	Shiprock Variant	-	0	0	416,510	70,420	486,930	2	B
Sz	Stumble	-	0	0	15,596	105,082	120,678	2	A
Ta	Trail	-	0	23,210	0	0	23,210	5	A
Th	Trail. very hard	-	0	16,144	0	4,538	20,682	5	A
TOTAL:			2,599,721	1,963,334	7,201,688	4,871,123	16,635,866		

(1) This information was generated from Chapter 8 Soil Resources, Approved PAP for Navajo Mine.

(2) Undifferentiated groups and complex SOil mapping units were delineated if the major components had contrasting hydrologic groups.
(3) Percentages of each major mapping unit component were derived from Chapter 8.5.2 Soil Mapping Unit Descriptions, Approved PAP for Navajo Mine.
(4) 1 = Soil Survey Coconino County, Arizona; 2= Soil Survey San Juan County, New Mexico, Eastern Part; 3= Soil Survey Sandoval County, New Mexico; 4= Soil Survey San Juan County, Utah; 5= Soil Survey Shiprock Area, Parts Of San Juan County, New Mexico and Apache County, Arizona.

Table 11-16

Land Types and Curve Numbers

Land Use/Condition (1)	Curve Numbers for Hydrologic Groups (5)			
	A	B	C	D
Reclaimed Lands (2)	65	78	86	91
Undisturbed Lands (3)	65	78	86	91
NAPI Cultivated lands (4)	67	78	85	89

(1) Land use/conditions and the associated curve numbers were taken from Ms. Pamela J. Schwab and Dr. Richard Warner (1987), "SEDCAD+ User's Manual", Civil Software Design, Table 5.3, pages 110-112.
(2) From reference (1) the land use/condition for reclaimed lands is between "Herbaceous" and "Desert Shrub", each with poor hydrologic condition. The curve numbers were determined by interpolating between the curve numbers associated with the two land use/conditions.
(3) The type of land use/condition for undisturbed areas will be identical to reclaimed lands (same curve numbers).
(4) The type of land use/conditions selected from reference (1) is "Row crops, Straight row" with good hydrologic conditions.
(5) The hydrologic group classification for the soil types will be obtained from the NRCS soil surveys.

TABLE 11-16A

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA I

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	37,061	1.43%	C	86	1.23
-	Monierco soils	57,967	2.23%	D	91	2.03
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	8,024	0.31%	D/D	91	0.28
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	503,634	19.37%	B/B	78	15.11
Jh	Jocity, very hard	0	0.00%	B	78	0.00
Ma	Mack	0	0.00%	C	86	0.00
Mn	Mayqueen	295,981	11.39%	B	78	8.88
Ms	Mayqueen -Shiprock	421,971	16.23%	B	78	12.66
Mv	Mayqueen -Shiprock, very hard	85,805	3.30%	B	78	2.57
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	2,159	0.08%	D	91	0.08
Ra	Razito	599,753	23.07%	A	65	15.00
Rh	Razito. very hard	73,893	2.84%	A	65	1.85
Rl	Redlands Variant	19,683	0.76%	B	78	0.59
Rv	Redlands Variant, very hard	0	0.00%	B	78	0.00
Sc	Shiprock	192,636	7.41%	B	78	5.78
Sh	Shiprock, very hard	22,430	0.86%	B	78	0.67
Sl	Shiprock -Blancot	278,724	10.72%	B/B	78	8.36
Sv	Shiprock Variant	0	0.00%	B	78	0.00
Sz	Stumble	0	0.00%	A	65	0.00
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	0	0.00%	A	65	0.00
Totals		2,599,721	100.00%			75.09

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.
(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey .

(3) Curve number associated with the hydrological group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16B

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA II

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	20,523	1.05%	C	86	0.90
-	Monierco soils	32,101	1.64%	D	91	1.49
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	83,158	4.24%	D/D	91	3.85
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	183,596	9.35%	B/B	78	7.29
Jh	Jocity, very hard	0	0.00%	B	78	0.00
Ma	Mack	0	0.00%	C	86	0.00
Mn	Mayqueen	55,176	2.81%	B	78	2.19
Ms	Mayqueen -Shiprock	341,951	17.42%	B	78	13.59
Mv	Mayqueen -Shiprock, very hard	0	0.00%	B	78	0.00
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	6,628	0.34%	D	91	0.31
Nv	Natrargids, overblown	82,861	4.22%	D	91	3.84
Ra	Razito	521,804	26.58%	A	65	17.28
Rh	Razito. very hard	0	0.00%	A	65	0.00
Rl	Redlands Variant	33,505	1.71%	B	78	1.33
Rv	Redlands Variant, very hard	0	0.00%	B	78	0.00
Sc	Shiprock	540,865	27.55%	B	78	21.49
Sh	Shiprock, very hard	21,812	1.11%	B	78	0.87
Sl	Shiprock -Blancot	0	0.00%	B/B	78	0.00
Sv	Shiprock Variant	0	0.00%	B	78	0.00
Sz	Stumble	0	0.00%	A	65	0.00
Ta	Trail	23,210	1.18%	A	65	0.77
Th	Trail. very hard	16,144	0.82%	A	65	0.53
Totals		1,963,334	100.00%			75.72

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.
(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey .

(3) Curve number associated with the hydrological group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16C

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA III

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	201,579	2.80%	C	86	2.41
-	Monierco soils	315,290	4.38%	D	91	3.98
Bc	Blancot	664,484	9.23%	B	78	7.20
Bh	Blancot, very hard	307,680	4.27%	B	78	3.33
Fa	Faro and Persayo Soils	0	0.00%	D/D	91	0.00
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	481,270	6.68%	B/B	78	5.21
Jh	Jocity, very hard	103,722	1.44%	B	78	1.12
Ma	Mack	1,433,038	19.90%	C	86	17.11
Mn	Mayqueen	0	0.00%	B	78	0.00
Ms	Mayqueen -Shiprock	614,672	8.54%	B	78	6.66
Mv	Mayqueen -Shiprock, very hard	61,024	0.85%	B	78	0.66
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	97,028	1.35%	D	91	1.23
Ra	Razito	458,595	6.37%	A	65	4.14
Rh	Razito. very hard	21,089	0.29%	A	65	0.19
Rl	Redlands Variant	945,193	13.12%	B	78	10.24
Rv	Redlands Variant, very hard	105,452	1.46%	B	78	1.14
Sc	Shiprock	868,130	12.05%	B	78	9.40
Sh	Shiprock, very hard	67,523	0.94%	B	78	0.73
Sl	Shiprock -Blancot	23,813	0.33%	B/B	78	0.26
Sv	Shiprock Variant	416,510	5.78%	B	78	4.51
Sz	Stumble	15,596	0.22%	A	65	0.14
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	0	0.00%	A	65	0.00
Totals		7,201,688	100.00%			79.67

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.
(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey .

(3) Curve number associated with the hydrological group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16D

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA IV NORTH

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	342,305	7.03%	C	86	6.04
-	Monierco soils	535,401	10.99%	D	91	10.00
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	161,922	3.32%	D/D	91	3.02
Gr	Grieta	69,104	1.42%	B	78	1.11
Jc	Jocity -Gilco	1,525,313	31.31%	B/B	78	24.42
Jh	Jocity, very hard	46,339	0.95%	B	78	0.74
Ma	Mack	176,992	3.63%	C	86	3.12
Mn	Mayqueen	23,851	0.49%	B	78	0.38
Ms	Mayqueen -Shiprock	333,565	6.85%	B	78	5.34
Mv	Mayqueen -Shiprock, very hard	0	0.00%	B	78	0.00
Na	Nakai	53,010	1.09%	B	78	0.85
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	218,490	4.49%	D	91	4.08
Ra	Razito	311,260	6.39%	A	65	4.15
Rh	Razito. very hard	196,707	4.04%	A	65	2.62
Rl	Redlands Variant	331,678	6.81%	B	78	5.31
Rv	Redlands Variant, very hard	61,901	1.27%	B	78	0.99
Sc	Shiprock	160,006	3.28%	B	78	2.56
Sh	Shiprock, very hard	143,239	2.94%	B	78	2.29
Sl	Shiprock -Blancot	0	0.00%	B/B	78	0.00
Sv	Shiprock Variant	70,420	1.45%	B	78	1.13
Sz	Stumble	105,082	2.16%	A	65	1.40
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	4,538	0.09%	A	65	0.06
Totals		4,871,123	100.00%			79.65

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.
(2) Hydrologic groups were taken from SCS soil surveys, see Table 11-15 for the respective location and title of each survey .

(3) Curve number associated with the hydrological group classification was taken from Table 11-16 (reclaimed).

NAPI direct discharges are a result of an over supply of water in the canal that is released directly to the wash. NAPI discharge events for both streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel. The indirect NAPI related discharges are a result of return flows to the washes caused by the infiltrating irrigation water. The irrigation return waters have changed the Chinde Arroyo into a perennial stream with a base flow containing elevated dissolved solids concentrations from irrigation return waters leaching the unconfined surface formations. The Cottonwood Arroyo is not impacted by perennial flows but increased mineralization is deposited on the stream banks as a result of seeps in the upper reaches that are carried down stream during precipitation flow events. The impacts of the NAPI activities on the baseline hydrologic balance of the Cottonwood Arroyo will be highly variable increases in the flow, discharge, and water quality concentrations of the channel's hydrologic balance. Moreover, these impacts increase the already highly variable hydrologic balance and further decrease the potential for post mining changes to the hydrologic balance as a result of mining. Quantitative data to characterize the NAPI impacts to these drainages is found in discussions of Chinde and Cottonwood Arroyos below, Sections 11.6.3.3.1, 11.6.3.3.1.1, and 11.6.3.3.7. , Table 7-7 and Appendix 11-OO and is also being collected as part of the surface water monitoring plan.

Specific probable hydrologic consequences for each major tributary to the Chaco River are described by watershed in the following sections. Channels are listed from north to south within the permit area.

11.6.3.3.1 Chinde Arroyo

The present watershed area of Chinde Arroyo is about 42.4 square miles (sq mile) (27,130 acres). An area of additional 11 square miles does not contribute to the present Chinde watershed as it is diverted by NIIP's Ojo Amarillo canal into Cottonwood Arroyo. About 4.86 square miles of the Chinde Arroyo drainage basin is disturbed by mining activities (Table 7-9). The post-mining Chinde Arroyo watershed increases in size by 1.7 sq miles (1,124 acres) primarily because of changes in the drainage divide between Hosteen Wash and Chinde Arroyo, and the drainage divide between Dodge Diversion and Chinde Arroyo.

The pre-mining drainage density of Chinde Arroyo was estimated to be 1.4 miles/sq mile for the entire drainage area and 2.8 miles/sq mile for the area disturbed by mining. Higher drainage density within the mine area reflects the greater relief in this area. Post-mining drainage density for Chinde Arroyo is 4.7 miles/sq mile over the area disturbed by mining. Both pre- and post-mining drainage densities appear to be relatively low. However, the calculated drainage density is dependent upon the criteria for measuring drainage length. The criterion used in this analysis was to include only stream channels identified on the topographic maps. Thus, conservatively, contour crenulations associated with badlands topography did not enter into the drainage density measurement, as they reflect an unstable geomorphic regime.

These results indicate a higher post-mining drainage density for the area disturbed by mining. This higher drainage density will be adequate to prevent gullies forming in light of the lower relief associated with the post-mining surface. Final surface configuration designs were developed in Chapter 12 (see Section 12.3, Exhibits 12-5A, 12-6A, and 12-6B). For design of reclaimed channels, see Section 11.6.5.

The largest hydrologic change to Chinde Arroyo is in the Doby reclamation area to the north, where the westward drainages from the off lease undisturbed surface are diverted towards the south via a post-mine channel (Doby North Channel) that runs north to south along the eastern lease boundary. The pre-mine topography had no major channel; the surface sloped down towards the west with primarily sheet flow drainages and some small channels. The post-mine channel also collects surface runoff from a portion of the reclaimed surface to the west and diverts the flow into a tributary of the Chinde Diversion. Refer to Exhibit 11-76A and 12-5A for the location and alignment of the post-mine channel.

Comparison of SEDCAD predictions for pre- (see Chapter 7, Appendix 7-G) and post-mining (see Chapter 11, Appendix 11-BB) flows and sedimentology from a 10-yr 6-hr event are provided in Table 11-17. Sediment yields for the 10-yr 6-hr event at the downstream outlet (Structure 24) are predicted to decline, despite an increase of 1,124 acres in watershed size post-mining, from a pre-mining yield of 8,657 tons to a post-mining yield of 8,159 tons. The predicted decreases in sediment yield are due to the lower slopes and better vegetation cover on reclaimed areas.

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 715 cubic feet per second (cfs) to a post-mining estimate of 705 cfs for Chinde Arroyo below the lease boundary (Structure 24). The runoff volume was predicted to decline from 502 acre-feet, pre-mining, to 488 acre-feet, post-mining. The post-mining SEDCAD modeling for the 10-yr 6-hr event indicates that although the total sediment is less than the pre-mine, the peak sediment concentration (mg/l) and peak settleable concentration (milliliters per liter or ml/l) increased following mining. The peak sediment concentration increased from 50,387 mg/l to 77,099 mg/l and the peak settleable concentration from 4.16 ml/l to 13.24 ml/l.

The Navajo Nation EPA standards (NNEPA 2008) indicate that Chaco Arroyo and its tributaries, including the Chinde Arroyo support livestock watering, aquatic and wildlife habitat, secondary human contact, and fish consumption when there is flow. The aquatic and wildlife habitat standards for trace metals are very low (NNEPA 2008). Chinde has a median hardness of 248.5 mg/L, which is utilized to establish the applicable standards for cadmium, chromium, copper, lead, and zinc.

Upstream, baseline water quality in Chinde Arroyo at CD-1 and CD-1A indicate that the median water quality appears to be suitable for livestock watering (see Chapter 7, Table 7-7). However, 31 of 117 samples at CD-1 and CD-1A exceeded the standard. Individual sample concentrations of fluoride (25 samples of 153 samples), lead (1 of 289 samples), sulfate (63 of 378 samples), and TDS (16 of 371 samples) did exceed their respective livestock standards.

Baseline water quality, as reflected at the upstream sites CD-1 and CD-1A have significant departures from aquatic and wildlife habitat standards. One of 45 samples exhibited a detection limit or result less than the dissolved aluminum standard of 0.087 mg/L. Cadmium, trivalent chromium, copper, lead, silver, and zinc standards are hardness dependent, and the Chinde sites have a median hardness of 248.5 mg/L. The median dissolved cadmium concentrations exceed the chronic aquatic and wildlife habitat standard of 0.0005 mg/L, with median values of <0.0025 mg/L at sites CD-1 and CD-1A. The calculated median values utilized 50 percent of the detection limit for the reported concentrations. Of the 289 samples acquired at the two sites, none had a detection limit capable of perceiving the chronic standard, although 275 were lower than the acute aquatic and wildlife standard of 0.005 mg/L. Similarly, the median dissolved lead values exceed the chronic aquatic and wildlife standards of 0.007 mg/L with a median concentration of <0.01 at the historic upstream CD-1. The median concentration at CD-1A is <0.0025 mg/L, less than the standard. There were 16 samples which had values greater than the lead chronic standard, and 170 samples where the detection limit was higher than the standard. All samples were less than the acute aquatic and wildlife standard. The aquatic life standard for total selenium is 0.002 mg/L, and many of the prior analyses of dissolved selenium had detection levels at or higher than this value. Eleven samples exceeded the limit at CD-1A with a median value of <0.0025 mg/L and maximum value of 0.02 mg/L. Two of 289 samples exceeded the zinc standard of 0.255 mg/L. There were no copper or mercury samples acquired to establish baseline compliance. This site is influenced by return flows from the NAPI fields upstream which have produced perennial flows in the Chinde Arroyo.

Downstream, the median nitrate concentration is 9.45 mg/L at CD-2 with 74 of 166 samples greater than the 10 mg/L. Detection limits were insufficient to establish if dissolved aluminum posed a chronic hazard to aquatic and wildlife habitat, although 21 of the 24 samples had aluminum concentrations less than the acute aquatic and wildlife habitat standard of 0.75 mg/L. Cadmium detection limits exceeded the chronic aquatic and wildlife habitat limit of 0.0005 mg/L, but only one of 168 samples exceeded the acute aquatic and wildlife limit. The median dissolved lead values exceed the chronic aquatic and wildlife standards of 0.007 mg/L with a median concentration of <0.01 mg/L at the downstream CD-2. Twelve of 168 samples exceeded the standard, but detection limits were higher than the standard for 149 samples. No samples exceeded the acute aquatic wildlife standard for lead. Eighty samples at CD-2 and seventeen samples at CD-2A exceeded or equaled the selenium limit of 0.002 mg/L. The median selenium concentration of CD-2 was <0.0025 mg/L and the median selenium concentration at CD-2A was 0.005 mg/L with a maximum value of 0.019 mg/L. Three zinc samples exceeded the chronic aquatic and wildlife habitat limit of 0.255 mg/L.

When contrasting the upstream and downstream sites, CD-1 and CD-2, respectively, median electrical conductivity, , TSS, chloride, bicarbonate, nitrate, sodium, potassium, dissolved iron, total manganese are elevated downstream compared with the upstream samples, while calcium, magnesium, boron, total iron, selenium and sulfate decreased downstream compared with upstream. The more recent data from CD-1A and CD-2A, show increases of median values between upstream and downstream of pH, TDS, conductivity, TSS, calcium, magnesium, potassium, sodium, chloride, sulfate, bicarbonate, dissolved and total iron, and dissolved selenium. Median values of pH, total settleable solids, fluoride, boron, dissolved and total manganese levels are often lower downstream at CD-2A.

Post-mining concentrations of sulfate, iron, manganese, and TDS parameters may actually decrease slightly, due to more favorable vegetative stabilization associated with better distribution of topdressing over the disturbed areas and lower concentrations of sediment in stream flows. However, any change would be marginal and chemical quality of surface water following mining would be expected to approximate pre-mining conditions. Acid forming or toxic materials are not present in the drainage.

TABLE 11-17

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
CHINDE ARROYO
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		**Pre-Mine**				**Post-Mine**				**Difference From Pre-Mine**			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S24	S24	27,130	715	8,657	0.3	28,254	705	8,159	0.3	1,124	-10	-498	0.0
S17 SW1	S17 SW1	1,100	34	141	0.1	824	40	66	0.1	-276	6	-75	0.0
S15 SW1	S15 SW1	595	43	92	0.2	600	26	45	0.1	5	-17	-47	-0.1
S11	S27	446	172	1,380	3.1	1,726	332	2,757	1.6	1,280	160	1,377	-1.5
S18 SW1	S18 SW1	146	10	24	0.2	120	10	15	0.1	-26	0	-9	0.0

11.6.3.3.1.1 Surface Water Gain/Loss in Chinde Arroyo

The results of a gain/loss study conducted from April 1999 through March 2000 are reported in Appendix 11-OO, Chinde Wash Surface Water Gain/Loss Report. The synoptic, NAPI, and continuous surface water monitoring data collected during the monitoring year for Chinde Arroyo finds that during base flow and NAPI operational spills there is a net loss of surface water from the NAPI discharge point to Navajo Mine monitoring station CD-2A, a distance of nine miles. For example, on April 18, 1999, flow volume declined from 8.0 acre-feet at CD-1A to 0.5 acre-feet at CD-2A during a NAPI operational discharge. Similar instances of flow volume decreases between CD-1A and CD-2A (Chapter 7 Figure 7-2) occurred throughout the year, such as on July 1, 1999 in which CD-1A recorded 11.11 acre-feet and CD-2A recorded only 0.82 acre-feet of volume for the same NAPI operational spill.

However, by dividing this nine-mile reach into smaller reaches and measuring flow between these reaches, the reach (Reach 3) above the Yazzie highwall and upstream of reclaimed lands was identified as losing a significant amount of flow. In addition, the synoptic data documents that surface flows across reclaimed lands consisting of spoil (Reach 4) change very little and in fact are dominated by a slight increase. Thus, the conclusion of the report is that the effects of mining on surface water flow volumes both during and after mining are minimal.

Changes in surface flows are minimal in the regraded spoil reach (Reach 4) because the spoil at Navajo Mine is comprised dominantly of sodic mudstone and siltstone that have a very low permeability. Synoptic monitoring identified that base flow increased across the reclaimed land during three measurements by 119 gpm (202 to 321 gpm), 11 gpm (0 to 11 gpm), and 49 gpm (458 to 507 gpm) and decreased during one measurement by 30 gpm (115 to 85 gpm) along Reach 4. Pit run spoil permeability was determined in the Leach Study (Appendix 11-K) to be 3.97×10^{-6} centimeters/second (cm/sec) (five samples that ranged from 1.66×10^{-6} to 5.4×10^{-6} cm/sec), which is a similar permeability to that of a compacted soil liner. Based on the data from the Chinde Wash Surface Water Gain/Loss Report and permeability values, future surface water losses along the permanent Chinde Arroyo diversion are expected to be negligible.

Losses of surface water from the NAPI discharge point to Navajo Mine monitoring station CD-2A are occurring above the Yazzie highwall due to a large and highly vegetated area upstream of the Yazzie highwall, and to a lesser extent due to seeps along the highwall itself immediately below the diversion. Synoptic monitoring recorded a decrease in flow of surface water during three measurements along Reach 3 for the first three-quarters of the study, (Q2 – Q4 1999) with a decrease in flow of 772 gpm (974 to 202 gpm), 283 gpm (283 to 0 gpm) and 275 gpm (390 to 115 gpm), respectively.

The effect that the large and densely vegetated area has on surface water flow is two-fold: 1) it reduces peak flows, and 2) it enhances surface water loss. Surface water losses occur due to the flows spreading out, creating a larger surface area for infiltration and evaporation. The extensive and dense vegetated area will consume water by transpiration during the majority of the year. In addition, un-quantified seeps have been observed on the Yazzie highwall face beneath the Chinde temporary diversion confirming that surface water is infiltrating in the vegetated area. The cumulative effects of these processes, without an additional source of incoming water, are to reduce the amount of available surface water for downstream flows.

Following backfilling of the Yazzie pit, the periodic seeps on the face of the highwall beneath the temporary diversion will decrease significantly or stop due to the placement of low-permeability spoil against the highwall.

The continuous monitoring data also recorded that during large storm events, for example the events between August 3 and 4, 1999, and August 5 and 6, 1999, there was an increase in flow volume from CD-1A to CD-2A (Figure 7-2). This flow volume increase is typical of an ephemeral channel and is the result of increasing watershed size and contributions of additional flow from tributaries progressively producing an increasing volume of flow downstream.

Synoptic flow measurements and continuous flow data collected and reported in the Chinde Wash Surface Water Gain/Loss Report (Appendix 11-OO) have characterized and documented gains and losses of surface water flows along specific reaches of Chinde Arroyo. Specifically, the data collected support the conclusion that future reconstructed channels built in spoils will not significantly alter surface water flows due to vertical infiltration.

11.6.3.3.2 Hosteen Wash

The Hosteen Wash watershed area is about 9.1 sq miles. Mining activities disturb approximately 3.7 sq miles of this drainage. The Hosteen Wash watershed will decrease in size by 1.7 sq miles or 1,274 acres post-mining. This is largely a result of post-mining changes in the drainage divide between Hosteen and Chinde Arroyo, in which Chinde Arroyo increases by 844 acres.

Pre-mining drainage density for Hosteen Wash was estimated to be 3.18 miles/sq mile for the entire drainage area and 2.8 miles/sq mile for the area disturbed by mining. Post-mining drainage density for Hosteen Wash is 6.1 miles/sq mile over the area disturbed by mining. These results indicate a higher post-mining drainage density for the wash. This higher drainage density is to ensure that gullying would not develop on this watershed due to insufficient drainage.

Final surface configuration designs were developed in Chapter 12 (see Section 12.3, Exhibits 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5 and Appendix 11-H. Drainage geometry and grade were selected to maximize stability. Similar to a natural channel, sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may be reworked, exhibiting down cutting following larger storm events, and redistributing some of the sediment further downstream. Some channel aggradation or channel degradation are expected to develop from natural conditions, despite the design of a graded longitudinal profile and channel cross-section.

With the post-mining channel, some reworking of channel materials will occur, especially during the large flood events. However, channel aggradation or channel degradation would not develop within the reclaimed channel because the graded profile and channel dimensions will be designed to maintain dynamic equilibrium. See the Reclamation Surface Stabilization Handbook (BNCC, 1992) for information regarding the design of reclamation structures.

Comparison of SEDCAD predictions for pre- (see Chapter 7 Appendix 7-A) and post-mining (see Chapter 11 Appendix 11-CC) flows and sedimentology are provided in Table 11-18. This comparison indicates decreases in flow and sediment yields associated with post-mining conditions. These predicted decreases are due to a reduction in the badlands area and a slightly lower curve number attributed to reclaimed areas.

The peak flow resulting from a 10-yr 6-hr precipitation event is predicted to decline from a pre-mining estimate of 1,417 cfs (Structure 9) to a post-mining estimate of 538 cfs (Structure 18) for the entire Hosteen drainage. The runoff volume was predicted to decline from 247 acre-feet, pre-mining, to 126 acre-feet, post-mining.

The SEDCAD modeling for the 10-yr 6-hr event indicates that the predicted peak sediment concentration for post-mining will decrease and the peak settleable concentration will increase. The peak sediment concentration decreased from 45,433 mg/l to 37,159 mg/l and the peak settleable concentration increased from 1.11 ml/l to 2.30 ml/l. The increase in peak settleable solids is attributable to replacement of pre-mining badland areas (clay-rich) with a post-mining topdressing material, typically a sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas will decrease the suspended solids concentration and increase the settable solids (sand) concentration. The SEDCAD analysis also indicates that the total sediment yield will decrease from a pre-mine yield of 8,658 tons to a post-mine yield of 3,400 tons.

Comparison of pre-mining and post-mining flows and sediment yields resulting from a 10-yr 6-hr precipitation event were performed separately for several sub-watersheds disturbed by mining within the Hosteen Drainage (Table 11-18). In all of the sub-watersheds compared, with one exception, the flows and sediment yields declined as a result of mining, even in sub-watersheds that increased in size following mining.

Baseline water quality in Hosteen Wash should be similar to that of Chinde Arroyo because of the similar soils, geology, and vegetation found within the basins (see Chapter 7). Post-mining concentrations for sulfate, iron, manganese, and TDS should be equivalent or decrease slightly due to reduction of badlands area and better distribution of topsoil over the disturbed areas.

TABLE 11-18

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
HOSTEEN WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S9	S18	5,833	1,417	8,658	1.5	4,518	538	3400	0.8	-1,316	-879	-5,258	-0.7
S2	S11	2,379	640	3,617	1.5	2,264	414	1843	0.8	-115	-226	-1,774	-0.7
S6	S15	1,964	668	3,655	1.9	818	64	181	0.2	-1,146	-604	-3,474	-1.6
S12SW1	S5SW1	279	144	479	1.7	240	15	30	0.1	-39	-129	-449	-1.6
S2SW2	S11SW1	146	79	259	1.8	213	13	31	0.1	67	-66	-228	-1.6
S6SW6	S14SW1	178	79	273	1.5	143	8	18	0.1	-36	-71	-255	-1.4
S6SW5	S13SW1	194	91	269	1.4	94	7	11	0.1	-100	-84	-258	-1.3
S12SW2	S6SW1	107	49	84	0.8	169	13	29	0.2	62	-36	-55	-0.6
S2SW1	S11SW2	203	25	49	0.2	86	14	34	0.4	-117	-11	-15	0.2
S13SW2	S9SW1	275	146	569	2.1	410	20	46	0.1	135	-126	-523	-2.0

11.6.3.3.3 Barber Wash

The Barber Wash watershed area is about 5.3 sq miles. Mining activities disturbs approximately 1.4 sq miles of this drainage. Barber Wash will decrease in size by 1.3 sq miles (849 acres) post-mining. This is largely due to post-mining topography changes at the drainage divide between the Barber and South Barber drainages, in which the South Barber drainage increases by 1.45 sq miles (928 acres) (see Exhibits 7-4C and 11-75A).

Pre-mining drainage density for Barber Wash was estimated to be 1.75 miles/sq mile for the entire drainage area and 1.46 miles/sq mile for the area disturbed by mining. Post-mining drainage density for Barber Wash is 6.7 miles/sq mile over the area disturbed by mining.

These results indicate a higher post-mining drainage density over the area disturbed by mining. The post-mining drainage density may be greater than necessary to achieve a stable topographic condition. The increased drainage density was deemed necessary to avoid excessive overland flow lengths. In the event the drainage network is too extensive for the associated flows and sediment yields, the drainage density would decrease where channel flows are insufficient to transport sediment yield from overland flow and upstream contributions. This may occur in the upper reaches of some channels. As these headwater channels fill with sediment, drainage density will decrease as the channel network approaches equilibrium with the flow and sediment yield regime of the contributing watershed.

Final surface configuration designs were developed in Chapter 12 (Section 12.3 and Exhibits 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5. Drainage geometry and grade were selected to encourage stability without causing excess sediment deposition. Sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may in turn exhibit down cutting following larger storm events, resulting in migration of re-worked sediments downstream. Natural forces will cause aggregation, degradation and down cutting.

Comparison of SEDCAD predictions for pre- (Chapter 7 Appendix 7-B) and post-mining (Chapter 11 Appendix 11-DD) peak flows and sediment yields resulting from a 10-yr 6-hr precipitation event are provided in Table 11-19. In all cases, the comparison indicates a decrease in flow and sediment yields associated with post-mining conditions. These predicted decreases are due to a reduction in the badlands area and a lower curve number attributed to reclaimed areas.

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decline from a pre-mining estimate of 404 cfs to a post-mining estimate of 284 cfs for the entire Barber drainage. The runoff volume was predicted to decline from 101 acre-feet, pre-mining, to 59 acre-feet, post-mining.

The SEDCAD modeling for the 10-yr 6-hr event indicates that the predicted peak sediment concentration for post-mine (24,586 mg/l) decreased compared to pre-mine (27,241 mg/l). Total sediment yields (tons) decreased for post-mining conditions while the predicted settleable solid concentrations increased. Sediment yields declined from a pre-mining yield of 1,672 tons to a post-mining yield of 1,076 tons. The settleable solids concentration for the post-mine is 2.2 ml/l compared to the pre-mine concentration of 0.36 ml/l. The change is attributable to replacement of pre-mining badland areas (clay-rich) with a post-mining topdressing material which is typically a sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas may decrease the suspended solids concentration and increase the settable solids concentration.

The peak concentrations of suspended solids and settleable solids are only order-of-magnitude predictions, it is concluded that there should be no significant change between pre- and post-mining in the peak concentrations of TSS and total settleable solids.

Baseline water quality in Barber Wash should be similar to Chinde Arroyo because of similar soils, geology, and vegetation found within the basins (see Chapter 7). Post-mining concentrations for sulfate, iron, and manganese should be equivalent or improve slightly due to a reduction of badlands area and better distribution of topsoil over the disturbed areas.

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TABLE 11-19
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
BARBER WASH
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		**Pre-Mine**				**Post-Mine**				**Difference From Pre-Mine**			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S2	S9	3,364	404	1,672	0.5	2,515	284	1,076	0.4	-849	-120	-596	-0.1
S7	S8	1,716	285	831	0.5	849	86	336	0.4	-867	-199	-495	-0.1
S6SW1	S5	678	175	503	0.7	437	23	44	0.1	-241	-152	-459	-0.6

11.6.3.3.4 South Barber Drainage

The South Barber Drainage has a watershed of about 0.8 sq miles. Mining activities will disturb approximately 0.03 sq miles (17 acres) of this drainage area. The post-mine topography will increase the South Barber drainage by 928 acres. This is largely due to the post-mining topography changes at the drainage divide between the Barber and South Barber. The most significant change from pre-mine is that the upper portion of the Barber drainage will be diverted into the South Barber Channel (see Exhibits 7-4C and 11-75A).

Pre-mining drainage density for the South Barber drainage was estimated to be 5.93 miles/sq mile for the entire drainage area. Post-mining drainage density for the South Barber drainage is 5.98 miles/sq mile over the area disturbed by mining. These results indicate that the post-mining and pre-mining drainage densities are about equal. This along with other erosion control practices on the reclaimed areas will ensure that the sediment yield from the post-mining surface will be equivalent to or less than pre-mine. Final surface configuration designs are presented in Chapter 12 (see Sections 12.3, Exhibits 12-6A and 12-6B). For design of reclaimed channels, see Section 11.6.5. Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Sediment deposition may produce local convexities as a result of the aggrading conditions in the channel. These convexities may in turn develop head cuts and begin to erode.

Comparison of SEDCAD predictions for pre-mining (Appendix 7-N) and post-mining (Appendix 11-EE) flows and sedimentology is provided in Table 11-20 for a 10-yr 6-hr event. The comparison indicates a decrease in the total sediment yield for post-mining and the peak flows remain about equal. The predicted sediment yield is 765 tons for post-mine and 599 tons for pre-mine. The predicted peak flows are approximately equal at 166 cfs. The increase in sediment yield for post-mine condition is primarily due to the increased drainage area; the yield in tons per acre is 1.1 tons/acre for pre-mine and 0.5 tons/acre for post-mine. The SEDCAD modeling also indicates for the post-mine condition a decrease in peak sediment concentration and an increase in peak settleable concentration. The predicted peak sediment concentration is 39,347 mg/l for post-mine and 40,564 mg/l for pre-mine. The predicted peak settleable concentration is 1.36 ml/l for post-mine and 0.0 ml/l for pre-mine. The change is attributable to replacement of pre-mining badland areas (clay-rich) with a post-mining sandy loam soil. The clay rich areas will increase the suspended solids concentration, while sandy loam areas may decrease the suspended solids concentration and increase the settable solids concentration. The comparison indicates there is no significant change between the pre and post-mine peak sediment and peak settleable concentrations. For the same storm event the total sediment yield in tons per acre declined for the post-mine condition.

11.6.3.3.5 Neck Arroyo

The Neck Arroyo watershed area is about 1.88 square miles. Approximately 14 percent of this drainage (0.26 square miles or 168 acres) lies within the permit area. Within the permit area, pit disturbance extends across about three percent of the drainage (0.06 square miles or 36 acres), while about one percent of the drainage (0.19 square miles or 132 acres) will be directly disturbed by the location of roads.

TABLE 11-20
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
SOUTH BARBER DRAINAGE
10-YEAR, 6-HOUR PRECIPITATION EVENT

Sedcad 4.0 Watershed Designation		**Pre-Mine**				**Post-Mine**				**Difference From Pre-Mine**			
Pre	Post	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S2	S6	526	166	599	1.1	1,454	166	765	0.5	928	0	166	-0.6

It is possible that road crossings and rail crossings could slightly alter the flow and sediment equilibrium resulting in either temporary aggrading or degrading conditions developing in the stream channel above or below the road crossing. After removal of the road crossing the affected channel reach will return to the approximate pre-mine condition.

Comparison of SEDCAD predictions for pre- (see Appendix 7-C) and post-mining flows and sedimentology are provided in Table 11-21. This comparison suggests slight decreases in flow and sediment yields under post-mining conditions. These decreases are due to the lower curve number attributed to reclaimed areas and also lower slopes and better vegetation cover on reclaimed areas.

Table 11-21

Comparison of Pre- & Post-Mining Flows and Sediment Yields Neck Arroyo 10-Year 6-Hour Precipitation Event

SEDCAD				Pre-Mining		Post-Mining		Difference from Pre-Mining	
Subwatershed				Flow	Sediment	Flow	Sediment	Flow	Sediment
J	B	S	SW	(cfs)	(Tons)	(cfs)	(Tons)	(cfs)	(Tons)
1	1	1	1	31.18	348.00	30.79	343.69	-0.39	-4.31
1	1	1	5	31.38	402.34	27.52	361.5	-3.86	-40.84

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decline from a pre-mining estimate of 31.38 cfs to a post-mining estimate of 27.52 cfs for the entire Neck drainage. Sediment yields for the same event declined from a pre-mining yield of 402.34 tons to a post-mining yield of 361.5 tons.

The SEDCAD modeling for the 10-yr 6-hr event indicates that predicted peak concentration of TSS increased slightly from pre-mining to post-mining conditions (426,430 mg/l and 428,223 mg/l, respectively) even though peak settleable solids concentrations and sediment yields decreased. This slight increase in total suspended solid concentrations appears to result from numerical error associated with routing high concentrations of sediment in flood flows. Since the peak concentrations of suspended solids and settleable solids are only order-of-magnitude predictions, it can be concluded that there should be no significant change between pre- and post-mining in the peak concentrations of TSS and total settleable solids.

Comparison of pre-mining and post-mining flows and sediment yields resulting from 10-yr 6-hr precipitation event were performed separately for each sub-watershed disturbed by mining within the Neck Arroyo drainage (Table 11-21). In all cases, the flows and sediment yields remained the same or declined as a result of mining.

Pre-mining drainage density for Neck Arroyo was estimated to be 3.11 miles/sq mile for the entire drainage area and should not change as a result of mining.

11.6.3.3.6 Lowe Arroyo

The Lowe Arroyo watershed area is about 11.00 sq miles. Approximately 4.00 sq miles of this drainage lies within the permit area, and 2.18 sq miles is expected to be disturbed. Final surface configuration and drainage designs have been developed as discussed in Chapter 12 (Section 12.3and Section 11.6.5.1).

Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Such sediment deposition may subsequently develop head cuts and erode as local convexities in the channel develop as a result of aggrading conditions. With the post-mining channel, some reworking of channel materials will occur especially during the large flood events. Similar to natural channels in the area, major channel aggradation or channel degradation may develop within the reclaimed channel despite the engineered graded profile and channel dimensions designed for stability. Channel instabilities could develop as a result of head cuts working upstream from changes in base level on Chaco River or the San Juan River.

The largest hydrologic change is the routing of undisturbed drainages east of the permit boundary. Pre-mine, the drainages east of the permit formed the main branch of the Lowe channel that flowed east to west toward SEDCAD structure 10 (Exhibit 7-4). In the post-mine, these drainages are routed to the south initially before flowing west and north toward SEDCAD structure 11 (Exhibit 11-77). As shown on Table 11-22, the watershed area to Structure 7 decreases by 1,808 acres in the post-mine while the watershed area to Structure 11 increases by 1,584 acres. The outlet for the Lowe Arroyo drainage is the same location (lease boundary) as the pre-mine at Structure 12.

The southern post-mining drainage that flows to Structure 11 differs from the pre-mine channel alignment in order to accommodate a lower gradient in the reclaimed channel. The post mining drainage that flows to Structure 10 has a similar alignment as the pre-mine channel.

In the post-mine, the Lowe Arroyo watershed increases by 93 acres due to a change in the drainage divide with Cottonwood Arroyo. This change in watershed acres occurs along the southern boundary between Lowe and Cottonwood drainages. The shifting of 93 acres from Cottonwood Arroyo to Lowe Arroyo will have no appreciable effect on the peak flows or sediment yields of either watershed due to their large size and reclamation practices.

Comparison of SEDCAD predictions for pre-mining (Appendix 7-D and Appendix11-X) and post-mining flows and sedimentology provided in Table 11-22 for a 10-yr 6-hr event. There is a decrease in peak flow and sediment yields from pre-mining conditions to post-mining at both the lease line and the outlet of the watershed. Sediment yields for the 10-yr 6-hr event at the downstream outlet (Structure 12, lease line) are predicted to decline, despite an increase of 93 acres in watershed size post-mining, from a pre-mining yield of 3,682 tons to a post-mining yield of 3,227 tons. The decline in sediment yields and peak flows is due primarily to a lower curve number resulting from reclaiming with sandy loam topdressing material, better vegetation cover on reclaimed areas and terraces that reduce the slope lengths for the post-mine drainage.

TABLE 11-22

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
LOWE ARROYO
10-YEAR, 6-HOUR PRECIPITATION EVENT

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre-mine	Post-mine	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S5	S5	386	55	76	0.2	2,074	317.93	1,071	0.5	1,688	263	996	0.3
S7	S7	2,087	382	1,132	0.5	279	38.37	63	0.2	-1,808	-344	-1,069	-0.3
S8	S6	609	96	166	0.3	2,599	371.51	1,279	0.5	1,990	276	1,113	0.2
S9	S9	541	241	1,005	1.9	341	124.17	416	1.2	-200	-117	-589	-0.6
S10	S10	4,659	735	2,431	0.5	6,798	490	2,811	0.4	2,139	-245	380	-0.1
S11	S11	1,846	129	246	0.1	3,430	329	1,313	0.4	1,584	200	1,067	0.2
S12 (Lease Line)	S12	7,046	926	3,682	0.5	7,139	514	3,227	0.5	93	-412	-455	-0.1
S13 (Outlet)	S13	7,855	919	3,951	0.5	7,945	527	3,426	0.4	90	-392	-525	-0.1

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 926 cfs to a post-mining estimate 514 cfs for Lowe Arroyo below the lease boundary (Structure 12). The runoff volume at structure 12 is predicted to decline from 238 acre-feet, pre-mining, to 192 acre-feet, post-mining.

11.6.3.3.7 Cottonwood Arroyo

The Cottonwood Arroyo watershed area is about 80 square miles. The pre-mining watershed areas are shown on Exhibit 7-4A. The final surface topography and drainage configuration has been developed and is discussed in Section 11.6.5.1 and Chapter 12.3.

Flow monitoring of the two upstream monitoring stations CN-1 and CS-1 on the North and South Fork of Cottonwood, and the downstream monitoring station CNS-1 occurred between 22 April 1990 and 14 September 1996. The results reflected the variability of regional storms, with two sites sometimes exhibiting flow, and the other site not having it, as well as variability from discharges to Cottonwood from NIIP. Furthermore, most storms are short-term high intensity events creating flash flooding. The downstream site often had lower flows than the upstream sites between 22 April 1990 and 21 May 1992, at which time, the results started to show more elevated flows at the downstream site, CNS-1, than the two upstream sites..

Appendix 7-L includes hydrographs from continuous monitoring gages of three events on 21 August 1998, 22 April 1999, and 2 August thru 3 August 1999. These are described in Section 7.2.9.3. On 21 August 1999, there were 10 hours of runoff at CN-1 with 1.44 hours of flow greater than 60 cfs, and 2.64 hours greater than 30 cfs. There were only 7.2 hours of runoff at CS-1, but the site had the earliest and highest flow of the three sites of approximately 88 cfs. CS-1 had 3.84 hours of flow above 30 cfs. The downstream site CNS-1 had 4.32 hours of flow above 30 cfs and 8.64 hours of flow. The peak flow at this site was over 100 cfs, and occurred later in the hydrograph than the two upgradient sites, as expected. A low intensity precipitation event induced by a low pressure system occurred on 22 April 1999 at CN-1 and CNS-1. Peak flows occurred at almost the same time at the two sites, with more than 140 cfs at the upstream CN-1, and approximately 85 cfs at the downstream CNS-1. Flows at CN-1 exceeded 20 cfs for

18 hours, while they exceeded 20 cfs at CNS-1 for less than 4 hours, reflecting substantial infiltration between sites. A short cloudburst occurred on 2 August 1999, and all three sites had peak flows within 15 minutes of the others. CN-1 had a peak flow of more than 50 cfs, CS-1 had a peak flow of more than 100 cfs, and CNS-1 had a peak flow of more than 145 cfs. Flows had a duration of 2.16 hours at CN-1, 1.7 hours at CS-1, and 3.84 hours at CNS-1. The last suite of hydrographs in Appendix 7-L reflects a storm moving south, and stalled on CS-1 and CNS-1. CN-1 had a peak flow of 27 cfs, around 5:00 pm, with flows lasting less than 3.4 hours. In sharp contrast, CNS-1 had a peak flow of 140 cfs at 6:00 pm, had sustained flows of greater than 20 cfs for 3.1 hours with more than 14.5 hours of flow recorded. Upstream at CS-1, a peak of 175 cfs around 5:50 pm, followed by persistent flows for 50 minutes of approximately 110 cfs. Sustained flows of more than 20 cfs occurred for 2.76 hours, and the channel was dry again within 7.7 hours of the beginning of the storm.

The primary hydrologic change to Cottonwood Arroyo is the disturbance of the North Fork of Cottonwood Arroyo. Approximately 10,662 feet of the North Fork will be permanently re-aligned from the pre-mine orientation due to reclamation (See Exhibit 11-77). As noted in the discussion of Lowe Arroyo, the Cottonwood Arroyo watershed will slightly increase from the pre-mine but with no appreciable hydrologic effects.

Table 11-23 shows the comparison of flow and sediment yield for the 10-yr 6-hr precipitation event for the portions of Cottonwood tributaries that drain the proposed Area 4 North mine area from modeling found in Appendices 7-H and 11-Y.. These results reflect disturbance conditions for the entire sub-watershed even though proposed mining affects only a portion of the sub-watershed. Yet the differences in sediment yields (tons) and peak flow are negligible between pre and post-mining at the lease line (Structure 36). Sediment yields for the 10-yr 6-hr event at the downstream lease line are predicted to slightly increase from a pre-mining yield of 26,947 tons to a post-mining yield of 27,017 tons (Structure 37). This is essentially no change in sediment yield. The incrementally small changes in the sediment and peak flow figures reflect the small acreage of mining disturbance in the Cottonwood watershed as a whole.

The peak flow resulting from a 10-yr 6-hr precipitation event at the lease line (Structure 36) is predicted to slightly increase from a pre-mining estimate of 2,879 cfs to a post-mining estimate 2,903 cfs. The runoff volume at Structure 36 is predicted to decline from 1,473 acre-feet, pre-mining, to 1,150acre-feet, post-mining.

TABLE 11-23

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
COTTONWOOD ARROYO
10-YEAR, 6-HOUR PRECIPITATION EVENT

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine				Post-Mine				Difference From Pre-Mine			
Pre	Post	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Sediment (tons)	Yield (tons/acre)
S21	S21	13,492	1,551	11,133	0.8	13,532	1,546	11,417	0.8	40	-5	284	0.0
S34	S34	18,191	674	7,201	0.4	18,279	665	7,298	0.4	88	-9	97	0.0
S36 (lease line)	S36	49,060	2,879	26,803	0.5	49,184	2,903	27,364	0.6	124	24	561	0.0
S37(Outlet)	S37	51,269	2,842	26,947	0.5	51,477	2,855	27,017	0.5	208	13	70	0.0

The pre-mining drainage density for Cottonwood Arroyo was estimated to be 2.64 miles/sq mile for the entire drainage area and 2.33 miles/sq mile for the permit area. Drainage densities will not change significantly as a result of mining. Final surface configuration design for Area III has allowed for a higher post-mining drainage density for the area disturbed by mining (see Exhibit 11-77). Furthermore, the gradient terraces to be installed according the Reclamation Surface Stabilization Handbook (BNCC, 1992) along with the lower relief associated with the post-mining surface should minimize gullies forming on the reclaimed surface.

BNCC monitored three sites along the Cottonwood Arroyo between 1990 and 1999. Upstream NAPI discharges from releases of water at the end of the irrigation canals heavily influenced the water quality at two of the sites, as the flows were eroding and mobilizing sediment from surficial eolian sand dunes. Active channel widening and head cut development followed discharges from NAPI and storm events. Multiple storm events in 1999 resulted in the destruction of the downstream monitoring station CNS-1. During the monitoring period, when flows occurred, sediment loss resulted in significant concentrations of TSS, which resulted in elevated salinity, iron, and manganese concentrations. Water quality parameter levels were often elevated at CN-1 which is located upstream of the mine on the North Fork of Cottonwood, and at the downstream site CNS-1. Median TSS concentrations ranged from approximately 59,400 mg/l at the upstream site, CS-1, to approximately 87,500 mg/l at the upstream site, CN-1.

As noted earlier, the Navajo Nation EPA standards (NNEPA 2008) indicate that Chaco Arroyo and its tributaries, including the Cottonwood Arroyo support livestock watering aquatic and wildlife habitat, secondary human contact and fish consumption, when there is flow (NNEPA 2008). Livestock standards and recommended water quality criteria drive the minimum standards for boron, total chromium, and nitrate. The chronic aquatic and wildlife habitat standards for trace metals are very low, and the lowest applicable standards for the parameters aluminum, cadmium, trivalent chromium, copper, lead, mercury, selenium, and zinc. Cottonwood has a median hardness of 105 mg/L, which is utilized to establish the applicable standards for cadmium, chromium, copper, lead, and zinc. As hardness concentrations drop, applicable water quality standards also decrease for aquatic and wildlife standards. Fish consumption standards of arsenic and copper represent the lowest applicable standards for those parameters.

Baseline water quality in Cottonwood Arroyo at the two upgradient sites, CN-1 and CS-1, indicates that the median water quality appears to be suitable for livestock watering (see Chapter 7, Table 7-7). Some parameters did have individual samples which exceed the livestock standards. Nitrate concentrations ranged from 1.7 – 180 mg/L. One of 141 samples exceeded the livestock standard of 0.2 mg/L total arsenic, with a dissolved arsenic value of 0.347 mg/L. Five of 144 samples exceeded the total lead livestock standard of 0.1 mg/L. Six of 185 samples had sulfate concentrations greater than 1000 mg/L and 8 of 184 samples had TDS concentrations exceeding the livestock standard of 3000 mg/L.

One of 141 samples exceeded the acute and chronic aquatic wildlife habitat standards of 0.34 and 0.15 mg/L dissolved arsenic at CN-1 grab, with a value of 0.347 mg/L. The dissolved cadmium limit for streams with a median hardness of 105 mg/L is <0.00025 mg/L. Detection limits were never that low and thus concentrations at CN-1 and CS-1 may exceed the limit. Detection limits were usually not sufficient to establish compliance with the acute aquatic and wildlife habitat standard for dissolved cadmium of 0.0211 mg/L. The lead standard for chronic aquatic and wildlife habitat at 105 mg/L is 0.00265 mg/L, and median concentrations at CN-1 and CD-1 are <0.01 and <0.01 mg/L respectively. Elevated detection limits are responsible, as thirty-one of 37 samples had detection limits of < 0.02 mg/L, 10 times higher than the standard. Nine of 135 samples exceeded the acute aquatic and wildlife habitat standard of 0.0681 mg/L lead. Median selenium concentrations exceeded chronic aquatic and wildlife habitat standard of 0.002 mg/L, as 129 of 282 samples had detection limits higher than the standard. All sample values were less than the acute aquatic and wildlife habitat standard. Six of 144 samples exceeded the chronic aquatic and wildlife habitat limit of 0.126 mg/L dissolved zinc, but 70 samples had detection limits higher than the standard.

The downstream site, CNS-1 had a median concentration of 8 mg/L and 32 samples exceeding the livestock standard of 10 mg/L nitrate. One of 226 samples exceeded the livestock water standard for lead of 0.1 mg/L with a value of 0.12 mg/L. Detection limits were inadequate to establish the site's compliance with the cadmium acute and chronic aquatic life and wildlife habitat standard and the lead chronic aquatic life and wildlife habitat standard. Eighty of 82 samples were compliant with the acute aquatic and wildlife habitat standard of 0.0681 mg/L lead. Thirty-five samples at CNS-1 had concentrations of dissolved selenium greater than the total selenium chronic aquatic and wildlife habitat limit of 0.002 mg/L, and eight had detection limits higher than the standard. All samples at the site met the acute selenium aquatic and wildlife habitat standard.

The downstream site, CNS-1, has lower median concentrations of the parameters TDS, conductivity, total settleable solids, calcium, potassium, sodium, bicarbonate, and sulfate than the upstream stations of CN-1 and CS-1. Results were more elevated downstream for median values of boron, dissolved iron, and nitrate. The rest of the results show the downstream site lower than one of the upstream sites, and higher than one of the upstream sites, but the results varied between the upstream sites.

Post-mining concentrations of TDS, total iron, total manganese, sulfate, and TSS may actually decrease slightly due to better distribution of topdressing over the disturbed areas and lower concentrations of sediment in stream flows. However, any change would be marginal and chemical quality of surface water following mining would be expected to reflect influences from upstream flows from the irrigation project.

11.6.3.3.8 San Juan River and Chaco River

The San Juan River Basin within the 1408 HUC codes extends across approximately 24,900 sq miles. Approximately 0.21 percent of this drainage lies within the lease area. The Chaco River has a watershed area of approximately 4,570 sq miles within the 14080106 HUC code. The lease occupies about 1.2 percent of the total drainage area.

The San Juan River and Chaco River channels and flood plains will not be directly impacted by mining activities. The only possible impact on these rivers would be through the discharge of surface or groundwater from the mine area or from reclaimed surface and backfill.

The Chaco River does not receive groundwater base flow and thus would not be impacted by changes in groundwater quality. A relatively small amount of groundwater from backfill areas could reach the San Juan River after a period of about 200 years. As explained in Section 11.6.2.3.1, this quantity is so small relative to flows in the San Juan River that little change in the water quality of the San Juan River would be expected. Furthermore, based on leaching studies of overburden and spoils, chemical quality expected from backfill leachate would be very similar to baseline quality in coal seams. Consequently, no change in water quality in the San Juan River would be expected from groundwater from the mine area.

Storm runoff from the active mine area is contained within the mine and is not directly discharged to surface water drainage courses. Consequently there would be no impact on surface water quality of the San Juan and Chaco Rivers as a result of mine water discharges.

Diversion of flows in the major channels such as Chinde Arroyo may result in minor disruption of dynamic equilibrium within the stream channel. These changes could increase or decrease sediment loads along segments of the channel but are usually unlikely to change sediment loads to the San Juan or Chaco Rivers. The diversion of Chinde Arroyo through the Big Fill culvert is one example where flood attenuation may reduce sediment loads downstream to the Chaco River. The hydrologic consequences of such changes are temporary adjustments in channel grade and geometry until a new equilibrium is reached. From field observations it appears that channel adjustments have already occurred downstream of the Big Fill culvert and the channel is approaching equilibrium conditions.

Analysis of impacts of reclamation of drainages and stream channels, as described in Section 11.6.3.1 through 11.6.3.8, indicates only minor changes in flow and sedimentology that are likely to have minimal impact on channel conditions and sediment loads in the San Juan and Chaco Rivers.

11.6.4 Post-Reclamation Probable Hydrologic Consequences

BNCC's objectives in establishing the post-reclamation topography are to restore the affected land to a condition supporting the land uses it was capable of supporting prior to mining. This is achieved by minimizing the disturbance to the hydrologic balance, restoring prominent drainage features of the permit area to approximate the pre-mining conditions, and establishing a diverse, effective, and long lasting vegetative cover of the same seasonal variety as the native vegetation (Chapter 12 Section 12.1). All reclamation strategies are implemented to reduce surface erosion and sediment yield. BNCC has designed the post-reclamation topography and drainages to conform with existing drainages along the perimeter of the mine in order to safely convey water from upstream, off-lease watersheds to area drainages. BNCC will use appropriate channel types, slopes, and drainage densities to construct landforms appropriate to the area.

BNCC is planning to reclaim all of the sediment and drainage control ponds utilized during the operation, except for impoundments designated as permanent impoundments (Chapter 12 Section 12.3.4.1). At some future date, the Navajo Nation may request that some or all of the ponds remain. Future discussions may result in the retention or construction of ponds replacing the original livestock ponds. Should pond retention occur, ponds located on-channel will modify the hydrograph associated with the storm event by lowering the peak flows, extending the runoff over a longer period of time, and reducing storm runoff volumes. For small runoff events, the ponds may retain all of the storm runoff from upstream. Pond reconstruction will be performed to generally reproduce the storage capacity and surface area of the original pre-mine impoundment. The spoil material at each pond location will be compacted under appropriate moisture conditions in order to reduce permeability and, thereby, prevent excess pond infiltration. Specific discussions of temporary and permanent sediment ponds and the replacement of surface water sources are presented in Chapter 11 Section 11.2.10 and Chapter 12 Section 12.3.4 and 12.11.

Water quality will be monitored to ensure that it is appropriate for the post-mine use. Table 12.3.4-1 lists the currently proposed permanent impoundments for Navajo Mine. Quarterly sampling in 2000 (Table 1 Appendix 12E) of Lowe Hole 3, also known as Lowe Permanent Impoundment, show that the alkaline sodium sulfate water is suitable for livestock, with one exception for pH, through a comparison of livestock criteria from a Cooperative Extension brochure from the Cattle Producer's Library (Bagley et al 1995). The table identifies that the suitable pH range is 6.0 – 8.0. Comparison with the original document suggests that this range is suitable for dairy cattle, while a range of 5.5-8.3 is acceptable for other livestock. The NNEPA (2008) identifies a suitable pH range of 6.5 to 9.0 for livestock, and the historic Lowe Hole 3 waters were within that range with pHs of 8.05-8.79.

The mining and reclamation plan for the Navajo Mine includes the development of a post-mine topography that minimizes the disturbance to the hydrologic balance and restores prominent drainage features of the permit area to approximate the pre-mining conditions. This post-mining topography may incorporate diversion channels developed during operations. BNCC will meet all the regulatory requirements for diversions as specified in 30 CFR 816.43. Ideally, these diversions will not employ channel lining, artificial channel roughness features, or retention basins, unless approved by the regulatory agency. The diversions will not diminish downstream water rights. The ephemeral channels traversing the post-mine topography are designed, located, and constructed to be stable within a condition of dynamic equilibrium, and will not increase the potential for downstream flooding or endanger property or public safety. The channels will be designed to minimize additional contributions of suspended solids to stream flows using features such as appropriate gradients, channel linings, and roughness features. Lastly, these channels will not be constructed to divert water into underground mines.

11.6.4.1 Post-Reclamation Erosion, Sediment Yields, and Water Quality

The Reclamation Surface Stabilization Handbook (BNCC, 1992) includes a description of the sediment control measures that will be used on the reclaimed lands to prevent additional contributions of suspended solids to stream flow to meet applicable federal, state, and tribal water quality laws, regulations, and standards.

Mining operations will minimize disturbance to the hydrologic balance within the permit area and prevent material damage outside. Reclamation of disturbed areas and replacement of poor quality sodic soils with suitable topdressing materials is expected to produce better or equivalent surface water quality as pre-mining under post-reclamation conditions. SEDCAD modeling results presented in the previous section indicate equivalent or reductions in post-reclamation sediment yields relative to baseline conditions. TDS, sulfate, iron, and manganese concentrations in surface runoff from reclaimed areas are expected to decline with time to concentrations well below the SPLP leaching test results for mine spoils in Table 11-14f. Also, trace constituents in surface runoff are expected to be well below the SPLP spoil leachate results, which are less than detection limits or livestock watering criteria as shown in Table 11-14f. Groundwater flow and transport modeling presented in Section 11.6.2.4.3 project the transport of dissolved solids and several trace constituents toward the topographic lows along the pre-mining channels. The rates of groundwater flow are very slow relative to storm water runoff volumes, and groundwater flows are expected to be retained within the alluvium and not contribute to surface water.

Following reclamation, surface water quality in drainages throughout the permit area is expected to be equivalent to or an improvement from pre-mine water quality for the following reasons:

- Sediment contribution from reclaimed areas is likely to decrease relative to baseline due to the overall reduction in slopes and improvement in the permanent vegetation cover.
- Sediment contribution from channel erosion is likely to decrease as incised unstable channels are replaced by stable channel configurations.
- Poor quality and sodic soils will be buried within the backfill, thus overland flow from the reclaimed areas is expected to exhibit lower concentrations of sodium and TDS.
- Trace metal concentrations such as boron or selenium are expected to be reduced, through spoil attenuation as shown in Table 11-14e.
- Dissolved aluminum concentrations should decline with the reduction in suspended solids associated with reduced surface and channel erosion.

Section 11.6.5 addresses the potential short-term and long-term impacts to surface water sources that have existing uses.

11.6.4.2 Site Channels

The reclaimed channels are engineered to have flow velocities equal to or less than the pre-mine channels. Some erosion is anticipated, particularly in the pilot channels shown on Figures 11-27 and 11-29. All natural channels erode because they are in constant state of flux based on the magnitude of flows conveyed. During low flows, deposition will occur in some reaches of the channel and erosion in other reaches. Deposition will occur in reaches of lower slopes or where the channel bed widens and the flow spreads out, thus reducing the velocity. Erosion (down cutting with some lateral movement) will happen in reaches where the channel bed narrows and confines the flow, thereby increasing the velocity. This generally occurs in reaches with increases in channel bed slopes.

During elevated flows the storm deposited sediment from low flows will be washed downstream in natural channels. Some lateral movement of the channel banks is expected as well as some down cutting of the channel bed. This process is also expected to occur in the reclaimed channels. Lateral movement of the low flow pilot channel is projected but will be confined within the banks of the main channel. The pilot channel is expected to resemble the surrounding natural channels in time. It could be incised in some reaches of the channel with depths as deep as 5 feet at the floodplain. The existing, incised channel depths in the existing or natural channels directly downstream of the lease are much deeper (See Exhibit 11-76E). Erosion is expected to occur in the reclaimed channels but the erosion rate will be equivalent or less than pre-mining conditions since the flow velocities in the reclaimed channels are less than the pre-mine (See Tables 11-24 and 11-24a).

Low frequency (10-yr 6-hr or greater) large storm flows with corresponding higher velocities are required to transport coarse materials. Inversely for the higher frequency (2-yr 6-hr) smaller flows, the abundant coarse materials in combination with vegetation will serve to stabilize the grade and minimize erosion and down cutting.

Cut bank depths up to 5 feet deep could result if a 3-foot deep incised pilot channel should migrate and abut against a 1.5 to 2.0 feet thick floodplain bank (See Figure 11-24a). The erosion depth or incised pilot channel depth of three feet was selected based on observations of channel erosion in adjacent, pre-law mine spoils. Usually at a scour depth of three feet or less into the spoil material, a protective shielding of the channel bottom has occurred as the finer-grained sediments are winnowed away. If the incised pilot channel excavates deeper than three feet or should erode beyond the toe of the main channel into the reclaimed slope, the area/erosion will be mitigated by stabilizing the channel. Channel stabilization options include armoring the channel with coarse materials that range in size from pea – sized gravel (>0.63 inches) up to large (3-foot length of the long axis) sandstone cobbles and boulders.

11.6.4.2.1 Area I South Reclaimed Channels

There is one reclaimed channel in the Area I South final surface configuration (FSC) with a watershed larger than 640 acres, which requires detailed designs according to the Reclamation Surface Stabilization Handbook (BNCC, 1992). The reclaimed channel is designated as the Doby North Channel. The alignment of the reclaimed channel is shown on Exhibits 11-85 and 85A.

11.6.4.2.1.1 Analysis of Pre-Mine Channels

In the vicinity of Doby Pit, the pre-mine surface sloped down towards the west with primarily sheet flow drainages and some small channels. The post-mine topography changed the pre-mine drainage pattern by diverting the westward drainages from the off lease undisturbed surface towards the south via a post-mine channel that runs north to south along the eastern lease boundary. The channel also collects surface runoff from a portion of the reclaimed surface to the west.

Since there was no main channel in the pre-mine surface, the pre and post-mine flow velocities cannot be compared. The design of the reclaimed channel was based on maintaining the flow velocity less than the erosive velocity of the channel bed material, which in this case is the spoil material. The spoil material is primarily composed of shale/clay with sandstone cobbles that has an erosive velocity of approximately 5 feet per second (fps). Specifically, the design philosophy was to design a channel that is: 1) stable by demonstrating that the flow velocities are less than 5 fps, and 2) able to safely convey the flow from the 100-yr 6-hr event.

11.6.4.2.1.2 Analysis of Reclaimed Channels

The SEDCAD hydrology software was utilized to design the reclaimed channel. The hydrology for the Doby North Channel was modeled in SEDCAD to simulate the 2-, 10-, 25- and 100-yr 6-hr storm events. The channel was designed to retain the 10-yr 6-hr peak flow without overflowing the banks. The watershed subdivisions used in the model are presented in Exhibit 11-85 and 85A. The results from the SEDCAD runs are presented in Appendix 11-FF. During storms greater than the 10-yr 6-hr event over bank flow will occur at the upper reach of the channel. For all the storm events simulated the flow velocities are less than 5 fps, indicating that the channel will be hydraulically stable.

The profile of the Doby North Channel at the south end of the Doby reclamation area has a significant drop; this reach of channel will require a riprapped drop structure to control erosion. The drop structure will be designed for a 25-yr 6-hr stability and 100-yr 6-hr capacity. The design of the drop structure is included in the SEDCAD hydrology model (Appendix 11-FF).

The location and design details for the Doby North Channel are presented on Exhibit 11-85.

11.6.4.2.2 Area II Reclaimed Channels

Four reclaimed channels in the Area II FSC have watersheds that are larger than 640 acres, which require detailed designs according to the Reclamation Surface Stabilization Handbook (BNCC, 1992). The three reclaimed channels are Chinde Arroyo Branch 1, Hosteen Wash Branch 1, Barber Reclaimed Channel, and South Barber Channel. The alignments of the reclaimed channels are shown on Exhibits 11-75, 11-76, 11-76A, 11-76B, 11-76C and the pre-mine surface configuration with channels is shown on Exhibits 11-76F, 11-76G, and 11-76H.

The design of the reclaimed channels was based on a comparison of pre-mine channel flow velocities with post-mine channel flow velocities using HEC-RAS. Specifically, the design philosophy was to design a channel that is: 1) equally or more stable than the pre-mine channel (by demonstrating that the post-mine flow velocities are less than the pre-mine), and 2) able to convey the 100-yr 6-hr event.

Table 11-24 compares pre-mining and post-mining channel velocities for the entire channel reach that was modeled. Both the maximum and average flow velocities are provided for each of the four drainages modeled. Table 11-24a provides a detailed breakdown between channel reaches (channel stations) by listing the design flows that were input at each station and the corresponding flow velocities for that particular channel reach. For all design storm events, the reclaimed channels have a lower maximum and average flow velocity than the pre-mine channels as noted in Table 11-24. Results of the HEC-RAS analysis also indicate that the reclaimed channels will convey the peak flows generated by the 100-yr 6-hr precipitation event. Complete HEC-RAS output files for all four modeled channels by design storm events (2-, 10-, 25-, 100-yr 6-hr peak flows) are provided in Appendix 11-NN (post-mine) and Appendix 11-PP (pre-mine).

The lower post-mine flow velocities are attributed to lower peak flows and different channel geometries in the reclaimed channel versus the pre-mine channel. The lower peak flows result from replacement of pre-mine badlands with reclaimed areas that have lower curve numbers. Generally, the pre-mine channels that were modeled are incised, which confines the flow and increases the flow depth, producing higher channel velocities than the reclaimed channel. The grades of the pre-mine channels were also steeper. The reclaimed channel section consists of a pilot channel and a main channel or a floodplain (See Figures 11-27 and 11-29, and Exhibit 11-76E). The geometry of the design sections for the reclaimed channels were proportioned from upstream to downstream depending on the magnitude of the flows.

Pre-mine and post-mine channel peak flows were estimated using SEDCAD for the 2-, 10-, 25-, and 100-yr 6-hr events. The supporting documentation for the pre-mine peak flow estimations are in Appendix 7-A (Hosteen Wash), 7-B (Barber Wash), 7-G (Chinde Arroyo) and 7-N (South Barber Channel). The supporting documentation for the post-mine peak flow estimations are in Appendix 11-BB (Chinde Arroyo), 11-CC (Hosteen Wash), 11-DD (Barber Wash), and 11-EE (South Barber Channel).

The pre-mining SEDCAD drainage subdivision for Chinde Arroyo is shown on Exhibit 7-3; the post-mining drainage subdivision is shown on Exhibit 11-75. The pre-mining SEDCAD drainage subdivision for Hosteen, Barber, and South Barber drainages is shown on Exhibit 7-4C, the post-mining drainage subdivision is shown on Exhibit 11-75A.

The peak flows were input upstream of the prediction points or SEDCAD structures for both the pre-mine and post-mine HEC-RAS analysis. Entering the peak flows in this manner will generate conservative results. The results of the HEC-RAS pre-mine analysis for the 2-, 10-, 25-, and 100-yr, 6-hr peak flow for the modeled channels are in Appendix 11-PP, HEC-RAS Results for Area II Pre-Mine Channels.

11.6.4.2.2.1 Analysis of Pre-mine Channels

Due to the lack of detailed cross-sectional channel data within the lease, the development of the pre-mine channel sections used in the HEC-RAS is based on one representative surveyed cross-section. This cross-section is taken from both upstream and downstream of the lease for each respective drainage. The surveyed downstream cross-section was repetitively projected upstream across the lease to a transition zone for that particular channel. Similarly, the surveyed upstream cross-section was repetitively projected downstream across the lease to the transition zone.

The transition zone, 1,300 to 1,500 feet in length, connects the upstream and downstream channel configuration. The length and location of the transition between the upstream and downstream cross-sections was based on topographic information. Natural pre-mine transitions (i.e. incised badland channel to a broad valley channel) are evident from the topography and these approximate locations determined the location of the modeled transitions.

This method of interpolation across the permit area for development of the pre-mine channel for the HEC-RAS analysis was applied for modeling Hosteen Wash Branch 1. Locations of the transitions and the representative upstream and downstream cross-sections used in the HEC-RAS modeling are shown on the pre-mine plan and profile sheets, Exhibit 11-76G.

The channel profiles used in the HEC-RAS pre-mine analysis were extracted from U.S. Geological Survey (USGS) and aerial surveys at 10-foot contours.

11.6.4.2.2.2 Analysis of Reclaimed Channels

The flow velocities in the reclaimed channels were determined by inputting the reclaimed channel sections into HEC-RAS. The reclaimed channel reaches are transitioned into the existing natural channel at the upstream and downstream ends. The transitions of the reclaimed channel to the natural channel generally occurred over a 500 to 700 foot reach. The post-mine peak flows and gradient for that particular drainage dictated the geometry of the reclaimed channel. The reclaimed channel cross-sections are shown on Exhibit 11-76E, Sheet 1. The locations of the transition reaches and the design sections used in the HEC-RAS model are shown on the plan and profile sheets Exhibit 11-76A, 11-76B, and 11-76C.

The reclaimed channel profiles are generally uniform, which was stipulated by the elevation of the channel bottom at the upstream and downstream lease boundaries, except where the reclamation has been completed, such as the downstream reach of the Barber Reclaimed Channel. In this case, the elevation of the channel just up-stream of the completed reclamation and the channel elevation downstream at the lease line will determine the grade.

Due to the completed reclamation in Up Dip Barber the grade of the Barber Reclaimed Channel is set and will not change. Because this area is reclaimed and includes an existing vegetated channel, the necessity of constructing a reclaimed channel and resultant disturbance to the area across the reclamation should be evaluated. Specifically, the natural channel that has developed and which will continue to develop during the time prior to final reclamation will likely have a similar geometry to the reclaimed channel, particularly the pilot channel. The lower reach of the Barber Reclaimed Channel will be monitored for channel development and stability in order to determine if construction of the reclaimed channel is required.

The profile of the Barber Reclaimed Channel just east of the rail line will have a significant drop; this reach of channel will require a riprapped drop structure to control erosion. The drop structure will be designed for a 25-yr 6-hr stability and 100-yr 6-hr capacity. The reclamation of the channel will be done during the final reclamation of the railroad embankment. The embankment material will be used to reduce the grade of the drop structure.

Chinde Branch 1 in the post-mining topography is a tributary of the Chinde Arroyo, which did not occur in the pre-mine topography. The post-mining topography changes the pre-mine drainage pattern by diverting the upstream watersheds of the Hosteen Wash into the Chinde Arroyo watershed. Consequently, the results of the HEC-RAS analysis could not be compared to a corresponding pre-mine channel. However, the flow velocities can be compared to velocities in the other pre-mine channels analyzed. The flow velocities in Chinde Branch 1 are all less than the velocities in the other pre-mine channels, except for the Barber Wash 2-yr 6-hr average velocity (see Table 11-24).

The Chinde Branch 1 Reclaimed Channel converges with the Chinde Arroyo at approximately Station 0+00, see Exhibit 11-76A. The HEC-RAS analysis for Chinde Branch 1 includes this station and the subsequent stations upstream. The channel reach downstream of Station 0+00 to the western permit boundary will be a part of the Chinde Permanent Diversion. The design section for Chinde Branch 1 is shown on Exhibit 11-76E, Sheet 1.

South Barber Channel in the post-mining topography is a tributary to the Neck Arroyo. The post-mining topography changes the pre-mine drainage pattern by diverting the upstream watersheds of the Barber Wash into the South Barber watershed. The reclaimed South Barber Channel will have a riprapped drop structure from Station 13+91 to 20+70. Refer to Appendix 11-EE for riprap size design and Exhibit 11-76C and 11-76E for the profile and typical section. The flow velocities in South Barber Channel are less than or equal to the velocities of the pre-mine channel (see Table 11-24).

11.6.4.2.3 Area III Reclaimed Channels

Seven post-mining or reclaimed channels in the Area III FSC have watersheds that are larger than 640 acres, which require detailed designs according to the Reclamation Surface Stabilization Handbook (BNCC, 1992). The alignment of the seven post-mining/reclaimed channels are shown on Exhibit 11-78 and are designated as Lowe, Lowe North, Lowe North R2, Lowe North R3, Lowe North R4, Lowe South, and North Fork. The pre-mine surface configuration with channels is shown on Exhibit 11-78A.

The design of the reclaimed channel was based on a comparison of pre-mine channel flow velocities with post-mine channel flow velocities using HEC-RAS. Specifically, the design philosophy was to design a channel that is: 1) equally or more stable than the pre-mine channel by demonstrating that the post-mine flow velocities are less than the pre-mine, and 2) able to convey the 100-yr 6-hr event.

Mining has disturbed the main channel and tributaries of Lowe North and Lowe South Branches; therefore detailed cross-sections of the pre-mine channels are not available to perform a HEC-RAS analysis for comparison with the reclaimed channels. In lieu of a comparison with pre-mining channel conditions, the reclaimed channels were designed to have average flow velocities less than 5 fps during the peak flow from a 2-yr 6-hr storm event. The limiting criterion of 5 fps is based on the erosive velocity of the spoils, which is 5 fps. The bottom and banks of the reclaimed channels will be in the regraded spoils. The channel bottoms and banks will not be topsoiled. Only the North Fork pre-mine channel and the downstream reach of the Lowe Arroyo near the western permit boundary were analyzed as pre-mine channels for comparisons with the post-mining channel.

TABLE 11-24

PRE-MINE AND POST-MINING CHANNEL VELOCITIES

Chinde Branch 1

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	4.43	4.02
10-Year	n/a	n/a	6.80	4.50
25-Year	n/a	n/a	7.62	4.88
100-Year	n/a	n/a	8.09	5.19

Hosteen Wash Branch 1

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	9.56	4.81	6.65	5.10
10-Year	12.91	6.23	9.42	4.63
25-Year	14.38	6.92	9.58	4.97
100-Year	15.97	7.62	10.63	5.42

South Barber Channel

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	7.65	5.13	7.65	3.53
10-Year	10.25	6.78	10.25	4.41
25-Year	11.05	7.42	11.05	4.85
100-Year	12.25	7.92	12.21	5.30

TABLE 11-24a

HEC-RAS RESULTS

Chinde Branch 1 Post-mining

Flow Change	2-Year			10-Year			25-Year			100-Year		
		Velocity (fps)			Velocity (fps)			Velocity (fps)			Velocity (fps)	
Location (Sta)	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg
192.92	38	3.59	3.47	104	4.92	4.76	149	5.61	4.82	213	6.19	4.85
170.00	101	4.22	4.18	258	6.80	4.31	468	7.62	4.88	511	7.75	4.93
123.00	112	4.43	4.10	332	6.21	4.49	496	7.04	4.92	741	8.05	5.41
37.00	108	4.33	4.19	333	6.17	4.48	503	7.06	4.89	758	8.09	5.36

Hosteen Branch 1 Pre-mine

Flow Change	2-Year			10-Year			25-Year			100-Year		
		Velocity (fps)			Velocity (fps)			Velocity (fps)			Velocity (fps)	
Location (Sta)	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg
104.00	62	6.46	2.20	192	7.91	2.72	286	12.90	3.22	423	8.94	3.23
74.00	135	8.76	4.28	395	10.39	4.91	583	11.00	5.16	854	11.77	5.51
46.00	180	8.79	7.01	511	11.87	9.58	748	13.27	10.70	1,089	14.73	12.17
6.00	226	9.56	8.91	640	12.91	12.16	937	14.38	13.53	1,366	15.97	15.03

Hosteen Branch 1 Post-mining

Flow Change	2-Year			10-Year			25-Year			100-Year		
		Velocity (fps)			Velocity (fps)			Velocity (fps)			Velocity (fps)	
Location (Sta)	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg
86.00	121	6.30	4.83	364	8.43	4.52	540	9.26	4.91	793	10.17	5.37
28.00	125	6.65	6.33	409	9.42	5.16	627	9.58	5.24	951	10.63	5.64

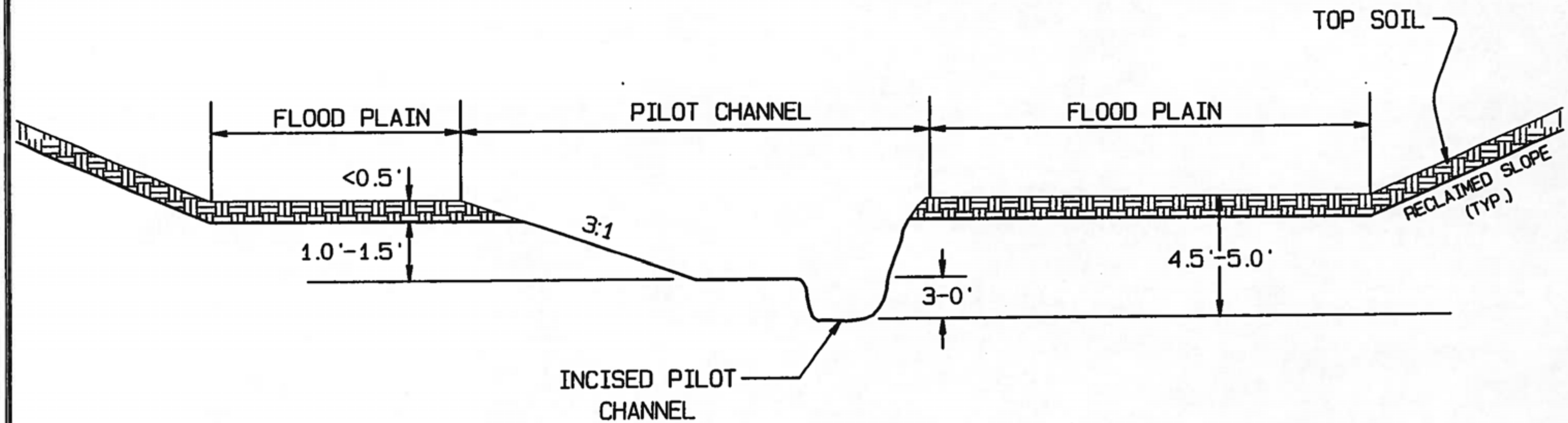
South Barber Channel Pre-mine

Flow Change	2-Year			10-Year			25-Year			100-Year		
		Velocity (fps)			Velocity (fps)			Velocity (fps)			Velocity (fps)	
Location (Sta)	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg
15.42	51	7.65	5.13	166	10.25	6.78	251	11.05	7.42	375	12.25	7.92

South Barber Channel Post-mining

Flow Change	2-Year			10-Year			25-Year			100-Year		
		Velocity (fps)			Velocity (fps)			Velocity (fps)			Velocity (fps)	
Location (Sta)	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg	Q (cfs)	Max	Avg
107.54	24	3.23	3.14	73	4.56	3.76	110	5.28	4.08	164	6.04	4.51
87.54	22	3.16	2.80	78	4.81	3.42	123	5.52	3.82	192	6.27	4.26
27.00	31	2.98	2.87	103	4.43	3.38	159	5.09	3.68	243	5.87	3.97
20.70	51	7.65	5.06	166	10.25	6.58	251	11.05	7.19	377	12.21	7.71

FIGURE 11-27



TYPICAL RECLAIMED INCISED PILOT CHANNEL SECTION
NTS

Table 11-26 compares pre-mining and post-mining channel velocities for the entire channel reaches that were modeled. Both the maximum and average flow velocities are provided for each of the drainages modeled. Table 11-26a provides a detailed breakdown between channel reaches (channel stations) by listing the design flows that were input at each station and the corresponding flow velocities for that particular channel reach. For all design storm events the reclaimed channels have a lower maximum and average flow velocity than the pre-mine channels. For all the reclaimed channels not compared to a pre-mining channel the average flow velocities during the 2-yr 6-hr storm event are less than 5 fps. Results of the HEC-RAS analysis also indicate that the reclaimed channels will convey the peak flows generated by the 100-yr 6-hr precipitation event. The HEC-RAS output files for all the reclaimed and pre-mining channels modeled are provided in Appendix 11-X1 and 11-Y1 (post-mining); and Appendix 11-X2 and 11-Y2 (pre-mining).

The lower post-mine flow velocities are attributed to lower peak flows and different channel geometries in the reclaimed channel versus the pre-mine channel. The lower peak flows result from the replacement of pre-mine badlands with reclaimed areas that have lower curve numbers. Generally, the pre-mine channels that were modeled are incised, which confines the flow and increases the flow depth, producing higher channel velocities than the reclaimed channel. The grades of the pre-mine channels were also steeper. The reclaimed typical channel section consists of a main channel that will retain the 2-yr 6-hr peak flow with a floodplain. The flows larger than the 2-yr 6-hr peak flow will overflow into the floodplain (See Exhibit 11-78C). The geometry of the design sections for the reclaimed channels was proportioned depending on the magnitude of the flows.

Pre-mine and post-mine channel peak flows were estimated using SEDCAD for the 2-, 10-, 25-, and 100-yr 6-hr events. The peak flows were input at the prediction points or SEDCAD structures for both the pre-mine and post-mine HEC-RAS analysis. The supporting documentation for the pre-mining peak flow estimations are in Appendix 7-D (Lowe Arroyo), and 7-H (Cottonwood Arroyo). The supporting documentation for the post-mining peak flow estimations are in Appendix 11-X (Lowe Arroyo), and 11-Y (Cottonwood Arroyo).

The pre-mining SEDCAD drainage subdivision for Lowe and Cottonwood Arroyo is shown on Exhibit 7-4, the post-mining drainage subdivision is shown on Exhibit 11-77.

11.6.4.2.3.1 Analysis of Pre-mine Channels

Prior to the construction of the North Fork Diversion, the North Fork of the Cottonwood Arroyo reach inside the permit boundary was field surveyed to obtain cross-sections on approximately 100-foot intervals. The locations of the cross-sections are shown on Exhibit 11-78A, Sheet 3. The cross-section data and the predicted peak flows from SEDCAD were input into HEC-RAS to obtain pre-mining channel flow velocities and depths. The HEC-RAS results are presented in Appendix 11-Y2 and summarized on Tables 11-26 and 11-26a in this section.

The downstream reach of the Lowe Arroyo at the western permit boundary was also surveyed to obtain cross-sections on approximately 100-foot intervals. Mining has not disturbed this reach of channel. The cross-section data and the predicted peak flows were input into HEC-RAS to obtain both pre-mining and post-mining channel flow velocities and depths for comparative purposes. The HEC-RAS results are presented in Appendix 11-X2 (pre-mining) and Appendix 11-X1 (post-mining) with results summarized on Table 11-26 and 11-26a in this section.

The Manning's roughness coefficients (n) used for the North Fork pre-mine channel in the HEC-RAS analysis were as follows: 0.045 for the floodplain, 0.035 for the channel banks, and 0.030 for the channel bottom. For the Lowe Arroyo pre-mine channel, the reach in the vicinity of the western permit boundary, the n values used were: 0.045 for the floodplain and a composite n of 0.033 for the channel bottom and channel banks.

Due to the lack of detailed cross-sectional data of the North Lowe and Lowe South main channels including its tributaries, the pre-mine HEC-RAS analysis were not performed for these channels.

11.6.4.2.3.2 <u>Analysis of Reclaimed Channels</u>

The flow velocities in the reclaimed channels were determined by entering the reclaimed channel sections into HEC-RAS. The reclaimed channel sections were taken from the Area III FSC on approximately 200-foot intervals. The reclaimed channel reaches are transitioned into the existing natural channel at the upstream and downstream ends. The transitions of the reclaimed channel to the natural channel generally occurred over a 100 to 200-foot reach. The post-mine peak flows and the gradient of that particular drainage channel dictated the geometry of the reclaimed channel. The locations of reclaimed channel cross-sections used in HEC-RAS are shown on Exhibit 11-78, Sheets 2-4. The typical reclaimed channel sections are shown on Exhibit 11-78C and the profiles are shown on Exhibit 11-78B.

The Manning's roughness coefficients (n) used for the reclaimed channels in the HEC-RAS analysis were as follows: 0.045 for the floodplain and a composite n of 0.033 for the channel bottom and channel banks. For the configuration of the reclaimed channels analyzed the composite n is approximately equivalent to a channel having n values of 0.030 for the channel bottom and 0.035 for the channel banks.

Due to lack of detailed cross-sections of the pre-mine channels in the Lowe Arroyo watershed a comparative analysis could not be made between pre-mining and post-mining conditions. In lieu of a comparative analysis, the reclaimed channels in the Lowe drainage area were designed to have flow velocities less than 5 fps during the 2-yr 6-hr peak flow. The gradients of the reclaimed channels in the Lowe drainage area are also generally less than pre-mine, except in the steep reaches where drop structures are required. This coupled with the cross-sectional configuration of the reclaimed channel strongly indicates that the post-mine flow velocities could possibly be less than the pre-mine. The HEC-RAS results for the reclaimed channels within the Lowe watershed are in Appendix 11-X1 and summarized on Table 11-26 and 11-26a.

Drop structures will be utilized in the steep reaches of the reclaimed channels to control erosion. The drop structures will be designed to remain stable during the 25-yr 6-hr peak flow and pass the 100-yr 6-hr peak flow with a 1-foot freeboard. A computer software, Rip-rap Design Systems, Version 2; WEST Consultants, Inc.; San Diego, Ca, which calculates rip-rap size utilizing seven different methods was used to determine the rip-rap size. Four design methods

(ASCE, USBR, Isbash, and HEC-11) were used to determine the D_{50} rock size. For the selected D_{50} rock size refer to the drop structure schedule on Exhibit 11-78C. The supporting design data for the drop structures is presented in Appendix 11-X3. The locations of the drop structures are shown on the plan and profile drawings, Exhibit 11-78, Sheets 2 and 3; and Exhibit 78B, Sheets 1 and 2, respectively.

Tributaries having less than 640 acres of watershed may require rip-rap down drains depending on the grade at the entrance into the main reclaimed channel. The designs for these down drains will be done during the final regrading process and will be presented on reclamation as-built drawings. The as-built drawings will be submitted to the regulatory agency.

TABLE 11-26
PRE-MINE AND POST-MINING CHANNEL VELOCITIES

North Fork

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	9.34	5.18	6.42	4.79
10-Year	12.08	6.46	8.71	4.73
25-Year	12.58	6.88	9.47	4.66
100-Year	13.48	7.20	10.73	4.70

Lowe

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	8.80	4.46	7.76	3.87
10-Year	11.59	5.95	8.70	5.20
25-Year	12.95	6.55	10.18	5.90
100-Year	14.51	7.13	12.03	6.56

Lowe North

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	5.58	4.32
10-Year	n/a	n/a	7.94	4.40
25-Year	n/a	n/a	8.38	4.42
100-Year	n/a	n/a	9.35	4.50

Lowe North R1

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	2.21	2.02
10-Year	n/a	n/a	3.76	3.40
25-Year	n/a	n/a	4.41	3.97
100-Year	n/a	n/a	5.11	4.57

Lowe North R2

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	3.93	3.83
10-Year	n/a	n/a	5.99	4.11
25-Year	n/a	n/a	7.06	4.03
100-Year	n/a	n/a	8.03	3.98

Lowe North R3

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	5.24	4.47
10-Year	n/a	n/a	7.15	6.14
25-Year	n/a	n/a	7.98	6.76
100-Year	n/a	n/a	9.09	7.49

Lowe North R4

	Pre-Mine		Post-Mining*	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	n/a	n/a
10-Year	n/a	n/a	n/a	n/a
25-Year	n/a	n/a	n/a	n/a
100-Year	n/a	n/a	n/a	n/a

Lowe South

	Pre-Mine		Post-Mining	
Storm Event	Maximum Velocity (fps)	Average Velocity (fps)	Maximum Velocity (fps)	Average Velocity (fps)
2-Year	n/a	n/a	4.87	3.38
10-Year	n/a	n/a	7.09	3.55
25-Year	n/a	n/a	7.39	3.57
100-Year	n/a	n/a	8.24	3.68

* The reclaimed reach is riprapped.

TABLE 11-26a
HEC-RAS RESULTS

North Fork Pre-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
150.00	256.0	9.34	5.18	674.0	12.08	6.46	971.0	12.58	6.88	1,401.0	13.48	7.20

North Fork Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
142.24	249	6.42	4.79	665	8.71	4.73	962	9.47	4.66	1,393	10.73	4.70
13.03*	1,050	N/A	N/A	2,880	N/A	N/A	4,196	N/A	N/A	6,107	N/A	N/A

* For the flow change the reach is undisturbed.

Lowe Pre-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
38.83	253.0	8.80	5.00	735.0	11.59	7.13	1,089.0	12.95	8.07	1,597.0	14.32	9.09
15.95	315.0	7.35	5.77	926.0	10.96	8.05	1,370.0	12.67	9.04	2,017.0	14.51	10.01

Lowe Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
38.83	127.0	7.76	3.94	386.0	7.09	4.56	578.0	8.25	5.08	859.0	9.66	5.47
33.20	146.0	7.09	3.60	490.0	8.47	5.33	755.0	9.97	6.20	1,156.0	11.21	7.02
15.95	155.0	7.09	3.87	514.0	8.70	5.29	791.0	10.18	6.01	1,206.0	12.03	6.72

Lowe North Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
90.01	125.00	5.26	4.14	372.0	7.03	4.24	553.0	7.69	4.35	820.0	8.78	4.46
53.09	127.00	5.58	4.73	386.0	7.94	4.77	578.0	8.38	4.59	859.0	9.35	4.58

Lowe North R1 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
12.73	17.0	2.21	2.02	77.0	3.76	3.40	126.0	4.41	3.97	202.0	5.11	4.57

Lowe North R2 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
14.00	112.0	3.93	3.83	307.0	5.99	4.11	445.0	7.06	4.03	643.0	8.03	3.98

Lowe North R3 Post-mining

Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
15.89	33.0	5.24	4.04	98.0	7.15	5.42	144.0	7.98	5.96	210.0	9.09	6.60

Lowe North R4 Post-mining

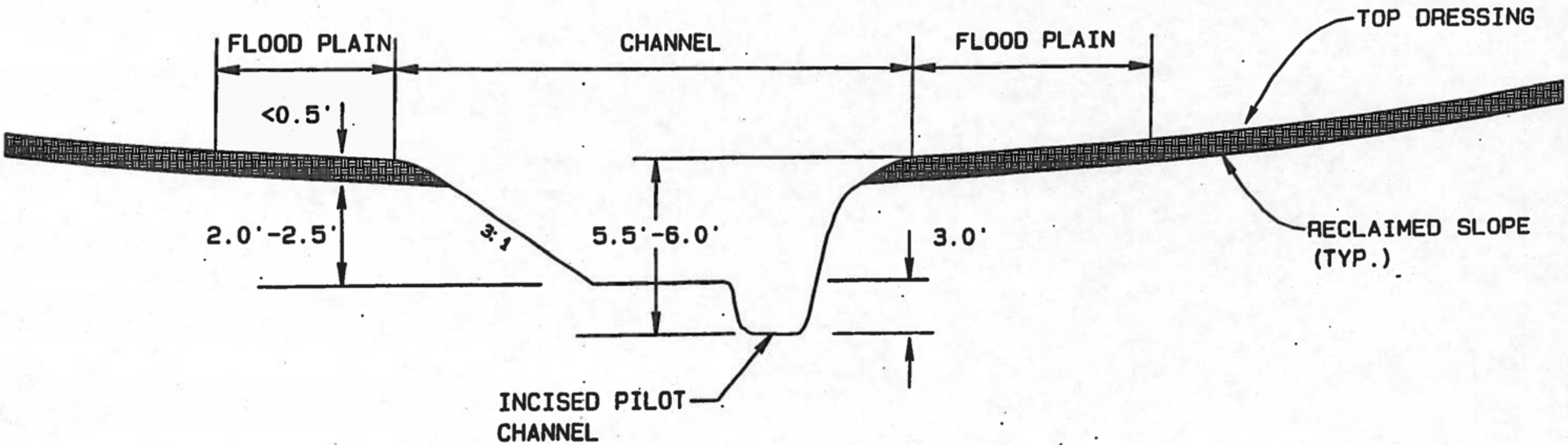
Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
11.71*	86.0	N/A	N/A	230.0	N/A	N/A	331.0	N/A	N/A	475.0	N/A	N/A

Lowe South Post-mining

Flow Change (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) Avg
258.72*	83	N/A	N/A	209	N/A	N/A	296	N/A	N/A	418	N/A	N/A
243.0	106	3.62	3.07	318	5.78	2.98	473	6.32	3.01	701	7.39	3.13
178.00	106	4.87	3.56	329	7.09	3.86	495	7.39	3.89	739	8.24	3.99
33.2*	106	N/A	N/A	490	N/A	N/A	755	N/A	N/A	1,156	N/A	N/A
15.95*	155	N/A	N/A	514	N/A	N/A	791	N/A	N/A	1,206	N/A	N/A

* For the flow change the entire reach is either undisturbed or riprapped.

FIGURE 11-29



TYPICAL RECLAIMED CHANNEL SECTION

N.T.S.

11.6.4.2.4 Ephemeral Stream Diversion Designs

All streams within the Navajo Mine permit area with the possible exception of Chinde Arroyo are hydrologically ephemeral streams. Nevertheless, OSM regulations classify all streams with drainage areas greater than one square mile as intermittent streams regardless of flow conditions. Reclamation features and structures will be designed in accordance with the Reclamation Surface Stabilization Handbook (BNCC, 1992), which provides information concerning design of permanent diversions for ephemeral streams and addresses low order stream segments with drainage areas less than one square mile.

Design flows were developed using the SEDCAD computer model following the procedures and assumptions described in Chapter 7.

11.6.4.2.5 Area IV North Reclaimed Channels

All of the drainage basins in post-mining topography are less than one square mile (640 acres). Per the Reclamation Surface Stabilization Handbook (BNCC, 1992) the channels for these drainage basins will not require detail designs. The detail designs will be developed during the final regrading and reclamation process.

11.6.5 Impacts to Surface Water Availability

Ephemeral surface flows are unpredictable and of such poor water quality that essentially no use is made of the water for agricultural or other purposes (Chapters 6 and 7). Stock watering ponds are the principal use made of water on or near the permit area. Steps are taken to assure that this use is not impaired. During surface coal mining operations there will be a temporary reduction in surface water flows in the mined out drainages.

Following reclamation, the water supplies for existing livestock use will be replaced. Water levels in the alluvium downstream of mining are expected to recover following mining and flows will be equivalent or may actually be higher than in pre-mine conditions due to enhanced recharge rates within reclaimed areas.

The ponds found in the permit areas during the baseline surveys do not appear to have water-right filings (Chapter 7); however, the small basins are periodically utilized by livestock and wildlife when water collects in them following a storm. Pond reconstruction, if executed, will be performed to generally reproduce the storage capacity and surface area of the original impoundment. The water availability at the reconstructed ponds should be comparable to pre-mine conditions, as SEDCAD modeling presented in Section 11.6.3.3 shows little change in surface flows and sediment yields following reclamation relative to baseline conditions. Additional water supplies may be available if new ponds are constructed or some of the sediment and/or drainage control ponds are converted to permanent stock water use at the request of the Navajo Nation.

BNCC has designed the Navajo Mine operations plan to minimize impacts to surface water through the use of sediment control measures for storm water runoff. These include reducing the disturbance area footprint, backfilling and stabilizing the pit areas as soon as practicable, and use of multiple hydrologic structures. The structures range from berms established around isolated areas of disturbance and coal stockpiles, to sedimentation ponds downgradient of mining, to armoring of channels in steep gradients. The Navajo Mine operations plan minimizes the potential for upland waters to commingle with runoff from disturbed areas through the diversion of streams upgradient of the operation around the active mining areas, and construction of upgradient or highwall impoundments. In addition, the BNCC implements a stream buffer zone policy to protect perennial and intermittent streams.

Sediment concentrations are predicted to be the same or less than pre-mining, however modeling suggests that post-mining, there may be increases in settleable solids concentrations from the mobilization of fine-grained materials. The best management practices are focused towards minimizing sediment, which will limit the dissolution of salts from fine particles entrained by runoff events. There is the potential for increases in TDS, sulfates, iron, and manganese in waters leaving the permit area, but ~~average~~ concentrations of these parameters will not exceed water quality criteria associated with the predominant use of surface waters for livestock watering. In addition, BNCC has an SPCC plan that identifies areas of risk, specifies specific locations for containment structures, and has spill management protocols to minimize impacts from accidental releases of petroleum hydrocarbons.

The mining and reclamation plan re-establishes a final surface configuration which is comparable to the pre-mine topography. The calculated drainage density is equal or greater than the pre-mining topography, except in areas of pre-mine badlands. Reclaimed channels will have a small pilot channel within a floodplain. The reclamation plan has been engineered to minimize the potential for long-term badland development through the design of stable post-mining reclamation channels which have the potential for self-armoring and through the use of topdressing that is a suitable plant growth medium. The latter should better support the establishment of a sustaining and stabilizing vegetative cover. These reclamation strategies will minimize the potential for gully establishment and head cutting should destructive storm flows drain through the reclaimed watersheds. Modeling predicts post-mining peak flows similar or lower than pre-mining flows.

The probable hydrologic projections suggest that mining will not have a deleterious impact on the hydrologic balance within the area, and BNCC will verify this through the hydrologic monitoring program and assessments prepared for bond release.

11.6.6 Hydrologic Monitoring Reporting

Hydrologic monitoring reports will be submitted to OSM on a quarterly frequency and a detailed monitoring report will be submitted twice during the permit term. The quarterly monitoring report will consist of a summary of the data collected and events for the quarter, identification of anomalies, inconsistencies, or non-compliances, and include an electronic copy of the raw analytical data electronically.

In addition to the quarterly hydrologic monitoring report, an in-depth hydrology report will be submitted twice during the permit term to OSM. This detailed hydrologic monitoring report will provide a detailed reduction, analysis, and interpretation of surface water and groundwater data collected to date, in addition to the raw data. The analysis will include plotting hydrographs, parameter concentration vs. time graphs, trilinear graphs, and statistical summaries. The monitoring data is then compared against historical data trends and water quality standards to identify changes in water quality or quantity. Specifically for the detailed report, flow and water quality data will be provided as detailed below.

Flow: For the nearly perennial Chinde Arroyo stations, CD-1A and CD-2A, quarterly hydrographs will be plotted. A comparison of the flow between the upstream and downstream stations will be provided.

Water Quality and Sediment: Stage and discharge corresponding to each sample will be reported along with the measured concentrations. For Chinde Arroyo, summary statistics will include water yield and sediment and analyte concentrations for each month. A comparison of water quality and sediment concentrations between the upstream and downstream stations will be provided.

A comparison will be made between surface water quality concentrations collected and the applicable water quality Navajo Nation Environmental Protection Agency Surface Water Quality Standards for both the in-depth hydrology report and the quarterly reports.

Additionally, every five years as part of the in-depth hydrology report, BNCC will provide to OSM a potentiometric surface map of Fruitland Formation coals, as both a hard copy and electronic file.

Discussion on requirements of the Clean Water Act, National Pollutant Discharge Elimination System, (NPDES) and the Stormwater Pollution Prevention Plan (SWPPP) is found in Section 11.2.6.

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APPENDIX 11-VV

Navajo Mine:

Mine Spoil Leachate Test Analyses

November 2011

NAVAJO MINE: MINE SPOIL LEACHATE TEST ANALYSES

Submitted to:
BHP NAVAJO COAL COMPANY

Date: November 14, 2011

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1 INTRODUCTION

This document has been prepared to provide results of mine spoil leaching tests performed to support the Probable Hydrologic Consequences (PHC) assessment of the planned placement of spoil generated from the mining of coal at the Navajo Mine. The mine spoil is the non coal overburden and interburden materials removed to allow access to the coals of the Fruitland Formation. The spoil is generally rock of varying sizes. Placement of spoil within the mine pit as backfill is an accepted practice for handling of the spoils and necessary to achieve approximate original contour requirements for mine reclamation. The probable hydrologic consequences of placement of spoil materials for mine backfill is dependent on the hydrologic properties of mine spoil, the surface and groundwater conditions at the mine following reclamation and the inorganic chemistry of mine spoil including the potential for leaching or adsorption of constituents of concern.

A spoil testing program was completed to generate the information on spoil properties and leaching characteristics. The resulting information is used to support the PHC assessment for proposed spoil placement as mine backfill at the Navajo Mine. The spoils used for testing in this study were collected from the Area III mine spoils. The same coal units mined at Area III will be mined at Area IV so the interburden and overburden rock characteristics are expected to be essentially the same between the two areas.

2 MINE SPOIL TESTING PROGRAM

The following discussion summarizes the sampling and testing procedures followed in this study in order to provide a background and understanding for interpreting the results presented in Section 3.

2.1 COLLECTION OF REPRESENTATIVE SAMPLES

The geochemical testing was conducted using available materials that are representative of expected mine spoil in Area IV. Representative samples of backfill spoils from Area III were obtained and used for the testing. Likewise a composite coal water samples from wells completed in the upper and lower coal seams at Area IV were obtained for the spoil leaching test study.

2.1.1 Mine Spoil Samples

Composite spoil samples were obtained from the Navajo Mine Area III in accordance with the regraded spoil sampling plan. Samples were collected on a 2.5-acre (ac) square grid. The 2.5-acplot was divided into four equal subplots (0.625 ac each). A four-foot deep sample pit was then excavated in the center of each subplot. In order to obtain a representative sample of composite spoil material, sub-samples were collected over the interval from zero to four feet at each of the four subplot locations and one composite sample was prepared from the four sub-samples. The composite sample was be comprised of a minimum of 2 kg of spoil material and was split in the field using a corner to corner sampling technique (USDA-NRCS 1996).

Composite samples were collected, following the same procedure, at three additional 2.5-ac plot locations. Solids analysis was conducted on sample splits from each of the four 2.5-acre grid locations. The other split samples from the four 2.5-ac plots were combined and mixed to form a single composite sample of approximately 4 kg. This composite sample and the four splits were sent to the laboratory for geochemical testing.

The four individual sample splits were analyzed for trace metals and major ions in order to characterize the broad spatial variability in spoil material. The composite sample was mixed again in the lab and reduced in particle size as required by EPA Method 1312. Three subsamples of the composite sample were obtained for chemical and mineralogical analysis.

2.1.2 Groundwater Samples

A composite sample of coal water was be obtained from equal proportions of water extracted from the No. 8 coal seam well KF-2007-01 and from the No. 3 coal seam well KF-98-02 located within Area IV. Two 5-gallon containers of coal water sample were obtained from each well. The 5-gallon containers were sent to the laboratory where composite coal water was prepared for use in the batch tests. Two duplicate samples were obtained from the composite coal water and submitted for chemical analysis.

2.2 LABORATORY LEACHING TEST PROCEDURES

The leaching tests were conducted using the EPA Synthetic Precipitation Leaching Procedure (SPLP, SW-846 Method 1312), the Synthetic Groundwater Leaching Procedure (SGLP), and modifications of these tests. Modifications to the standard test were performed to address site specific conditions. The modifications were as follows:

1. Use of leaching fluids that are appropriate to the site through collection of groundwater samples in addition to the synthetic rainwater that is specified in the SPLP method.
2. Inclusion of a 45-day leach test in addition to the method specified 18-hour leaching procedure, in order to assess the impacts of longer exposure to the leachant.
3. For the 45-day leach test, it was not practical for the laboratory to tumble the sample for the entire period. Thus the procedure was modified to include periodic 18-hour tumble of the sample: at the start of the test, after 15-days, after 30 days and with a final 18-hour tumble at the end of the 45-day period. The periodic tumbling was followed by an extended period of time during which the solids remain in contact with the fluid without tumbling intended to provide an indication of any leaching changes due to mineral aging, hydrolysis, and or diffusion.

Proposed leaching procedures consist of the following components. The leachate name as used in the discussions in Section 3 is included in bold in the discussion below.

1. A sequence in which spoil was leached in duplicate (18-hr tests) with coal well water (**Spoil Leachate 1 and Spoil Leachate 1 DUP**). Analyses of all leachates were performed, providing a duplicate analysis of the spoil leaching and a single analysis of the final leach with spoil-exposed coal water.
2. A test in which spoil is exposed to coal water for 45 days according to the long-term leaching procedure described above (**Spoil 45-Day**).
3. 18-hour leaching tests of spoil using the synthetic leaching fluid described in the SPLP (**Spoil SPLP**).

2.3 SOLIDS ANALYSES

The spoil composites were analyzed using Rietveld XRD for mineral identification, total metals analysis for major element identification, and cation exchange capacity (CEC) for determining the amount of exchange of cations between solution and solids. As discussed in Section 2.2.1, the spoil composites are comprised of samples collected from spoil backfill from the Navajo Mine Area III.

Solids analysis was performed on sample splits from each of the four composite samples from the 2.5-ac grid locations. The individual sample splits (four samples) were analyzed for total trace metals and major ions in order to characterize the broad spatial variability in spoil material. The other split samples from the four 2.5-ac plots were combined and mixed to form a single composite sample of spoil material that was used for the leaching tests. Three splits of this composite spoil sample were taken for replicate for chemical and mineralogical analysis in order to assess homogeneity of the composite spoil sample. The four individual sample split results are contained in Attachment A and Attachment B. The following discussions focus on the three splits analyzed for the mixed composite sample discussed above.

2.3.1 Rietveld X-ray Diffraction Results

Rietveld XRD analysis was carried out in triplicate for the spoil composite samples at the Department of Earth and Ocean Sciences, The University of British Columbia, Vancouver, British Columbia under the direction of Professor Mati Raudsepp. The laboratory results are provided in Attachment A.

A summary of the Rietveld XRD data for the composite spoil sample is presented in Table 2-1. The spoil composite samples were analyzed in triplicate and the results summarized in Table 2-1 as Spoil A, Spoil B and Spoil C indicate good reproducibility. The spoils contain a large amount of amorphous material with no definite crystalline structure. The mineralogical composition of the amorphous material is not included in Table 2-1. The spoil samples were modeled by the XRD laboratory to fit a smectite model in order to characterize the amorphous material. These results are provided in Table 2-2. The initial spoil model without a smectite fit indicates that the spoil is primarily comprised of quartz, kaolinite, and K-feldspar with lesser amounts (<5%) of gypsum, anhydrite, and calcite. Fitting the smectite model to the XRD data resulted in additional minerals montmorillonite, albite, and orthoclase. Although gypsum, anhydrite, and calcite were found in smaller relative amounts (<5%) in both interpretative results, their role in reactive chemistry is very important. This is due to their high solubility and relatively quick dissolution and precipitation rates as well as the buffering capacity of calcite on pH where pH controls the sorption of trace metals and other potentially important constituents.

TABLE 2-1.
RESULTS OF COMPOSITE MINE SPOIL SAMPLES QUANTITATIVE PHASE ANALYSIS (WT. %)

First Model without Fit to Amorphous Material					
Mineral	**Ideal Formula**	**Spoil A**	**Spoil B**	**Spoil C**	**Average (wt %)**
Quartz	SiO_2	36.5	35.4	35.4	36
Plagioclase	$NaAlSi_3O_8$ - $CaAl_2Si_2O_8$	10.3	10.1	10.1	10
K-feldspar	$KAlSi_3O_8$	6	6.5	7	7
Kaolinite	$Al_2Si_2O_5(OH)_4$	40.8	40.8	40.6	41
Gypsum	$CaSO_4 \cdot 2H_2O$	2.6	3.1	2.8	3
Anhydrite	$CaSO_4$	0.9	1	1.1	1
Calcite	$CaCO_3$	2.9	3.1	2.9	3

TABLE 2-2.
RESULTS OF COMPOSITE MINE SPOIL SAMPLES SMECTITE MODEL QUANTITATIVE PHASE ANALYSIS (WT. %)

Smectite Model Fit to Amorphous Material					
Mineral	**Ideal formula**	**Spoil A**	**Spoil B**	**Spoil C**	**Average (wt %)**
Quartz	SiO_2	29.68	27.56	28.28	29
Calcite	$CaCO_3$	0.9	2.03	2.14	2
Gypsum	$CaSO_4 \cdot 2H_2O$	2.9	3.12	2.69	3
Albite low, calcium	$Na_{0.95}Ca_{0.05}Al_{1.05}Si_{2.95}O_8$, $NaAlSi_3O_8$	6.41	5.92	6.05	6
Anhydrite	$CaSO_4$	0.83	0.67	0.88	1
Orthoclase	$KAlSi_3O_8$	3.87	2.39	3.32	3
Kaolinite	$Al_2Si_2O_5(OH)_4$	11.68	12.08	10.46	11
Montmorillonite	$(Na,Ca)_{0.3}(Al,Mg)_2Si_4O_{10}(OH)_2 \cdot n(H2O)$	43.74	46.24	46.18	45

2.3.2 Total Metals Results

Total metals analysis was carried out in triplicate for the spoil composite samples using method 6010B at Analytica Environmental Laboratories, 12189 Pennsylvania Street, Thornton, Colorado. Laboratory results are provided in Attachment B.

The composite spoil samples were analyzed for metals (Table 2-3) The composite spoils are primarily comprised of Ca, Fe, Al, Na, Mg, and K. There are trace amounts (<1%) of several other trace metals. However, the results for all three analyses indicate As and thallium (Tl) are not present. The major cations also correlate with the primary minerals identified in the Rietveld XRD analyses:

- Ca with gypsum, calcite, and montmorillonite;
- Al with plagioclase, K-feldspar, kaolinite, albite, orthoclase, and montmorillonite;
- Na with plagioclase, albite, and montmorillonite;
- K with K-feldspar and orthoclase; and
- Mg with montmorillonite.

Although relatively high Fe concentrations are observed in the total Fe, no Fe containing minerals were identified in the XRD analyses. The Fe is associated with the non-identifiable amorphous material in the XRD analyses, most likely as amorphous Fe hydroxide. Additionally, siderite has been identified in the literature by Lucas et al. (2006) in the form of sideritic concretions.

2.3.3 Cation Exchange Capacity

The CEC was measured for spoil composites by Colorado Analytical Laboratories, Inc. using EPA method 9081 (US EPA 2007). The laboratory results are provided in Attachment C. Table 2-4 provides a summary of the results. The analyses were carried out for the seven collected spoil samples; including the four individual samples from each plot and the three composited samples.

The CEC value for the spoil samples ranged between 8.7 and 9.9 milli-equivalents per 100 grams (meq/100g) with an average of 9.3 meq/100g. These results indicate the relative ability of spoil materials to sorb and exchange different cations. The CEC is an indicator of major cation and trace metal attenuation the spoil may provide.

TABLE 2-3. TOTAL METALS ANALYSIS RESULTS FOR COMPOSITE SPOIL SAMPLES

	Spoil A			Spoil B			Spoil C					
Analyte (mg/Kg)	Result	PQL	MDL	Result	PQL	MDL	Result	PQL	MDL	RPD 1	RPD 2	RPD3
Al	10000	7.4	1.8	9500	6.8	1.7	9400	7.7	1.9	5%	6%	3%
Sb	0	10	0.58	0.052	9.3	0.52	0.9	11	0.59	-200%	-284%	159%
As	0	12	1.6	0	11	1.5	0	12	1.7			
Ba	170	0.37	0.029	180	0.34	0.026	170	0.38	0.03	-6%	0%	3%
Be	1	0.19	0.0082	1	0.17	0.0075	1	0.19	0.0085	0%	0%	0%
B	13	4.7	0.63	12	4.2	0.57	12	4.8	0.64	8%	8%	5%
Cd	0.64	0.74	0.054	0.63	0.68	0.049	0.59	0.77	0.055	2%	8%	4%
Ca	20000	13	5	22000	12	4.5	20000	13	5.1	-10%	0%	6%
Cr	6.7	1.9	0.28	6	1.7	0.25	6.1	1.9	0.28	11%	10%	6%
Co	11	2.8	0.24	11	2.5	0.22	11	2.9	0.25	0%	0%	0%
Cu	26	0.56	0.15	23	0.51	0.13	24	0.57	0.15	12%	8%	6%
Fe	20000	5.6	0.41	20000	5.1	0.37	20000	5.7	0.42	0%	0%	0%
Pb	16	5.6	0.98	17	5.1	0.89	18	5.7	1	-6%	-12%	6%
Mg	3100	9.3	0.89	2900	8.5	0.81	3000	9.6	0.92	7%	3%	3%
Mn	440	0.93	0.1	430	0.85	0.094	390	0.96	0.11	2%	12%	6%
Mo	0	1.9	0.22	0.0034	1.7	0.2	0	1.9	0.23	-200%	0%	173%
Ni	13	3.7	0.4	13	3.4	0.36	14	3.8	0.41	0%	-8%	4%
K	1900	93	29	1700	85	27	1800	96	30	11%	6%	6%
Se	2.9	9.3	2.3	2.7	8.5	2.1	2.9	9.6	2.4	7%	0%	4%
Na	4000	280	0.95	3900	250	0.86	4100	290	0.98	3%	-3%	3%
Tl	0	19	1.1	0	17	1	0	19	1.1			
V	23	0.93	0.18	22	0.85	0.16	22	0.96	0.19	4%	4%	3%
Zn	62	0.56	0.21	65	0.51	0.19	62	0.57	0.21	-5%	0%	3%
Li	8.6	4.7	0.045	8.2	4.2	0.041	8.1	4.8	0.047	5%	6%	3%
Hg	0.087	0.044	0.0061	0.073	0.044	0.006	0.068	0.044	0.006	18%	25%	13%
Moisture %	7.98	0.0465	0.0093	8.13	0.0465	0.0093	7.87	0.0466	0.00933	-2%	1%	2%

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TABLE 2-4.
CATION EXCHANGE CAPACITY LABORATORY RESULTS SUMMARIZED

Sample ID	Sample Name	CEC (meq/100g)
B0711172-2B	123 S 87W 0-4' Spoil	9.7
B0711172-3B	123 S 89W 0-4' Spoil	8.7
B0711172-4B	125 S 88W 0-4' Spoil	9.4
B0711172-5B	120 S 89W 0-4' Spoil	9.0
B0711172-6B	Spoil A	9.0
B0711172-7B	Spoil B	9.6
B0711172-8B	Spoil C	9.9

3 LEACHATE TEST RESULTS OVERVIEW

3.1 LEACHATE SOLUTIONS

The solutions used as the beginning leachant solutions included groundwater collected and composited from two coal monitoring wells in Area IV and synthetic precipitation prepared in the laboratory. The laboratory water quality analysis reports for beginning leachant solutions and spoil leachate solutions are provide in Attachment D. These results are summarized in Table 3-1. The EPA drinking water standards and health advisories and the Navajo Nation livestock watering and aquatic and wildlife habitat criteria are also included in Table 3-1 for comparison.

Table 3-1 presents all reported values above the PQL from the laboratory with the exception of quality assurance quality control analyses. The data below the PQL are listed with a "<" sign followed by the PQL value and data below the method detection limit (MDL) are presented with "<<" followed by the MDL. The Navajo Nation aquatic and wildlife habitat chronic criteria for Hg and Pb and the EPA drinking water criteria for antimony Sb, As, and Tl are below the laboratory method MDL while the MDL for Cd of 0.00051 is essentially the same as the Navajo Nation aquatic and wildlife habitat chronic criteria. Additionally, the reported PQL values for Cd, Pb, and Se are above the EPA drinking water criteria. Detected values below the EPA drinking water criteria are included in Table 3-1 with the reported value listed in the table after the PQL value. However, the PQL is the lowest level of quantification that a laboratory can reliably achieve based on specified limits of precision and accuracy relating to instrumentation and sample interferences. Thus, the values below the PQL reported in Table 3-1 are not considered reliable and should be considered non-detect.

3.1.1 Synthetic Precipitation Leachate Solution Chemistry

Synthetic precipitation was prepared in the laboratory and used as a surrogate for field site precipitation that could percolate through the backfill and provide recharge to groundwater and potentially surface water discharge. The prepared solution is highly purified water with strong solvating properties. The water quality for the synthetic precipitation solution is presented in Table 3-1 under the heading "Initial Synthetic Precipitation".

NORWEST CORPORATION

TABLE 3-1.
BATCH LEACHING TEST RESULTS

Analyte (mg/L)	EPA Drinking Water Criteria	Aquatic & Wildlife Habitat (Acute)[1]	Aquatic & Wildlife Habitat (Chronic)[1]	Livestock (LW) [1]	Initial Coal Water Sample	Initial Coal Water DUP	Initial Synthetic Precipitation	Spoil SPLP	Spoil 45-Day	Spoil Leachate	Spoil Leachate Dup
Al[3]		0.750 mg/L	0.87 mg/L	NCNS	0.13	0.14	0.056	< 0.05	0.38	0.29	0.3
Sb	0.0056				<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067	<< 0.0067
As	0.01	0.340 mg/L D	0.150 mg/L D	0.200 mg/L	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015	<< 0.015
Ba	1	NCNS	NCNS	NCNS	0.093	0.088		0.07	0.079	0.25	0.2
Be	0.004				< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
HCO_3					1300	1200		33	960	1000	1000
B	0.63	NCNS	NCNS	5.0 mg/L D	0.31	0.29		0.084	0.36	0.44	0.45
Cd[2]	0.005	0.005	0.0005	0.05 mg/L	<< 0.00051	<< 0.00051	<< 0.00051	<< 0.00051	<< 0.00051	< 0.006, 0.00087*	<< 0.00051
Ca					3.4	3.3	0.27	150	56	64	69
CO_3					260	300	< 7	14	< 7	< 7	< 7
Cl	250				710	700		1.5	600	610	610
Cr (III + VI)[2]	0.1	1.2	0.156	1.0 mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Co		NCNS	NCNS	1.0 mg/L D	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cu	1.3	0.032	0.019	0.5 mg/L D	< 0.005	< 0.005	< 0.005	< 0.005	0.053	< 0.005	< 0.005
F	2	NCNS	NCNS	NCNS	2.4	2.5	0.0067	0.54	1.5	1.6	1.6
Fe	0.3				0.067	0.073	< 0.05	< 0.05	< 0.05	0.17	0.18
Pb	0.015	0.171	0.007	0.100 mg/L	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011	<< 0.011
Li					< 0.1	< 0.1	< 0.1	< 0.1	0.11	0.1	0.1
Mg					1.3	1.2		15	12	13	13
Mn	0.05[3]				< 0.01	< 0.01	< 0.01	0.19	0.098	0.11	0.1
Hg	0.002	0.0024 mg/L	0.000001 mg/L	NCNS	<< 0.00005	<< 0.00005	<< 0.00005	<< 0.00005	<< 0.00005	< 0.00024, 0.0001*	< 0.0002, 0.00008*
Mo		NCNS	NCNS	NCNS	0.012	< 0.01	< 0.01	< 0.01	0.015	0.014	0.014
Ni	0.61	1.011	0.112	NCNS	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
pH (standard units)	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	6.5 - 9.0	9	8.9	5	7.5	8	8	7.9
K					11	10	< 1	7	14	14	14
Se	0.05	0.033 mg/L	0.002 mg/L	0.05 mg/L	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026	<< 0.026
Ag	0.035	0.0154	NCNS	NCNS	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015	< 0.015
Na					1200	1100	5.7	150	1200	1200	1200
SO_4	250				300	260	3.4	670	930	970	990
Tl	0.0017	0.700 mg/L D	0.150 mg/L D	NCNS	<< 0.011	<< 0.011	<< 0.011	<< 0.011	< 0.4, 0.014*	<< 0.011	<< 0.011
TDS	500				3100	3000	28	1200	3500	3500	3600
V		NCNS	NCNS	0.100 mg/L D	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	5	0.253	0.255	25 mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0095

[1] Navajo Nation Water Quality Program, **2007**, Navajo Nation Surface Water Quality Standards
[2]Hardness dependent criteria in NN SWQ Standards 2007 calculated based on median hardness for Chinde Arroyo of 248.5 mg/L as CaCO3. [2]Hardness dependent criteria in NN SWQ Standards 2007 for Cr(III) only
[3] pH 6.5 – 9
<< Reported value is less than the MDL
*Above MDL, but below PQL
D – Dissolved: NCNS – no current Navajo standard
NCNS – No Current Numeric Standard

3.1.2 Coal Groundwater Leachate Solution Chemistry

In order to simulate the effects of natural background groundwater interaction and flow through the backfill, batch leachate tests were performed using groundwater collected from the site. The composite groundwater sample was obtained from samples collected from well KF2007-01, completed in the No. 8 coal seam of the Fruitland Formation, and from well KF-98-02, completed in the No. 3 coal seam of the Fruitland Formation. Each sample was combined to form a composite sample for use as the leachant in leachate batch testing. The groundwater from the coal zones and precipitation recharge represent the water sources that are expected to re-saturate the backfill materials after mining. The groundwater quality data for the composite coal water sample is presented in Table 3-1 under the field heading “Initial Coal Water”.

The composite coal groundwater sample results indicate that the groundwater would not be suitable for drinking water due to elevated TDS, chloride, fluoride, and sulfate concentrations above the regulatory standards for drinking water (Table 3-1). The composite coal water sampling results are consistent with the sampling results reported in Appendix 6.G of the PAP for coal monitoring wells in Area III and IV.

3.2 LEACHATE MAJOR ION CHANGES AND TRACE ELEMENT DETECTIONS

The data was plotted and reviewed for overall general geochemical changes between initial groundwater and the final leachates.

3.2.1 Leachate Major Ion Changes

Major ion changes can be observed in the Durov diagram provided in Figure 3-1 and as major ion water types (Table 3-2). The TDS in the leachate from spoil only increases by approximately 500 mg/L from 3,027 mg/L in coal groundwater to approximately 3,525 mg/L in the supernatant. The TDS increases in spoil leachates resulted primarily as a function of leaching of Ca and sulfate. For those tests performed using coal water, the water changes from a Na bicarbonate water-type to a Na sulfate water-type.

For the leaching tests performed using synthetic precipitation, the water changes from a Na bicarbonate water type to a Ca sulfate water type. These results indicate a significant source of sulfate in the spoil materials.

FIGURE 3-1. DUROV DIAGRAM OF SPOIL LEACHATE ANALYSES AND INITIAL WATER COMPOSITIONS

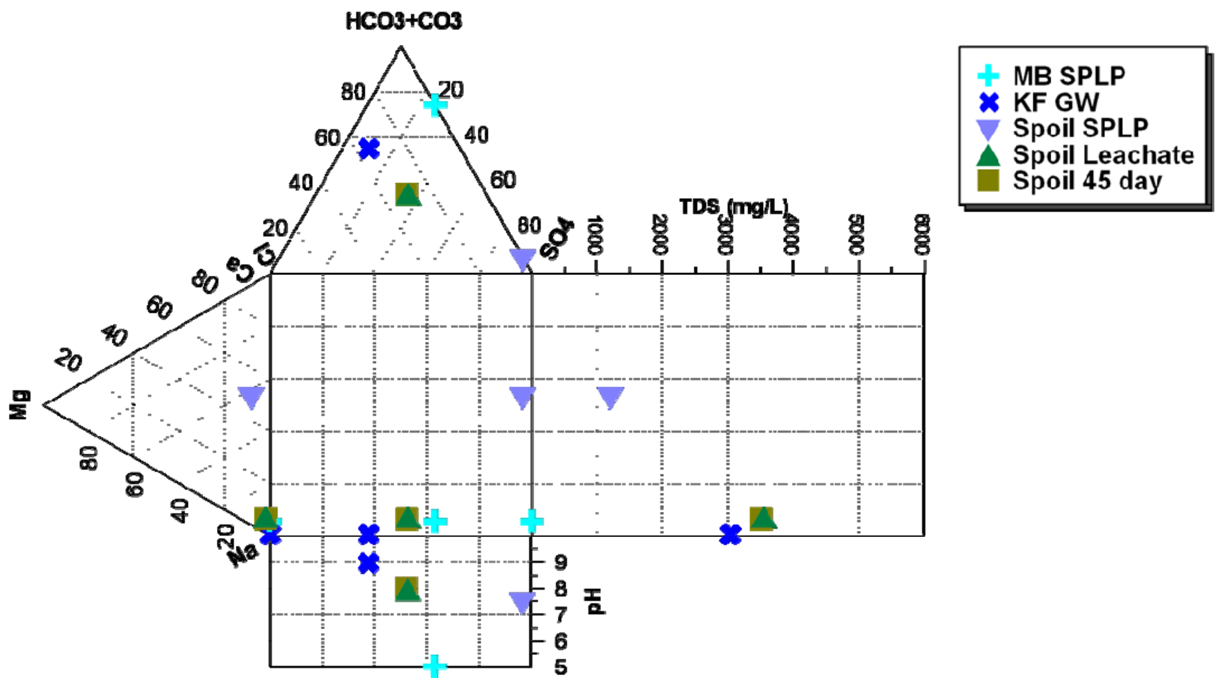

TABLE 3-2. MAJOR ION WATER TYPES

Sample ID	Water Type	Simple Water Type
Initial Synthetic Precipitation	Na-CO3-HCO3	Sodium Bicarbonate
Initial Coal Water	Na-HCO3-Cl	Sodium Bicarbonate
Spoil Leachate 1	Na-SO4-HC03-Cl	Sodium Sulfate
Spoil 45-Day	Na-SO4-HCO3-Cl	Sodium Sulfate
Spoil SPLP	Ca-Na-SO4	Calcium Sulfate

As the sulfate is increased both bicarbonate and carbonate in the initial coal groundwater are reduced in spoil leachates. Reduction in carbonate concentrations is reflected by a pH drop from approximately 9.0 in the coal groundwater to 8.0 in the spoil leachates. The sulfate and TDS in all the leachates exceed criteria for the drinking water use .

The EPA secondary drinking water limits for chloride are exceeded in all samples except for SPLP leachate. Additionally, chloride does not increase in value in groundwater leachates and increases from non-detect to 1.5 mg/L in spoil leachate. Chloride is removed in all final leachates compared to background groundwater when groundwater is used as the initial solution. The loss of chloride is significant (as much as 104 mg/L) and not attributed to sampling or analytical error. Typically, chloride is considered conservative meaning that it is not involved in sorption, oxidation, reduction, or degradation reactions. However, sorption of chloride on soils has been documented in the literature (Yu and Li 1997, Wang et al. 1987, Borggaard 1984). Sorption is a possible mechanism for the removal of chloride in these leachate tests. The leachate test results indicate spoil is not a source of chloride and that chloride is elevated in the natural groundwater at the site.

3.2.2 Leachate Trace Element Detections

Concentrations of Sb, beryllium (Be), Cd, cobalt (Co), Hg, Ni, Pb, Ag, and Tl are non-detect at levels reported below the PQL in all samples, while the Pb results for all samples were below the MDL (Table 3-1). Trace elements detected at concentrations above the PQL and above one or more of the relevant water quality criteria are as follows:

- Mn was detected at values above the PQL and above the EPA secondary drinking water criteria in all leachates.
- Zn was found in a duplicate split Spoil Leachate sample. The results for Zn indicate that it is potentially present in trace amounts in both spoil and is spatially variable but significantly below relevant Navajo Nation and EPA water quality criteria.

The reported values for Cd (only in one 18 hour duplicate), Hg, and Tl (only in the 45 day test) are above the MDL but below the PQL and are included in Table 3-1 for comparison with the Navajo Nation and EPA water quality criteria. Since the PQL is the lowest level of quantification that a laboratory can reliably achieve based on specified limits of precision and accuracy relating to instrumentation and sample interferences, the values below the PQL reported in Table 3-1 are not considered reliable and should be considered non-detect below the PQL. The non-detect analytes in leachate are not considered for further investigation.

3.2.3 Distribution Ratios

A distribution ratio (K_r) was calculated for Ba and F. The distribution ratio is similar to a sorption isotherm where the concentration in solution is related to the concentration associated with the mass in or on the solid phase. The distribution ratio is defined in equation 3.1.

eq. 3.1 $$K_r = \frac{\text{mass of solute on solid phase per unit mass of solute}}{\text{concentration of solute in solution}}$$

The calculated K_r values (Table 3-3) reflect overall geochemical reactions of sorption and precipitation that result in attenuation of the solutes. As discussed in detail within the literature review section, the pH, redox conditions, temperature, solids characteristics, and the constituents in solution will affect the distribution of solutes on the solid phase. The precipitation of oxides and oxyhydroxides, such as Fe and Mn oxides, can significantly increase sorption capacity. Thus, as precipitation reactions occur the number of sorption sites also increases providing greater attenuation. The results indicate that the majority of constituents show either no attenuation or are below detection limits such that a value could not be calculated (Table 3-1). However, the spoil showed the ability to attenuate Ba and F. The spoil attenuation was observed for leachate from coal groundwater.

TABLE 3-3.
CALCULATED DISTRIBUTION RATIOS FOR SELECTED TRACE METALS

Analyte	Spoil Leachate	Spoil 45-Day	Spoil SPLP
Al	--	--	BD
As	BD	BD	BD
B	--	--	--
Ba	--	2.91	--
Cr	BD	BD	BD
Cu	BD	--	BD
Fe	--	BD	BD
F	10.63	12.67	--
Mn	--	--	--
Mo	--	--	BD
Se	BD	BD	BD
SO4	--	--	--
V	BD	BD	BD
Zn	--	BD	BD

-- No observed attenuation
BD is below detection limit (PQL)

ATTACHMENT A
Rietveld X-ray Diffraction Laboratory Results

QUANTITATIVE PHASE ANALYSIS OF TWO POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.

Project: NavajoMine Extension Leaching Study – P.O. 62651

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January 18, 2008

EXPERIMENTAL METHODS

The six samples from Project Navajo Mine were reduced to the optimum grain-size range for quantitative X-ray analysis (<5 μm) by grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Fine grain-size is an important factor in reducing micro-absorption contrast between phases.

Step-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with CoKα radiation on a standard Siemens (Bruker) D5000 Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a Vantec-1 strip detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 using Search-Match software by Siemens (Bruker). X-ray powder-diffraction data were refined with Rietveld program Topas 3 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinements are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots are shown in Figures 1-6.

The patterns of the three "Spoil" samples show a hump between about 6 and 10º2θ that likely corresponds to either amorphous or nanoscale material (disordered clays?) we cannot identify. Therefore, the related results must be considerate approximate.

Table 1. Results of quantitative phase analysis (wt. %) – NORWEST Applied Hydrology - Project Navajo Mine

Mineral	**Ideal formula**	**BR3* Composite Spoil A**	**BR3* Composite Spoil B**	**BR3* Composite Spoil C**	**Ash Composite 70% FA**	**Ash Composite DUP 1 70%FA**	**Ash Composite DUP 2 70%FA**
Quartz	SiO_2	36.5	35.4	35.4	21.3	26.3	24.8
Plagioclase	$NaAlSi_3O_8 – CaAl_2Si_2O_8$	10.3	10.1	10.1			
K-feldspar	$KAlSi_3O_8$	6.0	6.5	7.0			
Kaolinite	$Al_2Si_2O_5(OH)_4$	40.8	40.8	40.6			
Gypsum	$CaSO_4·2H_2O$	2.6	3.1	2.8	50.1	38.5	45.2
Anhydrite	$CaSO_4$	0.9	1.0	1.1			
Calcite	$CaCO_3$	2.9	3.1	2.9	1.8	1.4	
Dolomite	$CaMg(CO_3)_2$				3.4	1.8	
Mullite	$Al_6Si_2O_{13}$				23.4	29.5	30.0
Magnetite	Fe_3O_4					2.4	
Total		100.0	100.0	100.0	100.0	100.0	100.0

*** Semi-quantitative results**

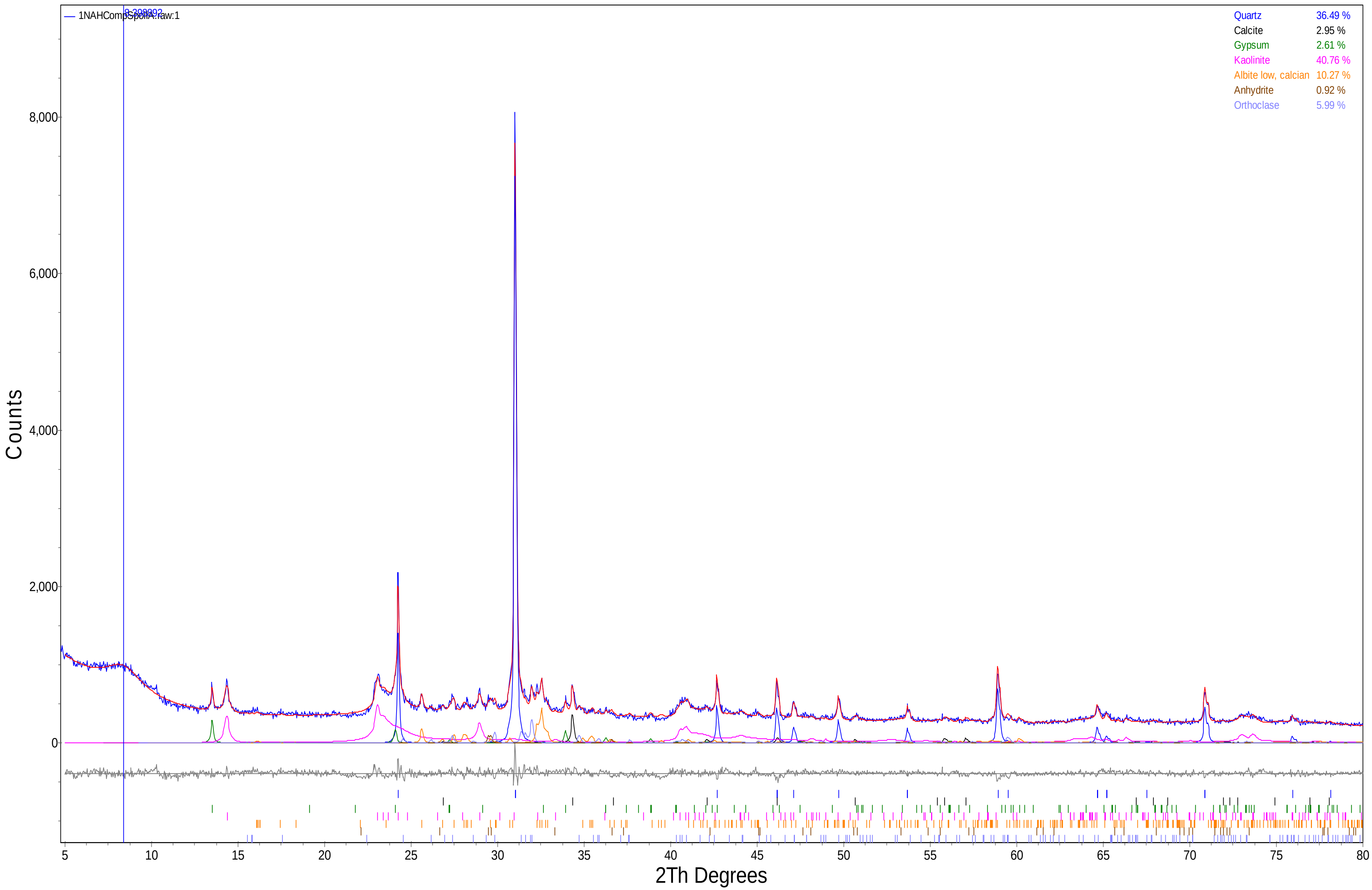

Figure 1. Rietveld refinement plot of sample **Norwest B.R.Composite Spoil A** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

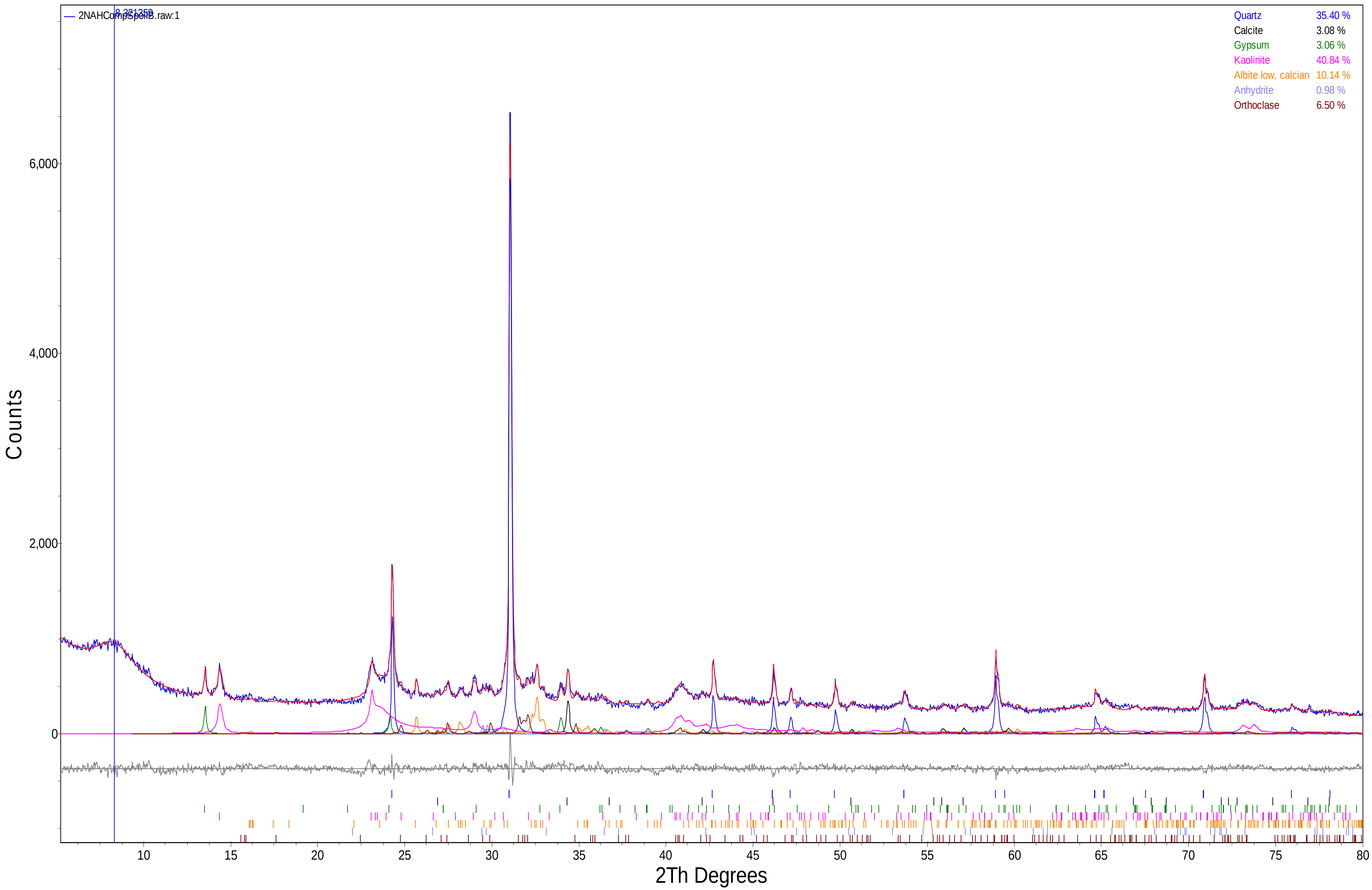

Figure 2. Rietveld refinement plot of sample **Norwest B.R. Composite Spoil B** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

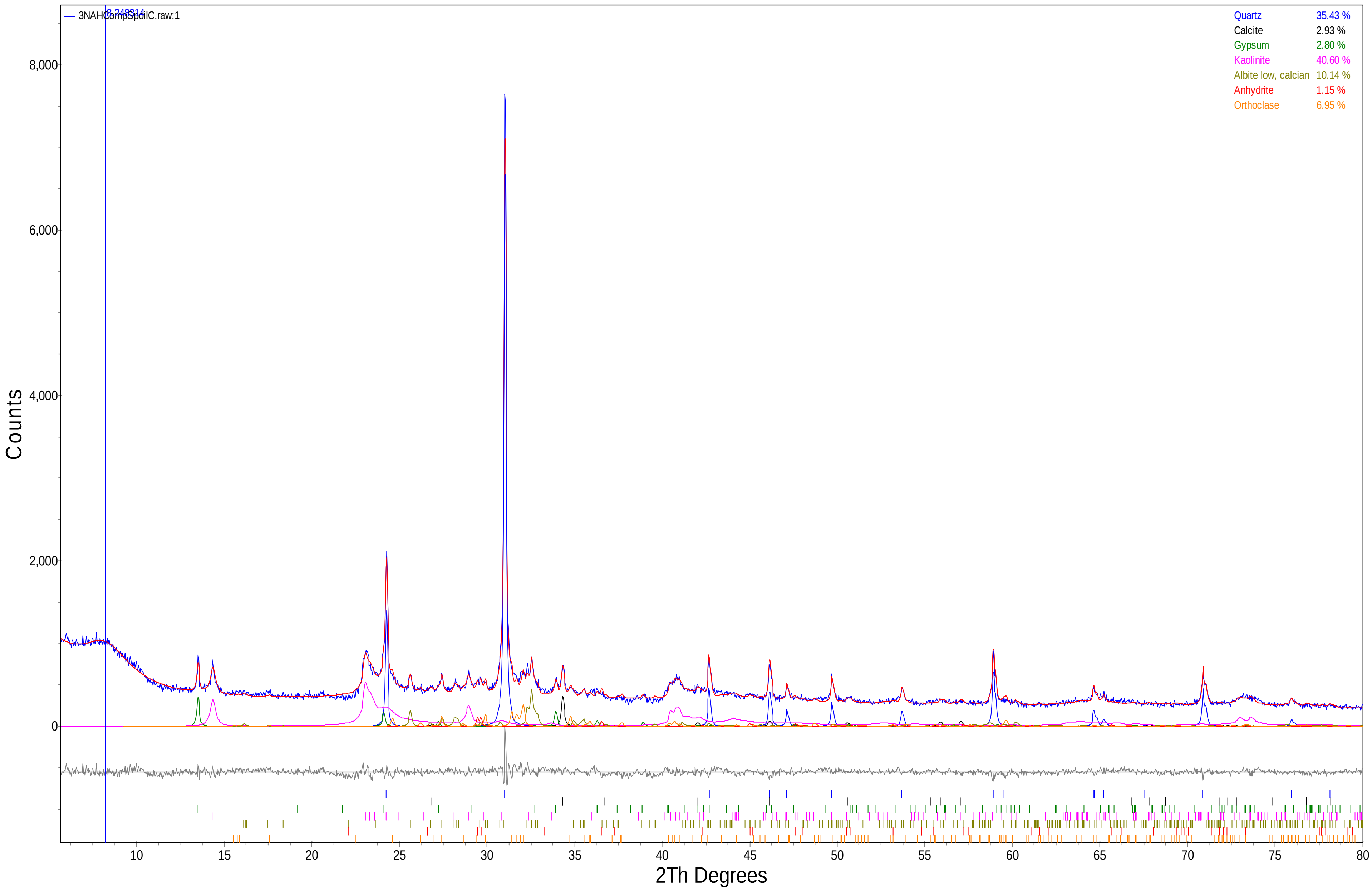

Figure 3. Rietveld refinement plot of sample **Norwest B.R. Composite Spoil C** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

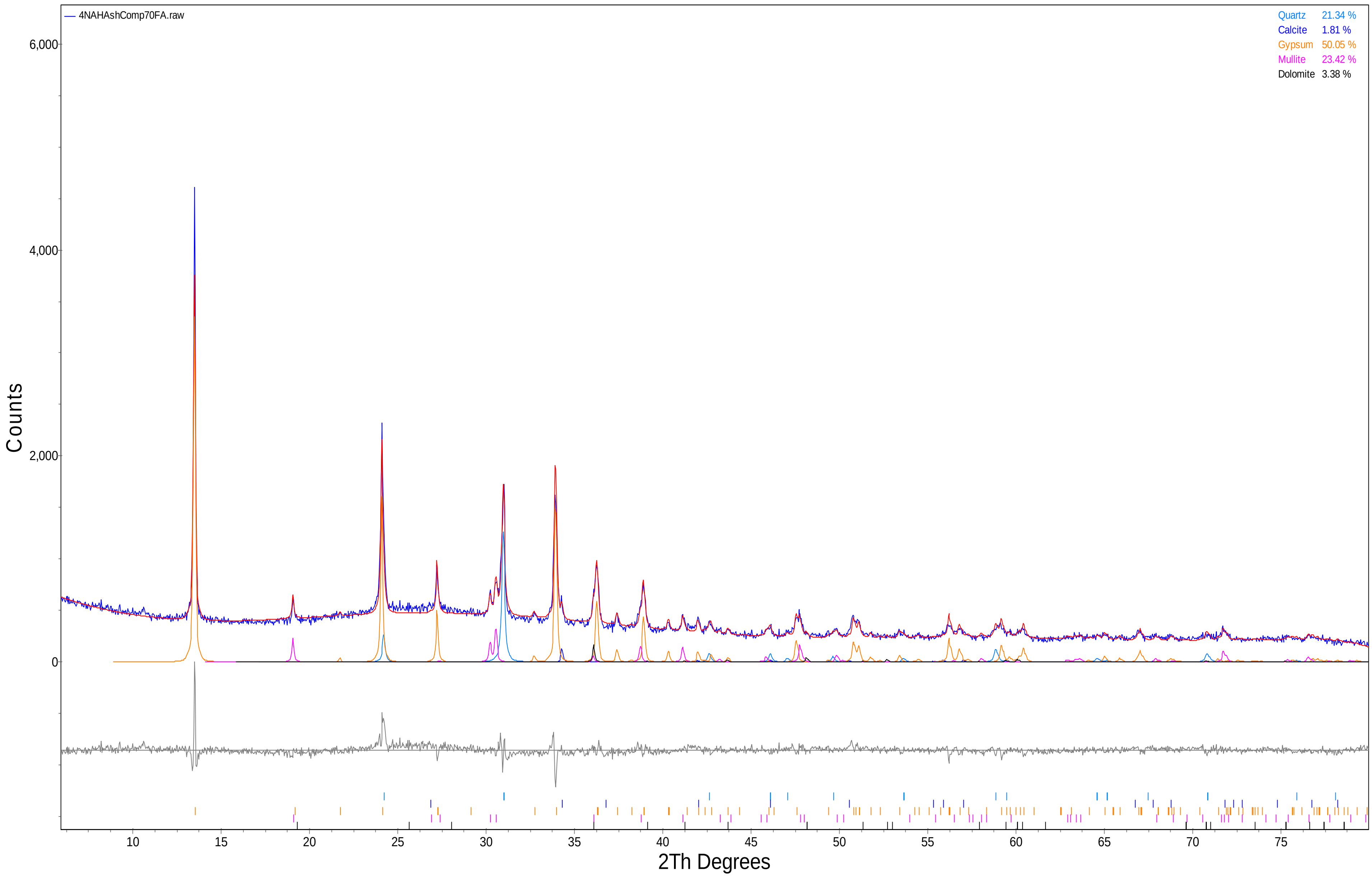

Figure 4. Rietveld refinement plot of sample **Norwest Ash Composite 70% FA** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

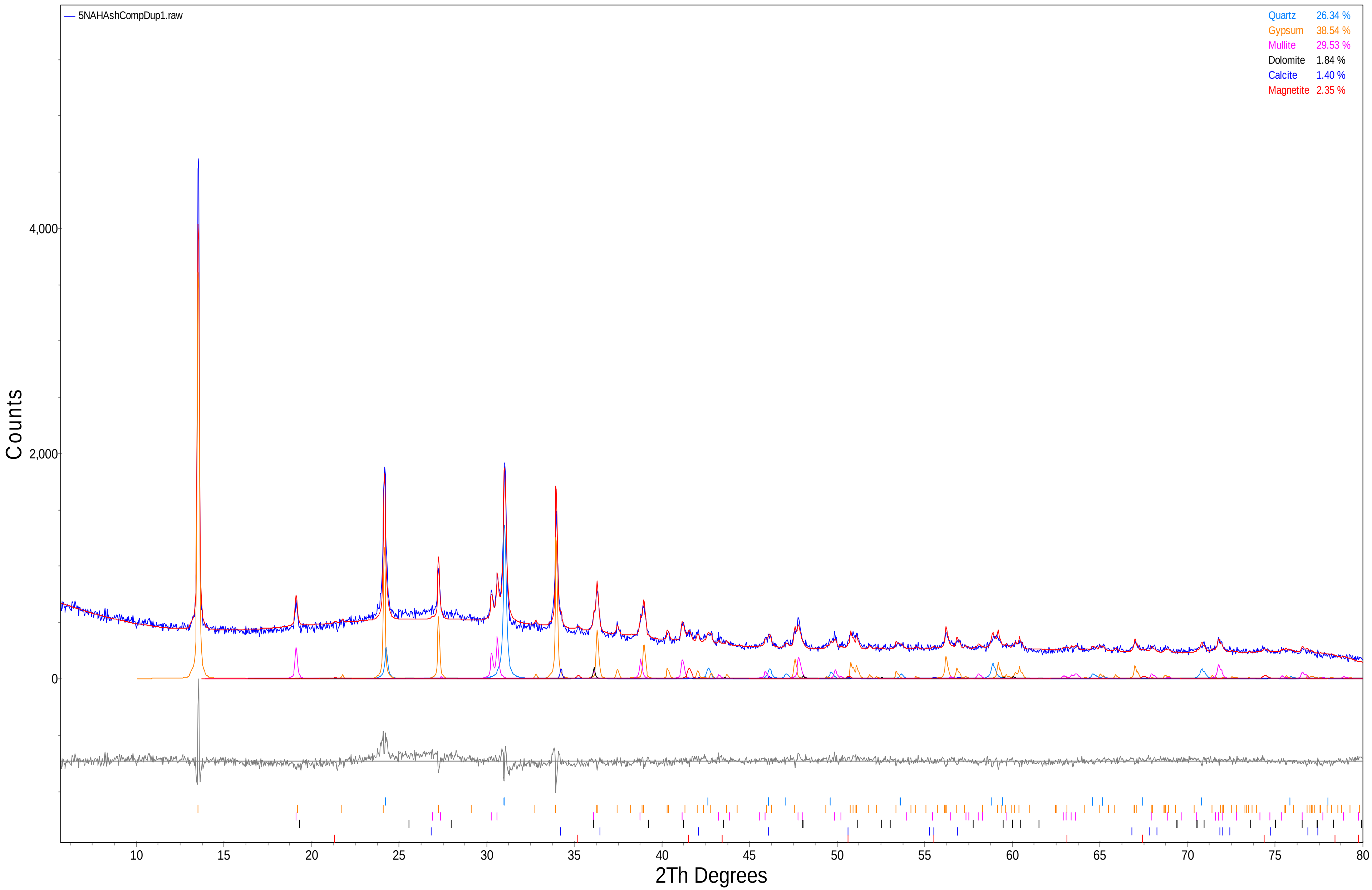

Figure 5. Rietveld refinement plot of sample **Norwest Ash Composite DUP 1 70% FA** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

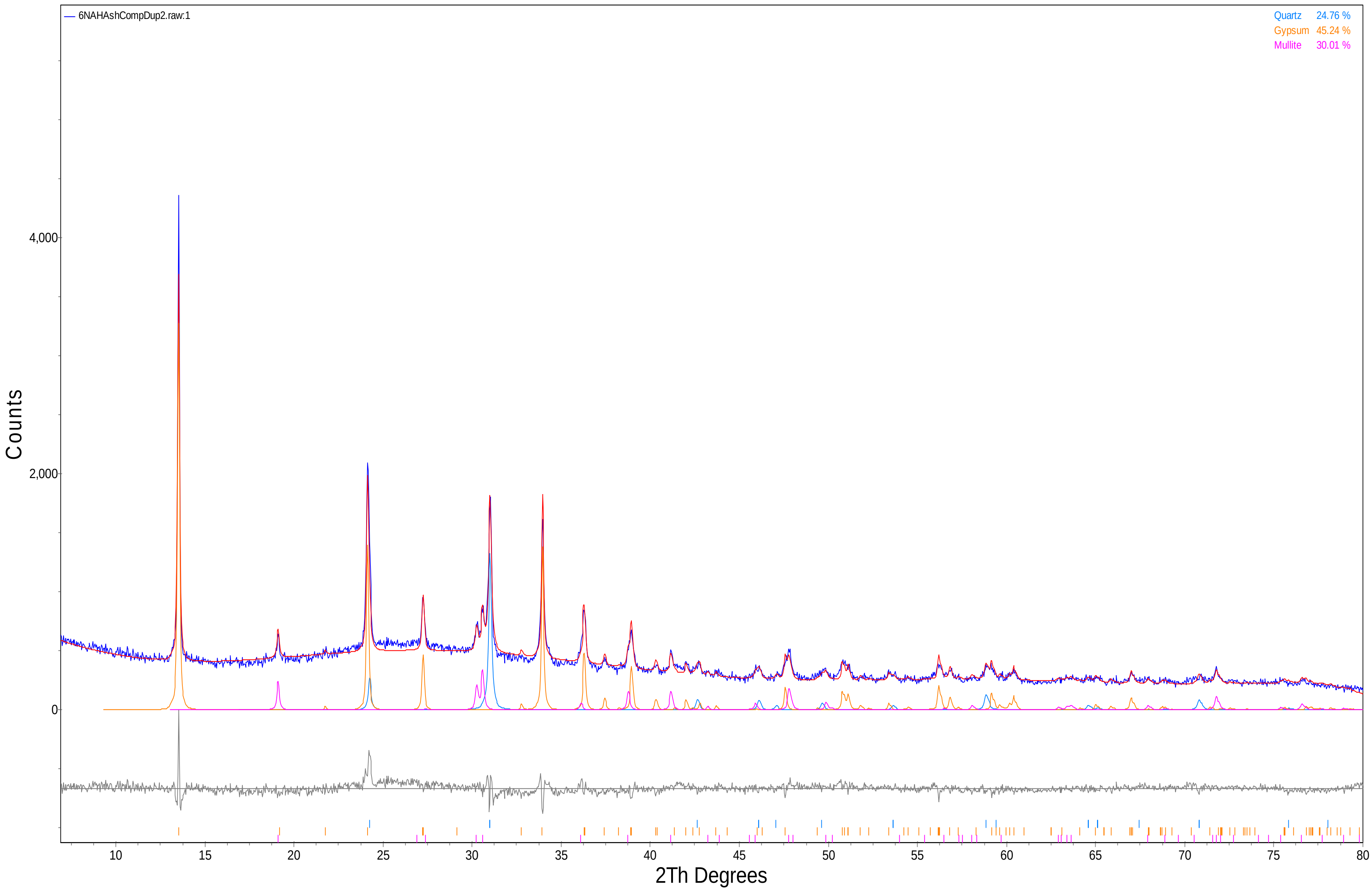

Figure 6. Rietveld refinement plot of sample **Norwest Ash Composite DUP 2 70% FA** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

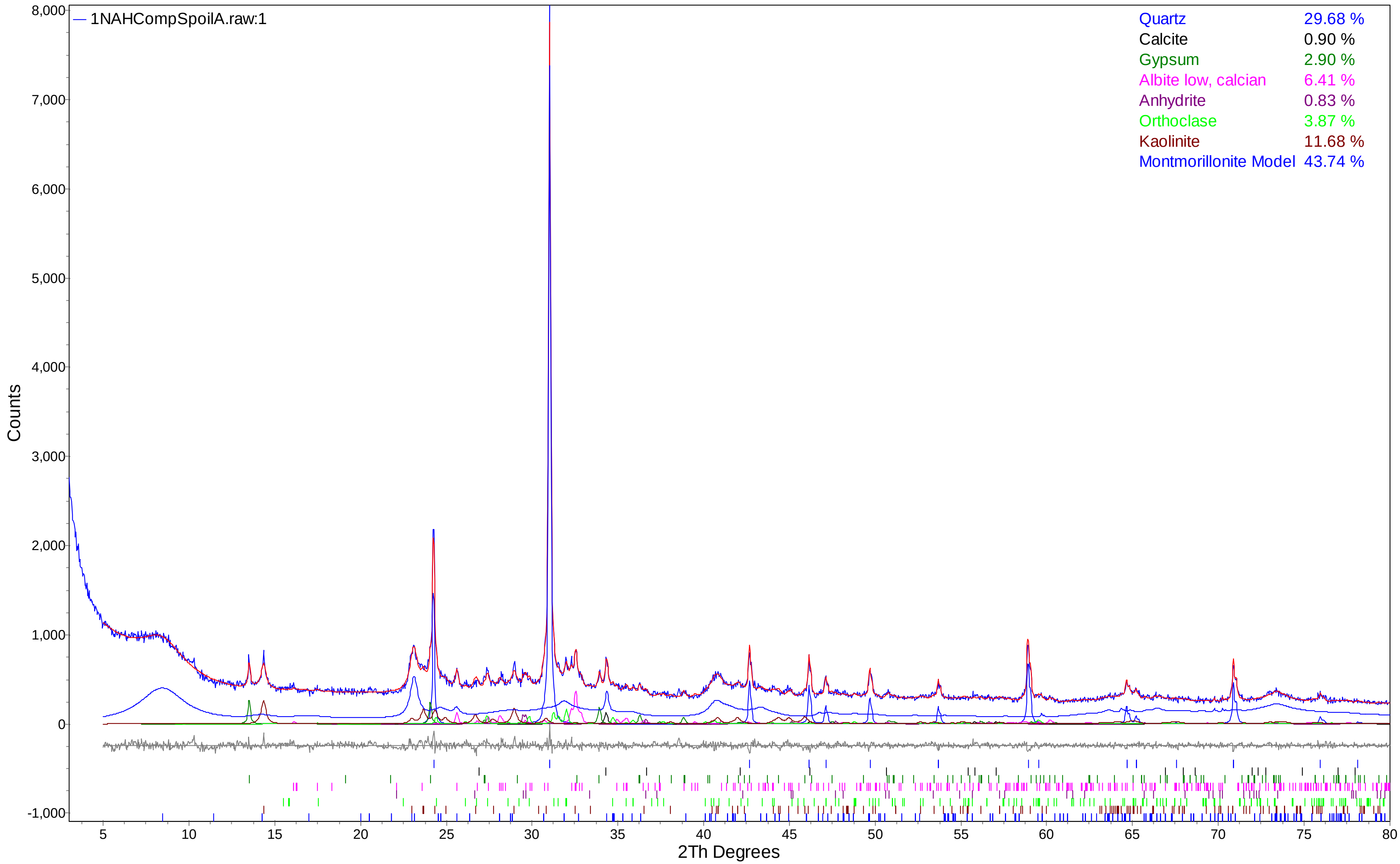

Figure 1. Rietveld refinement plot of sample **Norwest B.R.Composite Spoil A** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

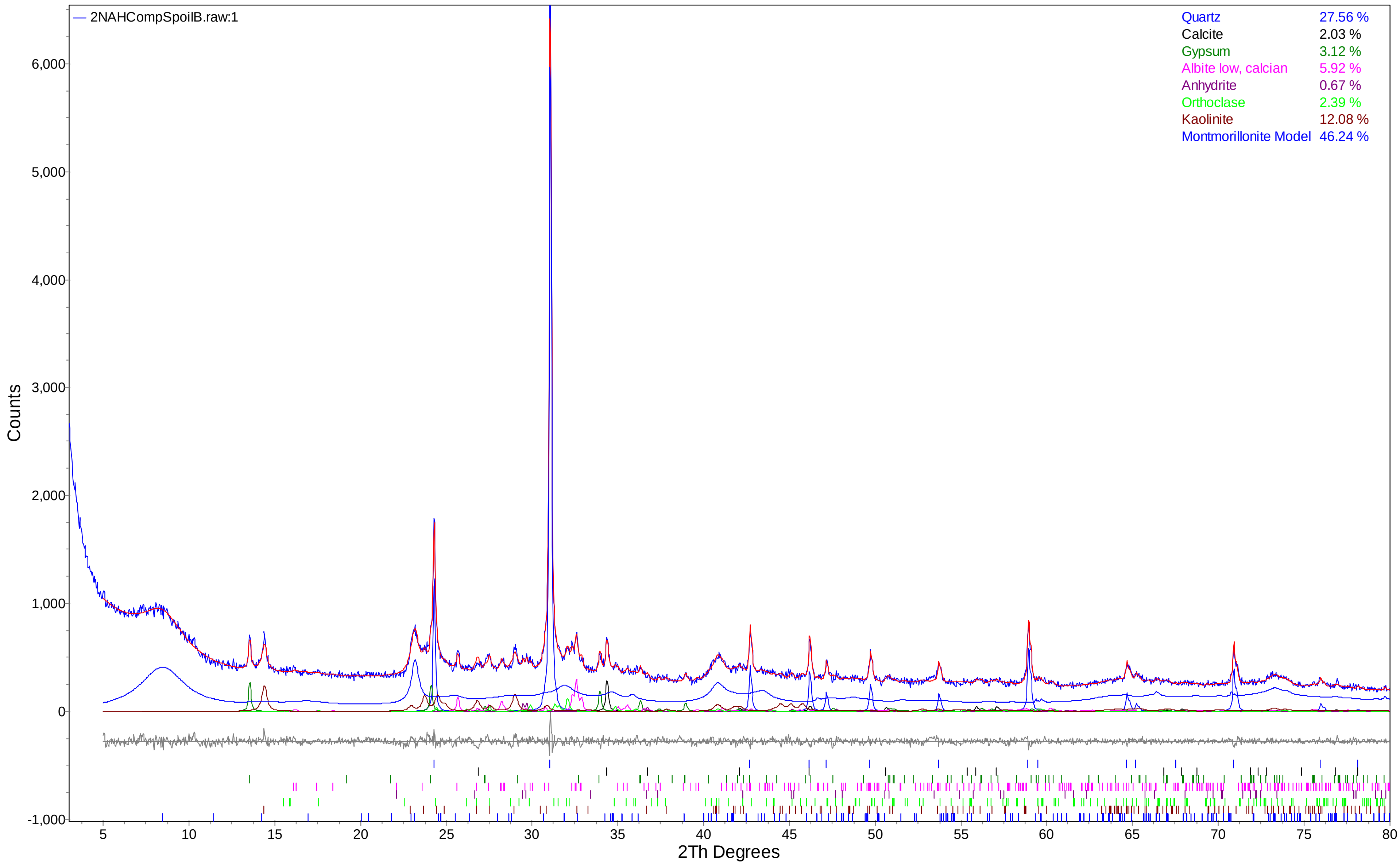

Figure 2. Rietveld refinement plot of sample **Norwest B.R. Composite Spoil B** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

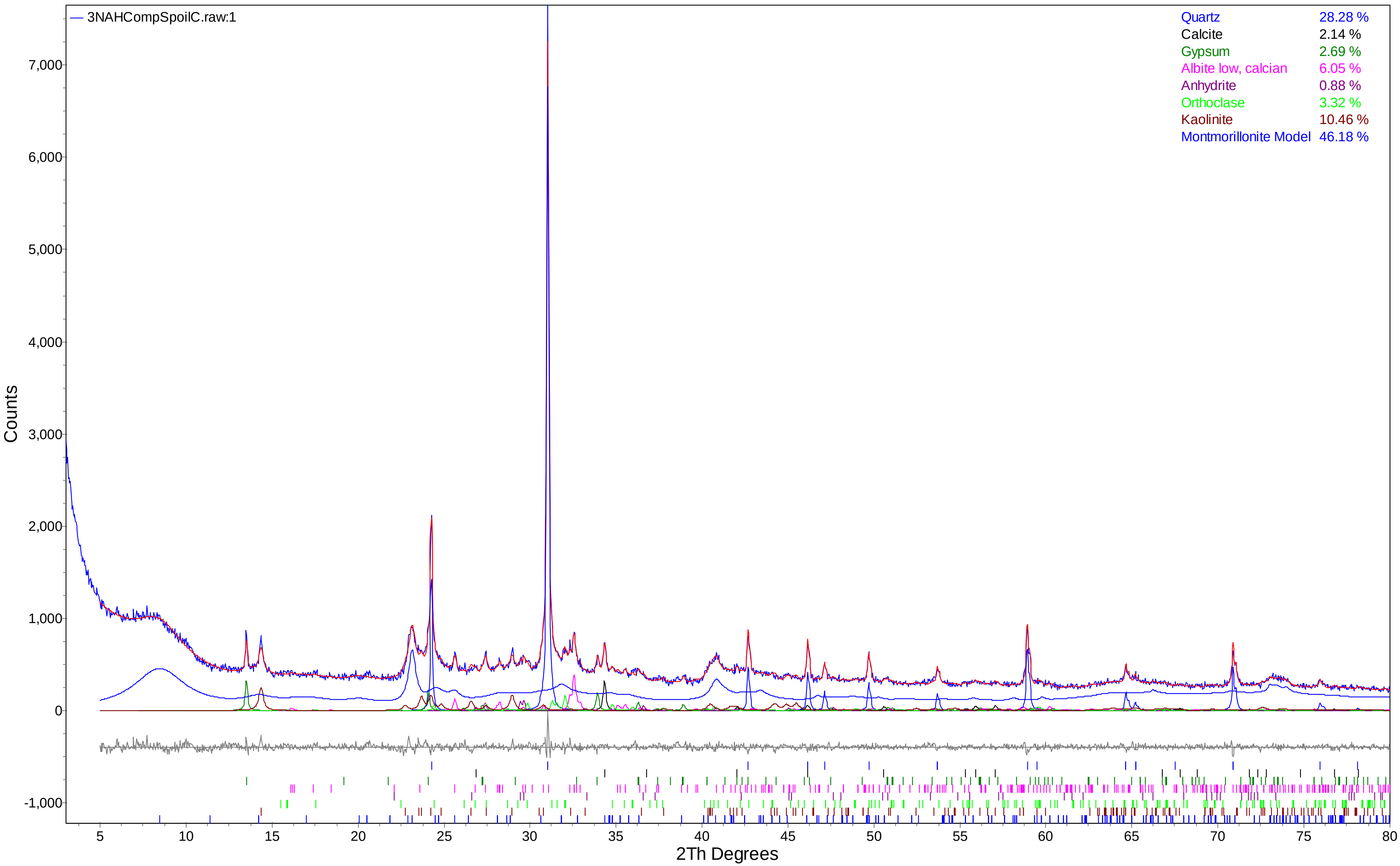

Figure 3. Rietveld refinement plot of sample **Norwest B.R. Composite Spoil C** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) and KF-98-02(53)**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01A	Analysis Date:	11/30/2007 4:07:17PM
Prep Date:	11/30/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B113007W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071130013		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	ND		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01A	Analysis Date:	12/3/2007 6:01:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.13**		mg/L	0.050	0.014	1
Antimony	7440-36-0	ND		mg/L	0.050	0.0067	
Arsenic	7440-38-2	ND		mg/L	0.10	0.015	
Barium	7440-39-3	**0.093**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	ND		mg/L	0.0010	0.000060	
Cadmium	7440-43-9	ND		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.4**		mg/L	0.10	0.013	
Chromium	7440-47-3	ND		mg/L	0.010	0.0018	
Cobalt	7440-48-4	ND		mg/L	0.0050	0.0016	
Copper	7440-50-8	ND		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.067**		mg/L	0.050	0.0027	
Lead	7439-92-1	ND		mg/L	0.050	0.011	
Lithium	7439-93-2	ND		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.3**		mg/L	0.10	0.012	
Manganese	7439-96-5	ND		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.012**		mg/L	0.010	0.0018	
Nickel	7440-02-0	ND		mg/L	0.040	0.0027	
Potassium	7440-09-7	**11**		mg/L	1.0	0.31	
Selenium	7784-49-2	ND		mg/L	0.10	0.026	
Silver	7440-22-4	ND		mg/L	0.015	0.00066	
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) and KF-98-02(53)**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

Lab Sample Number:	B0711172-01A	Analysis Date:	12/3/2007 6:01:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	1

Lab Sample Number:	B0711172-01A	Analysis Date:	12/4/2007 5:19:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Boron	7440-42-8	**0.31**		mg/L	0.050	0.0018	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **123 S 87W 0-4' SPOIL**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-02A	Analysis Date:	12/4/2007 3:25:10PM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	7.06
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.67 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.12**		mg/Kg	0.040	0.0055	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-02A	Analysis Date:	12/3/2007 1:27:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.06
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.60 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**9,700**		mg/Kg	7.1	1.8	1
Antimony	7440-36-0	ND		mg/Kg	9.8	0.55	
Arsenic	7440-38-2	ND		mg/Kg	12	1.6	
Barium	7440-39-3	**150**		mg/Kg	0.36	0.028	
Beryllium	7440-41-7	**1.0**		mg/Kg	0.18	0.0079	
Boron	7440-42-8	**13**		mg/Kg	4.5	0.60	
Cadmium	7440-43-9	**0.74**		mg/Kg	0.71	0.051	
Calcium	7440-70-2	**14,000**		mg/Kg	12	4.8	
Chromium	7440-47-3	**6.7**		mg/Kg	1.8	0.26	
Cobalt	7440-48-4	**12**		mg/Kg	2.7	0.23	
Copper	7440-50-8	**28**		mg/Kg	0.54	0.14	
Iron	7439-89-6	**22,000**		mg/Kg	5.4	0.39	
Lead	7439-92-1	**17**		mg/Kg	5.4	0.94	
Magnesium	7439-96-4	**3,100**		mg/Kg	8.9	0.85	
Manganese	7439-96-5	**360**		mg/Kg	0.89	0.099	
Molybdenum	7439-98-7	ND		mg/Kg	1.8	0.21	
Nickel	7440-02-0	**15**		mg/Kg	3.6	0.38	
Potassium	7440-09-7	**1,800**		mg/Kg	89	28	
Selenium	7784-49-2	ND		mg/Kg	8.9	2.2	
Silver	7440-22-4	ND		mg/Kg	1.3	0.14	
Sodium	7440-23-5	**3,900**		mg/Kg	270	0.91	
Thallium	7440-28-0	ND		mg/Kg	18	1.1	
Vanadium	7440-62-2	**22**		mg/Kg	0.89	0.17	

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **123 S 87W 0-4' SPOIL**

Matrix: Solid Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-02A	Analysis Date:	12/3/2007 1:27:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.06
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.60 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**73**		mg/Kg	0.54	0.20	1

Lab Sample Number:	B0711172-02A	Analysis Date:	12/4/2007 3:03:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.06
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.60 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**9.1**		mg/Kg	4.5	0.043	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **123 S 89W 0-4' SPOIL**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-03A	Analysis Date:	12/4/2007 4:05:31PM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	8.64
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.63 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.075**		mg/Kg	0.044	0.0060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-03A	Analysis Date:	12/3/2007 1:32:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.64
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.59 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**9,600**		mg/Kg	7.5	1.8	1
Antimony	7440-36-0	ND		mg/Kg	10	0.58	
Arsenic	7440-38-2	ND		mg/Kg	12	1.6	
Barium	7440-39-3	**170**		mg/Kg	0.37	0.029	
Beryllium	7440-41-7	**1.0**		mg/Kg	0.19	0.0083	
Boron	7440-42-8	**13**		mg/Kg	4.7	0.63	
Cadmium	7440-43-9	**0.85**		mg/Kg	0.75	0.054	
Calcium	7440-70-2	**21,000**		mg/Kg	13	5.0	
Chromium	7440-47-3	**6.6**		mg/Kg	1.9	0.28	
Cobalt	7440-48-4	**11**		mg/Kg	2.8	0.24	
Copper	7440-50-8	**25**		mg/Kg	0.56	0.15	
Iron	7439-89-6	**24,000**		mg/Kg	5.6	0.41	
Lead	7439-92-1	**17**		mg/Kg	5.6	0.98	
Magnesium	7439-96-4	**3,100**		mg/Kg	9.3	0.89	
Manganese	7439-96-5	**590**		mg/Kg	0.93	0.10	
Molybdenum	7439-98-7	ND		mg/Kg	1.9	0.22	
Nickel	7440-02-0	**15**		mg/Kg	3.7	0.40	
Potassium	7440-09-7	**1,800**		mg/Kg	93	29	
Selenium	7784-49-2	ND		mg/Kg	9.3	2.3	
Silver	7440-22-4	ND		mg/Kg	1.4	0.14	
Sodium	7440-23-5	**3,800**		mg/Kg	280	0.95	
Thallium	7440-28-0	ND		mg/Kg	19	1.1	
Vanadium	7440-62-2	**24**		mg/Kg	0.93	0.18	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **123 S 89W 0-4' SPOIL**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-03A	Analysis Date:	12/3/2007 1:32:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.64
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.59 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**69**		mg/Kg	0.56	0.21	1

Lab Sample Number:	B0711172-03A	Analysis Date:	12/4/2007 3:08:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.64
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.59 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**9.0**		mg/Kg	4.7	0.045	2

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **125 S 88W 0-4' SPOIL**

Matrix: Solid Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-04A	Analysis Date:	12/4/2007 4:13:55PM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	7.60
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.62 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.053**		mg/Kg	0.044	0.0060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-04A	Analysis Date:	12/3/2007 1:37:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.60
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.61 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**10,000**		mg/Kg	7.1	1.7	1
Antimony	7440-36-0	ND		mg/Kg	9.7	0.55	
Arsenic	7440-38-2	ND		mg/Kg	12	1.6	
Barium	7440-39-3	**220**		mg/Kg	0.35	0.027	
Beryllium	7440-41-7	**1.1**		mg/Kg	0.18	0.0078	
Boron	7440-42-8	**13**		mg/Kg	4.4	0.60	
Cadmium	7440-43-9	ND		mg/Kg	0.71	0.051	
Calcium	7440-70-2	**16,000**		mg/Kg	12	4.7	
Chromium	7440-47-3	**6.8**		mg/Kg	1.8	0.26	
Cobalt	7440-48-4	**11**		mg/Kg	2.7	0.23	
Copper	7440-50-8	**28**		mg/Kg	0.53	0.14	
Iron	7439-89-6	**22,000**		mg/Kg	5.3	0.39	
Lead	7439-92-1	**18**		mg/Kg	5.3	0.93	
Magnesium	7439-96-4	**3,100**		mg/Kg	8.9	0.85	
Manganese	7439-96-5	**380**		mg/Kg	0.89	0.098	
Molybdenum	7439-98-7	ND		mg/Kg	1.8	0.21	
Nickel	7440-02-0	**14**		mg/Kg	3.5	0.38	
Potassium	7440-09-7	**1,900**		mg/Kg	89	28	
Selenium	7784-49-2	ND		mg/Kg	8.9	2.2	
Silver	7440-22-4	ND		mg/Kg	1.3	0.14	
Sodium	7440-23-5	**4,200**		mg/Kg	270	0.90	
Thallium	7440-28-0	ND		mg/Kg	18	1.0	
Vanadium	7440-62-2	**25**		mg/Kg	0.89	0.17	

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **125 S 88W 0-4' SPOIL**

Matrix: Solid Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-04A	Analysis Date:	12/3/2007 1:37:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.60
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.61 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**66**		mg/Kg	0.53	0.20	1

Lab Sample Number:	B0711172-04A	Analysis Date:	12/4/2007 3:13:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.60
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.61 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**8.8**		mg/Kg	4.4	0.043	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **120 S 89W 0-4' SPOIL**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-05A	Analysis Date:	12/5/2007 9:42:00AM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	6.86
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.62 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.12**		mg/Kg	0.044	0.0060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-05A	Analysis Date:	12/3/2007 1:43:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	6.86
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.56 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**9,200**		mg/Kg	7.7	1.9	1
Antimony	7440-36-0	ND		mg/Kg	11	0.60	
Arsenic	7440-38-2	ND		mg/Kg	13	1.7	
Barium	7440-39-3	**140**		mg/Kg	0.39	0.030	
Beryllium	7440-41-7	**0.84**		mg/Kg	0.19	0.0085	
Boron	7440-42-8	**11**		mg/Kg	4.8	0.65	
Cadmium	7440-43-9	ND		mg/Kg	0.77	0.056	
Calcium	7440-70-2	**27,000**		mg/Kg	13	5.1	
Chromium	7440-47-3	**6.1**		mg/Kg	1.9	0.29	
Cobalt	7440-48-4	**11**		mg/Kg	2.9	0.25	
Copper	7440-50-8	**20**		mg/Kg	0.58	0.15	
Iron	7439-89-6	**19,000**		mg/Kg	5.8	0.42	
Lead	7439-92-1	**17**		mg/Kg	5.8	1.0	
Molybdenum	7439-98-7	ND		mg/Kg	1.9	0.23	
Nickel	7440-02-0	**14**		mg/Kg	3.9	0.41	
Potassium	7440-09-7	**1,900**		mg/Kg	96	30	
Selenium	7784-49-2	ND		mg/Kg	9.6	2.4	
Silver	7440-22-4	ND		mg/Kg	1.4	0.15	
Sodium	7440-23-5	**4,100**		mg/Kg	290	0.98	
Thallium	7440-28-0	ND		mg/Kg	19	1.1	
Vanadium	7440-62-2	**18**		mg/Kg	0.96	0.19	
Zinc	7440-66-6	**59**		mg/Kg	0.58	0.21	

Lab Sample Number: B0711172-05A Analysis Date: 12/4/2007 3:18:00PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **120 S 89W 0-4' SPOIL**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	6.86
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.56 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**8.2**		mg/Kg	4.8	0.047	3
Magnesium	7439-96-4	**3,200**		mg/Kg	9.6	0.92	
Manganese	7439-96-5	**370**		mg/Kg	0.96	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil A**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-06A	Analysis Date:	12/5/2007 9:49:39AM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	7.98
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.61 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.087**		mg/Kg	0.044	0.0061	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-06A	Analysis Date:	12/3/2007 2:28:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.98
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.58 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**10,000**		mg/Kg	7.4	1.8	1
Antimony	7440-36-0	ND		mg/Kg	10	0.58	
Arsenic	7440-38-2	ND		mg/Kg	12	1.6	
Barium	7440-39-3	**170**		mg/Kg	0.37	0.029	
Beryllium	7440-41-7	**1.0**		mg/Kg	0.19	0.0082	
Boron	7440-42-8	**13**		mg/Kg	4.7	0.63	
Cadmium	7440-43-9	ND		mg/Kg	0.74	0.054	
Calcium	7440-70-2	**20,000**		mg/Kg	13	5.0	
Chromium	7440-47-3	**6.7**		mg/Kg	1.9	0.28	
Cobalt	7440-48-4	**11**		mg/Kg	2.8	0.24	
Copper	7440-50-8	**26**		mg/Kg	0.56	0.15	
Iron	7439-89-6	**20,000**		mg/Kg	5.6	0.41	
Lead	7439-92-1	**16**		mg/Kg	5.6	0.98	
Magnesium	7439-96-4	**3,100**		mg/Kg	9.3	0.89	
Manganese	7439-96-5	**440**		mg/Kg	0.93	0.10	
Molybdenum	7439-98-7	ND		mg/Kg	1.9	0.22	
Nickel	7440-02-0	**13**		mg/Kg	3.7	0.40	
Potassium	7440-09-7	**1,900**		mg/Kg	93	29	
Selenium	7784-49-2	ND		mg/Kg	9.3	2.3	
Silver	7440-22-4	ND		mg/Kg	1.4	0.14	
Sodium	7440-23-5	**4,000**		mg/Kg	280	0.95	
Thallium	7440-28-0	ND		mg/Kg	19	1.1	
Vanadium	7440-62-2	**23**		mg/Kg	0.93	0.18	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil A**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-06A	Analysis Date:	12/3/2007 2:28:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.98
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.58 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**62**		mg/Kg	0.56	0.21	1

Lab Sample Number:	B0711172-06A	Analysis Date:	12/4/2007 4:04:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.98
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.58 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**8.6**		mg/Kg	4.7	0.045	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil B**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-07A	Analysis Date:	12/5/2007 9:57:26AM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	8.13
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.62 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.073**		mg/Kg	0.044	0.0060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-07A	Analysis Date:	12/3/2007 2:33:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.13
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.64 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**9,500**		mg/Kg	6.8	1.7	1
Antimony	7440-36-0	ND		mg/Kg	9.3	0.52	
Arsenic	7440-38-2	ND		mg/Kg	11	1.5	
Barium	7440-39-3	**180**		mg/Kg	0.34	0.026	
Beryllium	7440-41-7	**1.0**		mg/Kg	0.17	0.0075	
Boron	7440-42-8	**12**		mg/Kg	4.2	0.57	
Cadmium	7440-43-9	ND		mg/Kg	0.68	0.049	
Calcium	7440-70-2	**22,000**		mg/Kg	12	4.5	
Chromium	7440-47-3	**6.0**		mg/Kg	1.7	0.25	
Cobalt	7440-48-4	**11**		mg/Kg	2.5	0.22	
Copper	7440-50-8	**23**		mg/Kg	0.51	0.13	
Iron	7439-89-6	**20,000**		mg/Kg	5.1	0.37	
Lead	7439-92-1	**17**		mg/Kg	5.1	0.89	
Magnesium	7439-96-4	**2,900**		mg/Kg	8.5	0.81	
Manganese	7439-96-5	**430**		mg/Kg	0.85	0.094	
Molybdenum	7439-98-7	ND		mg/Kg	1.7	0.20	
Nickel	7440-02-0	**13**		mg/Kg	3.4	0.36	
Potassium	7440-09-7	**1,700**		mg/Kg	85	27	
Selenium	7784-49-2	ND		mg/Kg	8.5	2.1	
Silver	7440-22-4	ND		mg/Kg	1.3	0.13	
Sodium	7440-23-5	**3,900**		mg/Kg	250	0.86	
Thallium	7440-28-0	ND		mg/Kg	17	1.00	
Vanadium	7440-62-2	**22**		mg/Kg	0.85	0.16	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil B**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-07A	Analysis Date:	12/3/2007 2:33:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.13
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.64 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**65**		mg/Kg	0.51	0.19	1

Lab Sample Number:	B0711172-07A	Analysis Date:	12/4/2007 4:09:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	8.13
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.64 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**8.2**		mg/Kg	4.2	0.041	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil C**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-08A	Analysis Date:	12/5/2007 10:05:12AM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	7.87
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.62 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**0.068**		mg/Kg	0.044	0.0060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-08A	Analysis Date:	12/3/2007 2:38:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.87
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.57 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**9,400**		mg/Kg	7.7	1.9	1
Antimony	7440-36-0	ND		mg/Kg	11	0.59	
Arsenic	7440-38-2	ND		mg/Kg	12	1.7	
Barium	7440-39-3	**170**		mg/Kg	0.38	0.030	
Beryllium	7440-41-7	**1.0**		mg/Kg	0.19	0.0085	
Boron	7440-42-8	**12**		mg/Kg	4.8	0.64	
Cadmium	7440-43-9	ND		mg/Kg	0.77	0.055	
Calcium	7440-70-2	**20,000**		mg/Kg	13	5.1	
Chromium	7440-47-3	**6.1**		mg/Kg	1.9	0.28	
Cobalt	7440-48-4	**11**		mg/Kg	2.9	0.25	
Copper	7440-50-8	**24**		mg/Kg	0.57	0.15	
Iron	7439-89-6	**20,000**		mg/Kg	5.7	0.42	
Lead	7439-92-1	**18**		mg/Kg	5.7	1.0	
Magnesium	7439-96-4	**3,000**		mg/Kg	9.6	0.92	
Manganese	7439-96-5	**390**		mg/Kg	0.96	0.11	
Molybdenum	7439-98-7	ND		mg/Kg	1.9	0.23	
Nickel	7440-02-0	**14**		mg/Kg	3.8	0.41	
Potassium	7440-09-7	**1,800**		mg/Kg	96	30	
Selenium	7784-49-2	ND		mg/Kg	9.6	2.4	
Silver	7440-22-4	ND		mg/Kg	1.4	0.15	
Sodium	7440-23-5	**4,100**		mg/Kg	290	0.98	
Thallium	7440-28-0	ND		mg/Kg	19	1.1	
Vanadium	7440-62-2	**22**		mg/Kg	0.96	0.19	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Barber Ramp 3 Composite Spoil C**

Matrix: Solid

Collection Date: 11/15/2007 12:00:00PM

Lab Sample Number:	B0711172-08A	Analysis Date:	12/3/2007 2:38:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.87
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.57 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**62**		mg/Kg	0.57	0.21	1

Lab Sample Number:	B0711172-08A	Analysis Date:	12/4/2007 4:14:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	7.87
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.57 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	**8.1**		mg/Kg	4.8	0.047	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) DUP and KF-98-02(53)DUP**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12A	Analysis Date:	11/30/2007 4:09:34PM
Prep Date:	11/30/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B113007W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071130013		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	ND		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12A	Analysis Date:	12/3/2007 6:06:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.14**		mg/L	0.050	0.014	1
Antimony	7440-36-0	ND		mg/L	0.050	0.0067	
Arsenic	7440-38-2	ND		mg/L	0.10	0.015	
Barium	7440-39-3	**0.088**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	ND		mg/L	0.0010	0.000060	
Cadmium	7440-43-9	ND		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.3**		mg/L	0.10	0.013	
Chromium	7440-47-3	ND		mg/L	0.010	0.0018	
Cobalt	7440-48-4	ND		mg/L	0.0050	0.0016	
Copper	7440-50-8	ND		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.073**		mg/L	0.050	0.0027	
Lead	7439-92-1	ND		mg/L	0.050	0.011	
Lithium	7439-93-2	ND		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.2**		mg/L	0.10	0.012	
Manganese	7439-96-5	ND		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	ND		mg/L	0.010	0.0018	
Nickel	7440-02-0	ND		mg/L	0.040	0.0027	
Potassium	7440-09-7	**10**		mg/L	1.0	0.31	
Selenium	7784-49-2	ND		mg/L	0.10	0.026	
Silver	7440-22-4	ND		mg/L	0.015	0.00066	
Sodium	7440-23-5	**1,100**		mg/L	3.0	0.028	
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) DUP and KF-98-02(53)DUP**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

Lab Sample Number:	B0711172-12A	Analysis Date:	12/3/2007 6:06:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	1

Lab Sample Number:	B0711172-12A	Analysis Date:	12/4/2007 5:24:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Boron	7440-42-8	**0.29**		mg/L	0.050	0.0018	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Solid

Collection Date: 12/4/2007 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071204013-MB	Analysis Date:	12/4/2007 3:00:38PM
Prep Date:	12/4/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Total H	File Name:	B120407S.WK
Prep Method ID:	7471A	Dilution Factor:	1
Prep Batch Number:	T071204013	Percent Moisture	NA
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	0.60 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	ND		mg/Kg	0.042	0.0057	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071203005-MB	Analysis Date:	12/3/2007 1:12:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	NA
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.50 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	ND		mg/Kg	8.0	2.0	1
Antimony	7440-36-0	ND		mg/Kg	11	0.62	
Arsenic	7440-38-2	ND		mg/Kg	13	1.8	
Barium	7440-39-3	ND		mg/Kg	0.40	0.031	
Beryllium	7440-41-7	ND		mg/Kg	0.20	0.0089	
Boron	7440-42-8	ND		mg/Kg	5.0	0.67	
Cadmium	7440-43-9	ND		mg/Kg	0.80	0.058	
Calcium	7440-70-2	ND		mg/Kg	14	5.3	
Chromium	7440-47-3	ND		mg/Kg	2.0	0.30	
Cobalt	7440-48-4	ND		mg/Kg	3.0	0.26	
Copper	7440-50-8	ND		mg/Kg	0.60	0.16	
Iron	7439-89-6	ND		mg/Kg	6.0	0.44	
Lead	7439-92-1	ND		mg/Kg	6.0	1.1	
Magnesium	7439-96-4	ND		mg/Kg	10	0.96	
Manganese	7439-96-5	ND		mg/Kg	1.0	0.11	
Molybdenum	7439-98-7	ND		mg/Kg	2.0	0.24	
Nickel	7440-02-0	ND		mg/Kg	4.0	0.43	
Potassium	7440-09-7	ND		mg/Kg	100	31	
Selenium	7784-49-2	ND		mg/Kg	10	2.5	
Silver	7440-22-4	ND		mg/Kg	1.5	0.15	
Sodium	7440-23-5	ND		mg/Kg	300	1.0	
Thallium	7440-28-0	ND		mg/Kg	20	1.2	
Vanadium	7440-62-2	ND		mg/Kg	1.0	0.20	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Solid

Collection Date: 12/3/2007 12:00:00AM

Lab Sample Number:	T071203005-MB	Analysis Date:	12/4/2007 2:48:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12047A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	NA
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.50 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lithium	7439-93-2	ND		mg/Kg	5.0	0.049	2

Lab Sample Number:	T071203005-MB	Analysis Date:	12/5/2007 1:51:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12057A
Prep Method ID:	3050B	Dilution Factor:	1
Prep Batch Number:	T071203005	Percent Moisture	NA
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	0.50 g	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	ND		mg/Kg	0.60	0.22	3

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071130013-MB	Analysis Date:	11/30/2007 4:00:22PM
Prep Date:	11/30/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B113007W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071130013		
Report Basis:	Dry Weight Basis	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	ND		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071203011-MB	Analysis Date:	12/3/2007 5:46:00PM
Prep Date:	12/3/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12037A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071203011		
Report Basis:	Dry Weight Basis	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	ND		mg/L	0.050	0.014	1
Antimony	7440-36-0	ND		mg/L	0.050	0.0067	
Arsenic	7440-38-2	ND		mg/L	0.10	0.015	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 12/3/2007 12:00:00AM

Lab Sample Number: T071203011-MB
Prep Date: 12/3/2007
Analytical Method ID: SW6010B - ICP - Total
Prep Method ID: 3010_ICP
Prep Batch Number: T071203011
Report Basis: Dry Weight Basis
Sample prep wt./vol: 50.00 ml

Analysis Date: 12/3/2007 5:46:00PM
Instrument: ICP_2
File Name: E12037A
Dilution Factor: 1
Analyst Initials: rm
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Barium	7440-39-3	ND		mg/L	0.010	0.00016	1
Beryllium	7440-41-7	ND		mg/L	0.0010	0.000060	
Cadmium	7440-43-9	ND		mg/L	0.0060	0.00051	
Calcium	7440-70-2	ND		mg/L	0.10	0.013	
Chromium	7440-47-3	ND		mg/L	0.010	0.0018	
Cobalt	7440-48-4	ND		mg/L	0.0050	0.0016	
Copper	7440-50-8	ND		mg/L	0.0050	0.0019	
Iron	7439-89-6	ND		mg/L	0.050	0.0027	
Lead	7439-92-1	ND		mg/L	0.050	0.011	
Lithium	7439-93-2	ND		mg/L	0.10	0.00072	
Magnesium	7439-96-4	ND		mg/L	0.10	0.012	
Manganese	7439-96-5	ND		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	ND		mg/L	0.010	0.0018	
Nickel	7440-02-0	ND		mg/L	0.040	0.0027	
Potassium	7440-09-7	ND		mg/L	1.0	0.31	
Selenium	7784-49-2	ND		mg/L	0.10	0.026	
Silver	7440-22-4	ND		mg/L	0.015	0.00066	
Sodium	7440-23-5	ND		mg/L	3.0	0.028	
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	

Lab Sample Number: T071203011-MB
Prep Date: 12/3/2007
Analytical Method ID: SW6010B - ICP - Total
Prep Method ID: 3010_ICP
Prep Batch Number: T071203011
Report Basis: Dry Weight Basis
Sample prep wt./vol: 50.00 ml

Analysis Date: 12/4/2007 5:04:00PM
Instrument: ICP_2
File Name: E12047A
Dilution Factor: 1
Analyst Initials: rm
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Boron	7440-42-8	ND		mg/L	0.050	0.0018	2

Lab Sample Number: T071203011-MB
Prep Date: 12/3/2007
Analytical Method ID: SW6010B - ICP - Total
Prep Method ID: 3010_ICP
Prep Batch Number: T071203011

Analysis Date: 12/5/2007 1:41:00PM
Instrument: ICP_2
File Name: E12057A
Dilution Factor: 1

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 12/3/2007 12:00:00AM

Report Basis: Dry Weight Basis

Analyst Initials: rm

Sample prep wt./vol: 50.00 ml

Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	3

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) and KF-98-02(53)**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01B	Analysis Date:	11/29/2007 10:08:49AM
Prep Date:	11/29/2007	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T071203006		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	25.00 ml	Prep Extract Vol:	25.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,300**		mg/L	5.0	1.5	1
Carbonate		**260**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01B	Analysis Date:	11/28/2007 10:05:27AM
Prep Date:	11/28/2007	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T071203004		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01B	Analysis Date:	12/4/2007 9:06:42AM
Prep Date:	11/29/2007	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T071203008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-01B	Analysis Date:	11/29/2007 1:54:49PM
Prep Date:	11/29/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071129_013.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T071130001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) and KF-98-02(53)**

Matrix: Aqueous — Collection Date: 11/15/2007 4:30:00PM

Lab Sample Number:	B0711172-01B	Analysis Date:	11/29/2007 1:54:49PM
Prep Date:	11/29/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071129_013.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T071130001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.4**		mg/L	0.40	0.031	2
Sulfate		**300**		mg/L	1.5	0.11	

Lab Sample Number:	B0711172-01B	Analysis Date:	11/30/2007 12:00:01PM
Prep Date:	11/29/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071130_007.D
Prep Method ID:	300.0	Dilution Factor:	27
Prep Batch Number:	T071130001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**710**		mg/L	21	1.1	1

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) DUP and KF-98-02(53)DUP**

Matrix: Aqueous

Collection Date: 11/15/2007 4:30:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12B	Analysis Date:	11/29/2007 10:08:49AM
Prep Date:	11/29/2007	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T071203006		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	25.00 ml	Prep Extract Vol:	25.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,200**		mg/L	5.0	1.5	1
Carbonate		**300**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12B	Analysis Date:	11/28/2007 10:05:27AM
Prep Date:	11/28/2007	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T071203004		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**8.9**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12B	Analysis Date:	12/4/2007 9:06:42AM
Prep Date:	11/29/2007	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T071203008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,000**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0711172-12B	Analysis Date:	11/29/2007 2:11:40PM
Prep Date:	11/29/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071129_014.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T071130001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **KF2007-01(58) DUP and KF-98-02(53)DUP**

Matrix: Aqueous Collection Date: 11/15/2007 4:30:00PM

Lab Sample Number: B0711172-12B Analysis Date: 11/29/2007 2:11:40PM
Prep Date: 11/29/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071129_014.D
Prep Method ID: 300.0 Dilution Factor: 1
Prep Batch Number: T071130001
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.5**		mg/L	0.40	0.031	2

Lab Sample Number: B0711172-12B Analysis Date: 11/29/2007 10:36:20PM
Prep Date: 11/29/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071129_044.D
Prep Method ID: 300.0 Dilution Factor: 10
Prep Batch Number: T071130001
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**260**		mg/L	15	1.1	3

Lab Sample Number: B0711172-12B Analysis Date: 11/30/2007 12:16:51PM
Prep Date: 11/29/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071130_008.D
Prep Method ID: 300.0 Dilution Factor: 27
Prep Batch Number: T071130001
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**700**		mg/L	21	1.1	1

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 11/29/2007 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071203006-MB	Analysis Date:	11/29/2007 10:08:49AM
Prep Date:	11/29/2007	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T071203006		
Report Basis:	Dry Weight Basis	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		ND		mg/L	5.0	1.5	1
Carbonate		ND		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071203008-MB	Analysis Date:	12/4/2007 9:06:42AM
Prep Date:	11/29/2007	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T071203008		
Report Basis:	Dry Weight Basis	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		ND		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071130001-MB	Analysis Date:	11/29/2007 1:04:19PM
Prep Date:	11/29/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071129_010.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T071130001		
Report Basis:	Dry Weight Basis	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		ND		mg/L	0.80	0.042	1
Fluoride		ND		mg/L	0.40	0.031	
Sulfate		ND		mg/L	1.5	0.11	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0711172
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203011**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total
MB: T071203011-MB
Prep Date: 12/3/2007
MB Anal. Date: 12/3/2007 5:46:00PM
Units: mg/L
LCS Anal. Date: 12/3/2007 5:51:00PM LCSD Anal. Date: 12/3/2007 5:56:00PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	2.09	2.05	2.00	2.00	104.5	102.5	1.9	89 - 117	20	
Antimony	ND	0.504	0.491	0.500	0.500	100.8	98.2	2.6	82 - 117	20	
Arsenic	ND	2.04	2.00	2.00	2.00	102.0	100.0	2.0	86 - 116	20	
Barium	ND	2.00	1.97	2.00	2.00	100.0	98.5	1.5	86 - 116	20	
Beryllium	ND	0.0511	0.0500	0.0500	0.0500	102.2	100.0	2.2	87 - 111	20	
Boron	ND	0.650	0.638	0.500	0.500	130.0	127.6	1.9	76 - 130	20	
Cadmium	ND	0.0500	0.0482	0.0500	0.0500	100.0	96.4	3.7	79 - 113	20	
Calcium	ND	10.0	9.85	10.0	10.0	100.0	98.5	1.5	79 - 119	20	
Chromium	ND	0.202	0.197	0.200	0.200	101.0	98.5	2.5	86 - 117	20	
Cobalt	ND	0.506	0.494	0.500	0.500	101.2	98.8	2.4	82 - 118	20	
Copper	ND	0.252	0.247	0.250	0.250	100.8	98.8	2.0	86 - 117	20	
Iron	ND	1.02	1.02	1.00	1.00	102.0	102.0	0.0	83 - 121	20	
Lead	ND	0.511	0.505	0.500	0.500	102.2	101.0	1.2	83 - 121	20	
Magnesium	ND	10.6	10.4	10.0	10.0	106.0	104.0	1.9	83 - 118	20	
Manganese	ND	0.507	0.497	0.500	0.500	101.4	99.4	2.0	82 - 121	20	
Molybdenum	ND	0.508	0.496	0.500	0.500	101.6	99.2	2.4	82 - 120	20	
Nickel	ND	0.510	0.496	0.500	0.500	102.0	99.2	2.8	84 - 117	20	
Potassium	ND	9.04	8.48	10.0	10.0	90.4	84.8	6.4	74 - 110	20	
Selenium	ND	2.01	1.96	2.00	2.00	100.5	98.0	2.5	87 - 117	20	
Silver	ND	0.266	0.259	0.250	0.250	106.4	103.6	2.7	80 - 127	20	
Sodium	ND	9.67	9.69	10.0	10.0	96.7	96.9	0.2	87 - 113	20	
Thallium	ND	0.204	0.189	0.200	0.200	102.0	94.5	7.6	89 - 113	20	
Vanadium	ND	0.514	0.503	0.500	0.500	102.8	100.6	2.2	87 - 119	20	
Zinc	ND	0.495	0.478	0.500	0.500	99.0	95.6	3.5	81 - 120	20	
Lithium	ND	0.479	0.475	0.500	0.500	95.8	95.0	0.8	80 - 120	20	

Prep Batch: **T071130013**

LCS/LCSD REPORT

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0711172
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071130013**

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg
MB: T071130013-MB
Prep Date: 11/30/2007
MB Anal. Date: 11/30/2007 4:00:22PM
Units: mg/L
LCS Anal. Date: 11/30/2007 4:02:28PM
LCSD Anal. Date: 11/30/2007 4:05:02PM
Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00233	0.00196	0.00200	0.0020	116.5	98.0	17.2	80 - 120	20	

Prep Batch: **T071203005**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0711172-05A
Prep Date: 12/3/2007
Samp. Anal. Date: 12/3/2007 1:43:00PM
Units: mg/Kg
DUP Anal. Date: 12/3/2007 1:48:00PM
Matrix: Solid

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	9,240	10,500	12.8	35	
Antimony	ND	ND	0.0	35	
Arsenic	ND	ND	0.0	35	
Barium	141	142	0.7	35	
Beryllium	0.838	0.943	11.8	35	
Boron	10.8	11.9	9.7	35	
Cadmium	ND	ND	0.0	35	
Calcium	27,500	25,500	7.5	35	
Chromium	6.15	6.34	3.0	35	
Cobalt	11.1	10.6	4.6	35	
Copper	20.3	19.2	5.6	35	
Iron	19,200	19,200	0.0	35	
Lead	17.0	16.9	0.6	35	
Magnesium	3,160	3,310	4.6	35	
Manganese	374	461	20.8	35	
Molybdenum	ND	ND	0.0	35	
Nickel	14.3	13.6	5.0	35	
Potassium	1,880	1,980	5.2	35	
Selenium	ND	ND	0.0	35	
Silver	ND	ND	0.0	35	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203005**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

DUP Anal. Date: 12/3/2007 1:48:00PM

Units: mg/Kg

Matrix: Solid

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Sodium	4,090	3,880	5.3	35	
Thallium	ND	ND	0.0	35	
Vanadium	17.9	19.5	8.6	35	
Zinc	59.4	60.1	1.2	35	
Lithium	8.19	9.07	10.2	35	

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T071203005-MB

Prep Date: 12/3/2007

MB Anal. Date: 12/3/2007 1:12:00PM

Units: mg/Kg

LCS Anal. Date: 12/3/2007 1:17:00PM LCSD Anal. Date: 12/3/2007 1:22:00PM

Matrix: Solid

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	204	203	200	200	102.0	101.5	0.5	70 - 130	35	
Antimony	ND	47.2	47.7	50.0	50.0	94.4	95.4	1.1	70 - 130	35	
Arsenic	ND	192	193	200	200	96.0	96.5	0.5	70 - 130	35	
Barium	ND	199	199	200	200	99.5	99.5	0.0	70 - 130	35	
Beryllium	ND	4.82	4.82	5.00	5.00	96.4	96.4	0.0	70 - 130	35	
Boron	ND	60.2	64.5	50.0	50.0	120.4	129.0	6.9	70 - 130	35	
Cadmium	ND	5.06	5.01	5.00	5.00	101.2	100.2	1.0	70 - 130	35	
Calcium	ND	954	947	1,000	1,000	95.4	94.7	0.7	70 - 130	35	
Chromium	ND	19.6	19.6	20.0	20.0	98.0	98.0	0.0	70 - 130	35	
Cobalt	ND	48.2	48.3	50.0	50.0	96.4	96.6	0.2	70 - 130	35	
Copper	ND	24.7	24.9	25.0	25.0	98.8	99.6	0.8	70 - 130	35	
Iron	ND	99.4	98.7	100	100	99.4	98.7	0.7	70 - 130	35	
Lead	ND	48.1	48.7	50.0	50.0	96.2	97.4	1.2	70 - 130	35	
Magnesium	ND	994	992	1,000	1,000	99.4	99.2	0.2	70 - 130	35	
Manganese	ND	49.0	48.8	50.0	50.0	98.0	97.6	0.4	70 - 130	35	
Molybdenum	ND	48.6	48.4	50.0	50.0	97.2	96.8	0.4	70 - 130	35	
Nickel	ND	47.9	48.1	50.0	50.0	95.8	96.2	0.4	70 - 130	35	
Potassium	ND	937	954	1,000	1,000	93.7	95.4	1.8	70 - 130	35	

ATTACHMENT B
Total Analyses Laboratory Results

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203005**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T071203005-MB

Prep Date: 12/3/2007

MB Anal. Date: 12/3/2007 1:12:00PM

Units: mg/Kg

LCS Anal. Date: 12/3/2007 1:17:00PM LCSD Anal. Date: 12/3/2007 1:22:00PM Matrix: Solid

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Selenium	ND	189	191	200	200	94.5	95.5	1.1	70 - 130	35	
Silver	ND	24.9	25.0	25.0	25.0	99.6	100.0	0.4	70 - 130	35	
Sodium	ND	1,010	1,000	1,000	1,000	101.0	100.0	1.0	70 - 130	35	
Thallium	ND	20.4	18.6	20.0	20.0	102.0	93.0	9.2	70 - 130	35	
Vanadium	ND	49.9	49.6	50.0	50.0	99.8	99.2	0.6	70 - 130	35	
Zinc	ND	54.1	62.4	50.0	50.0	108.2	124.8	14.2	70 - 130	35	
Lithium	ND	47.3	47.0	50.0	50.0	94.6	94.0	0.6	70 - 130	35	

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

Units: mg/Kg

MS Anal. Date: 12/3/2007 1:53:00PM MSD Anal. Date: 12/3/2007 1:58:00PM Matrix: Solid

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag	
Aluminum	9,240	13,400	13,700	192	191	2,171.5	2,334.7	2.2	70 - 130	35	*NOTE 2*	*NOTE 2*
Antimony	ND	19.7	18.6	47.9	47.8	41.1	38.9	5.7	70 - 130	35	*lowMS*	*lowMSD*
Arsenic	ND	158	157	192	191	82.5	82.2	0.6	70 - 130	35		
Barium	141	319	320	192	191	92.9	93.7	0.3	70 - 130	35		
Beryllium	0.838	5.47	5.46	4.79	4.78	96.7	96.8	0.2	70 - 130	35		
Boron	10.8	67.1	66.8	47.9	47.8	117.6	117.3	0.4	70 - 130	35		
Cadmium	ND	5.48	5.44	4.79	4.78	114.4	113.9	0.7	70 - 130	35		
Calcium	27,500	25,900	25,900	958	955	-167.0	-167.5	0.0	70 - 130	35	*NOTE 2*	*NOTE 2*
Chromium	6.15	25.8	26.2	19.2	19.1	102.6	105.0	1.5	70 - 130	35		
Cobalt	11.1	54.1	54.3	47.9	47.8	89.8	90.5	0.4	70 - 130	35		
Copper	20.3	42.4	43.0	23.9	23.9	92.3	95.1	1.4	70 - 130	35		
Iron	19,200	18,800	20,200	95.8	95.5	-417.6	1,046.9	7.2	70 - 130	35	*NOTE 2*	*NOTE 2*
Lead	17.0	60.7	61.4	47.9	47.8	91.2	93.0	1.1	70 - 130	35		
Magnesium	3,160	4,370	4,600	1,030	955	117.7	150.8	5.1	70 - 130	35		*highMSD*

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203005**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/4/2007 3:18:00PM

Units: mg/Kg

MS Anal. Date: 12/4/2007 3:28:00PM MSD Anal. Date: 12/4/2007 3:33:00PM

Matrix: Solid

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim		Flag
Manganese	374	431	419	51.4	47.8	110.9	94.2	2.8	70 - 130	35	*NOTE 2*	*NOTE 2*
Molybdenum	ND	43.2	42.4	47.9	47.8	90.2	88.8	1.9	70 - 130	35		
Nickel	14.3	56.9	58.1	47.9	47.8	88.9	91.7	2.1	70 - 130	35		
Potassium	1,880	2,870	2,920	958	955	103.4	108.9	1.7	70 - 130	35		
Selenium	ND	189	187	192	191	98.7	97.9	1.1	70 - 130	35		
Silver	ND	23.6	23.3	23.9	23.9	98.6	97.6	1.3	70 - 130	35		
Sodium	4,090	4,710	5,020	958	955	64.7	97.4	6.4	70 - 130	35	*NOTE 2*	*NOTE 2*
Thallium	ND	13.6	12.1	19.2	19.1	71.0	63.3	11.7	70 - 130	35		*lowMSD*
Vanadium	17.9	67.0	67.8	47.9	47.8	102.5	104.5	1.2	70 - 130	35		
Zinc	59.4	97.6	105	47.9	47.8	79.8	95.5	7.3	70 - 130	35		
Lithium	8.19	58.0	54.6	51.4	47.8	96.9	97.2	6.0	70 - 130	35		

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

Units: mg/Kg

PDS Anal. Date: 12/3/2007 2:18:00PM

Matrix: Solid

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Aluminum	9,240	14,100	206	2,369.3	70 - 130	Note 2
Antimony	ND	20.7	51.4	39.5	70 - 130	lowPDS
Arsenic	ND	168	206	93.7	70 - 130	
Barium	141	334	206	94.1	70 - 130	Note 2
Beryllium	0.838	5.72	5.14	95.0	70 - 130	
Boron	10.8	70.3	51.4	115.6	70 - 130	
Cadmium	ND	5.59	5.14	96.6	70 - 130	
Calcium	27,500	27,300	1,030	-23.3	70 - 130	Note 2
Chromium	6.15	27.1	20.6	102.0	70 - 130	Note 2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203005**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

Units: mg/Kg

PDS Anal. Date: 12/3/2007 2:18:00PM

Matrix: Solid

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Cobalt	11.1	57.0	51.4	89.3	70 - 130	
Copper	20.3	44.2	25.7	93.2	70 - 130	Note 2
Iron	19,200	19,800	103	569.3	70 - 130	Note 2
Lead	17.0	64.3	51.4	92.0	70 - 130	Note 2
Magnesium	3,160	4,600	1,030	139.6	70 - 130	Note 2
Manganese	374	446	51.4	139.5	70 - 130	Note 2
Molybdenum	ND	45.1	51.4	87.9	70 - 130	
Nickel	14.3	59.6	51.4	88.1	70 - 130	Note 2
Potassium	1,880	3,030	1,030	111.8	70 - 130	Note 2
Selenium	ND	203	206	98.3	70 - 130	
Silver	ND	24.9	25.7	98.3	70 - 130	
Sodium	4,090	4,990	1,030	87.3	70 - 130	Note 2
Thallium	ND	13.7	20.6	83.1	70 - 130	
Vanadium	17.9	70.3	51.4	102.0	70 - 130	Note 2
Zinc	59.4	103	51.4	84.3	70 - 130	Note 2
Lithium	8.19	59.1	51.4	99.0	70 - 130	

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

Units: mg/Kg

SER DIL. Date: 12/4/2007 3:59:00PM

Matrix: Solid

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	9,240	7.7	1.9	9,470	39	2.4	
Antimony	ND	11	0.60	ND	53		
Arsenic	ND	13	1.7	ND	63		
Barium	141	0.39	0.030	128	1.9	9.6	
Beryllium	0.838	0.19	0.0085	ND	0.96		
Boron	10.8	4.8	0.65	ND	24		

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203005**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0711172-05A

Prep Date: 12/3/2007

Samp. Anal. Date: 12/3/2007 1:43:00PM

Units: mg/Kg

SER DIL. Date: 12/4/2007 3:59:00PM

Matrix: Solid

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Cadmium	ND	0.77	0.056	ND	3.9		
Calcium	27,500	13	5.1	23,800	67	14.4	OUT
Chromium	6.15	1.9	0.29	ND	9.6		
Cobalt	11.1	2.9	0.25	ND	14		
Copper	20.3	0.58	0.15	16.7	2.9	19.4	OUT
Iron	19,200	5.8	0.42	16,500	29	15.1	OUT
Lead	17.0	5.8	1.0	ND	29		
Magnesium	3,160	9.6	0.92	2,990	48	5.5	
Manganese	374	0.96	0.11	429	4.8	13.7	OUT
Molybdenum	ND	1.9	0.23	ND	9.6		
Nickel	14.3	3.9	0.41	ND	19		
Potassium	1,880	96	30	1,720	480	8.8	
Selenium	ND	9.6	2.4	ND	48		
Silver	ND	1.4	0.15	ND	7.2		
Sodium	4,090	290	0.98	3,400	1,400	18.4	OUT
Thallium	ND	19	1.1	ND	96		
Vanadium	17.9	0.96	0.19	19.6	4.8	9.0	
Zinc	59.4	0.58	0.21	55.1	2.9	7.5	
Lithium	8.19	4.8	0.047	ND	24		

Prep Batch: **T071204013**

SAMPLE DUPLICATE REPORT

Analysis: SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Tot

Base Sample: B0711172-02A

Prep Date: 12/4/2007

Samp. Anal. Date: 12/4/2007 3:25:10PM

Units: mg/Kg

DUP Anal. Date: 12/4/2007 3:33:00PM

Matrix: Solid

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Mercury	0.124	0.134	7.8	35	

LCS/LCSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071204013**

LCS/LCSD REPORT

Analysis: SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Tot | MB: T071204013-MB

Prep Date: 12/4/2007

MB Anal. Date: 12/4/2007 3:00:38PM | Units: mg/Kg

LCS Anal. Date: 12/4/2007 3:08:17PM LCSD Anal. Date: 12/4/2007 3:16:19PM | Matrix: Solid

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.845	0.843	0.833	0.833	101.4	101.2	0.2	70 - 130	35	

MS/MSD REPORT

Analysis: SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Tot | Parent: B0711172-02A

Prep Date: 12/4/2007

Samp. Anal. Date: 12/4/2007 3:25:10PM | Units: mg/Kg

MS Anal. Date: 12/4/2007 3:41:00PM MSD Anal. Date: 12/4/2007 3:49:21PM | Matrix: Solid

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Mercury	0.124	0.966	0.999	0.845	0.873	99.7	100.2	3.4	70 - 130	35	

POST DIGESTION SPIKE REPORT

Analysis: SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Tot | Base Sample: B0711172-02A

Prep Date: 12/4/2007

Samp. Anal. Date: 12/4/2007 3:25:10PM | Units: mg/Kg

PDS Anal. Date: 12/4/2007 3:57:39PM | Matrix: Solid

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Mercury	0.124	1.01	0.876	101.3	80 - 130	

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071207005**

SAMPLE DUPLICATE REPORT

Analysis: ASTM D2216 - Pmoist

Base Sample: B0711172-11A

Prep Date: 12/6/2007

Samp. Anal. Date: 12/7/2007 9:39:41AM

DUP Anal. Date: 12/7/2007 9:39:41AM

Units: %

Matrix: Solid

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Moisture	6.98	6.39	8.8	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0711172
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071130001**

SAMPLE DUPLICATE REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC
Base Sample: B0711172-12B
Prep Date: 11/29/2007
Samp. Anal. Date: 11/29/2007 2:11:40PM
Units: mg/L
DUP Anal. Date: 11/29/2007 2:28:30PM
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Fluoride	2.46	2.45	0.4	30	
Chloride	700	702	0.3	30	
Sulfate	263	263	0.0	30	

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC
MB: T071130001-MB
Prep Date: 11/29/2007
MB Anal. Date: 11/29/2007 1:04:19PM
Units: mg/L
LCS Anal. Date: 11/29/2007 1:21:08PM LCSD Anal. Date: 11/29/2007 1:37:58PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.62	2.55	2.50	2.50	104.8	102.0	2.7	90 - 110	20	
Chloride	ND	5.13	5.12	5.00	5.00	102.6	102.4	0.2	90 - 110	20	
Sulfate	ND	39.0	39.1	37.5	37.5	104.0	104.3	0.3	90 - 110	20	

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC
Parent: B0711172-12B
Prep Date: 11/29/2007
Samp. Anal. Date: 11/29/2007 2:11:40PM
Units: mg/L
MS Anal. Date: 11/29/2007 2:45:21PM
Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Fluoride	2.46	5.28	2.50	112.8	70 - 130		
Chloride	700	845	133	108.8	70 - 130	*NOTE 2*	
Sulfate	263	693	375	114.7	70 - 130		

Prep Batch: **T071203008**

SAMPLE DUPLICATE REPORT

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203008**

SAMPLE DUPLICATE REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Base Sample: B0711172-01B
Prep Date: 11/29/2007

Samp. Anal. Date: 12/4/2007 9:06:42AM
DUP Anal. Date: 12/4/2007 9:06:42AM

Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Total Dissolved Solids	3,070	2,980	3.0	20	

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T071203008-MB
Prep Date: 11/29/2007

MB Anal. Date: 12/4/2007 9:06:42AM
LCS Anal. Date: 12/4/2007 9:06:42AM LCSD Anal. Date: 12/4/2007 9:06:42AM

Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	730	735	744	744	98.1	98.8	0.7	80 - 120	20	

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0711172-01B
Prep Date: 11/29/2007

Samp. Anal. Date: 12/4/2007 9:06:42AM
MS Anal. Date: 12/4/2007 9:06:42AM

Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Total Dissolved Solids	3,070	3,790	744	96.8	70 - 130	*NOTE 2*	

Prep Batch: **T071203004**

SAMPLE DUPLICATE REPORT

Analysis: 150.1 - pH, Elecrometric - pH

Base Sample: B0711172-01B
Prep Date: 11/28/2007

Samp. Anal. Date: 11/28/2007 10:05:27AM
DUP Anal. Date: 11/28/2007 10:05:27AM

Units: pH
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
pH	8.97	8.95	0.2	20	

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0711172

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071203004**

Prep Batch: **T071203006**

SAMPLE DUPLICATE REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

Base Sample: B0711172-01B

Prep Date: 11/29/2007

Samp. Anal. Date: 11/29/2007 10:08:49AM

Units: mg/L

DUP Anal. Date: 11/29/2007 10:08:49AM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Bicarbonate	1,280	1,230	4.0	20	
Carbonate	256	288	11.8	20	

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

MB: T071203006-MB

Prep Date: 11/29/2007

MB Anal. Date: 11/29/2007 10:08:49AM

Units: mg/L

LCS Anal. Date: 11/29/2007 10:08:49AM LCSD Anal. Date: 11/29/2007 10:08:49AM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	24.0	26.0	25.0	25.0	96.0	104.0	8.0	80 - 120	20	
Carbonate	ND	49.0	50.0	50.0	50.0	98.0	100.0	2.0	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 11/29/2007

Lab Method Blank Id: T071130001-MB

Prep Batch ID: T071130001

Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T071130001-LCS	LCS	071129_011.DXD	11/29/2007 1:21:08PM
T071130001-LCSD	LCSD	071129_012.DXD	11/29/2007 1:37:58PM
B0711172-01B	KF2007-01(58) and KF-98-02(53)	071129_013.DXD	11/29/2007 1:54:49PM
B0711172-12B	KF2007-01(58) DUP and KF-98-02(53)DUP	071129_014.DXD	11/29/2007 2:11:40PM
B0711172-12B-DUP	DUP	071129_015.DXD	11/29/2007 2:28:30PM
B0711172-12B-MS	MS	071129_016.DXD	11/29/2007 2:45:21PM
B0711172-12B	KF2007-01(58) DUP and KF-98-02(53)DUP	071129_044.DXD	11/29/2007 10:36:20PM
B0711172-12B-DUP	DUP	071129_045.DXD	11/29/2007 10:53:10PM
B0711172-12B-MS	MS	071129_046.DXD	11/29/2007 11:09:59PM
B0711172-01B	KF2007-01(58) and KF-98-02(53)	071130_007.DXD	11/30/2007 12:00:01PM
B0711172-12B	KF2007-01(58) DUP and KF-98-02(53)DUP	071130_008.DXD	11/30/2007 12:16:51PM
B0711172-12B-DUP	DUP	071130_009.DXD	11/30/2007 12:33:40PM
B0711172-12B-MS	MS	071130_010.DXD	11/30/2007 12:50:29PM

Prep Date: 11/30/2007

Lab Method Blank Id: T071130013-MB

Prep Batch ID: T071130013

Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-01A	KF2007-01(58) and KF-98-02(53)	B113007W.WKS	11/30/2007 4:07:17PM
B0711172-12A	KF2007-01(58) DUP and KF-98-02(53)DUP	B113007W.WKS	11/30/2007 4:09:34PM
J0711112-01B	Batch QC	B113007W.WKS	11/30/2007 4:14:48PM
T071130013-LCS	LCS	B113007W.WKS	11/30/2007 4:02:28PM
T071130013-LCSD	LCSD	B113007W.WKS	11/30/2007 4:05:02PM
J0711112-01B-DUP	DUP	B113007W.WKS	11/30/2007 4:17:01PM
J0711112-01B-MS	MS	B113007W.WKS	11/30/2007 4:19:11PM
J0711112-01B-MSD	MSD	B113007W.WKS	11/30/2007 4:21:35PM
J0711112-01B-PDS	PDS	B113007W.WKS	11/30/2007 4:23:43PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 12/3/2007

Lab Method Blank Id: T071203005-MB
Prep Batch ID: T071203005
Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-02A	123 S 87W 0-4' SPOIL	E12037A	12/3/2007 1:27:00PM
B0711172-03A	123 S 89W 0-4' SPOIL	E12037A	12/3/2007 1:32:00PM
B0711172-04A	125 S 88W 0-4' SPOIL	E12037A	12/3/2007 1:37:00PM
B0711172-05A	120 S 89W 0-4' SPOIL	E12037A	12/3/2007 1:43:00PM
B0711172-06A	Barber Ramp 3 Composite Spoil A	E12037A	12/3/2007 2:28:00PM
B0711172-07A	Barber Ramp 3 Composite Spoil B	E12037A	12/3/2007 2:33:00PM
B0711172-08A	Barber Ramp 3 Composite Spoil C	E12037A	12/3/2007 2:38:00PM
B0711172-09A	Ash Composite 70% FA	E12037A	12/3/2007 2:43:00PM
B0711172-10A	Ash Composite Dup 1 70% FA	E12037A	12/3/2007 2:48:00PM
B0711172-11A	Ash Composite Dup2 70% FA	E12037A	12/3/2007 2:53:00PM
T071203005-LCS	LCS	E12037A	12/3/2007 1:17:00PM
T071203005-LCS	LCS	E12037A	12/3/2007 2:58:00PM
T071203005-LCSD	LCSD	E12037A	12/3/2007 1:22:00PM
B0711172-05A-DUP	DUP	E12037A	12/3/2007 1:48:00PM
B0711172-05A-MS	MS	E12037A	12/3/2007 1:53:00PM
B0711172-05A-MSD	MSD	E12037A	12/3/2007 1:58:00PM
B0711172-05A-PDS	PDS	E12037A	12/3/2007 2:18:00PM
B0711172-02A	123 S 87W 0-4' SPOIL	E12047A	12/4/2007 3:03:00PM
B0711172-03A	123 S 89W 0-4' SPOIL	E12047A	12/4/2007 3:08:00PM
B0711172-04A	125 S 88W 0-4' SPOIL	E12047A	12/4/2007 3:13:00PM
B0711172-05A	120 S 89W 0-4' SPOIL	E12047A	12/4/2007 3:18:00PM
B0711172-06A	Barber Ramp 3 Composite Spoil A	E12047A	12/4/2007 4:04:00PM
B0711172-07A	Barber Ramp 3 Composite Spoil B	E12047A	12/4/2007 4:09:00PM
B0711172-08A	Barber Ramp 3 Composite Spoil C	E12047A	12/4/2007 4:14:00PM
B0711172-09A	Ash Composite 70% FA	E12047A	12/4/2007 4:19:00PM
B0711172-10A	Ash Composite Dup 1 70% FA	E12047A	12/4/2007 4:24:00PM
B0711172-11A	Ash Composite Dup2 70% FA	E12047A	12/4/2007 4:29:00PM
T071203005-LCS	LCS	E12047A	12/4/2007 2:53:00PM
T071203005-LCSD	LCSD	E12047A	12/4/2007 2:58:00PM
B0711172-05A-DUP	DUP	E12047A	12/4/2007 3:23:00PM
B0711172-05A-MS	MS	E12047A	12/4/2007 3:28:00PM
B0711172-05A-MSD	MSD	E12047A	12/4/2007 3:33:00PM
B0711172-05A-PDS	PDS	E12047A	12/4/2007 3:54:00PM

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 11/29/2007

Lab Method Blank Id: T071203006-MB
Prep Batch ID: T071203006
Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-01B	KF2007-01(58) and KF-98-02(53)		11/29/2007 10:08:49AM
B0711172-12B	KF2007-01(58) DUP and KF-98-02(53)DUP		11/29/2007 10:08:49AM
T071203006-LCS	LCS		11/29/2007 10:08:49AM
T071203006-LCSD	LCSD		11/29/2007 10:08:49AM
B0711172-01B-DUP	DUP		11/29/2007 10:08:49AM

Prep Date: 11/29/2007

Lab Method Blank Id: T071203008-MB
Prep Batch ID: T071203008
Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-01B	KF2007-01(58) and KF-98-02(53)		12/4/2007 9:06:42AM
B0711172-12B	KF2007-01(58) DUP and KF-98-02(53)DUP		12/4/2007 9:06:42AM
T071203008-LCS	LCS		12/4/2007 9:06:42AM
T071203008-LCSD	LCSD		12/4/2007 9:06:42AM
B0711172-01B-DUP	DUP		12/4/2007 9:06:42AM
B0711172-01B-MS	MS		12/4/2007 9:06:42AM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 12/3/2007

Lab Method Blank Id: T071203011-MB

Prep Batch ID: T071203011

Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-01A	KF2007-01(58) and KF-98-02(53)	E12037A	12/3/2007 6:01:00PM
B0711172-12A	KF2007-01(58) DUP and KF-98-02(53)DUP	E12037A	12/3/2007 6:06:00PM
F0711221-01A	Batch QC	E12037A	12/3/2007 6:11:00PM
T071203011-LCS	LCS	E12037A	12/3/2007 5:51:00PM
T071203011-LCSD	LCSD	E12037A	12/3/2007 5:56:00PM
F0711221-01A-DUP	DUP	E12037A	12/3/2007 6:16:00PM
F0711221-01A-MS	MS	E12037A	12/3/2007 6:21:00PM
F0711221-01A-MSD	MSD	E12037A	12/3/2007 6:26:00PM
F0711221-01A-PDS	PDS	E12037A	12/3/2007 6:31:00PM
B0711172-01A	KF2007-01(58) and KF-98-02(53)	E12047A	12/4/2007 5:19:00PM
B0711172-12A	KF2007-01(58) DUP and KF-98-02(53)DUP	E12047A	12/4/2007 5:24:00PM
F0711221-01A	Batch QC	E12047A	12/5/2007 9:03:00AM
T071203011-LCS	LCS	E12047A	12/4/2007 5:09:00PM
T071203011-LCSD	LCSD	E12047A	12/4/2007 5:14:00PM
F0711221-01A-DUP	DUP	E12047A	12/5/2007 9:08:00AM
F0711221-01A-MS	MS	E12047A	12/5/2007 9:13:00AM
F0711221-01A-MSD	MSD	E12047A	12/5/2007 9:18:00AM
F0711221-01A-PDS	PDS	E12047A	12/5/2007 9:23:00AM
F0711221-01A-MS	MS	E12057A	12/5/2007 6:20:00PM
F0711221-01A-MSD	MSD	E12057A	12/6/2007 10:14:00AM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 12/4/2007

Lab Method Blank Id: T071204013-MB

Prep Batch ID: T071204013

Method: SW7471A - Mercury in Solid or Semisolid Waste by CVAA - Tot

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-02A	123 S 87W 0-4' SPOIL	B120407S.WKS	12/4/2007 3:25:10PM
B0711172-03A	123 S 89W 0-4' SPOIL	B120407S.WKS	12/4/2007 4:05:31PM
B0711172-04A	125 S 88W 0-4' SPOIL	B120407S.WKS	12/4/2007 4:13:55PM
B0711172-05A	120 S 89W 0-4' SPOIL	B120407S.WKS	12/5/2007 9:42:00AM
B0711172-06A	Barber Ramp 3 Composite Spoil A	B120407S.WKS	12/5/2007 9:49:39AM
B0711172-07A	Barber Ramp 3 Composite Spoil B	B120407S.WKS	12/5/2007 9:57:26AM
B0711172-08A	Barber Ramp 3 Composite Spoil C	B120407S.WKS	12/5/2007 10:05:12AM
B0711172-09A	Ash Composite 70% FA	B120407S.WKS	12/5/2007 10:21:36AM
B0711172-10A	Ash Composite Dup 1 70% FA	B120407S.WKS	12/5/2007 10:31:17AM
B0711172-11A	Ash Composite Dup2 70% FA	B120407S.WKS	12/5/2007 10:40:18AM
T071204013-LCS	LCS	B120407S.WKS	12/4/2007 3:08:17PM
T071204013-LCSD	LCSD	B120407S.WKS	12/4/2007 3:16:19PM
B0711172-02A-DUP	DUP	B120407S.WKS	12/4/2007 3:33:00PM
B0711172-02A-MS	MS	B120407S.WKS	12/4/2007 3:41:00PM
B0711172-02A-MSD	MSD	B120407S.WKS	12/4/2007 3:49:21PM
B0711172-02A-PDS	PDS	B120407S.WKS	12/4/2007 3:57:39PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **81,530** **Lab Project Number:** **B0711172**

Prep Date: 12/6/2007

Lab Method Blank Id: T071207005-MB

Prep Batch ID: T071207005

Method: ASTM D2216 - Pmoist

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0711172-02A	123 S 87W 0-4' SPOIL		12/7/2007 9:39:41AM
B0711172-03A	123 S 89W 0-4' SPOIL		12/7/2007 9:39:41AM
B0711172-04A	125 S 88W 0-4' SPOIL		12/7/2007 9:39:41AM
B0711172-05A	120 S 89W 0-4' SPOIL		12/7/2007 9:39:41AM
B0711172-06A	Barber Ramp 3 Composite Spoil A		12/7/2007 9:39:41AM
B0711172-07A	Barber Ramp 3 Composite Spoil B		12/7/2007 9:39:41AM
B0711172-08A	Barber Ramp 3 Composite Spoil C		12/7/2007 9:39:41AM
B0711172-09A	Ash Composite 70% FA		12/7/2007 9:39:41AM
B0711172-10A	Ash Composite Dup 1 70% FA		12/7/2007 9:39:41AM
B0711172-11A	Ash Composite Dup2 70% FA		12/7/2007 9:39:41AM
B0711172-11A-DUP	DUP		12/7/2007 9:39:41AM

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:
- ND = Not Detected at or above the Reporting Limit
- NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:
- LOW = Recovery is below Lower Control Limit
- HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
- E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:
- B = Analyte was detected in the laboratory method blank
- J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:
- J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
- W = Post digestion spike did not meet criteria
- S = Reported value determined by the Method of Standard Additions (MSA)

Other Flags may be applied. See Case Narrative for Description

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0711172

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0711172

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received		Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received		Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received		Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received		Report to PQL
6010B/3010A (Aqueous) - Total	As Received		Report to PQL
6010B/3050B (Solid) - Total	Dry Weight Basis		Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received		Report to PQL
7471A/7471A (Solid) - Total Hg	Dry Weight Basis		Report to PQL
ASTMD2216/ASTMD2216 (Solid) - Pmoist	As Received		Report to MDL, J qual below PQL

NORWEST
CORPORATION

ATTACHMENT C
Cation Exchange Capacity Laboratory Results

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **123 S 87W 0-4' Spoil (B0711172-2B)**
Sample Date/Time: 11/15/07 12:00 PM

Lab Number: 07112932-01
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.7 meq/100g**	0.1	EPA 9081

ASA - "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison, WI, 1982.
SW-846 - "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA - "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **123 S 89W 0-4' Spoil (B0711172-3B)**
Sample Date/Time: 11/15/07 12:00 PM

Lab Number: 07112932-02
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**8.7 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison. WI. 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID 125 S 88W 0-4' Spoil (B0711172-4B)
Sample Date/Time: 11/15/07 12:00 PM
Lab Number: 07112932-03
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.4 meq/100g**	0.1	EPA 9081

ASA – "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America, Madison, WI. 1982.
SW-846 – "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA – "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **120 S 89W 0-4' Spoil (B0711172-5B)**
Sample Date/Time: 11/15/07 12:00 PM
Lab Number: 07112932-04
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.0 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison, WI. 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

Shane Nielson
DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Barber Ramp 3 Composite Soil A (B0711172**
Sample Date/Time: 11/15/07 12:00 PM
Lab Number: 07112932-05
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.0 meq/100g**	0.1	EPA 9081

ASA – "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America, Madison, WI, 1982.
SW-846 – "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA – "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

Shane Nielson

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Barber Ramp 3 Composite Soil B (B0711172**
Sample Date/Time: 11/15/07 12:00 PM
Lab Number: 07112932-06
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.6 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison, WI, 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman. PN Soltanpour and RH Follett.

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Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Barber Ramp 3 Composite Soil C (B0711172**
Sample Date/Time: 11/15/07 12:00 PM
Lab Number: 07112932-07
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**9.9 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison, WI, 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

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Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Ash Composite 70% FA (B0711172-9B)**
Sample Date/Time: 11/26/07 10:00 AM
Lab Number: 07112932-08
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**0.4 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America. Madison, WI, 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

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Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Ash Composite Dup 1 70% FA (B0711172-10**
Sample Date/Time: 11/26/07 10:00 AM
Lab Number: 07112932-09
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**0.2 meq/100g**	0.1	EPA 9081

ASA – "Methods of Soil Analysis, Parts 1 and 2", Second Edition, American Society of Agronomy and Soil Science Society of America, Madison, WI, 1982.
SW-846 – "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA – "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB88-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

Colorado Analytical Laboratories, Inc.

Analytical Results

Report To: Claire Toon
Company: Analytica Environmental Labs
12189 Pennsylvania Street
Thornton CO 80241-3115

Task No: 07112932
Date Received 11/29/07
Reported: 12/13/07
Client PO: T13190
Client Project: B0711172

Customer Sample ID **Ash Composite Dup 2 70% FA (B0711172-11**
Sample Date/Time: 11/26/07 10:00 AM
Lab Number: 07112932-10
Matrix: Soil - Environmental

Test	Result	Reporting Limit	Method
Dry Weight Basis			
Cation Exchange Capacity	**0.2 meq/100g**	0.1	EPA 9081

ASA = "Methods of Soil Analysis, Parts 1 and 2", Second Edition. American Society of Agronomy and Soil Science Society of America, Madison, WI. 1982.
SW-846 = "Test Methods for Evaluating Solid Waste"; USEPA; November 1986
AB-DTPA = "Soil Testing Methods Used at Colorado State University for the Evaluation of Fertility, Salinity and Trace Element Toxicity"; Colorado State University Technical Bulletin LTB98-2; Jan 1998; SM Workman, PN Soltanpour and RH Follett.

Shane Nielson

DATA APPROVED FOR RELEASE BY

240 South Main Street / Brighton, CO 80601-0507 / 303-659-2313
Mailing Address: P.O. Box 507 / Brighton, CO 80601-0507 / Fax: 303-659-2315

07112932

Analytica Chain of Custody Form

ANALYTICA GROUP

12189 Pennsylvania St. Thornton, CO 80241 (303) 469-8868 (303) 469-5254 fax

4307 Arctic Boulevard Anchorage, AK 99503 (907) 258-2155 (907) 258-6634 fax

475 Hall St. Fairbanks, AK 99701 (907) 456-3116 (907) 456-3125 Fax

5438 Shaune Drive Juneau, AK 99801 (907) 780-6668 (907) 780-6670 fax

Page ____ of ____

Chain of Custody No: 62661

Client Name & Address:

Report to: Claire Toon

Phone No: 303-301-2237

Fax No: above

E-mail: ctoon@analyticagroup.com

Special Instructions/Comments: Sub to CAL

Kit Prep/Shipping Charge: $

Public Water System (PWS) ID#:

Project Name: B0711172

Turnaround Time for Results (TAT)

___ Standard ___ Expedited (< 10 days, prior authorization required) (please specify due date below; add'l charges may apply)

Requested Due Date for Results:

Section To Be Completed by Analytica

Quote ID: LGN:

Account #: Cash Credit Card

Invoice to Name & Address: Same as Client

P.O. or Contract No: T13190

Requested Analysis/Method

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	9081 Cation Exchange Cap.								Field Preserved	Field Filtered	MS/MSD ?
123 S 87 W 0-4' Spoil (B0711172-2B)	11/15/07	12:00	Solid	1	X										
123 S 89 W 0-4' Spoil (3B)	↓	↓	↓	↓	X										
125 S 88 W 0-4' Spoil (4B)					X										
130 S 89 W 0-4' Spoil (5B)					X										
Barber Ramp 3 Composite Spoil A (6B)					X										
Barber Ramp 3 Composite Spoil B (7B)					X										
Barber Ramp 3 Composite Spoil C (8B)					X										
Ash Composite 70% FA (9B)	11/26/07	10:00			X										
Ash Composite Dup1 70% FA (10B)	↓	↓			X										
Ash Composite Dup2 70% FA (11B)			↓	↓	X										

Relinquished by:	Date	Time	Received by:	Date	Time
[signature]	11/29/07	10:00	R. Lopez	11-29-07	1420
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

Name of Sampler: (printed)

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:				
Initialed By:				
Temp/Loc:				
Thermo ID#:				
Shipped Via:				

Version 2.0

ATTACHMENT D
Leachate Water Quality Laboratory Results

ANALYTICA
Environmental Laboratories

Analytica Environmental
Laboratories, Inc.
12189 Pennsylvania Street
Thornton, CO 80241
Phone: 303-469-8868
Fax: 303-469-5254

1/3/2008

Applied Hydrology Associates, Inc.
950 South Cherry Street
Suite 810
Denver, CO 80246
Attn: Art O'Hayre

Work Order #: B0712127
Date: 1/3/2008
Work ID: Navajo Mine Extension Leaching Study
Date Received: 12/17/2007
Proj #: none

Sample Identification

Lab Sample Number	Client Description	Lab Sample Number	Client Description
B0712127-01	MB Leachate 1	B0712127-02	Ash Leachate 1
B0712127-03	Ash Leachate 1 Dup	B0712127-04	Spoil Leachate 1
B0712127-05	Spoil Leachate 1 Dup		

Enclosed are the analytical results for the submitted sample(s). Please review the CASE NARRATIVE for a discussion of any data and/or quality control issues. Listings of data qualifiers, analytical codes, key dates, and QC relationships are provided at the end of the report.

Sincerely,

Claire Toon
Project Manager

"The Science of Analysis, The Art of Service"

Case Narrative

Analytica Environmental Laboratories, Inc.
Work Order: B0712127

Samples were prepared and analyzed according to EPA or equivalent methods outlined in the following references:

Methods for Chemical Analysis of Water and Wastes, USEPA 600/4-79-020,March 1983.

Pfaff, J. D., C. A. Brockhoff and J. W. O'Dell. 1994. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0A. U. S. Environmental Protection Agency. Environmental Monitoring Systems Lab.

Methods for the Determination of Metals in Environmental Samples, EPA/600/R-94/111, May 1994.

SAMPLE RECEIPT:
Five (5) samples were received on 12/17/2007 3:10:00 PM., at a temperature of 20 deg C., at Analytica-Thornton. The samples were received in good condition and in order per chain of custody.

REVIEW FOR COMPLIANCE WITH ANALYTICA QA PLAN
A summary of our review is shown below.

All analytical results contained in this report have been reviewed under Analytica's internal quality assurance and quality control program. Any deviations in quality control parameters for specific analyses are noted in the following text. A complete quality assurance report, including laboratory control, matrix spike, and sample duplicate recoveries is kept on file in our office and is available upon request.

All method specifications were met for the following tests:

Test Method: 150.1 - pH, Elecrometric - pH - Aqueous

Test Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS - Aqueous

Test Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity - Aqueous

Test Method: Inorganic Anions by Ion Chromatography - Anions by IC - Aqueous

Test Method: SW6010B - ICP - Total - Aqueous

MS/MSD and DUP OUTLIERS:
As shown below, the MS/MSD was outside of limits for Sodium. The sample had Sodium concentrations greater than four times the spike amount. In these cases it is not appropriate to calculate a recovery. The result should be used as a replicate.

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MS	MB Leachate 1	B0712127-01A	Sodium	418	75	125	1180	10.0
MSD	MB Leachate 1	B0712127-01A	Sodium	-76.	75	125	1180	10.0

Test Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg - Aqueous

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Leachate 1**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-01A	Analysis Date:	12/18/2007 5:51:20PM
Prep Date:	12/18/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B121807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071218023		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-01A	Analysis Date:	12/19/2007 4:17:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.056**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.12**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.33**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**2.9**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.073**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.2**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.014**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**11**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Leachate 1**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-01A
Prep Date: 12/18/2007
Analytical Method ID: SW6010B - ICP - Total
Prep Method ID: 3010_ICP
Prep Batch Number: T071218012
Report Basis: As Received
Sample prep wt./vol: 50.00 ml

Analysis Date: 12/19/2007 4:17:00PM
Instrument: ICP_2
File Name: E12197A
Dilution Factor: 1
Analyst Initials: rm
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-01B
Prep Date: 12/19/2007
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
Prep Method ID: Alkalinity_W
Prep Batch Number: T071219013
Report Basis: As Received
Sample prep wt./vol: 100.00 ml

Analysis Date: 12/19/2007 2:30:16PM
Instrument: Titrametric
File Name:
Dilution Factor: 1
Analyst Initials: kl
Prep Extract Vol: 100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,300**		mg/L	5.0	1.5	1
Carbonate		**260**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-01B
Prep Date: 12/18/2007
Analytical Method ID: 150.1 - pH, Elecrometric - pH
Prep Method ID: 150.1
Prep Batch Number: T071218019
Report Basis: As Received
Sample prep wt./vol: 10.00 ml

Analysis Date: 12/18/2007 9:45:23AM
Instrument: Probe
File Name:
Dilution Factor: 1
Analyst Initials: kl
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Leachate 1**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-01B
Analysis Date: 12/31/2007 10:51:30AM
Prep Date: 12/21/2007
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Prep Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T071221010
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,000**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-01B
Analysis Date: 12/18/2007 8:44:03PM
Prep Date: 12/18/2007
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 071218_026.D
Prep Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T071218016
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	1
Sulfate		**280**		mg/L	1.5	0.11	

Lab Sample Number: B0712127-01B
Analysis Date: 12/20/2007 5:51:04PM
Prep Date: 12/18/2007
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 071220_003.D
Prep Method ID: 300.0
Dilution Factor: 20
Prep Batch Number: T071218016
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**620**		mg/L	16	0.84	3

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Leachate 1**

Matrix: Aqueous — Collection Date: 12/17/2007 9:40:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-02A	Analysis Date:	12/18/2007 5:58:45PM
Prep Date:	12/18/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B121807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071218023		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-02A	Analysis Date:	12/19/2007 4:58:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.053**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.099**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**2.6**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**570**		mg/L	0.10	0.013	
Chromium	7440-47-3	**0.011**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.13**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**7.7**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.095**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.15**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**0.14**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Leachate 1**

Matrix: Aqueous | Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number:	B0712127-02A	Analysis Date:	12/19/2007 4:58:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.12**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-02B	Analysis Date:	12/19/2007 2:30:16PM
Prep Date:	12/19/2007	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T071219013		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**810**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-02B	Analysis Date:	12/18/2007 9:45:23AM
Prep Date:	12/18/2007	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T071218019		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.7**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: **Client Sample Report**

Client Sample Name: **Ash Leachate 1**

Matrix: Aqueous   Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-02B   Analysis Date: 12/31/2007 10:51:30AM
Prep Date: 12/21/2007   Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS   File Name:
Prep Method ID: 160.1   Dilution Factor: 1
Prep Batch Number: T071221010
Report Basis: As Received   Analyst Initials: kl
Sample prep wt./vol: 100.00 ml   Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**5,400**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-02B   Analysis Date: 12/19/2007 9:50:23AM
Prep Date: 12/18/2007   Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC   File Name: 071218_027.D
Prep Method ID: 300.0   Dilution Factor: 1
Prep Batch Number: T071218016
Report Basis: As Received   Analyst Initials: KB
Sample prep wt./vol: 20.00 ml   Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**5.0**		mg/L	0.40	0.031	1

Lab Sample Number: B0712127-02B   Analysis Date: 12/20/2007 6:27:50PM
Prep Date: 12/18/2007   Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC   File Name: 071220_005.D
Prep Method ID: 300.0   Dilution Factor: 20
Prep Batch Number: T071218016
Report Basis: As Received   Analyst Initials: KB
Sample prep wt./vol: 20.00 ml   Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**620**		mg/L	16	0.84	4
Sulfate		**2,400**		mg/L	30	2.2	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Leachate 1 Dup**

Matrix: Aqueous | Collection Date: 12/17/2007 9:40:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-03A	Analysis Date:	12/18/2007 6:00:49PM
Prep Date:	12/18/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B121807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071218023		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-03A	Analysis Date:	12/19/2007 5:03:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.10**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**2.5**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**560**		mg/L	0.10	0.013	
Chromium	7440-47-3	**0.011**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.13**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**7.6**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.095**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.14**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**0.13**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Leachate 1 Dup**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-03A | Analysis Date: 12/19/2007 5:03:00PM
Prep Date: 12/18/2007 | Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total | File Name: E12197A
Prep Method ID: 3010_ICP | Dilution Factor: 1
Prep Batch Number: T071218012
Report Basis: As Received | Analyst Initials: rm
Sample prep wt./vol: 50.00 ml | Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.12**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-03B | Analysis Date: 12/19/2007 2:30:16PM
Prep Date: 12/19/2007 | Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity | File Name:
Prep Method ID: Alkalinity_W | Dilution Factor: 1
Prep Batch Number: T071219013
Report Basis: As Received | Analyst Initials: kl
Sample prep wt./vol: 100.00 ml | Prep Extract Vol: 100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**820**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-03B | Analysis Date: 12/18/2007 9:45:23AM
Prep Date: 12/18/2007 | Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH | File Name:
Prep Method ID: 150.1 | Dilution Factor: 1
Prep Batch Number: T071218019
Report Basis: As Received | Analyst Initials: kl
Sample prep wt./vol: 10.00 ml | Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.6**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Leachate 1 Dup**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-03B
Prep Date: 12/21/2007
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
Prep Method ID: 160.1
Prep Batch Number: T071221010
Report Basis: As Received
Sample prep wt./vol: 100.00 ml

Analysis Date: 12/31/2007 10:51:30AM
Instrument: SCALE
File Name:
Dilution Factor: 1
Analyst Initials: kl
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**5,400**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-03B
Prep Date: 12/18/2007
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
Prep Method ID: 300.0
Prep Batch Number: T071218016
Report Basis: As Received
Sample prep wt./vol: 20.00 ml

Analysis Date: 12/19/2007 10:08:47AM
Instrument: IC
File Name: 071218_028.D
Dilution Factor: 1
Analyst Initials: KB
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**5.0**		mg/L	0.40	0.031	1

Lab Sample Number: B0712127-03B
Prep Date: 12/18/2007
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
Prep Method ID: 300.0
Prep Batch Number: T071218016
Report Basis: As Received
Sample prep wt./vol: 20.00 ml

Analysis Date: 12/20/2007 5:57:55AM
Instrument: IC
File Name: 071219_058.D
Dilution Factor: 10
Analyst Initials: KB
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**2,500**		mg/L	15	1.1	2

Lab Sample Number: B0712127-03B
Prep Date: 12/18/2007
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
Prep Method ID: 300.0
Prep Batch Number: T071218016
Report Basis: As Received
Sample prep wt./vol: 20.00 ml

Analysis Date: 12/20/2007 7:04:36PM
Instrument: IC
File Name: 071220_007.D
Dilution Factor: 27
Analyst Initials: KB
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	21	1.1	3

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1**

Matrix: Aqueous | Collection Date: 12/17/2007 9:40:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-04A	Analysis Date:	12/18/2007 6:03:02PM
Prep Date:	12/18/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B121807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071218023		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	25.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00024	0.000060	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-04A	Analysis Date:	12/19/2007 5:08:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.29**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.25**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.44**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**64**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.17**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.10**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**13**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.11**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.014**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**14**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1**

Matrix: Aqueous Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-04A Analysis Date: 12/19/2007 5:08:00PM
Prep Date: 12/18/2007 Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total File Name: E12197A
Prep Method ID: 3010_ICP Dilution Factor: 1
Prep Batch Number: T071218012
Report Basis: As Received Analyst Initials: rm
Sample prep wt./vol: 50.00 ml Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-04B Analysis Date: 12/19/2007 2:30:16PM
Prep Date: 12/19/2007 Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity File Name:
Prep Method ID: Alkalinity_W Dilution Factor: 1
Prep Batch Number: T071219013
Report Basis: As Received Analyst Initials: kl
Sample prep wt./vol: 100.00 ml Prep Extract Vol: 100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,000**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-04B Analysis Date: 12/18/2007 9:45:23AM
Prep Date: 12/18/2007 Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH File Name:
Prep Method ID: 150.1 Dilution Factor: 1
Prep Batch Number: T071218019
Report Basis: As Received Analyst Initials: kl
Sample prep wt./vol: 10.00 ml Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**8.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1**

Matrix: Aqueous Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-04B Analysis Date: 12/31/2007 10:51:30AM
Prep Date: 12/21/2007 Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS File Name:
Prep Method ID: 160.1 Dilution Factor: 1
Prep Batch Number: T071221010
Report Basis: As Received Analyst Initials: kl
Sample prep wt./vol: 100.00 ml Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,500**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-04B Analysis Date: 12/19/2007 10:27:11AM
Prep Date: 12/18/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071218_029.D
Prep Method ID: 300.0 Dilution Factor: 1
Prep Batch Number: T071218016
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**1.6**		mg/L	0.40	0.031	1

Lab Sample Number: B0712127-04B Analysis Date: 12/20/2007 6:16:18AM
Prep Date: 12/18/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071219_059.D
Prep Method ID: 300.0 Dilution Factor: 10
Prep Batch Number: T071218016
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**970**		mg/L	15	1.1	2

Lab Sample Number: B0712127-04B Analysis Date: 12/20/2007 7:23:00PM
Prep Date: 12/18/2007 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 071220_008.D
Prep Method ID: 300.0 Dilution Factor: 27
Prep Batch Number: T071218016
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	21	1.1	3

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1 Dup**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-05A	Analysis Date:	12/18/2007 6:05:14PM
Prep Date:	12/18/2007	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B121807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T071218023		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0712127-05A	Analysis Date:	12/19/2007 5:13:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.30**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.20**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.45**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**69**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.18**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.10**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**13**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.10**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.014**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**14**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1 Dup**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-05A
Analysis Date: 12/19/2007 5:13:00PM
Prep Date: 12/18/2007
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E12197A
Prep Method ID: 3010_ICP
Dilution Factor: 1
Prep Batch Number: T071218012
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**0.0095**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-05B
Analysis Date: 12/19/2007 2:30:16PM
Prep Date: 12/19/2007
Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
File Name:
Prep Method ID: Alkalinity_W
Dilution Factor: 1
Prep Batch Number: T071219013
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,000**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-05B
Analysis Date: 12/18/2007 9:45:23AM
Prep Date: 12/18/2007
Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH
File Name:
Prep Method ID: 150.1
Dilution Factor: 1
Prep Batch Number: T071218019
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 10.00 ml
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.9**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Leachate 1 Dup**

Matrix: Aqueous

Collection Date: 12/17/2007 9:40:00AM

Lab Sample Number: B0712127-05B
Analysis Date: 12/31/2007 10:51:30AM
Prep Date: 12/21/2007
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Prep Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T071221010
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,600**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0712127-05B
Analysis Date: 12/19/2007 10:45:34AM
Prep Date: 12/18/2007
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 071218_030.D
Prep Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T071218016
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**1.6**		mg/L	0.40	0.031	1

Lab Sample Number: B0712127-05B
Analysis Date: 12/20/2007 6:34:42AM
Prep Date: 12/18/2007
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 071219_060.D
Prep Method ID: 300.0
Dilution Factor: 10
Prep Batch Number: T071218016
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**990**		mg/L	15	1.1	2

Lab Sample Number: B0712127-05B
Analysis Date: 12/20/2007 7:41:22PM
Prep Date: 12/18/2007
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 071220_009.D
Prep Method ID: 300.0
Dilution Factor: 27
Prep Batch Number: T071218016
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	21	1.1	3

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 12/18/2007 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number: T071218023-MB

Analysis Date: 12/18/2007 5:28:28PM

Prep Date: 12/18/2007

Instrument: CVAA_1

Analytical Method ID: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

File Name: B121807W.W

Prep Method ID: 7470A

Dilution Factor: 1

Prep Batch Number: T071218023

Report Basis: As Received

Analyst Initials: DL

Sample prep wt./vol: 30.00 ml

Prep Extract Vol: 30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: T071218012-MB

Analysis Date: 12/19/2007 3:57:00PM

Prep Date: 12/18/2007

Instrument: ICP_2

Analytical Method ID: SW6010B - ICP - Total

File Name: E12197A

Prep Method ID: 3010_ICP

Dilution Factor: 1

Prep Batch Number: T071218012

Report Basis: As Received

Analyst Initials: rm

Sample prep wt./vol: 50.00 ml

Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**ND**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 12/18/2007 12:00:00AM

Lab Sample Number:	T071218012-MB	Analysis Date:	12/19/2007 3:57:00PM
Prep Date:	12/18/2007	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E12197A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T071218012		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	ND		mg/L	3.0	0.028	1
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071219013-MB	Analysis Date:	12/19/2007 2:30:16PM
Prep Date:	12/19/2007	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T071219013		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		ND		mg/L	5.0	1.5	1
Carbonate		ND		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T071221010-MB	Analysis Date:	12/31/2007 10:51:30AM
Prep Date:	12/21/2007	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T071221010		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		ND		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 12/18/2007 12:00:00AM

Lab Sample Number:	T071218016-MB	Analysis Date:	12/18/2007 6:17:08PM
Prep Date:	12/18/2007	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	071218_018.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T071218016		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	1
Fluoride		**ND**		mg/L	0.40	0.031	
Sulfate		**ND**		mg/L	1.5	0.11	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0712127
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218012**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0712127-01A
Prep Date: 12/18/2007

Samp. Anal. Date: 12/19/2007 4:17:00PM
DUP Anal. Date: 12/19/2007 4:22:00PM
Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.0556	0.211	116.6	20	OUT
Antimony	ND	ND	0.0	20	
Arsenic	ND	ND	0.0	20	
Barium	0.118	0.143	19.2	20	
Beryllium	ND	ND	0.0	20	
Boron	0.331	0.340	2.7	20	
Cadmium	ND	ND	0.0	20	
Calcium	2.89	3.28	12.6	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	0.00726	0.0	20	
Copper	ND	0.00783	0.0	20	
Iron	0.0733	0.313	124.1	20	OUT
Lead	ND	ND	0.0	20	
Magnesium	1.24	1.42	13.5	20	
Manganese	ND	0.0116	0.0	20	
Molybdenum	0.0141	0.0180	24.3	20	OUT
Nickel	ND	ND	0.0	20	
Potassium	11.0	11.6	5.3	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	1,180	1,200	1.7	20	
Thallium	ND	ND	0.0	20	
Vanadium	ND	ND	0.0	20	
Zinc	ND	0.00930	0.0	20	
Lithium	ND	ND	0.0	20	

LCS/LCSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0712127

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218012**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T071218012-MB

Prep Date: 12/18/2007

MB Anal. Date: 12/19/2007 3:57:00PM

Units: mg/L

LCS Anal. Date: 12/19/2007 4:02:00PM

LCSD Anal. Date: 12/19/2007 4:07:00PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	2.06	2.08	2.00	2.00	103.0	104.0	1.0	89 - 117	20	
Antimony	ND	0.487	0.492	0.500	0.500	97.4	98.4	1.0	82 - 117	20	
Arsenic	ND	1.96	1.97	2.00	2.00	98.0	98.5	0.5	86 - 116	20	
Barium	ND	1.95	1.98	2.00	2.00	97.5	99.0	1.5	86 - 116	20	
Beryllium	ND	0.0507	0.0517	0.0500	0.0500	101.4	103.4	2.0	87 - 111	20	
Boron	ND	0.648	0.616	0.500	0.500	129.6	123.2	5.1	76 - 130	20	
Cadmium	ND	0.0434	0.0442	0.0500	0.0500	86.8	88.4	1.8	79 - 113	20	
Calcium	ND	9.92	10.2	10.0	10.0	99.2	102.0	2.8	79 - 119	20	
Chromium	ND	0.200	0.200	0.200	0.200	100.0	100.0	0.0	86 - 117	20	
Cobalt	ND	0.494	0.500	0.500	0.500	98.8	100.0	1.2	82 - 118	20	
Copper	ND	0.244	0.249	0.250	0.250	97.6	99.6	2.0	86 - 117	20	
Iron	ND	1.03	1.07	1.00	1.00	103.0	107.0	3.8	83 - 121	20	
Lead	ND	0.497	0.493	0.500	0.500	99.4	98.6	0.8	83 - 121	20	
Magnesium	ND	10.1	10.2	10.0	10.0	101.0	102.0	1.0	83 - 118	20	
Manganese	ND	0.497	0.505	0.500	0.500	99.4	101.0	1.6	82 - 121	20	
Molybdenum	ND	0.491	0.501	0.500	0.500	98.2	100.2	2.0	82 - 120	20	
Nickel	ND	0.490	0.496	0.500	0.500	98.0	99.2	1.2	84 - 117	20	
Potassium	ND	9.25	8.89	10.0	10.0	92.5	88.9	4.0	74 - 110	20	
Selenium	ND	1.93	1.97	2.00	2.00	96.5	98.5	2.1	87 - 117	20	
Silver	ND	0.256	0.259	0.250	0.250	102.4	103.6	1.2	80 - 127	20	
Sodium	ND	9.79	9.97	10.0	10.0	97.9	99.7	1.8	87 - 113	20	
Thallium	ND	0.199	0.207	0.200	0.200	99.5	103.5	3.9	89 - 113	20	
Vanadium	ND	0.504	0.512	0.500	0.500	100.8	102.4	1.6	87 - 119	20	
Zinc	ND	0.476	0.495	0.500	0.500	95.2	99.0	3.9	81 - 120	20	
Lithium	ND	0.492	0.500	0.500	0.500	98.4	100.0	1.6	80 - 120	20	

MS/MSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0712127

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218012**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0712127-01A

Prep Date: 12/18/2007

Samp. Anal. Date: 12/19/2007 4:17:00PM

Units: mg/L

MS Anal. Date: 12/19/2007 4:27:00PM

MSD Anal. Date: 12/19/2007 4:42:00PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Aluminum	0.0556	2.11	2.04	2.00	2.00	102.7	99.2	3.4	75 - 125	20	
Antimony	ND	0.497	0.482	0.500	0.500	99.4	96.4	3.1	75 - 125	20	
Arsenic	ND	2.04	1.98	2.00	2.00	102.0	99.0	3.0	75 - 125	20	
Barium	0.118	2.03	1.93	2.00	2.00	95.6	90.6	5.1	75 - 125	20	
Beryllium	ND	0.0510	0.0495	0.0500	0.0500	102.0	99.0	3.0	75 - 125	20	
Boron	0.331								75 - 125		
Cadmium	ND	0.0445	0.0459	0.0500	0.0500	89.0	91.8	3.1	75 - 125	20	
Calcium	2.89	12.9	12.7	10.0	10.0	100.1	98.1	1.6	75 - 125	20	
Chromium	ND	0.198	0.196	0.200	0.200	99.0	98.0	1.0	75 - 125	20	
Cobalt	ND	0.490	0.482	0.500	0.500	98.0	96.4	1.6	75 - 125	20	
Copper	ND	0.244	0.234	0.250	0.250	97.6	93.6	4.2	75 - 125	20	
Iron	0.0733	1.05	1.02	1.00	1.00	97.7	94.7	2.9	75 - 125	20	
Lead	ND	0.499	0.484	0.500	0.500	99.8	96.8	3.1	75 - 125	20	
Magnesium	1.24	11.4	10.9	10.0	10.0	101.6	96.6	4.5	75 - 125	20	
Manganese	ND	0.499	0.484	0.500	0.500	99.8	96.8	3.1	75 - 125	20	
Molybdenum	0.0141	0.508	0.496	0.500	0.500	98.8	96.4	2.4	75 - 125	20	
Nickel	ND	0.487	0.478	0.500	0.500	97.4	95.6	1.9	75 - 125	20	
Potassium	11.0	21.0	20.3	10.0	10.0	100.0	93.0	3.4	75 - 125	20	
Selenium	ND	2.03	1.97	2.00	2.00	101.5	98.5	3.0	75 - 125	20	
Silver	ND	0.251	0.245	0.250	0.250	100.4	98.0	2.4	75 - 125	20	
Sodium	1,180	1,230	1,180	10.0	10.0	500.0	0.0	4.1	75 - 125	20	*NOTE 2 NOTE 2*
Thallium	ND		0.167		0.200		83.5		75 - 125	20	
Vanadium	ND	0.509	0.494	0.500	0.500	101.8	98.8	3.0	75 - 125	20	
Zinc	ND	0.492	0.484	0.500	0.500	98.4	96.8	1.6	75 - 125	20	
Lithium	ND	0.578	0.548	0.500	0.500	115.6	109.6	5.3	75 - 125	20	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0712127
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218012**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0712127-01A
Prep Date: 12/18/2007
Samp. Anal. Date: 12/19/2007 4:17:00PM
Units: mg/L
PDS Anal. Date: 12/19/2007 4:48:00PM
Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.0556	2.04	2.00	99.3	75 - 117		
Antimony	ND	0.485	0.500	96.5	75 - 117		
Arsenic	ND	1.99	2.00	99.3	75 - 116		
Barium	0.118	1.93	2.00	90.7	75 - 116		
Beryllium	ND	0.0492	0.0500	98.0	75 - 111		
Cadmium	ND	0.0447	0.0500	89.7	75 - 113		
Calcium	2.89	12.6	10.0	97.4	75 - 119		
Chromium	ND	0.193	0.200	96.4	75 - 117		
Cobalt	ND	0.477	0.500	95.0	75 - 118		
Copper	ND	0.234	0.250	93.4	75 - 117		
Iron	0.0733	1.02	1.00	94.6	75 - 121		
Lead	ND	0.487	0.500	97.1	75 - 121		
Magnesium	1.24	11.0	10.0	97.3	75 - 118		
Manganese	ND	0.482	0.500	95.9	75 - 121		
Molybdenum	0.0141	0.494	0.500	96.1	75 - 120		
Nickel	ND	0.473	0.500	94.4	75 - 117		
Potassium	11.0	20.6	10.0	96.2	75 - 110		
Selenium	ND	1.98	2.00	99.7	75 - 117		
Silver	ND	0.245	0.250	98.4	75 - 127		
Sodium	1,180	1,180	10.0	-54.9	75 - 113	lowPDS	Note 2
Thallium	ND	0.191	0.200	90.7	75 - 113		
Vanadium	ND	0.492	0.500	98.0	75 - 119		
Zinc	ND	0.482	0.500	98.8	75 - 120		
Lithium	ND	0.553	0.500	94.5	75 - 120		

SERIAL DILUTION REPORT

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0712127
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218012**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0712127-01A
Prep Date: 12/18/2007
Samp. Anal. Date: 12/19/2007 4:17:00PM
Units: mg/L
SER DIL. Date: 12/19/2007 4:53:00PM
Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.0556	0.050	0.014	ND	0.25		
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	ND	0.10	0.015	ND	0.50		
Barium	0.118	0.0100	0.00016	0.133	0.050	11.9	OUT
Beryllium	ND	0.0010	0.000060	ND	0.0050		
Boron	0.331	0.050	0.0018	0.365	0.25	9.7	
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	2.89	0.10	0.013	3.32	0.50	13.8	OUT
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	0.0733	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	1.24	0.10	0.012	1.32	0.50	6.2	
Manganese	ND	0.0100	0.00066	ND	0.050		
Molybdenum	0.0141	0.0100	0.0018	ND	0.050		
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	11.0	1.0	0.31	12.1	5.0	9.5	
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	1,180	3.0	0.028	1,310	15	10.4	OUT
Thallium	ND	0.40	0.011	ND	2.0		
Vanadium	ND	0.0100	0.00072	ND	0.050		
Zinc	ND	0.0050	0.0010	ND	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Prep Batch: **T071218023**

LCS/LCSD REPORT

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0712127

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218023**

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

MB: T071218023-MB

Prep Date: 12/18/2007

MB Anal. Date: 12/18/2007 5:28:28PM

Units: mg/L

LCS Anal. Date: 12/18/2007 5:31:45PM LCSD Anal. Date: 12/18/2007 5:33:52PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00218	0.00214	0.00200	0.0020	109.0	107.0	1.9	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0712127

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071218016**

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

MB: T071218016-MB

Prep Date: 12/18/2007

MB Anal. Date: 12/18/2007 6:17:08PM

Units: mg/L

LCS Anal. Date: 12/18/2007 6:35:30PM LCSD Anal. Date: 12/18/2007 6:53:53PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.25	2.29	2.50	2.50	90.0	91.6	1.8	90 - 110	20	
Chloride	ND	4.68	4.68	5.00	5.00	93.6	93.6	0.0	90 - 110	20	
Sulfate	ND	38.6	36.4	37.5	37.5	102.9	97.1	5.9	90 - 110	20	

Prep Batch: **T071221010**

SAMPLE DUPLICATE REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Base Sample: B0712127-01B

Prep Date: 12/21/2007

Samp. Anal. Date: 12/31/2007 10:51:30AM

Units: mg/L

DUP Anal. Date: 12/31/2007 10:51:30AM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Total Dissolved Solids	3,030	3,030	0.0	20	

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T071221010-MB

Prep Date: 12/21/2007

MB Anal. Date: 12/31/2007 10:51:30AM

Units: mg/L

LCS Anal. Date: 12/31/2007 10:51:30AM LCSD Anal. Date: 12/31/2007 10:51:30AM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	742	753	744	744	99.7	101.2	1.5	80 - 120	20	

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0712127-01B

Prep Date: 12/21/2007

Samp. Anal. Date: 12/31/2007 10:51:30AM

Units: mg/L

MS Anal. Date: 12/31/2007 10:51:30AM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Total Dissolved Solids	3,030	3,820	744	106.2	70 - 130	*NOTE 2*	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0712127
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T071221010**

MS REPORT

Prep Batch: **T071218019**

SAMPLE DUPLICATE REPORT

Analysis: 150.1 - pH, Elecrometric - pH
Base Sample: B0712127-01B
Prep Date: 12/18/2007

Samp. Anal. Date: 12/18/2007 9:45:23AM
Units: pH
DUP Anal. Date: 12/18/2007 9:45:23AM
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
pH	9.01	8.95	0.7	20	

Prep Batch: **T071219013**

SAMPLE DUPLICATE REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
Base Sample: B0712127-01B
Prep Date: 12/19/2007

Samp. Anal. Date: 12/19/2007 2:30:16PM
Units: mg/L
DUP Anal. Date: 12/19/2007 2:30:16PM
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Bicarbonate	1,270	1,230	3.2	20	
Carbonate	264	284	7.3	20	

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
MB: T071219013-MB
Prep Date: 12/19/2007

MB Anal. Date: 12/19/2007 2:30:16PM
Units: mg/L
LCS Anal. Date: 12/19/2007 2:30:16PM LCSD Anal. Date: 12/19/2007 2:30:16PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	25.0	25.0	25.0	25.0	100.0	100.0	0.0	80 - 120	20	
Carbonate	ND	51.0	50.0	50.0	50.0	102.0	100.0	2.0	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,236** **Lab Project Number:** **B0712127**

Prep Date: 12/18/2007

Lab Method Blank Id: T071218012-MB

Prep Batch ID: T071218012

Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0712127-01A	MB Leachate 1	E12197A	12/19/2007 4:17:00PM
B0712127-02A	Ash Leachate 1	E12197A	12/19/2007 4:58:00PM
B0712127-03A	Ash Leachate 1 Dup	E12197A	12/19/2007 5:03:00PM
B0712127-04A	Spoil Leachate 1	E12197A	12/19/2007 5:08:00PM
B0712127-05A	Spoil Leachate 1 Dup	E12197A	12/19/2007 5:13:00PM
T071218012-LCS	LCS	E12197A	12/19/2007 4:02:00PM
T071218012-LCSD	LCSD	E12197A	12/19/2007 4:07:00PM
B0712127-01A-DUP	DUP	E12197A	12/19/2007 4:22:00PM
B0712127-01A-MS	MS	E12197A	12/19/2007 4:27:00PM
B0712127-01A-MSD	MSD	E12197A	12/19/2007 4:42:00PM
B0712127-01A-PDS	PDS	E12197A	12/19/2007 4:48:00PM
T071218012-LCSD	LCSD	E12207A	12/20/2007 12:58:00PM

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,236** **Lab Project Number:** **B0712127**

Prep Date: 12/18/2007

Lab Method Blank Id: T071218016-MB
Prep Batch ID: T071218016
Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T071218016-LCS	LCS	071218_019.DXD	12/18/2007 6:35:30PM
T071218016-LCSD	LCSD	071218_020.DXD	12/18/2007 6:53:53PM
B0712136-01C	Batch QC	071218_022.DXD	12/18/2007 7:30:41PM
B0712136-01C-DUP	DUP	071218_023.DXD	12/18/2007 7:49:04PM
B0712136-01C-MS	MS	071218_024.DXD	12/18/2007 8:07:29PM
B0712127-01B	MB Leachate 1	071218_026.DXD	12/18/2007 8:44:03PM
B0712127-02B	Ash Leachate 1	071218_027.DXD	12/19/2007 9:50:23AM
B0712127-03B	Ash Leachate 1 Dup	071218_028.DXD	12/19/2007 10:08:47AM
B0712127-04B	Spoil Leachate 1	071218_029.DXD	12/19/2007 10:27:11AM
B0712127-05B	Spoil Leachate 1 Dup	071218_030.DXD	12/19/2007 10:45:34AM
T071218016-LCS	LCS	071219_049.DXD	12/20/2007 3:12:25AM
T071218016-LCSD	LCSD	071219_050.DXD	12/20/2007 3:30:48AM
B0712136-01C	Batch QC	071219_052.DXD	12/20/2007 4:07:34AM
B0712136-01C-DUP	DUP	071219_053.DXD	12/20/2007 4:25:58AM
B0712136-01C-MS	MS	071219_054.DXD	12/20/2007 4:44:21AM
B0712127-03B	Ash Leachate 1 Dup	071219_058.DXD	12/20/2007 5:57:55AM
B0712127-04B	Spoil Leachate 1	071219_059.DXD	12/20/2007 6:16:18AM
B0712127-05B	Spoil Leachate 1 Dup	071219_060.DXD	12/20/2007 6:34:42AM
B0712127-01B	MB Leachate 1	071220_003.DXD	12/20/2007 5:51:04PM
B0712127-02B	Ash Leachate 1	071220_005.DXD	12/20/2007 6:27:50PM
B0712127-03B	Ash Leachate 1 Dup	071220_007.DXD	12/20/2007 7:04:36PM
B0712127-04B	Spoil Leachate 1	071220_008.DXD	12/20/2007 7:23:00PM
B0712127-05B	Spoil Leachate 1 Dup	071220_009.DXD	12/20/2007 7:41:22PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,236** **Lab Project Number:** **B0712127**

Prep Date: 12/18/2007

Lab Method Blank Id: T071218023-MB
Prep Batch ID: T071218023
Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
J0712041-01B-MS	MS	B1218072.WKS	12/19/2007 12:58:57PM
B0712127-01A	MB Leachate 1	B121807W.WKS	12/18/2007 5:51:20PM
B0712127-02A	Ash Leachate 1	B121807W.WKS	12/18/2007 5:58:45PM
B0712127-03A	Ash Leachate 1 Dup	B121807W.WKS	12/18/2007 6:00:49PM
B0712127-04A	Spoil Leachate 1	B121807W.WKS	12/18/2007 6:03:02PM
B0712127-05A	Spoil Leachate 1 Dup	B121807W.WKS	12/18/2007 6:05:14PM
J0712041-01B	Batch QC	B121807W.WKS	12/18/2007 6:13:47PM
T071218023-LCS	LCS	B121807W.WKS	12/18/2007 5:31:45PM
T071218023-LCSD	LCSD	B121807W.WKS	12/18/2007 5:33:52PM
J0712041-01B-DUP	DUP	B121807W.WKS	12/18/2007 6:15:51PM
J0712041-01B-MSD	MSD	B121807W.WKS	12/18/2007 6:25:46PM
J0712041-01B-PDS	PDS	B121807W.WKS	12/18/2007 6:27:55PM

Prep Date: 12/19/2007

Lab Method Blank Id: T071219013-MB
Prep Batch ID: T071219013
Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0712127-01B	MB Leachate 1		12/19/2007 2:30:16PM
B0712127-02B	Ash Leachate 1		12/19/2007 2:30:16PM
B0712127-03B	Ash Leachate 1 Dup		12/19/2007 2:30:16PM
B0712127-04B	Spoil Leachate 1		12/19/2007 2:30:16PM
B0712127-05B	Spoil Leachate 1 Dup		12/19/2007 2:30:16PM
T071219013-LCS	LCS		12/19/2007 2:30:16PM
T071219013-LCSD	LCSD		12/19/2007 2:30:16PM
B0712127-01B-DUP	DUP		12/19/2007 2:30:16PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,236** **Lab Project Number:** **B0712127**

Prep Date: 12/21/2007

Lab Method Blank Id: T071221010-MB

Prep Batch ID: T071221010

Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0712127-01B	MB Leachate 1		12/31/2007 10:51:30AM
B0712127-02B	Ash Leachate 1		12/31/2007 10:51:30AM
B0712127-03B	Ash Leachate 1 Dup		12/31/2007 10:51:30AM
B0712127-04B	Spoil Leachate 1		12/31/2007 10:51:30AM
B0712127-05B	Spoil Leachate 1 Dup		12/31/2007 10:51:30AM
T071221010-LCS	LCS		12/31/2007 10:51:30AM
T071221010-LCSD	LCSD		12/31/2007 10:51:30AM
B0712127-01B-DUP	DUP		12/31/2007 10:51:30AM
B0712127-01B-MS	MS		12/31/2007 10:51:30AM

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:

ND = Not Detected at or above the Reporting Limit
NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:

LOW = Recovery is below Lower Control Limit
HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:

B = Analyte was detected in the laboratory method blank
J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:

J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
W = Post digestion spike did not meet criteria
S = Reported value determined by the Method of Standard Additions (MSA)

Several ways of defining the limit of detection and quantitation are prevalent in the laboratory industry and may appear in Analytica reports. These include the following:

MRL = "minimum reporting level", from the EPA Safe Drinking Water program (SDW)
PQL = "practical quantitation limit", from SW-846
EQL = "estimated quantitation limit", from SW-846
LOQ = "limit of quantitation", from a number of authoritative sources

In Analytica's work, all of these terms have the same meaning, equivalent to the EPA definition of the MRL. This reporting level is supported by a satisfactory calibration data point which is at that level or lower, and also is supported by a method detection limit (MDL) determined by the procedure in 40CFR. The MDL is lower than the MRL and represents an estimate of the level where positive detections have a 99% probability of being real, but where quantitation accuracy is unknown.

The MRL as defined by Analytica is the lowest demonstrated point of known quantitation accuracy.
The MRL should not be confused with the MCL, which is the EPA-defined "maximum contaminant level" allowed for certain regulated targets under specific regulations, such as the National Primary Drinking Water Regulations. Normally, the MRL is set at a level which is much lower than the MCL in order to ensure that levels are well below those limits. Not all target analytes have MCL levels established.

Other Flags may be applied. See Case Narrative for Description

Workorder (SDG): B0712127

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0712127

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received	2	Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received	2	Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received	2	Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received	2	Report to PQL
6010B/3010A (Aqueous) - Total	As Received	2	Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received	2	Report to PQL

Analytica Chain of Custody Form

ANALYTICA GROUP®

12189 Pennsylvania St. Thornton, CO 80241 (303) 469-8868 (303) 469-5254 fax	4307 Arctic Boulevard Anchorage, AK 99503 (907) 258-2155 (907) 258-6634 fax	475 Hall St. Fairbanks, AK 99701 (907) 456 - 3116 (907) 456-3125 Fax	5438 Shaune Drive Juneau, AK 99801 (907) 780-6668 (907) 780-6670 fax

Page ____ of ____

Chain of Custody No: 62854

Client Name & Address: Applied Hydrology Associates, Inc.

Public Water System (PWS) ID#:

Project Name: Navajo Mine Extension Leaching Study

Section To be Completed by Analytica

Quote ID:
LGN: B0712127
Account #: 030188 | Cash | Credit Card

Report to:

Phone No:

Fax No:

E-mail:

Turnaround Time for Results (TAT)

___ Standard ___ **Expedited** (< 10 days, prior authorization required) *(please specify due date below; add'l charges may apply)*

Requested Due Date for Results:

Invoice to Name & Address:

Special Instructions/Comments:
Tumbled in house by R.S.
Duplicate 18 hour tumble step 1

P.O. or Contract No:

Kit Prep/Shipping Charge: $

Requested Analysis/Method

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	6010B/3010A - TTL (Lot #: Pres:)	7470A/7470A - Hg (Lot #: Pres:)	150.1 pH (Lot #: Pres:)	160.1 TDS (Lot #: Pres:)	300.0 Anions/IC (Lot #: Pres:)	310.1 Alk (Lot #: Pres:)	(Lot #: Pres:)	Field Preserved	Field Filtered	MS/MSD ?
MB Leachate 1	12/17/07	0940	other	2	X	X	X	X	X	X				
Ash leachate 1	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓				
Ash Leachate 1 Dup	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓				
Spoil leachate 1	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓				
Spoil leachate 1 Dup	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓				

Relinquished by:	Date	Time	Received by:	Date	Time
R. Seeman	12/17/07	1510	[illegible]	12/17/07	15:10
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time
Name of Sampler: (printed)					

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:				
Initialed By:				
Temp/Loc:				
Thermo ID#:				
Shipped Via:				

Version 2.0

ANALYTICA

Cooler Receipt Form

Client: Applied Hydrology Associates **Client Code:** 030188 **Order #:** B0712127
Project: Navajo Mine Extension Leaching Study

Cooler ID: 1

A. Preliminary Examination Phase:

Date cooler opened: 12/17/2007
Cooler opened by: gp **Signature:** GP

1. **Was airbill Attached?** N/A **Airbill #:** **Carrier Name:** Other
2. **Custody Seals?** N/A **How many?** 0 **Location:** **Seal Name:**
3. **Seals intact?** N/A
4. **COC Attached?** Yes **Properly Completed?** Yes **Signed by AEL employee?** Yes
5. **Project Identification from custody paper:** Navajo Mine Extension Leaching Study
6. **Preservative:** None **Temperature:** 20.0 **deg. C**

Designated person initial here to acknowledge receipt: GP **Date:** 12/17/07

COMMENTS:

B. Log-In Phase: **Samples Log-in Date:** 12/17/2007 **Log-in By:** gp

1. **Packing Type:** Other
2. **Were samples in separate bags?** N/A
3. **Were containers intact?** Yes **Labels agree with COC?** Yes
4. **Number of bottles received:** 10 **Number of samples received:** 5
5. **Correct containers used?** Yes **Correct preservatives added?** Yes
6. **Sufficient sample volume?** Yes
7. **Bubbles in VOA samples?** N/A
8. **Was Project manager called and status discussed?** No
9. **Was anyone called?** No **Who was called?** ______ **By whom?** ______ **Date:** ______

COMMENTS:

The Analytica Group
CLIENT INVOICE

Remit to:	Accounting Dpt Analytica Environmental Laboratories, Inc. P.O. Box 973426 Dallas,TX 75397-3426	**Invoice #:**	**81993**
		Work Order#:	**B0801027**
		Account#:	030188
		Quote ID#:	11340
		Invoice Date:	1/21/2008
		Work ID:	Navajo Mine Extension Leaching Study
Phone:	(303) 469-8868	**PO #:**	none
Attention:	Mr.Art O'Hayre	**Received:**	1/7/2008
Invoice to:	Applied Hydrology Associates, Inc. 950 South Cherry Street Suite 810 Denver, CO 80246	**Reported:**	1/21/2008
		Client Project#:	Navajo Mine Extension Leach

Comments:

Item charges		**Qty**	**Price**	**Total**
SW7470A - Mercury in Liquid Waste by CVAA - Total Hg In Aqueous	M	2	35.00	70.00
160.1 - Total Dissolved Solids dried at 180°C - TDS In Liquid	Matrix	2	22.00	44.00
150.1 - pH, Elecrometric - pH In Liquid	Matrix	2	10.00	20.00
SW6010B - ICP - Total In Aqueous	Matrix	2	312.00	624.00
Inorganic Anions by Ion Chromatography - Anions by IC In Liquid	Matrix	2	54.00	108.00
310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity In Liquid	Matrix	2	36.00	72.00
	Total of Items Above:			**$938.00**

Adjustments or Special Services	**Qty**	**Price**	**Total**
One Gallon of DI water	4	24.00	96.00
Tumbling Charge	1	95.00	95.00
Total of Items Above:			**$191.00**
Grand Total:			**$1,129.00**

All invoices are due and payable upon receipt. Outstanding balances over 30 days are subject to a finance charge of 1.5% per month, plus a late fee of $25.00. If Analytica engages legal counsel to enforce its rights or any other rights under an application for payment, the customer will be liable to Analytica for all costs of collection and other legal expenses, including reasonable attorney fees.

The Analytica Group
CLIENT INVOICE

REMITTANCE ADVICE
PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

Mr.Art O'Hayre		**Account#:**	030188
Applied Hydrology Associates, Inc.		**Invoice #:**	**81993**
950 South Cherry Street		**Invoice Date:**	1/21/2008

Suite 810
Denver, CO 80246

TOTAL INVOICE AMOUNT: **$1,129.00**

PAYMENT AMOUNT ENCLOSED: ______________________

Analytica Environmental
Laboratories, Inc.
12189 Pennsylvania Street
Thornton, CO 80241
Phone: 303-469-8868
Fax: 303-469-5254

ANALYTICA
Environmental Laboratories

1/21/2008

Applied Hydrology Associates, Inc.
950 South Cherry Street
Suite 810
Denver, CO 80246
Attn: Art O'Hayre

Work Order #: B0801027
Date: 1/21/2008
Work ID: Navajo Mine Extension Leaching Study
Date Received: 1/7/2008
Proj #: none

Sample Identification

Lab Sample Number	Client Description	Lab Sample Number	Client Description
B0801027-01	MB	B0801027-02	4 Corners PP Bottom Ash Leac

Enclosed are the analytical results for the submitted sample(s). Please review the CASE NARRATIVE for a discussion of any data and/or quality control issues. Listings of data qualifiers, analytical codes, key dates, and QC relationships are provided at the end of the report.

Sincerely,

Kristen Stone
Project Manager

"The Science of Analysis, The Art of Service"

Case Narrative

Analytica Environmental Laboratories, Inc.
Work Order: B0801027

Samples were prepared and analyzed according to EPA or equivalent methods outlined in the following references:

Methods for Chemical Analysis of Water and Wastes, USEPA 600/4-79-020, March 1983.

Pfaff, J. D., C. A. Brockhoff and J. W. O'Dell. 1994. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0A. U. S. Environmental Protection Agency. Environmental Monitoring Systems Lab.

Methods for the Determination of Metals in Environmental Samples, EPA/600/R-94/111, May 1994.

SAMPLE RECEIPT:
Two (2) samples were received on 1/7/2008 1:55:00 PM., at a temperature of 3.1 deg C., at Analytica-Thornton. The samples were received in good condition and in order per chain of custody. The samples were tumbled upon arrival to the laboratory.

REVIEW FOR COMPLIANCE WITH ANALYTICA QA PLAN
A summary of our review is shown below.

All analytical results contained in this report have been reviewed under Analytica's internal quality assurance and quality control program. Any deviations in quality control parameters for specific analyses are noted in the following text. A complete quality assurance report, including laboratory control, matrix spike, and sample duplicate recoveries is kept on file in our office and is available upon request.

All method specifications were met for the following tests:

Test Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg - Aqueous
Test Method: 150.1 - pH, Elecrometric - pH - Aqueous
Test Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS - Aqueous
Test Method: Inorganic Anions by Ion Chromatography - Anions by IC - Aqueous

Test Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity - Aqueous

MS/MSD and DUP OUTLIERS:
As shown below, the MS was outside of limits for Bicarbonate and Carbonate. Bicarbonate had a sample concentration that was greater than four times the spike amount. In these cases it is not appropriate to calculate a recovery. The result should be used as a replicate. The MS recovery of Carbonate was slightly low. No corrective action was taken, as the recoveries of this compounds in the LCS/LCSD were acceptable.

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MS	4 Corners PP Bot	B0801027-02B	Bicarbonate	56.0	70	130	1250	50.0
MS	4 Corners PP Bot	B0801027-02B	Carbonate	68.0	70	130	228	100

Test Method: SW6010B - ICP - Total - Aqueous

MS/MSD and DUP OUTLIERS:

As shown below, the MS/MSD were outside of the limits for Sodium. Sodium had a sample concentration that was greater than four times the spike amount. In these cases it is not appropriate to calculate a recovery. The result should be used as a replicate. The MSD recovery of Potassium is slightly low. No corrective action was taken, as the recovery of Pottasium in the LCS/LCSD/MS were acceptable.

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MS	4 Corners PP Bot	B0801027-02A	Sodium	-149	75	125	1130	10.0
MSD	4 Corners PP Bot	B0801027-02A	Potassium	71.2	75	125	10.9	10.0
MSD	4 Corners PP Bot	B0801027-02A	Sodium	-607	75	125	1130	10.0

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 1/4/2008 1:20:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-01A	Analysis Date:	1/8/2008 5:17:11PM
Prep Date:	1/8/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B010807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080108012		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-01A	Analysis Date:	1/8/2008 7:53:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01088A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.058**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.088**		mg/L	0.010	0.00016	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**2.4**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**0.0073**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.2**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**11**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB**

Matrix: Aqueous Collection Date: 1/4/2008 1:20:00PM

Lab Sample Number: B0801027-01A Analysis Date: 1/8/2008 7:53:00PM
Prep Date: 1/8/2008 Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total File Name: E01088A
Prep Method ID: 3010_ICP Dilution Factor: 1
Prep Batch Number: T080108015
Report Basis: As Received Analyst Initials: rm
Sample prep wt./vol: 50.00 ml Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	1

Lab Sample Number: B0801027-01A Analysis Date: 1/9/2008 1:35:00PM
Prep Date: 1/8/2008 Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total File Name: E01098A
Prep Method ID: 3010_ICP Dilution Factor: 1
Prep Batch Number: T080108015
Report Basis: As Received Analyst Initials: rm
Sample prep wt./vol: 50.00 ml Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	2
Boron	7440-42-8	**0.35**		mg/L	0.050	0.0018	
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-01B Analysis Date: 1/17/2008 2:31:55PM
Prep Date: 1/17/2008 Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity File Name:
Prep Method ID: Alkalinity_W Dilution Factor: 1
Prep Batch Number: T080117013
Report Basis: As Received Analyst Initials: kl
Sample prep wt./vol: 50.00 ml Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,300**		mg/L	5.0	1.5	1
Carbonate		**220**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-01B Analysis Date: 1/5/2008 9:29:27AM
Prep Date: 1/5/2008 Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH File Name:
Prep Method ID: 150.1 Dilution Factor: 1
Prep Batch Number: T080117001
Report Basis: As Received Analyst Initials: rs
Sample prep wt./vol: 10.00 ml Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB**

Matrix: Aqueous | Collection Date: 1/4/2008 1:20:00PM

Lab Sample Number: B0801027-01B | Analysis Date: 1/5/2008 9:29:27AM
Prep Date: 1/5/2008 | Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH | File Name:
Prep Method ID: 150.1 | Dilution Factor: 1
Prep Batch Number: T080117001
Report Basis: As Received | Analyst Initials: rs
Sample prep wt./vol: 10.00 ml | Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-01B | Analysis Date: 1/16/2008 1:50:18PM
Prep Date: 1/11/2008 | Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS | File Name:
Prep Method ID: 160.1 | Dilution Factor: 1
Prep Batch Number: T080111013
Report Basis: As Received | Analyst Initials: KLibhart
Sample prep wt./vol: 100.00 ml | Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-01B | Analysis Date: 1/8/2008 2:44:31AM
Prep Date: 1/7/2008 | Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC | File Name: 080107_047.D
Prep Method ID: 300.0 | Dilution Factor: 25
Prep Batch Number: T080107001
Report Basis: As Received | Analyst Initials: CS
Sample prep wt./vol: 20.00 ml | Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**630**		mg/L	20	1.1	1

Lab Sample Number: B0801027-01B | Analysis Date: 1/8/2008 3:21:16AM
Prep Date: 1/7/2008 | Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC | File Name: 080107_049.D
Prep Method ID: 300.0 | Dilution Factor: 1
Prep Batch Number: T080107001
Report Basis: As Received | Analyst Initials: CS
Sample prep wt./vol: 20.00 ml | Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	3
Sulfate		**280**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **4 Corners PP Bottom Ash Leachate**

Matrix: Aqueous

Collection Date: 1/4/2008 1:20:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-02A	Analysis Date:	1/8/2008 5:19:17PM
Prep Date:	1/8/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B010807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080108012		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-02A	Analysis Date:	1/8/2008 7:58:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01088A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.20**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.13**		mg/L	0.010	0.00016	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.1**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.054**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.3**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**11**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	
Sodium	7440-23-5	**1,100**		mg/L	3.0	0.028	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: **Client Sample Report**

Client Sample Name: **4 Corners PP Bottom Ash Leachate**

Matrix: Aqueous

Collection Date: 1/4/2008 1:20:00PM

Lab Sample Number:	B0801027-02A	Analysis Date:	1/8/2008 7:58:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01088A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	1

Lab Sample Number:	B0801027-02A	Analysis Date:	1/9/2008 1:40:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01098A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	3
Boron	7440-42-8	**0.39**		mg/L	0.050	0.0018	
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-02B	Analysis Date:	1/17/2008 2:31:55PM
Prep Date:	1/17/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080117013		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,300**		mg/L	5.0	1.5	1
Carbonate		**230**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801027-02B	Analysis Date:	1/5/2008 9:29:27AM
Prep Date:	1/5/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080117001		
Report Basis:	As Received	Analyst Initials:	rs
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: **Client Sample Report**

Client Sample Name: **4 Corners PP Bottom Ash Leachate**

Matrix: Aqueous

Collection Date: 1/4/2008 1:20:00PM

Lab Sample Number: B0801027-02B
Analysis Date: 1/5/2008 9:29:27AM
Prep Date: 1/5/2008
Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH
File Name:
Prep Method ID: 150.1
Dilution Factor: 1
Prep Batch Number: T080117001
Report Basis: As Received
Analyst Initials: rs
Sample prep wt./vol: 10.00 ml
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-02B
Analysis Date: 1/16/2008 1:50:18PM
Prep Date: 1/11/2008
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Prep Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T080111013
Report Basis: As Received
Analyst Initials: KLibhart
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801027-02B
Analysis Date: 1/8/2008 3:58:04AM
Prep Date: 1/7/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080107_051.D
Prep Method ID: 300.0
Dilution Factor: 25
Prep Batch Number: T080107001
Report Basis: As Received
Analyst Initials: CS
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**630**		mg/L	20	1.1	1

Lab Sample Number: B0801027-02B
Analysis Date: 1/8/2008 4:34:49AM
Prep Date: 1/7/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080107_053.D
Prep Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T080107001
Report Basis: As Received
Analyst Initials: CS
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	3
Sulfate		**280**		mg/L	1.5	0.11	

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous Collection Date: 1/8/2008 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080108012-MB	Analysis Date:	1/8/2008 5:04:24PM
Prep Date:	1/8/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B010807W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080108012		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.00020	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080108015-MB	Analysis Date:	1/8/2008 7:38:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01088A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**ND**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	
Sodium	7440-23-5	**ND**		mg/L	3.0	0.028	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous Collection Date: 1/8/2008 12:00:00AM

Lab Sample Number:	T080108015-MB	Analysis Date:	1/8/2008 7:38:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01088A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	1

Lab Sample Number:	T080108015-MB	Analysis Date:	1/9/2008 1:05:00PM
Prep Date:	1/8/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01098A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080108015		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	2
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080117013-MB	Analysis Date:	1/17/2008 2:31:55PM
Prep Date:	1/17/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080117013		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**ND**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080111013-MB	Analysis Date:	1/16/2008 1:50:18PM
Prep Date:	1/11/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080111013		
Report Basis:	As Received	Analyst Initials:	KLibhart
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous | Collection Date: 1/11/2008 12:00:00AM

Lab Sample Number:	T080111013-MB	Analysis Date:	1/16/2008 1:50:18PM
Prep Date:	1/11/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080111013		
Report Basis:	As Received	Analyst Initials:	KLibhart
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**ND**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080107001-MB	Analysis Date:	1/8/2008 12:12:51PM
Prep Date:	1/7/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080108_009.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080107001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**ND**		mg/L	1.5	0.11	2

Lab Sample Number:	T080107001-MB	Analysis Date:	1/9/2008 3:32:33AM
Prep Date:	1/7/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080108_059.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080107001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**ND**		mg/L	0.40	0.031	3

Lab Sample Number:	T080107001-MB	Analysis Date:	1/10/2008 9:49:26PM
Prep Date:	1/7/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080110_032.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080107001		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	4

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0801027
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108015**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0801027-02A
Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 7:58:00PM
DUP Anal. Date: 1/8/2008 8:03:00PM
Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.198	0.205	3.5	20	
Antimony	ND	ND	0.0	20	
Arsenic	ND	ND	0.0	20	
Barium	0.127	0.128	0.8	20	
Beryllium	ND	ND	0.0	20	
Boron	0.390	0.386	1.0	20	
Cadmium	ND	ND	0.0	20	
Calcium	3.11	3.12	0.3	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	ND	0.0	20	
Copper	ND	ND	0.0	20	
Iron	0.0542	0.0637	16.1	20	
Lead	ND	ND	0.0	20	
Magnesium	1.32	1.33	0.8	20	
Manganese	ND	ND	0.0	20	
Molybdenum	ND	ND	0.0	20	
Nickel	ND	ND	0.0	20	
Potassium	10.9	11.2	2.7	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	1,130	1,140	0.9	20	
Thallium	ND	ND	0.0	20	
Vanadium	ND	ND	0.0	20	
Zinc	ND	ND	0.0	20	
Lithium	ND	ND	0.0	20	

LCS/LCSD REPORT

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108015**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T080108015-MB

Prep Date: 1/8/2008

MB Anal. Date: 1/8/2008 7:38:00PM

Units: mg/L

LCS Anal. Date: 1/8/2008 7:43:00PM LCSD Anal. Date: 1/8/2008 7:48:00PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	1.83	1.85	2.00	2.00	91.5	92.5	1.1	89 - 117	20	
Antimony	ND	0.433	0.446	0.500	0.500	86.6	89.2	3.0	82 - 117	20	
Arsenic	ND	1.77	1.78	2.00	2.00	88.5	89.0	0.6	86 - 116	20	
Barium	ND	1.84	1.86	2.00	2.00	92.0	93.0	1.1	86 - 116	20	
Beryllium	ND	0.0507	0.0505	0.0500	0.0500	101.4	101.0	0.4	87 - 111	20	
Boron	ND	0.509	0.507	0.500	0.500	101.8	101.4	0.4	76 - 130	20	
Cadmium	ND	0.0475	0.0471	0.0500	0.0500	95.0	94.2	0.8	79 - 113	20	
Calcium	ND	8.53	8.99	10.0	10.0	85.3	89.9	5.3	79 - 119	20	
Chromium	ND	0.178	0.184	0.200	0.200	89.0	92.0	3.3	86 - 117	20	
Cobalt	ND	0.436	0.443	0.500	0.500	87.2	88.6	1.6	82 - 118	20	
Copper	ND	0.234	0.237	0.250	0.250	93.6	94.8	1.3	86 - 117	20	
Iron	ND	0.913	0.952	1.00	1.00	91.3	95.2	4.2	83 - 121	20	
Lead	ND	0.442	0.454	0.500	0.500	88.4	90.8	2.7	83 - 121	20	
Magnesium	ND	9.31	9.42	10.0	10.0	93.1	94.2	1.2	83 - 118	20	
Manganese	ND	0.444	0.451	0.500	0.500	88.8	90.2	1.6	82 - 121	20	
Molybdenum	ND	0.431	0.435	0.500	0.500	86.2	87.0	0.9	82 - 120	20	
Nickel	ND	0.434	0.440	0.500	0.500	86.8	88.0	1.4	84 - 117	20	
Potassium	ND	9.01	8.87	10.0	10.0	90.1	88.7	1.6	74 - 110	20	
Selenium	ND	1.78	1.84	2.00	2.00	89.0	92.0	3.3	87 - 117	20	
Silver	ND	0.244	0.246	0.250	0.250	97.6	98.4	0.8	80 - 127	20	
Sodium	ND	9.55	10.6	10.0	10.0	95.5	106.0	10.4	87 - 113	20	
Thallium	ND	0.198	0.218	0.200	0.200	99.0	109.0	9.6	89 - 113	20	
Vanadium	ND	0.450	0.456	0.500	0.500	90.0	91.2	1.3	87 - 119	20	
Zinc	ND	0.436	0.473	0.500	0.500	87.2	94.6	8.1	81 - 120	20	
Lithium	ND	0.490	0.497	0.500	0.500	98.0	99.4	1.4	80 - 120	20	

MS/MSD REPORT

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108015**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 7:58:00PM

Units: mg/L

MS Anal. Date: 1/8/2008 8:23:00PM MSD Anal. Date: 1/8/2008 8:28:00PM Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Aluminum	0.198	1.73	1.94	2.00	2.00	76.6	87.1	11.4	75 - 125	20	
Antimony	ND	0.378	0.430	0.500	0.500	75.6	86.0	12.9	75 - 125	20	
Arsenic	ND	1.54	1.73	2.00	2.00	77.0	86.5	11.6	75 - 125	20	
Barium	0.127	2.08	1.83	2.00	2.00	97.7	85.2	12.8	75 - 125	20	
Beryllium	ND	0.0499	0.0498	0.0500	0.0500	99.8	99.6	0.2	75 - 125	20	
Boron	0.390	0.870	0.869	0.500	0.500	96.0	95.8	0.1	75 - 125	20	
Cadmium	ND	0.0410	0.0413	0.0500	0.0500	82.0	82.6	0.7	75 - 125	20	
Calcium	3.11	13.1	11.0	10.0	10.0	99.9	78.9	17.4	75 - 125	20	
Chromium	ND	0.192	0.166	0.200	0.200	96.0	83.0	14.5	75 - 125	20	
Cobalt	ND	0.475	0.410	0.500	0.500	95.0	82.0	14.7	75 - 125	20	
Copper	ND	0.196	0.221	0.250	0.250	78.4	88.4	12.0	75 - 125	20	
Iron	0.0542	0.819	0.905	1.00	1.00	76.5	85.1	10.0	75 - 125	20	
Lead	ND	0.376	0.414	0.500	0.500	75.2	82.8	9.6	75 - 125	20	
Magnesium	1.32	8.91	9.93	10.0	10.0	75.9	86.1	10.8	75 - 125	20	
Manganese	ND	0.379	0.422	0.500	0.500	75.8	84.4	10.7	75 - 125	20	
Molybdenum	ND	0.377	0.423	0.500	0.500	75.4	84.6	11.5	75 - 125	20	
Nickel	ND	0.481	0.409	0.500	0.500	96.2	81.8	16.2	75 - 125	20	
Potassium	10.9	19.0	18.0	10.0	10.0	81.0	71.0	5.4	75 - 125	20	*lowMSD*
Selenium	ND	1.56	1.75	2.00	2.00	78.0	87.5	11.5	75 - 125	20	
Silver	ND	0.207	0.229	0.250	0.250	82.8	91.6	10.1	75 - 125	20	
Sodium	1,130	984	1,070	10.0	10.0	-1,460.0	-600.0	8.4	75 - 125	20	*NOTE 2 NOTE 2*
Thallium	ND	0.187	0.174	0.200	0.200	93.5	87.0	7.2	75 - 125	20	
Vanadium	ND	0.381	0.429	0.500	0.500	76.2	85.8	11.9	75 - 125	20	
Zinc	ND	0.383	0.424	0.500	0.500	76.6	84.8	10.2	75 - 125	20	
Lithium	ND	0.465	0.524	0.500	0.500	93.0	104.8	11.9	75 - 125	20	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0801027
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108015**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0801027-02A
Prep Date: 1/8/2008
Samp. Anal. Date: 1/8/2008 7:58:00PM
Units: mg/L
PDS Anal. Date: 1/8/2008 8:33:00PM
Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.198	1.98	2.00	88.9	75 - 117		
Antimony	ND	0.438	0.500	87.0	75 - 117		
Arsenic	ND	1.78	2.00	88.8	75 - 116		
Barium	0.127	1.88	2.00	87.5	75 - 116		
Beryllium	ND	0.0478	0.0500	95.4	75 - 111		
Boron	0.390	0.846	0.500	91.1	75 - 130		
Cadmium	ND	0.0408	0.0500	86.7	75 - 113		
Calcium	3.11	11.2	10.0	80.8	75 - 119		
Chromium	ND	0.172	0.200	85.4	75 - 117		
Cobalt	ND	0.418	0.500	83.5	75 - 118		
Copper	ND	0.228	0.250	91.1	75 - 117		
Iron	0.0542	0.925	1.00	87.1	75 - 121		
Lead	ND	0.430	0.500	86.0	75 - 121		
Magnesium	1.32	10.1	10.0	88.3	75 - 118		
Manganese	ND	0.431	0.500	84.9	75 - 121		
Molybdenum	ND	0.429	0.500	84.0	75 - 120		
Nickel	ND	0.417	0.500	83.0	75 - 117		
Potassium	10.9	17.8	10.0	69.0	75 - 110	lowPDS	
Selenium	ND	1.79	2.00	89.2	75 - 117		
Silver	ND	0.234	0.250	93.2	75 - 127		
Sodium	1,130	1,100	10.0	-349.9	75 - 113	lowPDS	Note 2
Thallium	ND	0.174	0.200	85.7	75 - 113		
Vanadium	ND	0.440	0.500	87.4	75 - 119		
Zinc	ND	0.432	0.500	86.5	75 - 120		
Lithium	ND	0.539	0.500	92.0	75 - 120		

SERIAL DILUTION REPORT

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108015**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 7:58:00PM

Units: mg/L

SER DIL. Date: 1/8/2008 8:38:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.198	0.050	0.014	ND	0.25		
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	ND	0.10	0.015	ND	0.50		
Barium	0.127	0.0100	0.00016	0.111	0.050	13.4	OUT
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	3.11	0.10	0.013	5.53	0.50	56.0	OUT
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	0.0542	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	1.32	0.10	0.012	1.11	0.50	17.2	OUT
Manganese	ND	0.0100	0.00066	ND	0.050		
Molybdenum	ND	0.0100	0.0018	ND	0.050		
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	10.9	1.0	0.31	10.3	5.0	5.6	
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	1,130	3.0	0.028	1,030	15	9.2	
Vanadium	ND	0.0100	0.00072	ND	0.050		
Zinc	ND	0.0050	0.0010	0.204	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Prep Batch: **T080108012**

SAMPLE DUPLICATE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 5:19:17PM

Units: mg/L

DUP Anal. Date: 1/8/2008 5:21:31PM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080108012**

SAMPLE DUPLICATE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 5:19:17PM

Units: mg/L

DUP Anal. Date: 1/8/2008 5:21:31PM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Mercury	ND	ND	0.0	20	

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

MB: T080108012-MB

Prep Date: 1/8/2008

MB Anal. Date: 1/8/2008 5:04:24PM

Units: mg/L

LCS Anal. Date: 1/8/2008 5:10:50PM LCSD Anal. Date: 1/8/2008 5:12:54PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00203	0.00208	0.00200	0.0020	101.5	104.0	2.4	80 - 120	20	

MS/MSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Parent: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 5:19:17PM

Units: mg/L

MS Anal. Date: 1/8/2008 5:23:34PM MSD Anal. Date: 1/8/2008 5:25:40PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00213	0.00210	0.00200	0.00200	106.5	105.0	1.4	70 - 130	20	

POST DIGESTION SPIKE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801027-02A

Prep Date: 1/8/2008

Samp. Anal. Date: 1/8/2008 5:19:17PM

Units: mg/L

PDS Anal. Date: 1/8/2008 5:27:45PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Mercury	ND	0.00216	0.00200	103.1	80 - 120	

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080107001**

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC | MB: T080107001-MB

Prep Date: 1/7/2008

MB Anal. Date: 1/9/2008 3:32:33AM | Units: mg/L

LCS Anal. Date: 1/7/2008 6:27:53PM LCSD Anal. Date: 1/7/2008 6:46:17PM | Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.31	2.25	2.50	2.50	92.4	90.0	2.6	90 - 110	20	
Chloride	ND	4.71	4.71	5.00	5.00	94.2	94.2	0.0	90 - 110	20	
Sulfate	ND	34.1	34.0	37.5	37.5	90.9	90.7	0.3	90 - 110	20	

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC | Parent: B0801027-02B

Prep Date: 1/7/2008

Samp. Anal. Date: 1/8/2008 4:34:49AM | Units: mg/L

MS Anal. Date: 1/9/2008 2:37:21AM | Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Fluoride	2.16	4.39	2.50	89.2	70 - 130		
Chloride	632	755	125	98.4	70 - 130	*NOTE 2*	
Sulfate	285	323	37.5	101.3	70 - 130	*NOTE 2*	

Prep Batch: **T080111013**

SAMPLE DUPLICATE REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS | Base Sample: B0801027-02B

Prep Date: 1/11/2008

Samp. Anal. Date: 1/16/2008 1:50:18PM | Units: mg/L

DUP Anal. Date: 1/16/2008 1:50:18PM | Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Total Dissolved Solids	3,070	3,060	0.3	20	

LCS/LCSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801027

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080111013**

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T080111013-MB

Prep Date: 1/11/2008

MB Anal. Date: 1/16/2008 1:50:18PM

Units: mg/L

LCS Anal. Date: 1/16/2008 1:50:18PM LCSD Anal. Date: 1/16/2008 1:50:18PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	815	826	825	825	98.8	100.1	1.3	80 - 120	20	

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801027-02B

Prep Date: 1/11/2008

Samp. Anal. Date: 1/16/2008 1:50:18PM

Units: mg/L

MS Anal. Date: 1/16/2008 1:50:18PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag
Total Dissolved Solids	3,070	3,850	825	94.5	70 - 130	

Prep Batch: **T080117001**

SAMPLE DUPLICATE REPORT

Analysis: 150.1 - pH, Elecrometric - pH

Base Sample: B0801027-02B

Prep Date: 1/5/2008

Samp. Anal. Date: 1/5/2008 9:29:27AM

Units: pH

DUP Anal. Date: 1/5/2008 9:29:27AM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
pH	8.97	8.97	0.0	20	

Prep Batch: **T080117013**

SAMPLE DUPLICATE REPORT

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0801027
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080117013**

SAMPLE DUPLICATE REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
Base Sample: B0801027-02B
Prep Date: 1/17/2008

Samp. Anal. Date: 1/17/2008 2:31:55PM
DUP Anal. Date: 1/17/2008 2:31:55PM
Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Bicarbonate	1,250	1,240	0.8	20	
Carbonate	228	248	8.4	20	

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
MB: T080117013-MB
Prep Date: 1/17/2008

MB Anal. Date: 1/17/2008 2:31:55PM
Units: mg/L
LCS Anal. Date: 1/17/2008 2:31:55PM LCSD Anal. Date: 1/17/2008 2:31:55PM
Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	28.0	26.0	25.0	25.0	112.0	104.0	7.4	80 - 120	20	
Carbonate	ND	51.0	49.0	50.0	50.0	102.0	98.0	4.0	80 - 120	20	

MS REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
Parent: B0801027-02B
Prep Date: 1/17/2008

Samp. Anal. Date: 1/17/2008 2:31:55PM
MS Anal. Date: 1/17/2008 2:31:55PM
Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Bicarbonate	1,250	1,280	50.0	60.0	70 - 130	*NOTE 2*	
Carbonate	228	296	100	68.0	70 - 130	*lowMS*	

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,878** **Lab Project Number:** **B0801027**

Prep Date: 1/7/2008

Lab Method Blank Id: T080107001-MB

Prep Batch ID: T080107001

Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080107001-LCS	LCS	080107_020.DXD	1/7/2008 6:27:53PM
T080107001-LCSD	LCSD	080107_021.DXD	1/7/2008 6:46:17PM
B0801018-08B	Batch QC	080107_036.DXD	1/7/2008 11:22:10PM
B0801027-01B	MB	080107_047.DXD	1/8/2008 2:44:31AM
B0801027-01B	MB	080107_049.DXD	1/8/2008 3:21:16AM
B0801027-02B	4 Corners PP Bottom Ash Leachate	080107_051.DXD	1/8/2008 3:58:04AM
B0801027-02B	4 Corners PP Bottom Ash Leachate	080107_053.DXD	1/8/2008 4:34:49AM
T080107001-LCS	LCS	080108_010.DXD	1/8/2008 12:31:14PM
T080107001-LCSD	LCSD	080108_011.DXD	1/8/2008 12:49:38PM
B0801018-08B-DUP	DUP	080108_026.DXD	1/8/2008 5:25:29PM
B0801018-08B-MS	MS	080108_027.DXD	1/8/2008 5:43:52PM
B0801027-02B-MS	MS	080108_052.DXD	1/9/2008 1:23:44AM
B0801027-02B-MS	MS	080108_056.DXD	1/9/2008 2:37:21AM
B0801018-08B	Batch QC	080111_042.DXD	1/12/2008 12:33:51AM
B0801018-08B-DUP	DUP	080111_043.DXD	1/12/2008 12:52:16AM

Prep Date: 1/8/2008

Lab Method Blank Id: T080108012-MB

Prep Batch ID: T080108012

Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801027-01A	MB	B010807W.WKS	1/8/2008 5:17:11PM
B0801027-02A	4 Corners PP Bottom Ash Leachate	B010807W.WKS	1/8/2008 5:19:17PM
T080108012-LCS	LCS	B010807W.WKS	1/8/2008 5:10:50PM
T080108012-LCSD	LCSD	B010807W.WKS	1/8/2008 5:12:54PM
B0801027-02A-DUP	DUP	B010807W.WKS	1/8/2008 5:21:31PM
B0801027-02A-MS	MS	B010807W.WKS	1/8/2008 5:23:34PM
B0801027-02A-MSD	MSD	B010807W.WKS	1/8/2008 5:25:40PM
B0801027-02A-PDS	PDS	B010807W.WKS	1/8/2008 5:27:45PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,878** **Lab Project Number:** **B0801027**

Prep Date: 1/8/2008

Lab Method Blank Id: T080108015-MB
Prep Batch ID: T080108015
Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801027-01A	MB	E01088A	1/8/2008 7:53:00PM
B0801027-02A	4 Corners PP Bottom Ash Leachate	E01088A	1/8/2008 7:58:00PM
T080108015-LCS	LCS	E01088A	1/8/2008 7:43:00PM
T080108015-LCSD	LCSD	E01088A	1/8/2008 7:48:00PM
B0801027-02A-DUP	DUP	E01088A	1/8/2008 8:03:00PM
B0801027-02A-MS	MS	E01088A	1/8/2008 8:23:00PM
B0801027-02A-MSD	MSD	E01088A	1/8/2008 8:28:00PM
B0801027-02A-PDS	PDS	E01088A	1/8/2008 8:33:00PM
B0801027-01A	MB	E01098A	1/9/2008 1:35:00PM
B0801027-02A	4 Corners PP Bottom Ash Leachate	E01098A	1/9/2008 1:40:00PM
T080108015-LCS	LCS	E01098A	1/9/2008 1:10:00PM
T080108015-LCSD	LCSD	E01098A	1/9/2008 1:15:00PM
B0801027-02A-DUP	DUP	E01098A	1/9/2008 1:45:00PM
B0801027-02A-MS	MS	E01098A	1/9/2008 1:50:00PM
B0801027-02A-MSD	MSD	E01098A	1/9/2008 1:56:00PM
B0801027-02A-PDS	PDS	E01098A	1/9/2008 2:01:00PM

Prep Date: 1/11/2008

Lab Method Blank Id: T080111013-MB
Prep Batch ID: T080111013
Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801027-01B	MB		1/16/2008 1:50:18PM
B0801027-02B	4 Corners PP Bottom Ash Leachate		1/16/2008 1:50:18PM
T080111013-LCS	LCS		1/16/2008 1:50:18PM
T080111013-LCSD	LCSD		1/16/2008 1:50:18PM
B0801027-02B-DUP	DUP		1/16/2008 1:50:18PM
B0801027-02B-MS	MS		1/16/2008 1:50:18PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **82,878** **Lab Project Number:** **B0801027**

Prep Date: 1/17/2008

Lab Method Blank Id: T080117013-MB

Prep Batch ID: T080117013

Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801027-01B	MB		1/17/2008 2:31:55PM
B0801027-02B	4 Corners PP Bottom Ash Leachate		1/17/2008 2:31:55PM
T080117013-LCS	LCS		1/17/2008 2:31:55PM
T080117013-LCSD	LCSD		1/17/2008 2:31:55PM
B0801027-02B-DUP	DUP		1/17/2008 2:31:55PM
B0801027-02B-MS	MS		1/17/2008 2:31:55PM

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:

ND = Not Detected at or above the Reporting Limit
NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:

LOW = Recovery is below Lower Control Limit
HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:

B = Analyte was detected in the laboratory method blank
J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:

J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
W = Post digestion spike did not meet criteria
S = Reported value determined by the Method of Standard Additions (MSA)

Several ways of defining the limit of detection and quantitation are prevalent in the laboratory industry and may appear in Analytica reports. These include the following:

MRL = "minimum reporting level", from the EPA Safe Drinking Water program (SDW)
PQL = "practical quantitation limit", from SW-846
EQL = "estimated quantitation limit", from SW-846
LOQ = "limit of quantitation", from a number of authoritative sources

In Analytica's work, all of these terms have the same meaning, equivalent to the EPA definition of the MRL. This reporting level is supported by a satisfactory calibration data point which is at that level or lower, and also is supported by a method detection limit (MDL) determined by the procedure in 40CFR. The MDL is lower than the MRL and represents an estimate of the level where positive detections have a 99% probability of being real, but where quantitation accuracy is unknown.

The MRL as defined by Analytica is the lowest demonstrated point of known quantitation accuracy.
The MRL should not be confused with the MCL, which is the EPA-defined "maximum contaminant level" allowed for certain regulated targets under specific regulations, such as the National Primary Drinking Water Regulations. Normally, the MRL is set at a level which is much lower than the MCL in order to ensure that levels are well below those limits. Not all target analytes have MCL levels established.

Other Flags may be applied. See Case Narrative for Description

Workorder (SDG): B0801027

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0801027

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received	2	Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received	2	Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received	2	Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received	2	Report to PQL
6010B/3010A (Aqueous) - Total	As Received	2	Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received	2	Report to PQL

Analytica Chain of Custody Form

ANALYTICA GROUP ®

12189 Pennsylvania St. Thornton, CO 80241 (303) 469-8868 (303) 469-5254 fax
4307 Arctic Boulevard Anchorage, AK 99503 (907) 258-2155 (907) 258-6634 fax
475 Hall St. Fairbanks, AK 99701 (907) 456 - 3116 (907) 456-3125 Fax
5438 Shaune Drive Juneau, AK 99801 (907) 780-6668 (907) 780-6670 fax

Page ____ of ____

Chain of Custody No: 62918

Client Name & Address: Applied Hydrology Associates, INC.

Public Water System (PWS) ID#:

Project Name: Navajo Mine Extension Leaching Study

Section To be Completed by Analytica
Quote ID:
LGN: B080102
Account #: 030188 Cash ___ Credit Card ___

Report to:
Phone No:
Fax No:
E-mail:

Turnaround Time for Results (TAT)
___ Standard ___ **Expedited** (< 10 days, prior authorization required) (please specify due date below; add'l charges may apply)

Requested Due Date for Results:

Invoice to Name & Address:

Special Instructions/Comments:
Tumbled in house by R.S.
Bottom Ash Leachate study

P.O. or Contract No:

Kit Prep/Shipping Charge: $

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	6010B/3010A-TTL	7470A Hg	150.1 pH	160.1 TDS	300.0 Anions/IC	310.1 Alk		Field Preserved	Field Filtered	MS/MSD ?
MB	1/4/08	13:20	AQ	8	✓	✓	✓	✓	✓	✓		1/2		
4 corners PP Bottom Ash Leachate	1/4/08	13:20	⊥	⊥	✓	✓	✓	✓	✓	✓		1/2		X

Requested Analysis/Method columns each include Lot #: / Pres:

Relinquished by:	Date	Time	Received by:	Date	Time
R. Seeman	1/7/08	13:55	[signature]	1/7/08	13:55
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

Name of Sampler: (printed)

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:	—			
Initialed By:	—			
Temp/Loc:	3.1			
Thermo ID#:				
Shipped Via:	Ryan Seeman			

Version 2.0

ANALYTICA

Cooler Receipt Form

Client: Applied Hydrology Associates **Client Code:** 030188 **Order #:** B0801027
Project: Navajo Mine Extension Leaching Study

Cooler ID: 1

A. Preliminary Examination Phase:

Date cooler opened: 1/7/2008
Cooler opened by: gp **Signature:** GP

1. Was airbill Attached? N/A **Airbill #:** **Carrier Name:** Other
2. Custody Seals? N/A **How many?** 0 **Location:** **Seal Name:**
3. Seals intact? N/A
4. COC Attached? Yes **Properly Completed?** Yes **Signed by AEL employee?** Yes
5. Project Identification from custody paper: Navajo Mine Extension Leaching Study
6. Preservative: None **Temperature:** 3.1 **deg. C**

Designated person initial here to acknowledge receipt: GP **Date:** 1/7/08

COMMENTS:

B. Log-In Phase: **Samples Log-in Date:** 1/7/2008 **Log-in By:** gp

1. Packing Type: Other
2. Were samples in separate bags? N/A
3. Were containers intact? Yes **Labels agree with COC?** Yes
4. Number of bottles received: 4 **Number of samples received:** 2
5. Correct containers used? Yes **Correct preservatives added?** Yes
6. Sufficient sample volume? Yes
7. Bubbles in VOA samples? N/A
8. Was Project manager called and status discussed? No
9. Was anyone called? No **Who was called?** ________ **By whom?** ________ **Date:** ________

COMMENTS:

The Analytica Group
CLIENT INVOICE

Remit to:	Accounting Dpt Analytica Environmental Laboratories, Inc. P.O. Box 973426 Dallas,TX 75397-3426	**Invoice #:**	**82649**
		Work Order#:	**B0801191**
		Account#:	030188
		Quote ID#:	11340
		Invoice Date:	2/11/2008
		Work ID:	Navajo Mine Extension Leaching Study
Phone:	(303) 469-8868	**PO #:**	none
Attention:	Mr.Art O'Hayre	**Received:**	1/28/2008
Invoice to:	Applied Hydrology Associates, Inc. 950 South Cherry Street Suite 810 Denver, CO 80246	**Reported:**	2/11/2008
		Client Project#:	Navajo Mine Extension Leach

Comments:

Item charges		**Qty**	**Price**	**Total**
SW7470A - Mercury in Liquid Waste by CVAA - Total Hg In Aqueous	M	6	35.00	210.00
160.1 - Total Dissolved Solids dried at 180°C - TDS In Liquid	Matrix	6	22.00	132.00
150.1 - pH, Elecrometric - pH In Liquid	Matrix	6	10.00	60.00
SW6010B - ICP - Total In Aqueous	Matrix	6	312.00	1,872.00
Inorganic Anions by Ion Chromatography - Anions by IC In Liquid	Matrix	6	54.00	324.00
310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity In Liquid	Matrix	6	36.00	216.00
	Total of Items Above:			**$2,814.00**

Adjustments or Special Services	**Qty**	**Price**	**Total**
Tumbling Charge	5	95.00	475.00
Total of Items Above:			**$475.00**
Grand Total:			**$3,289.00**

All invoices are due and payable upon receipt. Outstanding balances over 30 days are subject to a finance charge of 1.5% per month, plus a late fee of $25.00. If Analytica engages legal counsel to enforce its rights or any other rights under an application for payment, the customer will be liable to Analytica for all costs of collection and other legal expenses, including reasonable attorney fees.

The Analytica Group
CLIENT INVOICE

REMITTANCE ADVICE
PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

Mr.Art O'Hayre		**Account#:**	030188
Applied Hydrology Associates, Inc.		**Invoice #:**	**82649**
950 South Cherry Street		**Invoice Date:**	2/11/2008
Suite 810 Denver, CO 80246			

TOTAL INVOICE AMOUNT: **$3,289.00**

PAYMENT AMOUNT ENCLOSED: ____________________

Analytica Environmental
Laboratories, Inc.
12189 Pennsylvania Street
Thornton, CO 80241
Phone: 303-469-8868
Fax: 303-469-5254

ANALYTICA
Environmental Laboratories

2/11/2008

Applied Hydrology Associates, Inc.
950 South Cherry Street
Suite 810
Denver, CO 80246
Attn: Art O'Hayre

Work Order #: B0801191
Date: 2/11/2008
Work ID: Navajo Mine Extension Leaching Study
Date Received: 1/28/2008
Proj #: none

Sample Identification

Lab Sample Number	Client Description	Lab Sample Number	Client Description
B0801191-01	MB 45 day	B0801191-02	Ash Composite 45 day
B0801191-03	Spoil Composite 45 day	B0801191-04	MB SPLP
B0801191-05	Ash Composite SPLP	B0801191-06	Spoil Composite SPLP

Enclosed are the analytical results for the submitted sample(s). Please review the CASE NARRATIVE for a discussion of any data and/or quality control issues. Listings of data qualifiers, analytical codes, key dates, and QC relationships are provided at the end of the report.

Sincerely,

Kristen Stone
Project Manager

"The Science of Analysis, The Art of Service"

Case Narrative

Analytica Environmental Laboratories, Inc.

Work Order: B0801191

Samples were prepared and analyzed according to EPA or equivalent methods outlined in the following references:

Methods for Chemical Analysis of Water and Wastes, USEPA 600/4-79-020, March 1983.

Pfaff, J. D., C. A. Brockhoff and J. W. O'Dell. 1994. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0A. U. S. Environmental Protection Agency. Environmental Monitoring Systems Lab.

Methods for the Determination of Metals in Environmental Samples, EPA/600/R-94/111, May 1994.

SAMPLE RECEIPT:
Six (6) samples were received on 1/28/2008 12:35:00 PM., at a temperature of 6 deg C., at Analytica-Thornton. The samples were received in good condition and in order per chain of custody. The samples were tumbled at the laboratory.

REVIEW FOR COMPLIANCE WITH ANALYTICA QA PLAN
A summary of our review is shown below.

All analytical results contained in this report have been reviewed under Analytica's internal quality assurance and quality control program. Any deviations in quality contro parameters for specific analyses are noted in the following text. A complete quality assurance report, including laboratory control, matrix spike, and sample duplicate recoveries is kept on file in our office and is available upon request.

All method specifications were met for the following tests:

Test Method: 150.1 - pH, Elecrometric - pH - Aqueous
Test Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS - Aqueous
Test Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity - Aqueous
Test Method: Inorganic Anions by Ion Chromatography - Anions by IC - Aqueous
Test Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg - Aqueous

Test Method: SW6010B - ICP - Total - Aqueous
MS/MSD and DUP OUTLIERS:
As shown below, the MSD was outside of limits for Calcium. The sample had Calcium concentrations greater than four times the spike amount. In these cases it is not appropriate to calculate a recovery. The result should be used as a replicate.

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MSD	Ash Composite SP	B0801191-05A	Calcium	-11.	75	125	562	10.0

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-01A	Analysis Date:	1/31/2008 1:50:33PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-01A	Analysis Date:	1/30/2008 12:59:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.85**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.081**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.32**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.0**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**0.14**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.2**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.013**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-01A	Analysis Date:	1/30/2008 12:59:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**0.0053**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-01B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,200**		mg/L	5.0	1.5	1
Carbonate		**260**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-01B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**8.7**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number: B0801191-01B

Analysis Date: 2/4/2008 12:47:24PM

Prep Date: 1/31/2008

Instrument: SCALE

Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS

File Name:

Prep Method ID: 160.1

Dilution Factor: 1

Prep Batch Number: T080131008

Report Basis: As Received

Analyst Initials: kl

Sample prep wt./vol: 100.00 ml

Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,000**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801191-01B

Analysis Date: 1/30/2008 4:18:17PM

Prep Date: 1/30/2008

Instrument: IC

Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC

File Name: 080130_011.D

Prep Method ID: 300.0

Dilution Factor: 25

Prep Batch Number: T080130013

Report Basis: As Received

Analyst Initials: KB

Sample prep wt./vol: 20.00 ml

Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**600**		mg/L	20	1.1	1

Lab Sample Number: B0801191-01B

Analysis Date: 1/30/2008 9:12:31PM

Prep Date: 1/30/2008

Instrument: IC

Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC

File Name: 080130_027.D

Prep Method ID: 300.0

Dilution Factor: 1

Prep Batch Number: T080130013

Report Basis: As Received

Analyst Initials: KB

Sample prep wt./vol: 20.00 ml

Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	2
Sulfate		**280**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-02A	Analysis Date:	1/31/2008 2:39:43PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-02A	Analysis Date:	1/30/2008 1:04:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**4.6**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.033**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**2.6**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**530**		mg/L	0.10	0.013	
Chromium	7440-47-3	**0.031**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**0.72**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.071**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.14**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**12**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.12**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.15**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**0.15**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-02A	Analysis Date:	1/30/2008 1:04:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.10**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**0.098**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-02B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,100**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-02B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.8**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-02B	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**5,300**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-02B	Analysis Date:	1/30/2008 4:36:41PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_012.D
Prep Method ID:	300.0	Dilution Factor:	25
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	20	1.1	1
Sulfate		**2,500**		mg/L	38	2.8	

Lab Sample Number:	B0801191-02B	Analysis Date:	1/30/2008 9:49:17PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_029.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**8.2**		mg/L	0.40	0.031	2

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite 45 day**

Matrix: Aqueous Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-03A	Analysis Date:	1/31/2008 2:41:52PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-03A	Analysis Date:	1/30/2008 1:09:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.38**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.079**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.36**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**56**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**0.053**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**0.11**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**12**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.098**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.015**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**14**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite 45 day**

Matrix: Aqueous   Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-03A	Analysis Date:	1/30/2008 1:09:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-03B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**960**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-03B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**8.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite 45 day**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number: B0801191-03B
Analysis Date: 2/4/2008 12:47:24PM
Prep Date: 1/31/2008
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Prep Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T080131008
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,500**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801191-03B
Analysis Date: 1/30/2008 5:50:15PM
Prep Date: 1/30/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080130_016.D
Prep Method ID: 300.0
Dilution Factor: 25
Prep Batch Number: T080130013
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**600**		mg/L	20	1.1	1
Sulfate		**930**		mg/L	38	2.8	

Lab Sample Number: B0801191-03B
Analysis Date: 1/30/2008 11:02:52PM
Prep Date: 1/30/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080130_033.D
Prep Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T080130013
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**1.5**		mg/L	0.40	0.031	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: **Client Sample Report**

Client Sample Name: **MB SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-04A	Analysis Date:	1/31/2008 2:44:26PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-04A	Analysis Date:	1/30/2008 1:14:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.056**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**0.27**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**0.0067**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-04A	Analysis Date:	1/30/2008 1:14:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**5.7**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-04B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**ND**		mg/L	5.0	1.5	1
Carbonate		**10**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-04B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**5.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-04B	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**ND**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-04B	Analysis Date:	1/31/2008 12:16:31AM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_037.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	2
Fluoride		**ND**		mg/L	0.40	0.031	
Sulfate		**3.4**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-05A	Analysis Date:	1/31/2008 2:46:54PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-05A	Analysis Date:	1/30/2008 1:19:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.36**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.11**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.28**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**560**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**0.88**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.089**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-05A	Analysis Date:	1/30/2008 1:19:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**8.8**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.088**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-05B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**ND**		mg/L	5.0	1.5	1
Carbonate		**18**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-05B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.4**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Composite SPLP**

Matrix: Aqueous Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number: B0801191-05B Analysis Date: 2/4/2008 12:47:24PM
Prep Date: 1/31/2008 Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS File Name:
Prep Method ID: 160.1 Dilution Factor: 1
Prep Batch Number: T080131008
Report Basis: As Received Analyst Initials: kl
Sample prep wt./vol: 100.00 ml Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**2,200**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801191-05B Analysis Date: 1/30/2008 6:27:01PM
Prep Date: 1/30/2008 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 080130_018.D
Prep Method ID: 300.0 Dilution Factor: 25
Prep Batch Number: T080130013
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**1,300**		mg/L	38	2.8	1

Lab Sample Number: B0801191-05B Analysis Date: 1/31/2008 12:34:55AM
Prep Date: 1/30/2008 Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC File Name: 080130_038.D
Prep Method ID: 300.0 Dilution Factor: 1
Prep Batch Number: T080130013
Report Basis: As Received Analyst Initials: KB
Sample prep wt./vol: 20.00 ml Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**5.6**		mg/L	0.80	0.042	2
Fluoride		**3.2**		mg/L	0.40	0.031	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-06A	Analysis Date:	1/31/2008 2:48:59PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-06A	Analysis Date:	1/30/2008 2:29:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.070**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.084**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**150**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**15**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.19**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**7.0**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number:	B0801191-06A	Analysis Date:	1/30/2008 2:29:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**150**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-06B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**33**		mg/L	5.0	1.5	1
Carbonate		**14**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801191-06B	Analysis Date:	1/25/2008 2:10:00PM
Prep Date:	1/25/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201005		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.5**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Spoil Composite SPLP**

Matrix: Aqueous

Collection Date: 1/25/2008 2:00:00PM

Lab Sample Number: B0801191-06B | Analysis Date: 2/4/2008 12:47:24PM
Prep Date: 1/31/2008 | Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS | File Name:
Prep Method ID: 160.1 | Dilution Factor: 1
Prep Batch Number: T080131008
Report Basis: As Received | Analyst Initials: kl
Sample prep wt./vol: 100.00 ml | Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**1,200**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801191-06B | Analysis Date: 1/30/2008 7:40:34PM
Prep Date: 1/30/2008 | Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC | File Name: 080130_022.D
Prep Method ID: 300.0 | Dilution Factor: 25
Prep Batch Number: T080130013
Report Basis: As Received | Analyst Initials: KB
Sample prep wt./vol: 20.00 ml | Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sulfate		**670**		mg/L	38	2.8	1

Lab Sample Number: B0801191-06B | Analysis Date: 1/31/2008 12:53:17AM
Prep Date: 1/30/2008 | Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC | File Name: 080130_039.D
Prep Method ID: 300.0 | Dilution Factor: 1
Prep Batch Number: T080130013
Report Basis: As Received | Analyst Initials: KB
Sample prep wt./vol: 20.00 ml | Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**1.5**		mg/L	0.80	0.042	2
Fluoride		**0.54**		mg/L	0.40	0.031	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 1/29/2008 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080131004-MB	Analysis Date:	1/31/2008 1:01:23PM
Prep Date:	1/29/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B013108W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080131004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080129008-MB	Analysis Date:	1/30/2008 12:34:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**ND**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous Collection Date: 1/29/2008 12:00:00AM

Lab Sample Number:	T080129008-MB	Analysis Date:	1/30/2008 12:34:00PM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01308A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	ND		mg/L	3.0	0.028	1
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	

Lab Sample Number:	T080129008-MB	Analysis Date:	1/31/2008 11:13:00AM
Prep Date:	1/29/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01318A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080129008		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080205001-MB	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		ND		mg/L	5.0	1.5	1
Carbonate		ND		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080131008-MB	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 1/31/2008 12:00:00AM

Lab Sample Number:	T080131008-MB	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**ND**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080130013-MB	Analysis Date:	1/30/2008 3:04:45PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_007.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	1
Fluoride		**ND**		mg/L	0.40	0.031	
Sulfate		**ND**		mg/L	1.5	0.11	

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080129008**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801191-05A

Prep Date: 1/29/2008

Samp. Anal. Date: 1/30/2008 1:19:00PM

DUP Anal. Date: 1/30/2008 1:40:00PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.359	0.346	3.7	20	
Antimony	ND	ND	0.0	20	
Arsenic	ND	ND	0.0	20	
Barium	0.113	0.110	2.7	20	
Beryllium	ND	ND	0.0	20	
Boron	0.282	0.278	1.4	20	
Cadmium	ND	ND	0.0	20	
Calcium	562	549	2.3	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	ND	0.0	20	
Copper	ND	ND	0.0	20	
Iron	ND	ND	0.0	20	
Lead	ND	ND	0.0	20	
Magnesium	0.883	0.856	3.1	20	
Manganese	ND	ND	0.0	20	
Molybdenum	0.0886	0.0859	3.1	20	
Nickel	ND	ND	0.0	20	
Potassium	ND	1.10	0.0	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	8.85	8.45	4.6	20	
Thallium	ND	ND	0.0	20	
Vanadium	0.0883	0.0868	1.7	20	
Zinc	ND	ND	0.0	20	
Lithium	ND	ND	0.0	20	

LCS/LCSD REPORT

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080129008**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T080129008-MB

Prep Date: 1/29/2008

MB Anal. Date: 1/30/2008 12:34:00PM

Units: mg/L

LCS Anal. Date: 1/30/2008 12:39:00PM LCSD Anal. Date: 1/30/2008 12:44:00PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	1.91	1.88	2.00	2.00	95.5	94.0	1.6	89 - 117	20	
Antimony	ND	0.474	0.458	0.500	0.500	94.8	91.6	3.4	82 - 117	20	
Arsenic	ND	1.81	1.82	2.00	2.00	90.5	91.0	0.6	86 - 116	20	
Barium	ND	1.87	1.85	2.00	2.00	93.5	92.5	1.1	86 - 116	20	
Beryllium	ND	0.0481	0.0477	0.0500	0.0500	96.2	95.4	0.8	87 - 111	20	
Boron	ND	0.463	0.459	0.500	0.500	92.6	91.8	0.9	76 - 130	20	
Cadmium	ND	0.0448	0.0430	0.0500	0.0500	89.6	86.0	4.1	79 - 113	20	
Calcium	ND	9.59	9.28	10.0	10.0	95.9	92.8	3.3	79 - 119	20	
Chromium	ND	0.189	0.185	0.200	0.200	94.5	92.5	2.1	86 - 117	20	
Cobalt	ND	0.468	0.464	0.500	0.500	93.6	92.8	0.9	82 - 118	20	
Copper	ND	0.231	0.231	0.250	0.250	92.4	92.4	0.0	86 - 117	20	
Iron	ND	0.981	0.972	1.00	1.00	98.1	97.2	0.9	83 - 121	20	
Lead	ND	0.472	0.453	0.500	0.500	94.4	90.6	4.1	83 - 121	20	
Magnesium	ND	9.61	9.54	10.0	10.0	96.1	95.4	0.7	83 - 118	20	
Manganese	ND	0.475	0.471	0.500	0.500	95.0	94.2	0.8	82 - 121	20	
Molybdenum	ND	0.468	0.463	0.500	0.500	93.6	92.6	1.1	82 - 120	20	
Nickel	ND	0.472	0.468	0.500	0.500	94.4	93.6	0.9	84 - 117	20	
Potassium	ND	7.84	7.75	10.0	10.0	78.4	77.5	1.2	74 - 110	20	
Selenium	ND	1.86	1.86	2.00	2.00	93.0	93.0	0.0	87 - 117	20	
Silver	ND	0.248	0.247	0.250	0.250	99.2	98.8	0.4	80 - 127	20	
Sodium	ND	9.34	10.1	10.0	10.0	93.4	101.0	7.8	87 - 113	20	
Thallium	ND	0.190	0.198	0.200	0.200	95.0	99.0	4.1	89 - 113	20	
Vanadium	ND	0.481	0.476	0.500	0.500	96.2	95.2	1.0	87 - 119	20	
Zinc	ND	0.476	0.543	0.500	0.500	95.2	108.6	13.2	81 - 120	20	
Lithium	ND	0.463	0.459	0.500	0.500	92.6	91.8	0.9	80 - 120	20	

MS/MSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080129008**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0801191-05A

Prep Date: 1/29/2008

Samp. Anal. Date: 1/30/2008 1:19:00PM

Units: mg/L

MS Anal. Date: 1/30/2008 1:45:00PM MSD Anal. Date: 1/30/2008 1:50:00PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Aluminum	0.359	2.23	2.20	2.00	2.00	93.6	92.1	1.4	75 - 125	20	
Antimony	ND	0.449	0.440	0.500	0.500	89.8	88.0	2.0	75 - 125	20	
Arsenic	ND	1.80	1.73	2.00	2.00	90.0	86.5	4.0	75 - 125	20	
Barium	0.113	1.89	1.82	2.00	2.00	88.9	85.4	3.8	75 - 125	20	
Beryllium	ND	0.0466	0.0452	0.0500	0.0500	93.2	90.4	3.1	75 - 125	20	
Boron	0.282	0.733	0.715	0.500	0.500	90.2	86.6	2.5	75 - 125	20	
Cadmium	ND	0.0408	0.0411	0.0500	0.0500	81.6	82.2	0.7	75 - 125	20	
Calcium	562	572	560	10.0	10.0	100.0	-20.0	2.1	75 - 125	20	*NOTE 2 NOTE 2*
Chromium	ND	0.184	0.180	0.200	0.200	92.0	90.0	2.2	75 - 125	20	
Cobalt	ND	0.437	0.427	0.500	0.500	87.4	85.4	2.3	75 - 125	20	
Copper	ND	0.229	0.221	0.250	0.250	91.6	88.4	3.6	75 - 125	20	
Iron	ND	0.935	0.925	1.00	1.00	93.5	92.5	1.1	75 - 125	20	
Lead	ND	0.434	0.429	0.500	0.500	86.8	85.8	1.2	75 - 125	20	
Magnesium	0.883	10.5	10.2	10.0	10.0	96.2	93.2	2.9	75 - 125	20	
Manganese	ND	0.445	0.431	0.500	0.500	89.0	86.2	3.2	75 - 125	20	
Molybdenum	0.0886	0.525	0.513	0.500	0.500	87.3	84.9	2.3	75 - 125	20	
Nickel	ND	0.445	0.433	0.500	0.500	89.0	86.6	2.7	75 - 125	20	
Potassium	ND	9.32	9.45	10.0	10.0	93.2	94.5	1.4	75 - 125	20	
Selenium	ND	1.94	1.87	2.00	2.00	97.0	93.5	3.7	75 - 125	20	
Silver	ND	0.241	0.234	0.250	0.250	96.4	93.6	2.9	75 - 125	20	
Sodium	8.85	18.0	17.5	10.0	10.0	91.5	86.5	2.8	75 - 125	20	
Thallium	ND	0.179	0.176	0.200	0.200	89.5	88.0	1.7	75 - 125	20	
Vanadium	0.0883	0.546	0.532	0.500	0.500	91.5	88.7	2.6	75 - 125	20	
Zinc	ND	0.428	0.419	0.500	0.500	85.6	83.8	2.1	75 - 125	20	
Lithium	ND	0.523	0.505	0.500	0.500	104.6	101.0	3.5	75 - 125	20	

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080129008**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801191-05A

Prep Date: 1/29/2008

Samp. Anal. Date: 1/30/2008 1:19:00PM

Units: mg/L

PDS Anal. Date: 1/30/2008 1:55:00PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.359	2.27	2.00	95.7	75 - 117		
Antimony	ND	0.444	0.500	87.5	75 - 117		
Arsenic	ND	1.76	2.00	88.3	75 - 116		
Barium	0.113	1.89	2.00	89.0	75 - 116		
Beryllium	ND	0.0467	0.0500	92.5	75 - 111		
Boron	0.282	0.736	0.500	90.7	75 - 130		
Cadmium	ND	0.0404	0.0500	79.3	75 - 113		
Calcium	562	580	10.0	186.5	75 - 119	highPDS	Note 2
Chromium	ND	0.185	0.200	88.3	75 - 117		
Cobalt	ND	0.438	0.500	87.3	75 - 118		
Copper	ND	0.227	0.250	89.9	75 - 117		
Iron	ND	0.957	1.00	95.5	75 - 121		
Lead	ND	0.438	0.500	88.0	75 - 121		
Magnesium	0.883	10.6	10.0	96.7	75 - 118		
Manganese	ND	0.443	0.500	88.4	75 - 121		
Molybdenum	0.0886	0.525	0.500	87.3	75 - 120		
Nickel	ND	0.443	0.500	88.9	75 - 117		
Potassium	ND	9.68	10.0	87.5	75 - 110		
Selenium	ND	1.94	2.00	95.6	75 - 117		
Silver	ND	0.240	0.250	96.5	75 - 127		
Sodium	8.85	18.4	10.0	95.2	75 - 113		
Thallium	ND	0.169	0.200	80.3	75 - 113		
Vanadium	0.0883	0.547	0.500	91.7	75 - 119		
Zinc	ND	0.428	0.500	88.6	75 - 120		
Lithium	ND	0.531	0.500	96.7	75 - 120		

SERIAL DILUTION REPORT

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080129008**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801191-05A

Prep Date: 1/29/2008

Samp. Anal. Date: 1/30/2008 1:19:00PM

Units: mg/L

SER DIL. Date: 1/30/2008 2:24:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.359	0.050	0.014	0.526	0.25	37.7	Note 4
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	ND	0.10	0.015	ND	0.50		
Barium	0.113	0.0100	0.00016	0.122	0.050	7.6	
Beryllium	ND	0.0010	0.000060	ND	0.0050		
Boron	0.282	0.050	0.0018	0.301	0.25	6.5	
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	562	0.10	0.013	585	0.50	4.0	
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	ND	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	0.883	0.10	0.012	0.965	0.50	8.8	
Manganese	ND	0.0100	0.00066	ND	0.050		
Molybdenum	0.0886	0.0100	0.0018	0.0920	0.050	3.7	
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	ND	1.0	0.31	ND	5.0		
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	8.85	3.0	0.028	ND	15		
Thallium	ND	0.40	0.011	ND	2.0		
Vanadium	0.0883	0.0100	0.00072	0.0903	0.050	2.2	
Zinc	ND	0.0050	0.0010	ND	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Prep Batch: **T080131004**

LCS/LCSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080131004**

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

MB: T080131004-MB

Prep Date: 1/29/2008

MB Anal. Date: 1/31/2008 1:01:23PM

Units: mg/L

LCS Anal. Date: 1/31/2008 1:03:28PM LCSD Anal. Date: 1/31/2008 1:06:14PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00204	0.00209	0.00200	0.0020	102.0	104.5	2.4	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130013**

SAMPLE DUPLICATE REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Base Sample: B0801191-02B

Prep Date: 1/30/2008

Samp. Anal. Date: 1/30/2008 9:49:17PM

DUP Anal. Date: 1/30/2008 10:07:41PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Fluoride	8.19	8.30	1.3	30	
Chloride	611	599	2.0	30	
Sulfate	2,480	2,440	1.6	30	

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

MB: T080130013-MB

Prep Date: 1/30/2008

MB Anal. Date: 1/30/2008 3:04:45PM

Units: mg/L

LCS Anal. Date: 1/31/2008 2:12:57PM LCSD Anal. Date: 1/31/2008 2:31:20PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.37	2.36	2.50	2.50	94.8	94.4	0.4	90 - 110	20	
Chloride	ND	4.75	4.75	5.00	5.00	95.0	95.0	0.0	90 - 110	20	
Sulfate	ND	34.1	34.1	37.5	37.5	90.9	90.9	0.0	90 - 110	20	

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Parent: B0801191-02B

Prep Date: 1/30/2008

Samp. Anal. Date: 1/30/2008 9:49:17PM

MS Anal. Date: 1/30/2008 10:26:05PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Fluoride	8.19	10.6	2.50	96.4	70 - 130		
Chloride	611	727	125	92.8	70 - 130	*NOTE 2*	
Sulfate	2,480	3,420	938	100.3	70 - 130		

Prep Batch: **T080131008**

SAMPLE DUPLICATE REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080131008**

SAMPLE DUPLICATE REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Base Sample: B0801191-02B

Prep Date: 1/31/2008

Samp. Anal. Date: 2/4/2008 12:47:24PM

Units: mg/L

DUP Anal. Date: 2/4/2008 12:47:24PM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Total Dissolved Solids	5,320	5,430	2.0	20	

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T080131008-MB

Prep Date: 1/31/2008

MB Anal. Date: 2/4/2008 12:47:24PM

Units: mg/L

LCS Anal. Date: 2/4/2008 12:47:24PM LCSD Anal. Date: 2/4/2008 12:47:24PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	802	765	821	821	97.6	93.1	4.7	80 - 120	20	

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801191-02B

Prep Date: 1/31/2008

Samp. Anal. Date: 2/4/2008 12:47:24PM

Units: mg/L

MS Anal. Date: 2/4/2008 12:47:24PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Total Dissolved Solids	5,320	6,190	821	105.9	70 - 130	*NOTE 2*	

Prep Batch: **T080205001**

SAMPLE DUPLICATE REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

Base Sample: B0801191-04B

Prep Date: 2/4/2008

Samp. Anal. Date: 2/4/2008 9:52:02AM

Units: mg/L

DUP Anal. Date: 2/4/2008 9:52:02AM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Bicarbonate	ND	ND	0.0	20	
Carbonate	10.0	8.00	22.2	20	OUT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801191

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205001**

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

MB: T080205001-MB

Prep Date: 2/4/2008

MB Anal. Date: 2/4/2008 9:52:02AM

Units: mg/L

LCS Anal. Date: 2/4/2008 9:52:02AM LCSD Anal. Date: 2/4/2008 9:52:02AM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	24.0	27.0	25.0	25.0	96.0	108.0	11.8	80 - 120	20	
Carbonate	ND	50.0	51.0	50.0	50.0	100.0	102.0	2.0	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,542** **Lab Project Number:** **B0801191**

Prep Date: 1/29/2008

Lab Method Blank Id: T080129008-MB

Prep Batch ID: T080129008

Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801191-01A	MB 45 day	E01308A	1/30/2008 12:59:00PM
B0801191-02A	Ash Composite 45 day	E01308A	1/30/2008 1:04:00PM
B0801191-03A	Spoil Composite 45 day	E01308A	1/30/2008 1:09:00PM
B0801191-04A	MB SPLP	E01308A	1/30/2008 1:14:00PM
B0801191-05A	Ash Composite SPLP	E01308A	1/30/2008 1:19:00PM
B0801191-06A	Spoil Composite SPLP	E01308A	1/30/2008 2:29:00PM
T080129008-LCS	LCS	E01308A	1/30/2008 12:39:00PM
T080129008-LCSD	LCSD	E01308A	1/30/2008 12:44:00PM
B0801191-05A-DUP	DUP	E01308A	1/30/2008 1:40:00PM
B0801191-05A-MS	MS	E01308A	1/30/2008 1:45:00PM
B0801191-05A-MSD	MSD	E01308A	1/30/2008 1:50:00PM
B0801191-05A-PDS	PDS	E01308A	1/30/2008 1:55:00PM
T080129008-LCS	LCS	E01318A	1/31/2008 11:18:00AM
T080129008-LCSD	LCSD	E01318A	1/31/2008 11:23:00AM
B0801191-05A-MS	MS	E01318A	1/31/2008 11:28:00AM
B0801191-05A-MSD	MSD	E01318A	1/31/2008 11:33:00AM
B0801191-05A-PDS	PDS	E01318A	1/31/2008 11:38:00AM

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,542** **Lab Project Number:** **B0801191**

Prep Date: 1/30/2008

Lab Method Blank Id: T080130013-MB

Prep Batch ID: T080130013

Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080130013-LCS	LCS	080130_008.DXD	1/30/2008 3:23:07PM
T080130013-LCSD	LCSD	080130_009.DXD	1/30/2008 3:41:32PM
B0801191-01B	MB 45 day	080130_011.DXD	1/30/2008 4:18:17PM
B0801191-02B	Ash Composite 45 day	080130_012.DXD	1/30/2008 4:36:41PM
B0801191-02B-DUP	DUP	080130_013.DXD	1/30/2008 4:55:04PM
B0801191-02B-MS	MS	080130_014.DXD	1/30/2008 5:13:28PM
B0801191-03B	Spoil Composite 45 day	080130_016.DXD	1/30/2008 5:50:15PM
B0801191-05B	Ash Composite SPLP	080130_018.DXD	1/30/2008 6:27:01PM
B0801191-06B	Spoil Composite SPLP	080130_022.DXD	1/30/2008 7:40:34PM
B0801197-02B	Batch QC	080130_024.DXD	1/30/2008 8:17:21PM
B0801197-02B-MS	MS	080130_025.DXD	1/30/2008 8:35:45PM
B0801191-01B	MB 45 day	080130_027.DXD	1/30/2008 9:12:31PM
B0801191-02B	Ash Composite 45 day	080130_029.DXD	1/30/2008 9:49:17PM
B0801191-02B-DUP	DUP	080130_030.DXD	1/30/2008 10:07:41PM
B0801191-02B-MS	MS	080130_031.DXD	1/30/2008 10:26:05PM
B0801191-03B	Spoil Composite 45 day	080130_033.DXD	1/30/2008 11:02:52PM
B0801191-04B	MB SPLP	080130_037.DXD	1/31/2008 12:16:31AM
B0801191-05B	Ash Composite SPLP	080130_038.DXD	1/31/2008 12:34:55AM
B0801191-06B	Spoil Composite SPLP	080130_039.DXD	1/31/2008 12:53:17AM
B0801197-02B	Batch QC	080130_043.DXD	1/31/2008 2:06:51AM
B0801197-02B-MS	MS	080130_044.DXD	1/31/2008 2:25:15AM
T080130013-LCS	LCS	080131_010.DXD	1/31/2008 2:12:57PM
T080130013-LCSD	LCSD	080131_011.DXD	1/31/2008 2:31:20PM

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,542** **Lab Project Number:** **B0801191**

Prep Date: 1/29/2008

Lab Method Blank Id: T080131004-MB

Prep Batch ID: T080131004

Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
A0801184-01D	Batch QC	B013108W.WKS	1/31/2008 1:13:50PM
B0801191-01A	MB 45 day	B013108W.WKS	1/31/2008 1:50:33PM
B0801191-02A	Ash Composite 45 day	B013108W.WKS	1/31/2008 2:39:43PM
B0801191-03A	Spoil Composite 45 day	B013108W.WKS	1/31/2008 2:41:52PM
B0801191-04A	MB SPLP	B013108W.WKS	1/31/2008 2:44:26PM
B0801191-05A	Ash Composite SPLP	B013108W.WKS	1/31/2008 2:46:54PM
B0801191-06A	Spoil Composite SPLP	B013108W.WKS	1/31/2008 2:48:59PM
T080131004-LCS	LCS	B013108W.WKS	1/31/2008 1:03:28PM
T080131004-LCSD	LCSD	B013108W.WKS	1/31/2008 1:06:14PM
A0801184-01D-DUP	DUP	B013108W.WKS	1/31/2008 1:16:26PM
A0801184-01D-MS	MS	B013108W.WKS	1/31/2008 1:18:43PM
A0801184-01D-MSD	MSD	B013108W.WKS	1/31/2008 1:20:47PM
A0801184-01D-PDS	PDS	B013108W.WKS	1/31/2008 1:23:11PM

Prep Date: 1/31/2008

Lab Method Blank Id: T080131008-MB

Prep Batch ID: T080131008

Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801191-01B	MB 45 day		2/4/2008 12:47:24PM
B0801191-02B	Ash Composite 45 day		2/4/2008 12:47:24PM
B0801191-03B	Spoil Composite 45 day		2/4/2008 12:47:24PM
B0801191-04B	MB SPLP		2/4/2008 12:47:24PM
B0801191-05B	Ash Composite SPLP		2/4/2008 12:47:24PM
B0801191-06B	Spoil Composite SPLP		2/4/2008 12:47:24PM
B0801197-02B	Batch QC		2/4/2008 12:47:24PM
T080131008-LCS	LCS		2/4/2008 12:47:24PM
T080131008-LCSD	LCSD		2/4/2008 12:47:24PM
B0801191-02B-DUP	DUP		2/4/2008 12:47:24PM
B0801191-02B-MS	MS		2/4/2008 12:47:24PM
B0801197-02B-MS	MS		2/4/2008 12:47:24PM

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,542** **Lab Project Number:** **B0801191**

Prep Date: 2/4/2008

Lab Method Blank Id: T080205001-MB

Prep Batch ID: T080205001

Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801191-01B	MB 45 day		2/4/2008 9:52:02AM
B0801191-02B	Ash Composite 45 day		2/4/2008 9:52:02AM
B0801191-03B	Spoil Composite 45 day		2/4/2008 9:52:02AM
B0801191-04B	MB SPLP		2/4/2008 9:52:02AM
B0801191-05B	Ash Composite SPLP		2/4/2008 9:52:02AM
B0801191-06B	Spoil Composite SPLP		2/4/2008 9:52:02AM
T080205001-LCS	LCS		2/4/2008 9:52:02AM
T080205001-LCSD	LCSD		2/4/2008 9:52:02AM
B0801191-04B-DUP	DUP		2/4/2008 9:52:02AM

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:

ND = Not Detected at or above the Reporting Limit
NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:

LOW = Recovery is below Lower Control Limit
HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:

B = Analyte was detected in the laboratory method blank
J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:

J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
W = Post digestion spike did not meet criteria
S = Reported value determined by the Method of Standard Additions (MSA)

Several ways of defining the limit of detection and quantitation are prevalent in the laboratory industry and may appear in Analytica reports. These include the following:

MRL = "minimum reporting level", from the EPA Safe Drinking Water program (SDW)
PQL = "practical quantitation limit", from SW-846
EQL = "estimated quantitation limit", from SW-846
LOQ = "limit of quantitation", from a number of authoritative sources

In Analytica's work, all of these terms have the same meaning, equivalent to the EPA definition of the MRL. This reporting level is supported by a satisfactory calibration data point which is at that level or lower, and also is supported by a method detection limit (MDL) determined by the procedure in 40CFR. The MDL is lower than the MRL and represents an estimate of the level where positive detections have a 99% probability of being real, but where quantitation accuracy is unknown.

The MRL as defined by Analytica is the lowest demonstrated point of known quantitation accuracy.
The MRL should not be confused with the MCL, which is the EPA-defined "maximum contaminant level" allowed for certain regulated targets under specific regulations, such as the National Primary Drinking Water Regulations. Normally, the MRL is set at a level which is much lower than the MCL in order to ensure that levels are well below those limits. Not all target analytes have MCL levels established.

Other Flags may be applied. See Case Narrative for Description

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801191

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0801191

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received	2	Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received	2	Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received	2	Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received	2	Report to PQL
6010B/3010A (Aqueous) - Total	As Received	2	Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received	2	Report to PQL

Analytica Chain of Custody Form

ANALYTICA GROUP®

12189 Pennsylvania St.
Thornton, CO 80241
(303) 469-8868
(303) 469-5254 fax

4307 Arctic Boulevard
Anchorage, AK 99503
(907) 258-2155
(907) 258-6634 fax

475 Hall St.
Fairbanks, AK 99701
(907) 456 - 3116
(907) 456-3125 Fax

5438 Shaune Drive
Juneau, AK 99801
(907) 780-6668
(907) 780-6670 fax

Page ____ of ____

Chain of Custody No: 63226

Client Name & Address: Applied Hydrology Associates, Inc.

Public Water System (PWS) ID#:

Project Name: Navajo Mine Extension Leaching Study

Section To be Completed by Analytica
Quote ID: | LGN: 60801191
Account #: | Cash | Credit Card

Report to:
Phone No:
Fax No:
E-mail:

Turnaround Time for Results (TAT)
X Standard ___ Expedited (< 10 days, prior authorization required) *(please specify due date below; add'l charges may apply)*

Requested Due Date for Results:

Invoice to Name & Address:

Special Instructions/Comments:
Tumbled in house by R. Seeman
45 day Coal Water and SPLP leach

P.O. or Contract No:

Kit Prep/Shipping Charge: $

Requested Analysis/Method

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	6010B/3010A·TTL (Lot #: 1107090 Pres: HNO_3)	7470A/7470A·Hg (Lot #: 1107090 Pres: HNO_3)	150.1 pH (Lot #: Pres:)	160.1 TDS (Lot #: Pres:)	300.0 Anions/IC (Lot #: Pres:)	310.1 Alk (Lot #: Pres:)	(Lot #: Pres:)	Field Preserved	Field Filtered	MS/MSD ?
MB 45 day	1/25/08	14:00	Aq	2	x	x	x	x	x	x		1/2	Yes	
Ash Composite 45 day				3	x	x	x	x	x	x		1/3		x
Spoil Composite 45 day				2	x	x	x	x	x	x		1/2		
MB SPLP				2	x	x	x	x	x	x				
Ash Composite SPLP				2	x	x	x	x	x	x				
Spoil Composite SPLP				2	x	x	x	x	x	x				

Relinquished by:	Date	Time	Received by:	Date	Time
R. Seeman	1/28/08	12:35	[signature]	1/28/08	12:35
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

Name of Sampler: (printed)

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:	—			
Initialed By:	—			
Temp/Loc:	6.0			
Thermo ID#:				
Shipped Via:	Ryan Seeman			

Version 2.0

ANALYTICA

Cooler Receipt Form

Client: Applied Hydrology Associates **Client Code:** 030188 **Order #:** B0801191
Project: Navajo Mine Extension Leaching Study

Cooler ID: 1

A. Preliminary Examination Phase:

Date cooler opened: 1/28/2008
Cooler opened by: gp **Signature:** GP

1. **Was airbill Attached?** N/A **Airbill #:** **Carrier Name:** Other
2. **Custody Seals?** N/A **How many?** 0 **Location:** **Seal Name:**
3. **Seals intact?** N/A
4. **COC Attached?** Yes **Properly Completed?** Yes **Signed by AEL employee?** Yes
5. **Project Identification from custody paper:** Navajo Mine Extension Leaching Study
6. **Preservative:** None **Temperature:** 6.0 **deg. C**

Designated person initial here to acknowledge receipt: GP **Date:** 1/28/08

COMMENTS: Tumbled in house by R. Seeman. 45 day coal water and SPLP Leach.

B. Log-In Phase: **Samples Log-in Date:** 1/28/2008 **Log-in By:** gp

1. **Packing Type:** Other
2. **Were samples in separate bags?** N/A
3. **Were containers intact?** Yes **Labels agree with COC?** Yes
4. **Number of bottles received:** 13 **Number of samples received:** 6
5. **Correct containers used?** Yes **Correct preservatives added?** Yes
6. **Sufficient sample volume?** Yes
7. **Bubbles in VOA samples?** N/A
8. **Was Project manager called and status discussed?** No
9. **Was anyone called?** No **Who was called?** ______ **By whom?** ______ **Date:** ______

COMMENTS:

The Analytica Group
CLIENT INVOICE

Remit to:	Accounting Dpt Analytica Environmental Laboratories, Inc. P.O. Box 973426 Dallas,TX 75397-3426	**Invoice #:**	**82691**
		Work Order#:	**B0801197**
		Account#:	030188
		Quote ID#:	11340
		Invoice Date:	2/11/2008
		Work ID:	Navajo Mine Extension Leaching Study
Phone:	(303) 469-8868	**PO #:**	none
Attention:	Mr.Art O'Hayre	**Received:**	1/29/2008
Invoice to:	Applied Hydrology Associates, Inc. 950 South Cherry Street Suite 810 Denver, CO 80246	**Reported:**	2/11/2008
		Client Project#:	Navajo Mine Extension Leach

Comments:

Item charges		**Qty**	**Price**	**Total**
SW7470A - Mercury in Liquid Waste by CVAA - Total Hg In Aqueous	M	2	35.00	70.00
160.1 - Total Dissolved Solids dried at 180°C - TDS In Liquid	Matrix	2	22.00	44.00
150.1 - pH, Elecrometric - pH In Liquid	Matrix	2	10.00	20.00
SW6010B - ICP - Total In Aqueous	Matrix	2	312.00	624.00
Inorganic Anions by Ion Chromatography - Anions by IC In Liquid	Matrix	2	54.00	108.00
310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity In Liquid	Matrix	2	36.00	72.00
	Total of Items Above:			**$938.00**

Adjustments or Special Services	**Qty**	**Price**	**Total**
Tumbling Charge	1	95.00	95.00
Total of Items Above:			**$95.00**

Grand Total: **$1,033.00**

All invoices are due and payable upon receipt. Outstanding balances over 30 days are subject to a finance charge of 1.5% per month, plus a late fee of $25.00. If Analytica engages legal counsel to enforce its rights or any other rights under an application for payment, the customer will be liable to Analytica for all costs of collection and other legal expenses, including reasonable attorney fees.

The Analytica Group
CLIENT INVOICE

REMITTANCE ADVICE
PLEASE RETURN THIS PORTION WITH YOUR PAYMENT

Mr.Art O'Hayre		**Account#:**	030188
Applied Hydrology Associates, Inc.		**Invoice #:**	**82691**
950 South Cherry Street		**Invoice Date:**	2/11/2008
Suite 810 Denver, CO 80246			

TOTAL INVOICE AMOUNT: **$1,033.00**

PAYMENT AMOUNT ENCLOSED: ____________________

Analytica Environmental
Laboratories, Inc.
12189 Pennsylvania Street
Thornton, CO 80241
Phone: 303-469-8868
Fax: 303-469-5254

2/11/2008

Applied Hydrology Associates, Inc.
950 South Cherry Street
Suite 810
Denver, CO 80246
Attn: Art O'Hayre

Work Order #: B0801197
Date: 2/11/2008
Work ID: Navajo Mine Extension Leaching Study
Date Received: 1/29/2008
Proj #: none

Sample Identification

Lab Sample Number	Client Description	Lab Sample Number	Client Description
B0801197-01	MB Successive #1	B0801197-02	Ash Successive #1

Enclosed are the analytical results for the submitted sample(s). Please review the CASE NARRATIVE for a discussion of any data and/or quality control issues. Listings of data qualifiers, analytical codes, key dates, and QC relationships are provided at the end of the report.

Sincerely,

Kristen Stone
Project Manager

"The Science of Analysis, The Art of Service"

Case Narrative

Analytica Environmental Laboratories, Inc.
Work Order: B0801197

Samples were prepared and analyzed according to EPA or equivalent methods outlined in the following references:

Methods for Chemical Analysis of Water and Wastes, USEPA 600/4-79-020, March 1983.

Pfaff, J. D., C. A. Brockhoff and J. W. O'Dell. 1994. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0A. U. S. Environmental Protection Agency. Environmental Monitoring Systems Lab.

Methods for the Determination of Metals in Environmental Samples, EPA/600/R-94/111, May 1994.

SAMPLE RECEIPT:
Two (2) samples were received on 1/29/2008 1:40:00 PM., at a temperature of 20 deg C., at Analytica-Thornton. The samples were received in good condition and in order per chain of custody. The samples were tumbled at the laboratory.

REVIEW FOR COMPLIANCE WITH ANALYTICA QA PLAN
A summary of our review is shown below.

All analytical results contained in this report have been reviewed under Analytica's internal quality assurance and quality control program. Any deviations in quality contro parameters for specific analyses are noted in the following text. A complete quality assurance report, including laboratory control, matrix spike, and sample duplicate recoveries is kept on file in our office and is available upon request.

All method specifications were met for the following tests:

Test Method: 150.1 - pH, Elecrometric - pH - Aqueous
Test Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS - Aqueous
Test Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity - Aqueous
Test Method: Inorganic Anions by Ion Chromatography - Anions by IC - Aqueous
Test Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg - Aqueous

Test Method: SW6010B - ICP - Total - Aqueous

MS/MSD and DUP OUTLIERS:
As shown below, the MS/MSD was outside of limits for Sodium and Calcium. The sample had Sodium and Calcium concentrations greater than four times the spike amount. In these case it is not appropriate to calculate a recovery. The result should be used as a replicate.

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MS	Ash Successive #	B0801197-02A	Sodium	52.8	75	125	1130	10.0
MSD	Ash Successive #	B0801197-02A	Calcium	217	75	125	472	10.0
MSD	Ash Successive #	B0801197-02A	Sodium	352	75	125	1130	10.0

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #1**

Matrix: Aqueous

Collection Date: 1/29/2008 11:10:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-01A	Analysis Date:	2/5/2008 4:36:31PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-01A	Analysis Date:	1/31/2008 1:35:00PM
Prep Date:	1/30/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01318A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080130010		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.063**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.085**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.31**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.2**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.3**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.016**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #1**

Matrix: Aqueous

Collection Date: 1/29/2008 11:10:00AM

Lab Sample Number: B0801197-01A

Analysis Date: 1/31/2008 1:35:00PM

Prep Date: 1/30/2008

Instrument: ICP_2

Analytical Method ID: SW6010B - ICP - Total

File Name: E01318A

Prep Method ID: 3010_ICP

Dilution Factor: 1

Prep Batch Number: T080130010

Report Basis: As Received

Analyst Initials: rm

Sample prep wt./vol: 50.00 ml

Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801197-01B

Analysis Date: 2/4/2008 9:52:02AM

Prep Date: 2/4/2008

Instrument: Titrametric

Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

File Name:

Prep Method ID: Alkalinity_W

Dilution Factor: 1

Prep Batch Number: T080205001

Report Basis: As Received

Analyst Initials: cs

Sample prep wt./vol: 50.00 ml

Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,100**		mg/L	5.0	1.5	1
Carbonate		**280**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801197-01B

Analysis Date: 1/29/2008 11:20:00AM

Prep Date: 1/29/2008

Instrument: Probe

Analytical Method ID: 150.1 - pH, Elecrometric - pH

File Name:

Prep Method ID: 150.1

Dilution Factor: 1

Prep Batch Number: T080201006

Report Basis: As Received

Analyst Initials: R. Seeman

Sample prep wt./vol: 10.00 ml

Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.1**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #1**

Matrix: Aqueous | Collection Date: 1/29/2008 11:10:00AM

Lab Sample Number:	B0801197-01B	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,000**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-01B	Analysis Date:	1/30/2008 7:58:57PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_023.D
Prep Method ID:	300.0	Dilution Factor:	25
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**600**		mg/L	20	1.1	1

Lab Sample Number:	B0801197-01B	Analysis Date:	1/31/2008 1:30:04AM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_041.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	2
Sulfate		**280**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #1**

Matrix: Aqueous

Collection Date: 1/29/2008 11:10:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-02A	Analysis Date:	2/5/2008 4:38:47PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-02A	Analysis Date:	1/31/2008 1:40:00PM
Prep Date:	1/30/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01318A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080130010		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.065**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.033**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.37**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**470**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**2.0**		mg/L	0.10	0.012	
Manganese	7439-96-5	**0.021**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.019**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #1**

Matrix: Aqueous

Collection Date: 1/29/2008 11:10:00AM

Lab Sample Number:	B0801197-02A	Analysis Date:	1/31/2008 1:40:00PM
Prep Date:	1/30/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01318A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080130010		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,100**		mg/L	3.0	0.028	1
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.034**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-02B	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Prep Method ID:	Alkalinity_W	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**790**		mg/L	5.0	1.5	1
Carbonate		**ND**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-02B	Analysis Date:	1/29/2008 11:20:00AM
Prep Date:	1/29/2008	Instrument:	Probe
Analytical Method ID:	150.1 - pH, Elecrometric - pH	File Name:	
Prep Method ID:	150.1	Dilution Factor:	1
Prep Batch Number:	T080201006		
Report Basis:	As Received	Analyst Initials:	R. Seeman
Sample prep wt./vol:	10.00 ml	Prep Extract Vol:	10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**7.4**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #1**

Matrix: Aqueous

Collection Date: 1/29/2008 11:10:00AM

Lab Sample Number:	B0801197-02B	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**4,900**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801197-02B	Analysis Date:	1/30/2008 8:17:21PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_024.D
Prep Method ID:	300.0	Dilution Factor:	25
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	20	1.1	1
Sulfate		**2,100**		mg/L	38	2.8	

Lab Sample Number:	B0801197-02B	Analysis Date:	1/31/2008 2:06:51AM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_043.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.6**		mg/L	0.40	0.031	2

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous Collection Date: 2/5/2008 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080205004-MB	Analysis Date:	2/5/2008 4:23:51PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Prep Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080130010-MB	Analysis Date:	1/31/2008 1:04:00PM
Prep Date:	1/30/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E01318A
Prep Method ID:	3010_ICP	Dilution Factor:	1
Prep Batch Number:	T080130010		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**ND**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	
Sodium	7440-23-5	**ND**		mg/L	3.0	0.028	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 1/30/2008 12:00:00AM

Lab Sample Number: T080130010-MB
Analysis Date: 1/31/2008 1:04:00PM
Prep Date: 1/30/2008
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E01318A
Prep Method ID: 3010_ICP
Dilution Factor: 1
Prep Batch Number: T080130010
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Thallium	7440-28-0	ND		mg/L	0.40	0.011	1
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	

Lab Sample Number: T080130010-MB
Analysis Date: 2/1/2008 12:48:00PM
Prep Date: 1/30/2008
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E02018A
Prep Method ID: 3010_ICP
Dilution Factor: 1
Prep Batch Number: T080130010
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Lead	7439-92-1	ND		mg/L	0.050	0.011	2
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: T080205001-MB
Analysis Date: 2/4/2008 9:52:02AM
Prep Date: 2/4/2008
Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
File Name:
Prep Method ID: Alkalinity_W
Dilution Factor: 1
Prep Batch Number: T080205001
Report Basis: As Received
Analyst Initials: cs
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		ND		mg/L	5.0	1.5	1
Carbonate		ND		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: T080131008-MB
Analysis Date: 2/4/2008 12:47:24PM
Prep Date: 1/31/2008
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Prep Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T080131008
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 1/31/2008 12:00:00AM

Lab Sample Number:	T080131008-MB	Analysis Date:	2/4/2008 12:47:24PM
Prep Date:	1/31/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Prep Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080131008		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**ND**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080130013-MB	Analysis Date:	1/30/2008 3:04:45PM
Prep Date:	1/30/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080130_007.D
Prep Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080130013		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	1
Fluoride		**ND**		mg/L	0.40	0.031	
Sulfate		**ND**		mg/L	1.5	0.11	

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0801197
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130010**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total
Base Sample: B0801197-02A
Prep Date: 1/30/2008

Samp. Anal. Date: 1/31/2008 1:40:00PM
DUP Anal. Date: 1/31/2008 1:45:00PM
Units: mg/L
Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.0655	ND	0.0	20	
Antimony	ND	ND	0.0	20	
Arsenic	ND	ND	0.0	20	
Barium	0.0334	0.0320	4.3	20	
Beryllium	ND	ND	0.0	20	
Boron	0.369	0.359	2.7	20	
Cadmium	ND	ND	0.0	20	
Calcium	472	452	4.3	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	ND	0.0	20	
Copper	ND	ND	0.0	20	
Iron	ND	ND	0.0	20	
Lead	ND	ND	0.0	20	
Magnesium	1.99	1.89	5.2	20	
Manganese	0.0213	0.0202	5.3	20	
Molybdenum	0.0188	0.0181	3.8	20	
Nickel	ND	ND	0.0	20	
Potassium	11.8	11.9	0.8	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	1,130	1,080	4.5	20	
Thallium	ND	ND	0.0	20	
Vanadium	0.0339	0.0313	8.0	20	
Zinc	ND	ND	0.0	20	
Lithium	ND	ND	0.0	20	

LCS/LCSD REPORT

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

QUALITY CONTROL REPORT

Project Number:

Prep Batch: **T080130010**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T080130010-MB

Prep Date: 1/30/2008

MB Anal. Date: 1/31/2008 1:04:00PM

Units: mg/L

LCS Anal. Date: 1/31/2008 1:25:00PM LCSD Anal. Date: 1/31/2008 1:30:00PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	1.89	1.94	2.00	2.00	94.5	97.0	2.6	89 - 117	20	
Antimony	ND	0.451	0.464	0.500	0.500	90.2	92.8	2.8	82 - 117	20	
Arsenic	ND	1.84	1.88	2.00	2.00	92.0	94.0	2.2	86 - 116	20	
Barium	ND	1.84	1.89	2.00	2.00	92.0	94.5	2.7	86 - 116	20	
Beryllium	ND	0.0499	0.0512	0.0500	0.0500	99.8	102.4	2.6	87 - 111	20	
Boron	ND	0.440	0.452	0.500	0.500	88.0	90.4	2.7	76 - 130	20	
Cadmium	ND	0.0438	0.0439	0.0500	0.0500	87.6	87.8	0.2	79 - 113	20	
Calcium	ND	9.54	9.93	10.0	10.0	95.4	99.3	4.0	79 - 119	20	
Chromium	ND	0.192	0.197	0.200	0.200	96.0	98.5	2.6	86 - 117	20	
Cobalt	ND	0.474	0.488	0.500	0.500	94.8	97.6	2.9	82 - 118	20	
Copper	ND	0.229	0.234	0.250	0.250	91.6	93.6	2.2	86 - 117	20	
Iron	ND	0.998	1.04	1.00	1.00	99.8	104.0	4.1	83 - 121	20	
Lead	ND	0.465	0.479	0.500	0.500	93.0	95.8	3.0	83 - 121	20	
Magnesium	ND	9.89	10.2	10.0	10.0	98.9	102.0	3.1	83 - 118	20	
Manganese	ND	0.480	0.493	0.500	0.500	96.0	98.6	2.7	82 - 121	20	
Molybdenum	ND	0.468	0.483	0.500	0.500	93.6	96.6	3.2	82 - 120	20	
Nickel	ND	0.478	0.490	0.500	0.500	95.6	98.0	2.5	84 - 117	20	
Potassium	ND	8.36	8.35	10.0	10.0	83.6	83.5	0.1	74 - 110	20	
Selenium	ND	1.89	1.93	2.00	2.00	94.5	96.5	2.1	87 - 117	20	
Silver	ND	0.248	0.253	0.250	0.250	99.2	101.2	2.0	80 - 127	20	
Sodium	ND	9.23	9.80	10.0	10.0	92.3	98.0	6.0	87 - 113	20	
Thallium	ND	0.199	0.178	0.200	0.200	99.5	89.0	11.1	89 - 113	20	lowdup
Vanadium	ND	0.484	0.497	0.500	0.500	96.8	99.4	2.7	87 - 119	20	
Zinc	ND	0.450	0.459	0.500	0.500	90.0	91.8	2.0	81 - 120	20	
Lithium	ND	0.457	0.471	0.500	0.500	91.4	94.2	3.0	80 - 120	20	

MS/MSD REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130010**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0801197-02A

Prep Date: 1/30/2008

Samp. Anal. Date: 1/31/2008 1:40:00PM

Units: mg/L

MS Anal. Date: 1/31/2008 1:50:00PM MSD Anal. Date: 1/31/2008 1:55:00PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag	
Aluminum	0.0655	1.96	1.96	2.00	2.00	94.7	94.7	0.0	75 - 125	20		
Antimony	ND	0.449	0.459	0.500	0.500	89.8	91.8	2.2	75 - 125	20		
Arsenic	ND	1.85	1.92	2.00	2.00	92.5	96.0	3.7	75 - 125	20		
Barium	0.0334	1.77	1.82	2.00	2.00	86.8	89.3	2.8	75 - 125	20		
Beryllium	ND	0.0469	0.0492	0.0500	0.0500	93.8	98.4	4.8	75 - 125	20		
Boron	0.369	0.789	0.815	0.500	0.500	84.0	89.2	3.2	75 - 125	20		
Cadmium	ND	0.0392	0.0387	0.0500	0.0500	78.4	77.4	1.3	75 - 125	20		
Calcium	472	480	493	10.0	10.0	80.0	210.0	2.7	75 - 125	20	*NOTE 2*	*NOTE 2*
Chromium	ND	0.177	0.184	0.200	0.200	88.5	92.0	3.9	75 - 125	20		
Cobalt	ND	0.430	0.450	0.500	0.500	86.0	90.0	4.5	75 - 125	20		
Copper	ND	0.223	0.232	0.250	0.250	89.2	92.8	4.0	75 - 125	20		
Iron	ND	0.925	0.956	1.00	1.00	92.5	95.6	3.3	75 - 125	20		
Lead	ND	0.432	0.448	0.500	0.500	86.4	89.6	3.6	75 - 125	20		
Magnesium	1.99	11.6	12.0	10.0	10.0	96.1	100.1	3.4	75 - 125	20		
Manganese	0.0213	0.463	0.479	0.500	0.500	88.3	91.5	3.4	75 - 125	20		
Molybdenum	0.0188	0.455	0.469	0.500	0.500	87.2	90.0	3.0	75 - 125	20		
Nickel	ND	0.439	0.455	0.500	0.500	87.8	91.0	3.6	75 - 125	20		
Potassium	11.8	20.4	21.4	10.0	10.0	86.0	96.0	4.8	75 - 125	20		
Selenium	ND	2.00	2.07	2.00	2.00	100.0	103.5	3.4	75 - 125	20		
Silver	ND	0.237	0.244	0.250	0.250	94.8	97.6	2.9	75 - 125	20		
Sodium	1,130	1,130	1,160	10.0	10.0	0.0	300.0	2.6	75 - 125	20	*NOTE 2*	*NOTE 2*
Thallium	ND	0.166	0.165	0.200	0.200	83.0	82.5	0.6	75 - 125	20		
Vanadium	0.0339	0.494	0.509	0.500	0.500	92.0	95.0	3.0	75 - 125	20		
Zinc	ND	0.434	0.445	0.500	0.500	86.8	89.0	2.5	75 - 125	20		
Lithium	ND	0.562	0.579	0.500	0.500	112.4	115.8	3.0	75 - 125	20		

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130010**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801197-02A

Prep Date: 1/30/2008

Samp. Anal. Date: 1/31/2008 1:40:00PM

Units: mg/L

PDS Anal. Date: 1/31/2008 2:00:00PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.0655	1.91	2.00	92.0	75 - 117		
Antimony	ND	0.447	0.500	87.2	75 - 117		
Arsenic	ND	1.85	2.00	91.2	75 - 116		
Barium	0.0334	1.76	2.00	86.3	75 - 116		
Beryllium	ND	0.0477	0.0500	94.4	75 - 111		
Boron	0.369	0.791	0.500	84.4	75 - 130		
Cadmium	ND	0.0391	0.0500	77.3	75 - 113		
Calcium	472	480	10.0	78.6	75 - 119		Note 2
Chromium	ND	0.178	0.200	88.8	75 - 117		
Cobalt	ND	0.435	0.500	86.7	75 - 118		
Copper	ND	0.225	0.250	89.0	75 - 117		
Iron	ND	0.931	1.00	93.2	75 - 121		
Lead	ND	0.442	0.500	87.1	75 - 121		
Magnesium	1.99	11.7	10.0	97.3	75 - 118		
Manganese	0.0213	0.466	0.500	89.0	75 - 121		
Molybdenum	0.0188	0.457	0.500	87.6	75 - 120		
Nickel	ND	0.444	0.500	88.3	75 - 117		
Potassium	11.8	21.1	10.0	93.1	75 - 110		
Selenium	ND	1.98	2.00	97.3	75 - 117		
Silver	ND	0.239	0.250	93.8	75 - 127		
Sodium	1,130	1,130	10.0	22.3	75 - 113	lowPDS	Note 2
Thallium	ND	0.165	0.200	79.3	75 - 113		
Vanadium	0.0339	0.496	0.500	92.4	75 - 119		
Zinc	ND	0.439	0.500	90.6	75 - 120		
Lithium	ND	0.559	0.500	94.3	75 - 120		

SERIAL DILUTION REPORT

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130010**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801197-02A

Prep Date: 1/30/2008

Samp. Anal. Date: 1/31/2008 1:40:00PM

Units: mg/L

SER DIL. Date: 1/31/2008 2:05:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.0655	0.050	0.014	ND	0.25		
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	ND	0.10	0.015	ND	0.50		
Barium	0.0334	0.0100	0.00016	ND	0.050		
Beryllium	ND	0.0010	0.000060	ND	0.0050		
Boron	0.369	0.050	0.0018	0.353	0.25	4.4	
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	472	0.10	0.013	435	0.50	8.1	
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	ND	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	1.99	0.10	0.012	1.72	0.50	14.5	OUT
Manganese	0.0213	0.0100	0.00066	ND	0.050		
Molybdenum	0.0188	0.0100	0.0018	ND	0.050		
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	11.8	1.0	0.31	11.7	5.0	0.8	
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	1,130	3.0	0.028	1,030	15	9.2	
Thallium	ND	0.40	0.011	ND	2.0		
Vanadium	0.0339	0.0100	0.00072	ND	0.050		
Zinc	ND	0.0050	0.0010	ND	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Prep Batch: **T080205004**

SAMPLE DUPLICATE REPORT

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205004**

SAMPLE DUPLICATE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801197-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:38:47PM

DUP Anal. Date: 2/5/2008 4:41:14PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Mercury	ND	ND	0.0	20	

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

MB: T080205004-MB

Prep Date: 2/5/2008

MB Anal. Date: 2/5/2008 4:23:51PM

LCS Anal. Date: 2/5/2008 4:26:44PM LCSD Anal. Date: 2/5/2008 4:29:07PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00223	0.00227	0.00200	0.0020	111.5	113.5	1.8	80 - 120	20	

MS/MSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Parent: B0801197-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:38:47PM

MS Anal. Date: 2/5/2008 4:43:28PM MSD Anal. Date: 2/5/2008 4:46:03PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00209	0.00203	0.00200	0.00200	104.5	101.5	2.9	70 - 130	20	

POST DIGESTION SPIKE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801197-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:38:47PM

PDS Anal. Date: 2/5/2008 4:52:53PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Mercury	ND	0.00211	0.00200	110.2	80 - 120	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080130013**

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

MB: T080130013-MB

Prep Date: 1/30/2008

MB Anal. Date: 1/30/2008 3:04:45PM

Units: mg/L

LCS Anal. Date: 1/31/2008 2:12:57PM LCSD Anal. Date: 1/31/2008 2:31:20PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.37	2.36	2.50	2.50	94.8	94.4	0.4	90 - 110	20	
Chloride	ND	4.75	4.75	5.00	5.00	95.0	95.0	0.0	90 - 110	20	
Sulfate	ND	34.1	34.1	37.5	37.5	90.9	90.9	0.0	90 - 110	20	

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Parent: B0801197-02B

Prep Date: 1/30/2008

Samp. Anal. Date: 1/31/2008 2:06:51AM

Units: mg/L

MS Anal. Date: 1/31/2008 2:25:15AM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag
Fluoride	2.55	4.83	2.50	91.2	70 - 130	
Chloride	605	743	125	110.4	70 - 130	*NOTE 2*
Sulfate	2,100	3,120	938	108.8	70 - 130	

Prep Batch: **T080131008**

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T080131008-MB

Prep Date: 1/31/2008

MB Anal. Date: 2/4/2008 12:47:24PM

Units: mg/L

LCS Anal. Date: 2/4/2008 12:47:24PM LCSD Anal. Date: 2/4/2008 12:47:24PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	802	765	821	821	97.6	93.1	4.7	80 - 120	20	

MS REPORT

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801197

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080131008**

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801197-02B

Prep Date: 1/31/2008

Samp. Anal. Date: 2/4/2008 12:47:24PM

Units: mg/L

MS Anal. Date: 2/4/2008 12:47:24PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Total Dissolved Solids	4,880	5,940	821	129.0	70 - 130	*NOTE 2*	

Prep Batch: **T080205001**

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

MB: T080205001-MB

Prep Date: 2/4/2008

MB Anal. Date: 2/4/2008 9:52:02AM

Units: mg/L

LCS Anal. Date: 2/4/2008 9:52:02AM LCSD Anal. Date: 2/4/2008 9:52:02AM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	24.0	27.0	25.0	25.0	96.0	108.0	11.8	80 - 120	20	
Carbonate	ND	50.0	51.0	50.0	50.0	100.0	102.0	2.0	80 - 120	20	

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,582** **Lab Project Number:** **B0801197**

Prep Date: 1/30/2008

Lab Method Blank Id: T080130010-MB

Prep Batch ID: T080130010

Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801197-02A-PDS	PDS	E02018A	2/1/2008 1:13:00PM
T080130010-LCSD	LCSD	E02018A	2/1/2008 12:58:00PM
B0801197-02A-MS	MS	E02018A	2/1/2008 1:03:00PM
B0801197-02A-MSD	MSD	E02018A	2/1/2008 1:08:00PM
B0801197-02A-MSD	MSD	E01318A	1/31/2008 1:55:00PM
B0801197-02A-PDS	PDS	E01318A	1/31/2008 2:00:00PM
T080130010-LCS	LCS	E02018A	2/1/2008 12:53:00PM
T080130010-LCSD	LCSD	E01318A	1/31/2008 1:30:00PM
B0801197-02A-DUP	DUP	E01318A	1/31/2008 1:45:00PM
B0801197-02A-MS	MS	E01318A	1/31/2008 1:50:00PM
B0801197-01A	MB Successive #1	E01318A	1/31/2008 1:35:00PM
B0801197-02A	Ash Successive #1	E01318A	1/31/2008 1:40:00PM
T080130010-LCS	LCS	E01318A	1/31/2008 1:25:00PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,582** **Lab Project Number:** **B0801197**

Prep Date: 1/30/2008

Lab Method Blank Id: T080130013-MB

Prep Batch ID: T080130013

Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080130013-LCSD	LCSD	080131_011.DXD	1/31/2008 2:31:20PM
B0801197-02B	Ash Successive #1	080130_043.DXD	1/31/2008 2:06:51AM
B0801197-02B-MS	MS	080130_044.DXD	1/31/2008 2:25:15AM
T080130013-LCS	LCS	080131_010.DXD	1/31/2008 2:12:57PM
B0801191-02B-DUP	DUP	080130_030.DXD	1/30/2008 10:07:41PM
B0801191-02B-MS	MS	080130_031.DXD	1/30/2008 10:26:05PM
B0801197-01B	MB Successive #1	080130_041.DXD	1/31/2008 1:30:04AM
B0801197-02B	Ash Successive #1	080130_024.DXD	1/30/2008 8:17:21PM
B0801197-02B-MS	MS	080130_025.DXD	1/30/2008 8:35:45PM
B0801191-02B	Batch QC	080130_029.DXD	1/30/2008 9:49:17PM
B0801191-02B-DUP	DUP	080130_013.DXD	1/30/2008 4:55:04PM
B0801191-02B-MS	MS	080130_014.DXD	1/30/2008 5:13:28PM
B0801197-01B	MB Successive #1	080130_023.DXD	1/30/2008 7:58:57PM
T080130013-LCS	LCS	080130_008.DXD	1/30/2008 3:23:07PM
T080130013-LCSD	LCSD	080130_009.DXD	1/30/2008 3:41:32PM
B0801191-02B	Batch QC	080130_012.DXD	1/30/2008 4:36:41PM

Prep Date: 1/31/2008

Lab Method Blank Id: T080131008-MB

Prep Batch ID: T080131008

Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801191-02B-MS	MS		2/4/2008 12:47:24PM
B0801197-02B-MS	MS		2/4/2008 12:47:24PM
T080131008-LCS	LCS		2/4/2008 12:47:24PM
T080131008-LCSD	LCSD		2/4/2008 12:47:24PM
B0801191-02B-DUP	DUP		2/4/2008 12:47:24PM
B0801191-02B	Batch QC		2/4/2008 12:47:24PM
B0801197-01B	MB Successive #1		2/4/2008 12:47:24PM
B0801197-02B	Ash Successive #1		2/4/2008 12:47:24PM

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,582** **Lab Project Number:** **B0801197**

Prep Date: 2/4/2008

Lab Method Blank Id: T080205001-MB

Prep Batch ID: T080205001

Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080205001-LCS	LCS		2/4/2008 9:52:02AM
T080205001-LCSD	LCSD		2/4/2008 9:52:02AM
B0801191-04B-DUP	DUP		2/4/2008 9:52:02AM
B0801191-04B	Batch QC		2/4/2008 9:52:02AM
B0801197-01B	MB Successive #1		2/4/2008 9:52:02AM
B0801197-02B	Ash Successive #1		2/4/2008 9:52:02AM

Prep Date: 2/5/2008

Lab Method Blank Id: T080205004-MB

Prep Batch ID: T080205004

Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801197-02A-PDS	PDS	B020508W.WKS	2/5/2008 4:52:53PM
B0801210-02A-PDS	PDS	B020508W.WKS	2/5/2008 5:08:38PM
B0801210-04A-PDS	PDS	B020508W.WKS	2/5/2008 5:27:21PM
B0801197-02A-MSD	MSD	B020508W.WKS	2/5/2008 4:46:03PM
B0801210-02A-MSD	MSD	B020508W.WKS	2/5/2008 5:06:23PM
B0801210-04A-MSD	MSD	B020508W.WKS	2/5/2008 5:25:08PM
B0801197-02A-MS	MS	B020508W.WKS	2/5/2008 4:43:28PM
B0801210-02A-MS	MS	B020508W.WKS	2/5/2008 5:04:18PM
B0801210-04A-MS	MS	B020508W.WKS	2/5/2008 5:22:59PM
B0801197-02A-DUP	DUP	B020508W.WKS	2/5/2008 4:41:14PM
B0801210-02A-DUP	DUP	B020508W.WKS	2/5/2008 5:02:05PM
B0801210-04A-DUP	DUP	B020508W.WKS	2/5/2008 5:20:14PM
B0801210-04A	Batch QC	B020508W.WKS	2/5/2008 5:13:23PM
T080205004-LCS	LCS	B020508W.WKS	2/5/2008 4:26:44PM
T080205004-LCSD	LCSD	B020508W.WKS	2/5/2008 4:29:07PM
B0801197-01A	MB Successive #1	B020508W.WKS	2/5/2008 4:36:31PM
B0801197-02A	Ash Successive #1	B020508W.WKS	2/5/2008 4:38:47PM
B0801210-02A	Batch QC	B020508W.WKS	2/5/2008 4:59:48PM

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:

- ND = Not Detected at or above the Reporting Limit
- NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:

- LOW = Recovery is below Lower Control Limit
- HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
- E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:

- B = Analyte was detected in the laboratory method blank
- J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:

- J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
- W = Post digestion spike did not meet criteria
- S = Reported value determined by the Method of Standard Additions (MSA)

Several ways of defining the limit of detection and quantitation are prevalent in the laboratory industry and may appear in Analytica reports. These include the following:

- MRL = "minimum reporting level", from the EPA Safe Drinking Water program (SDW)
- PQL = "practical quantitation limit", from SW-846
- EQL = "estimated quantitation limit", from SW-846
- LOQ = "limit of quantitation", from a number of authoritative sources

In Analytica's work, all of these terms have the same meaning, equivalent to the EPA definition of the MRL. This reporting level is supported by a satisfactory calibration data point which is at that level or lower, and also is supported by a method detection limit (MDL) determined by the procedure in 40CFR. The MDL is lower than the MRL and represents an estimate of the level where positive detections have a 99% probability of being real, but where quantitation accuracy is unknown.

The MRL as defined by Analytica is the lowest demonstrated point of known quantitation accuracy.
The MRL should not be confused with the MCL, which is the EPA-defined "maximum contaminant level" allowed for certain regulated targets under specific regulations, such as the National Primary Drinking Water Regulations. Normally, the MRL is set at a level which is much lower than the MCL in order to ensure that levels are well below those limits. Not all target analytes have MCL levels established.

Other Flags may be applied. See Case Narrative for Description

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801197

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0801197

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received	2	Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received	2	Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received	2	Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received	2	Report to PQL
6010B/3010A (Aqueous) - Total	As Received	2	Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received	2	Report to PQL

ANALYTICA GROUP®

Analytica Chain of Custody Form

12189 Pennsylvania St.
Thornton, CO 80241
(303) 469-8868
(303) 469-5254 fax

4307 Arctic Boulevard
Anchorage, AK 99503
(907) 258-2155
(907) 258-6634 fax

475 Hall St.
Fairbanks, AK 99701
(907) 456 - 3116
(907) 456-3125 Fax

5438 Shaune Drive
Juneau, AK 99801
(907) 780-6668
(907) 780-6670 fax

Page ____ of ____

Chain of Custody No: 63243

Client Name & Address: Applied Hydrology Associates Inc.

Public Water System (PWS) ID#:

Project Name: Navajo Mine extension Leaching Study

Section To be Completed by Analytica

Quote ID: | LGN: B0801197

Account #: | Cash | Credit Card

Report to:

Phone No:

Fax No:

E-mail:

Turnaround Time for Results (TAT)

X Standard ___ Expedited (< 10 days, prior authorization required) (please specify due date below; add'l charges may apply)

Requested Due Date for Results:

Invoice to Name & Address:

P.O. or Contract No:

Special Instructions/Comments:
Tumbled in house by R. Seeman
Successive Ash leaching Study

Kit Prep/Shipping Charge: $

Requested Analysis/Method

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	6010B/3010A TTL (Lot #: 1107090 Pres: HNO3)	7470A/7470A Hg (Lot #: 1107090 Pres: HNO3)	150.1 pH (Lot #: Pres:)	160.1 TDS (Lot #: Pres:)	300.0 Anions IC (Lot #: Pres:)	310.1 Alk (Lot #: Pres:)	(Lot #: Pres:)	Field Preserved	Field Filtered	MS/MSD ?
MB Successive #1	1/29/08	11:10	Aq	2	X	X	X	X	X	X		½	✓	
Ash Successive #1	1/29/08	11:10	Aq	2	X	X	X	X	X	X		½	✓	X

Relinquished by:	Date	Time	Received by:	Date	Time
R. Seeman	1/29/08	13:40	[signature]	1/29/08	13:40
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

Name of Sampler: (printed)

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:	—			
Initialed By:	—			
Temp/Loc:	20			
Thermo ID#:				
Shipped Via:	Ajen Seeman			

Version 2.0

ANALYTICA

Cooler Receipt Form

Client: Applied Hydrology Associates **Client Code:** 030188 **Order #:** B0801197
Project: Navajo Mine Extension Leaching Study

Cooler ID: 1

A. Preliminary Examination Phase: **Date cooler opened:** 1/29/2008
Cooler opened by: gp **Signature:** GP

1. **Was airbill Attached?** N/A **Airbill #:** **Carrier Name:** Other
2. **Custody Seals?** N/A **How many?** 0 **Location:** **Seal Name:**
3. **Seals intact?** N/A
4. **COC Attached?** Yes **Properly Completed?** Yes **Signed by AEL employee?** Yes
5. **Project Identification from custody paper:** Navajo Mine Extension Leaching Study
6. **Preservative:** None **Temperature:** 20.0 **deg. C**

Designated person initial here to acknowledge receipt: GP **Date:** 1/29/08

COMMENTS: Tumbled in house by R. Seeman. Successive Ash leaching study.

B. Log-In Phase: **Samples Log-in Date:** 1/29/2008 **Log-in By:** gp

1. **Packing Type:** Other
2. **Were samples in separate bags?** N/A
3. **Were containers intact?** Yes **Labels agree with COC?** Yes
4. **Number of bottles received:** 4 **Number of samples received:** 2
5. **Correct containers used?** Yes **Correct preservatives added?** Yes
6. **Sufficient sample volume?** Yes
7. **Bubbles in VOA samples?** N/A
8. **Was Project manager called and status discussed?** No
9. **Was anyone called?** No **Who was called?** ______ **By whom?** ______ **Date:** ______

COMMENTS:

Analytica Environmental
Laboratories, Inc.
12189 Pennsylvania Street
Thornton, CO 80241
Phone: 303-469-8868
Fax: 303-469-5254

ANALYTICA
Environmental Laboratories

2/21/2008

Applied Hydrology Associates, Inc.
950 South Cherry Street
Suite 810
Denver, CO 80246
Attn: Art O'Hayre

Work Order #: B0801210
Date: 2/21/2008
Work ID: Navajo Mine Extension Leaching Study
Date Received: 1/31/2008
Proj #: none

Sample Identification

Lab Sample Number	Client Description	Lab Sample Number	Client Description
B0801210-01	MB Successive #2	B0801210-02	Ash Successive #2
B0801210-03	MB Successive #3	B0801210-04	Ash Successive #3

Enclosed are the analytical results for the submitted sample(s). Please review the CASE NARRATIVE for a discussion of any data and/or quality control issues. Listings of data qualifiers, analytical codes, key dates, and QC relationships are provided at the end of the report.

Sincerely,

Kristen Stone
Project Manager

"The Science of Analysis, The Art of Service"

Case Narrative

Analytica Environmental Laboratories, Inc.

Work Order: B0801210

Samples were prepared and analyzed according to EPA or equivalent methods outlined in the following references:

Methods for Chemical Analysis of Water and Wastes, USEPA 600/4-79-020, March 1983.

Pfaff, J. D., C. A. Brockhoff and J. W. O'Dell. 1994. The Determination of Inorganic Anions in Water by Ion Chromatography. Method 300.0 A. U. S. Environmental Protection Agency. Environmental Monitoring Systems Lab.

Test Methods for Evaluating Solid Waste, USEPA SW-846, Third Edition, Revision 4, Decembe 1996.

PLEASE NOTE: THIS (2/21/08) IS A RE-ISSUE OF THE REPORT. ALL RESULTS ARE UNCHANGED EXCEPT FOR THE ICP METALS RESULTS. THE DATA VALIDATOR CONTACTED THE LABORATORY NOTING THAT THE ION BALANCE WAS OUT OF CONTROL FOR ALL SAMPLES ON THIS SDG, AND REQUESTED REANALYSIS FOR METALS. THE METALS WERE REANALYZED WITH THE EXCEPTION OF THE MATRIX SPIKES, FOR WHICH THERE WAS NOT SUFFICIENT SAMPLE. RESULTS WERE HIGHER, AND THE DATA VALIDATOR INDICATED THAT THE ION BALANCE WAS NOW IN CONTROL. THEREFORE THESE RESULTS ARE PREFERRED AND ARE SUBMITTED WITH THIS REPORT.

SAMPLE RECEIPT:
Four (4) samples were received on 1/31/2008 3:05:00 PM., at a temperature of 3 deg C., at Analytica-Thornton. The samples were received in good condition and in order per chain of custody.

REVIEW FOR COMPLIANCE WITH ANALYTICA QA PLAN
A summary of our review is shown below.

All analytical results contained in this report have been reviewed under Analytica's internal quality assurance and quality control program. Any deviations in quality contro parameters for specific analyses are noted in the following text. A complete quality assurance report, including laboratory control, matrix spike, and sample duplicate recoveries is kept on file in our office and is available upon request.

All method specifications were met for the following tests:

Test Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg - Aqueous
Test Method: 150.1 - pH, Elecrometric - pH - Aqueous
Test Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS - Aqueous
Test Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity - Aqueous
Test Method: Inorganic Anions by Ion Chromatography - Anions by IC - Aqueous

Test Method: SW6010B - ICP - Total - Aqueous

CLOSING CONTINUING CALIBRATIONS:
The closing CCV immediately following these samples was slightly elevated for Sodium. Th samples are high in Sodium and this is due to small amounts of carryover. A subsequent CCV was analyzed and is in control. The results are not expected to be significantly impacted and are submitted as they are. There is not sufficient sample remaining for reanalysis.

Case Narrative

Analytica Environmental Laboratories, Inc.
Work Order: B0801210
(continued)

RunDate	Data File	Analyte	Recovery	LCL	UCL
2/19/2008 3:01:00 PM	E02198A	Sodium	111.	90	110

MS/MSD and DUP OUTLIERS:

As shown below, the MS/MSD were outside of limits for a number of targets. With the exception of Cadmium, Aluminum, Potassium, and Boron, these samples had target concentrations greater than four times the spike amount. In these cases it is not appropriate to calculate recoveries. The results should be used as replicates. Although reanalyses were conducted, there was not sufficient sample remaining to re-spike for the targets that are out of limits. These should be reviewed for potential low bias.

MS/MSD and DUP OUTLIERS:

Type	Client Sample	LabSample	Analyte	Recovery	LCL	UCL	Parent	Spike
MS	Ash Successive #2	B0801210-02A	Aluminum	71.9	75	125	0.984	2.00
MS	Ash Successive #3	B0801210-04A	Boron	72.9	75	125	0.341	0.500
MS	Ash Successive #3	B0801210-04A	Cadmium	71.9	75	125	-0.00124	0.0500
MS	Ash Successive #3	B0801210-04A	Potassium	59.6	75	125	12.4	10.0
MS	Ash Successive #3	B0801210-04A	Sodium	-291	75	125	1270	10.0
MS	Ash Successive #2	B0801210-02A	Cadmium	67.8	75	125	-0.00148	0.0500
MS	Ash Successive #2	B0801210-02A	Sodium	-272	75	125	1220	10.0
MSD	Ash Successive #2	B0801210-02A	Potassium	70.4	75	125	11.5	10.0
MSD	Ash Successive #2	B0801210-02A	Sodium	-247	75	125	1220	10.0
MSD	Ash Successive #3	B0801210-04A	Boron	72.4	75	125	0.341	0.500
MSD	Ash Successive #3	B0801210-04A	Cadmium	72.1	75	125	-0.00124	0.0500
MSD	Ash Successive #3	B0801210-04A	Potassium	60.6	75	125	12.4	10.0
MSD	Ash Successive #3	B0801210-04A	Sodium	-290	75	125	1270	10.0
MSD	Ash Successive #2	B0801210-02A	Aluminum	73.8	75	125	0.984	2.00
MSD	Ash Successive #2	B0801210-02A	Boron	69.9	75	125	0.345	0.500
MSD	Ash Successive #2	B0801210-02A	Cadmium	69.0	75	125	-0.00148	0.0500

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #2**

Matrix: Aqueous Collection Date: 1/30/2008 11:20:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-01A	Analysis Date:	2/5/2008 4:57:34PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Reg. Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-01A	Analysis Date:	2/19/2008 2:36:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02198A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.051**		mg/L	0.050	0.014	2
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.089**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.31**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.0**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.3**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.010**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #2**

Matrix: Aqueous

Collection Date: 1/30/2008 11:20:00AM

Lab Sample Number: B0801210-01A
Analysis Date: 2/19/2008 2:36:00PM
Prep Date: 2/5/2008
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E02198A
Reg. Method ID: 6010B
Dilution Factor: 1
Prep Batch Number: T080205002
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	2
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-01B
Analysis Date: 2/4/2008 9:52:02AM
Prep Date: 2/4/2008
Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
File Name:
Reg. Method ID: 310.1
Dilution Factor: 1
Prep Batch Number: T080205001
Report Basis: As Received
Analyst Initials: cs
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,100**		mg/L	5.0	1.5	1
Carbonate		**320**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-01B
Analysis Date: 1/31/2008 11:25:00AM
Prep Date: 1/31/2008
Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH
File Name:
Reg. Method ID: 150.1
Dilution Factor: 1
Prep Batch Number: T080201007
Report Basis: As Received
Analyst Initials: R. Seeman
Sample prep wt./vol: 10.00 ml
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.1**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #2**

Matrix: Aqueous

Collection Date: 1/30/2008 11:20:00AM

Lab Sample Number:	B0801210-01B	Analysis Date:	2/12/2008 10:07:15AM
Prep Date:	2/6/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Reg. Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080207003		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,000**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-01B	Analysis Date:	2/4/2008 4:07:47PM
Prep Date:	2/4/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080204_017.D
Reg. Method ID:	300.0	Dilution Factor:	25
Prep Batch Number:	T080204004		
Report Basis:	As Received	Analyst Initials:	CS
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**600**		mg/L	20	1.1	1

Lab Sample Number:	B0801210-01B	Analysis Date:	2/4/2008 7:30:06PM
Prep Date:	2/4/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080204_028.D
Reg. Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080204004		
Report Basis:	As Received	Analyst Initials:	CS
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	2
Sulfate		**280**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #2**

Matrix: Aqueous

Collection Date: 1/30/2008 11:20:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-02A	Analysis Date:	2/5/2008 4:59:48PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Reg. Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-02A	Analysis Date:	2/19/2008 2:41:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02198A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.98**		mg/L	0.050	0.014	3
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**0.11**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.053**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.34**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.6**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.5**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.016**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**11**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #2**

Matrix: Aqueous

Collection Date: 1/30/2008 11:20:00AM

Lab Sample Number: B0801210-02A
Analysis Date: 2/19/2008 2:41:00PM
Prep Date: 2/5/2008
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E02198A
Reg. Method ID: 6010B
Dilution Factor: 1
Prep Batch Number: T080205002
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,200**		mg/L	3.0	0.028	3
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.063**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**0.0081**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-02B
Analysis Date: 2/4/2008 9:52:02AM
Prep Date: 2/4/2008
Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
File Name:
Reg. Method ID: 310.1
Dilution Factor: 1
Prep Batch Number: T080205001
Report Basis: As Received
Analyst Initials: cs
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,200**		mg/L	5.0	1.5	1
Carbonate		**160**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-02B
Analysis Date: 1/31/2008 11:25:00AM
Prep Date: 1/31/2008
Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH
File Name:
Reg. Method ID: 150.1
Dilution Factor: 1
Prep Batch Number: T080201007
Report Basis: As Received
Analyst Initials: R. Seeman
Sample prep wt./vol: 10.00 ml
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**8.8**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #2**

Matrix: Aqueous

Collection Date: 1/30/2008 11:20:00AM

Lab Sample Number:	B0801210-02B	Analysis Date:	2/12/2008 10:07:15AM
Prep Date:	2/6/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Reg. Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080207003		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-02B	Analysis Date:	2/4/2008 4:26:11PM
Prep Date:	2/4/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080204_018.D
Reg. Method ID:	300.0	Dilution Factor:	25
Prep Batch Number:	T080204004		
Report Basis:	As Received	Analyst Initials:	KB
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**610**		mg/L	20	1.1	1
Sulfate		**350**		mg/L	38	2.8	

Lab Sample Number:	B0801210-02B	Analysis Date:	2/4/2008 7:48:30PM
Prep Date:	2/4/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080204_029.D
Reg. Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080204004		
Report Basis:	As Received	Analyst Initials:	CS
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**10**		mg/L	0.40	0.031	2

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-03A	Analysis Date:	2/5/2008 5:11:03PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Reg. Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-03A	Analysis Date:	2/19/2008 2:46:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02198A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	2
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.089**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.32**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.0**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**0.051**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.3**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.011**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

Lab Sample Number: B0801210-03A
Prep Date: 2/5/2008
Analytical Method ID: SW6010B - ICP - Total
Reg. Method ID: 6010B
Prep Batch Number: T080205002
Report Basis: As Received
Sample prep wt./vol: 50.00 ml

Analysis Date: 2/19/2008 2:46:00PM
Instrument: ICP_2
File Name: E02198A
Dilution Factor: 1
Analyst Initials: rm
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,300**		mg/L	3.0	0.028	2
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**ND**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-03B
Prep Date: 2/4/2008
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
Reg. Method ID: 310.1
Prep Batch Number: T080205001
Report Basis: As Received
Sample prep wt./vol: 50.00 ml

Analysis Date: 2/4/2008 9:52:02AM
Instrument: Titrametric
File Name:
Dilution Factor: 1
Analyst Initials: cs
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,200**		mg/L	5.0	1.5	1
Carbonate		**320**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-03B
Prep Date: 1/31/2008
Analytical Method ID: 150.1 - pH, Elecrometric - pH
Reg. Method ID: 150.1
Prep Batch Number: T080201007
Report Basis: As Received
Sample prep wt./vol: 10.00 ml

Analysis Date: 1/31/2008 11:25:00AM
Instrument: Probe
File Name:
Dilution Factor: 1
Analyst Initials: R. Seeman
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.1**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **MB Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

Lab Sample Number: B0801210-03B
Analysis Date: 2/12/2008 10:07:15AM
Prep Date: 2/6/2008
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Reg. Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T080207003
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-03B
Analysis Date: 2/4/2008 5:39:45PM
Prep Date: 2/4/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080204_022.D
Reg. Method ID: 300.0
Dilution Factor: 25
Prep Batch Number: T080204004
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**620**		mg/L	20	1.1	1

Lab Sample Number: B0801210-03B
Analysis Date: 2/4/2008 9:02:06PM
Prep Date: 2/4/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080204_033.D
Reg. Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T080204004
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**2.2**		mg/L	0.40	0.031	2
Sulfate		**280**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-04A	Analysis Date:	2/5/2008 5:13:23PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Reg. Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	0.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	B0801210-04A	Analysis Date:	2/19/2008 2:51:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02198A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**0.67**		mg/L	0.050	0.014	3
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**0.070**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**0.34**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**3.3**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**1.9**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**0.013**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**12**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

Lab Sample Number: B0801210-04A
Analysis Date: 2/19/2008 2:51:00PM
Prep Date: 2/5/2008
Instrument: ICP_2
Analytical Method ID: SW6010B - ICP - Total
File Name: E02198A
Reg. Method ID: 6010B
Dilution Factor: 1
Prep Batch Number: T080205002
Report Basis: As Received
Analyst Initials: rm
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	**1,300**		mg/L	3.0	0.028	3
Thallium	7440-28-0	**ND**		mg/L	0.40	0.011	
Vanadium	7440-62-2	**0.031**		mg/L	0.010	0.00072	
Zinc	7440-66-6	**ND**		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-04B
Analysis Date: 2/4/2008 9:52:02AM
Prep Date: 2/4/2008
Instrument: Titrametric
Analytical Method ID: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity
File Name:
Reg. Method ID: 310.1
Dilution Factor: 1
Prep Batch Number: T080205001
Report Basis: As Received
Analyst Initials: cs
Sample prep wt./vol: 50.00 ml
Prep Extract Vol: 50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		**1,100**		mg/L	5.0	1.5	1
Carbonate		**340**		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-04B
Analysis Date: 1/31/2008 11:25:00AM
Prep Date: 1/31/2008
Instrument: Probe
Analytical Method ID: 150.1 - pH, Elecrometric - pH
File Name:
Reg. Method ID: 150.1
Dilution Factor: 1
Prep Batch Number: T080201007
Report Basis: As Received
Analyst Initials: R. Seeman
Sample prep wt./vol: 10.00 ml
Prep Extract Vol: 10.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
pH		**9.0**		pH	0.10	0.10	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Client Sample Report

Client Sample Name: **Ash Successive #3**

Matrix: Aqueous

Collection Date: 1/31/2008 11:00:00AM

Lab Sample Number: B0801210-04B
Analysis Date: 2/12/2008 10:07:15AM
Prep Date: 2/6/2008
Instrument: SCALE
Analytical Method ID: 160.1 - Total Dissolved Solids dried at 180°C - TDS
File Name:
Reg. Method ID: 160.1
Dilution Factor: 1
Prep Batch Number: T080207003
Report Basis: As Received
Analyst Initials: kl
Sample prep wt./vol: 100.00 ml
Prep Extract Vol: 1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		**3,100**		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Lab Sample Number: B0801210-04B
Analysis Date: 2/4/2008 5:58:09PM
Prep Date: 2/4/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080204_023.D
Reg. Method ID: 300.0
Dilution Factor: 25
Prep Batch Number: T080204004
Report Basis: As Received
Analyst Initials: KB
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**620**		mg/L	20	1.1	1

Lab Sample Number: B0801210-04B
Analysis Date: 2/4/2008 9:20:30PM
Prep Date: 2/4/2008
Instrument: IC
Analytical Method ID: Inorganic Anions by Ion Chromatography - Anions by IC
File Name: 080204_034.D
Reg. Method ID: 300.0
Dilution Factor: 1
Prep Batch Number: T080204004
Report Basis: As Received
Analyst Initials: CS
Sample prep wt./vol: 20.00 ml
Prep Extract Vol: 20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Fluoride		**4.7**		mg/L	0.40	0.031	2
Sulfate		**290**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 2/5/2008 12:00:00AM

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080205004-MB	Analysis Date:	2/5/2008 4:23:51PM
Prep Date:	2/5/2008	Instrument:	CVAA_1
Analytical Method ID:	SW7470A - Mercury in Liquid Waste by CVAA - Total Hg	File Name:	B020508W.W
Reg. Method ID:	7470A	Dilution Factor:	1
Prep Batch Number:	T080205004		
Report Basis:	As Received	Analyst Initials:	DL
Sample prep wt./vol:	30.00 ml	Prep Extract Vol:	30.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Mercury	7439-97-6	**ND**		mg/L	0.000200	.000050	2

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080205002-MB	Analysis Date:	2/5/2008 4:27:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02058A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Aluminum	7429-90-5	**ND**		mg/L	0.050	0.014	1
Antimony	7440-36-0	**ND**		mg/L	0.050	0.0067	
Arsenic	7440-38-2	**ND**		mg/L	0.10	0.015	
Barium	7440-39-3	**ND**		mg/L	0.010	0.00016	
Beryllium	7440-41-7	**ND**		mg/L	0.0010	0.000060	
Boron	7440-42-8	**ND**		mg/L	0.050	0.0018	
Cadmium	7440-43-9	**ND**		mg/L	0.0060	0.00051	
Calcium	7440-70-2	**ND**		mg/L	0.10	0.013	
Chromium	7440-47-3	**ND**		mg/L	0.010	0.0018	
Cobalt	7440-48-4	**ND**		mg/L	0.0050	0.0016	
Copper	7440-50-8	**ND**		mg/L	0.0050	0.0019	
Iron	7439-89-6	**ND**		mg/L	0.050	0.0027	
Lead	7439-92-1	**ND**		mg/L	0.050	0.011	
Lithium	7439-93-2	**ND**		mg/L	0.10	0.00072	
Magnesium	7439-96-4	**ND**		mg/L	0.10	0.012	
Manganese	7439-96-5	**ND**		mg/L	0.010	0.00066	
Molybdenum	7439-98-7	**ND**		mg/L	0.010	0.0018	
Nickel	7440-02-0	**ND**		mg/L	0.040	0.0027	
Potassium	7440-09-7	**ND**		mg/L	1.0	0.31	
Selenium	7784-49-2	**ND**		mg/L	0.10	0.026	
Silver	7440-22-4	**ND**		mg/L	0.015	0.00066	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous | Collection Date: 2/5/2008 12:00:00AM

Lab Sample Number:	T080205002-MB	Analysis Date:	2/5/2008 4:27:00PM
Prep Date:	2/5/2008	Instrument:	ICP_2
Analytical Method ID:	SW6010B - ICP - Total	File Name:	E02058A
Reg. Method ID:	6010B	Dilution Factor:	1
Prep Batch Number:	T080205002		
Report Basis:	As Received	Analyst Initials:	rm
Sample prep wt./vol:	50.00 ml	Prep Extract Vol:	50.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Sodium	7440-23-5	ND		mg/L	3.0	0.028	1
Thallium	7440-28-0	ND		mg/L	0.40	0.011	
Vanadium	7440-62-2	ND		mg/L	0.010	0.00072	
Zinc	7440-66-6	ND		mg/L	0.0050	0.0010	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080205001-MB	Analysis Date:	2/4/2008 9:52:02AM
Prep Date:	2/4/2008	Instrument:	Titrametric
Analytical Method ID:	310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity	File Name:	
Reg. Method ID:	310.1	Dilution Factor:	1
Prep Batch Number:	T080205001		
Report Basis:	As Received	Analyst Initials:	cs
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	100.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Bicarbonate		ND		mg/L	5.0	1.5	1
Carbonate		ND		mg/L	7.0	1.2	

The following test was conducted by: Analytica - Thornton

Lab Sample Number:	T080207003-MB	Analysis Date:	2/12/2008 10:07:15AM
Prep Date:	2/6/2008	Instrument:	SCALE
Analytical Method ID:	160.1 - Total Dissolved Solids dried at 180°C - TDS	File Name:	
Reg. Method ID:	160.1	Dilution Factor:	1
Prep Batch Number:	T080207003		
Report Basis:	As Received	Analyst Initials:	kl
Sample prep wt./vol:	100.00 ml	Prep Extract Vol:	1.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Total Dissolved Solids		ND		mg/L	10	8.2	1

The following test was conducted by: Analytica - Thornton

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Report Section: Method Blank Report

Client Sample Name: **MB**

Matrix: Aqueous

Collection Date: 2/4/2008 12:00:00AM

Lab Sample Number:	T080204004-MB	Analysis Date:	2/4/2008 2:54:13PM
Prep Date:	2/4/2008	Instrument:	IC
Analytical Method ID:	Inorganic Anions by Ion Chromatography - Anions by IC	File Name:	080204_013.D
Reg. Method ID:	300.0	Dilution Factor:	1
Prep Batch Number:	T080204004		
Report Basis:	As Received	Analyst Initials:	CS
Sample prep wt./vol:	20.00 ml	Prep Extract Vol:	20.00 ml

Analyte	CASNo	Result	Flags	Units	PQL	MDL	run #:
Chloride		**ND**		mg/L	0.80	0.042	1
Fluoride		**ND**		mg/L	0.40	0.031	
Sulfate		**ND**		mg/L	1.5	0.11	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:41:00PM

DUP Anal. Date: 2/5/2008 4:52:00PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.984	0.855	14.0	20	
Antimony	ND	ND	0.0	20	
Arsenic	0.108	ND	0.0	20	
Barium	0.0533	0.0470	12.6	20	
Beryllium	ND	ND	0.0	20	
Boron	0.345	0.309	11.0	20	
Cadmium	ND	ND	0.0	20	
Calcium	3.61	3.34	7.8	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	ND	0.0	20	
Copper	ND	ND	0.0	20	
Iron	ND	ND	0.0	20	
Lead	ND	ND	0.0	20	
Magnesium	1.50	1.36	9.8	20	
Manganese	ND	ND	0.0	20	
Molybdenum	0.0160	0.0193	18.7	20	
Nickel	ND	ND	0.0	20	
Potassium	11.5	10.2	12.0	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	1,220	994	20.4	20	OUT
Thallium	ND	ND	0.0	20	
Vanadium	0.0630	0.0540	15.4	20	
Zinc	0.00809	0.00785	3.0	20	
Lithium	ND	ND	0.0	20	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

SAMPLE DUPLICATE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:51:00PM

DUP Anal. Date: 2/5/2008 6:06:00PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Aluminum	0.674	0.601	11.5	20	
Antimony	ND	ND	0.0	20	
Arsenic	ND	ND	0.0	20	
Barium	0.0701	0.0615	13.1	20	
Beryllium	ND	ND	0.0	20	
Boron	0.341	0.311	9.2	20	
Cadmium	ND	ND	0.0	20	
Calcium	3.27	2.96	10.0	20	
Chromium	ND	ND	0.0	20	
Cobalt	ND	ND	0.0	20	
Copper	ND	ND	0.0	20	
Iron	ND	ND	0.0	20	
Lead	ND	ND	0.0	20	
Magnesium	1.88	1.65	13.0	20	
Manganese	ND	ND	0.0	20	
Molybdenum	0.0127	0.0147	14.6	20	
Nickel	ND	ND	0.0	20	
Potassium	12.4	10.4	17.5	20	
Selenium	ND	ND	0.0	20	
Silver	ND	ND	0.0	20	
Sodium	1,270	1,040	19.9	20	
Thallium	ND	ND	0.0	20	
Vanadium	0.0313	0.0268	15.5	20	
Zinc	ND	ND	0.0	20	
Lithium	ND	ND	0.0	20	

LCS/LCSD REPORT

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

LCS/LCSD REPORT

Analysis: SW6010B - ICP - Total

MB: T080205002-MB

Prep Date: 2/5/2008

MB Anal. Date: 2/5/2008 4:27:00PM

Units: mg/L

LCS Anal. Date: 2/5/2008 4:32:00PM LCSD Anal. Date: 2/5/2008 4:37:00PM Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Aluminum	ND	1.91	1.92	2.00	2.00	95.5	96.0	0.5	89 - 117	20	
Antimony	ND	0.445	0.442	0.500	0.500	89.0	88.4	0.7	82 - 117	20	
Arsenic	ND	1.81	1.82	2.00	2.00	90.5	91.0	0.6	86 - 116	20	
Barium	ND	1.89	1.91	2.00	2.00	94.5	95.5	1.1	86 - 116	20	
Beryllium	ND	0.0497	0.0500	0.0500	0.0500	99.4	100.0	0.6	87 - 111	20	
Boron	ND	0.458	0.461	0.500	0.500	91.6	92.2	0.7	76 - 130	20	
Cadmium	ND	0.0425	0.0428	0.0500	0.0500	85.0	85.6	0.7	79 - 113	20	
Calcium	ND	9.41	9.45	10.0	10.0	94.1	94.5	0.4	79 - 119	20	
Chromium	ND	0.191	0.191	0.200	0.200	95.5	95.5	0.0	86 - 117	20	
Cobalt	ND	0.468	0.471	0.500	0.500	93.6	94.2	0.6	82 - 118	20	
Copper	ND	0.233	0.235	0.250	0.250	93.2	94.0	0.9	86 - 117	20	
Iron	ND	1.01	1.02	1.00	1.00	101.0	102.0	1.0	83 - 121	20	
Lead	ND	0.456	0.465	0.500	0.500	91.2	93.0	2.0	83 - 121	20	
Magnesium	ND	9.99	10.0	10.0	10.0	99.9	100.0	0.1	83 - 118	20	
Manganese	ND	0.472	0.474	0.500	0.500	94.4	94.8	0.4	82 - 121	20	
Molybdenum	ND	0.464	0.467	0.500	0.500	92.8	93.4	0.6	82 - 120	20	
Nickel	ND	0.483	0.484	0.500	0.500	96.6	96.8	0.2	84 - 117	20	
Potassium	ND	8.29	8.02	10.0	10.0	82.9	80.2	3.3	74 - 110	20	
Selenium	ND	1.87	1.87	2.00	2.00	93.5	93.5	0.0	87 - 117	20	
Silver	ND	0.248	0.250	0.250	0.250	99.2	100.0	0.8	80 - 127	20	
Sodium	ND	9.48	9.59	10.0	10.0	94.8	95.9	1.2	87 - 113	20	
Thallium	ND	0.212	0.206	0.200	0.200	106.0	103.0	2.9	89 - 113	20	
Vanadium	ND	0.483	0.485	0.500	0.500	96.6	97.0	0.4	87 - 119	20	
Zinc	ND	0.455	0.457	0.500	0.500	91.0	91.4	0.4	81 - 120	20	
Lithium	ND	0.477	0.482	0.500	0.500	95.4	96.4	1.0	80 - 120	20	

MS/MSD REPORT

Project: **Navajo Mine Extension Leaching Study**
Client: **Applied Hydrology Associates, Inc.**
Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado
Workorder (SDG): B0801210
Project: Navajo Mine Extension Leaching Study
Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total
Parent: B0801210-02A
Prep Date: 2/5/2008
Samp. Anal. Date: 2/19/2008 2:41:00PM
Units: mg/L
MS Anal. Date: 2/5/2008 4:57:00PM MSD Anal. Date: 2/5/2008 5:02:00PM
Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Aluminum	0.984	2.42	2.46	2.00	2.00	71.8	73.8	1.6	75 - 125	20	*lowMS lowMSD*
Antimony	ND	0.395	0.403	0.500	0.500	79.0	80.6	2.0	75 - 125	20	
Arsenic	0.108	1.69	1.74	2.00	2.00	79.1	81.6	2.9	75 - 125	20	
Barium	0.0533	1.57	1.61	2.00	2.00	75.8	77.8	2.5	75 - 125	20	
Beryllium	ND	0.0421	0.0432	0.0500	0.0500	84.2	86.4	2.6	75 - 125	20	
Boron	0.345	0.737	0.694	0.500	0.500	78.4	69.8	6.0	75 - 125	20	*lowMSD*
Cadmium	ND	0.0339	0.0345	0.0500	0.0500	67.8	69.0	1.8	75 - 125	20	*lowMS lowMSD*
Calcium	3.61	11.4	11.6	10.0	10.0	77.9	79.9	1.7	75 - 125	20	
Chromium	ND	0.165	0.169	0.200	0.200	82.5	84.5	2.4	75 - 125	20	
Cobalt	ND	0.403	0.412	0.500	0.500	80.6	82.4	2.2	75 - 125	20	
Copper	ND	0.198	0.202	0.250	0.250	79.2	80.8	2.0	75 - 125	20	
Iron	ND	0.891	0.907	1.00	1.00	89.1	90.7	1.8	75 - 125	20	
Lead	ND	0.405	0.414	0.500	0.500	81.0	82.8	2.2	75 - 125	20	
Magnesium	1.50	9.70	9.90	10.0	10.0	82.0	84.0	2.0	75 - 125	20	
Manganese	ND	0.400	0.409	0.500	0.500	80.0	81.8	2.2	75 - 125	20	
Molybdenum	0.0160	0.414	0.424	0.500	0.500	79.6	81.6	2.4	75 - 125	20	
Nickel	ND	0.415	0.423	0.500	0.500	83.0	84.6	1.9	75 - 125	20	
Potassium	11.5	19.7	18.5	10.0	10.0	82.0	70.0	6.3	75 - 125	20	*lowMSD*
Selenium	ND	1.69	1.75	2.00	2.00	84.5	87.5	3.5	75 - 125	20	
Silver	ND	0.215	0.214	0.250	0.250	86.0	85.6	0.5	75 - 125	20	
Sodium	1,220	945	970	10.0	10.0	-2,750.0	-2,500.0	2.6	75 - 125	20	*NOTE 2 NOTE 2*
Thallium	ND	0.181	0.153	0.200	0.200	90.5	76.5	16.8	75 - 125	20	
Vanadium	0.0630	0.460	0.473	0.500	0.500	79.4	82.0	2.8	75 - 125	20	
Zinc	0.00809	0.417	0.424	0.500	0.500	81.8	83.2	1.7	75 - 125	20	
Lithium	ND	0.482	0.495	0.500	0.500	96.4	99.0	2.7	75 - 125	20	

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

MS/MSD REPORT

Analysis: SW6010B - ICP - Total

Parent: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:51:00PM

Units: mg/L

MS Anal. Date: 2/5/2008 6:11:00PM MSD Anal. Date: 2/5/2008 6:16:00PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Aluminum	0.674	2.32	2.29	2.00	2.00	82.3	80.8	1.3	75 - 125	20	
Antimony	ND	0.434	0.444	0.500	0.500	86.8	88.8	2.3	75 - 125	20	
Arsenic	ND	1.76	1.77	2.00	2.00	88.0	88.5	0.6	75 - 125	20	
Barium	0.0701	1.71	1.71	2.00	2.00	82.0	82.0	0.0	75 - 125	20	
Beryllium	ND	0.0424	0.0420	0.0500	0.0500	84.8	84.0	0.9	75 - 125	20	
Boron	0.341	0.705	0.703	0.500	0.500	72.8	72.4	0.3	75 - 125	20	*lowMS lowMSD*
Cadmium	ND	0.0359	0.0361	0.0500	0.0500	71.8	72.2	0.6	75 - 125	20	*lowMS lowMSD*
Calcium	3.27	12.6	12.5	10.0	10.0	93.3	92.3	0.8	75 - 125	20	
Chromium	ND	0.170	0.169	0.200	0.200	85.0	84.5	0.6	75 - 125	20	
Cobalt	ND	0.417	0.416	0.500	0.500	83.4	83.2	0.2	75 - 125	20	
Copper	ND	0.217	0.215	0.250	0.250	86.8	86.0	0.9	75 - 125	20	
Iron	ND	1.02	1.02	1.00	1.00	102.0	102.0	0.0	75 - 125	20	
Lead	ND	0.428	0.418	0.500	0.500	85.6	83.6	2.4	75 - 125	20	
Magnesium	1.88	10.3	10.3	10.0	10.0	84.2	84.2	0.0	75 - 125	20	
Manganese	ND	0.427	0.425	0.500	0.500	85.4	85.0	0.5	75 - 125	20	
Molybdenum	0.0127	0.446	0.443	0.500	0.500	86.7	86.1	0.7	75 - 125	20	
Nickel	ND	0.425	0.419	0.500	0.500	85.0	83.8	1.4	75 - 125	20	
Potassium	12.4	18.3	18.4	10.0	10.0	59.0	60.0	0.5	75 - 125	20	*lowMS lowMSD*
Selenium	ND	1.76	1.75	2.00	2.00	88.0	87.5	0.6	75 - 125	20	
Silver	ND	0.222	0.219	0.250	0.250	88.8	87.6	1.4	75 - 125	20	
Sodium	1,270	982	983	10.0	10.0	-2,880.0	-2,870.0	0.1	75 - 125	20	*NOTE 2 NOTE 2*
Thallium	ND	0.170	0.160	0.200	0.200	85.0	80.0	6.1	75 - 125	20	
Vanadium	0.0313	0.469	0.467	0.500	0.500	87.5	87.1	0.4	75 - 125	20	
Zinc	ND	0.448	0.444	0.500	0.500	89.6	88.8	0.9	75 - 125	20	
Lithium	ND	0.512	0.512	0.500	0.500	102.4	102.4	0.0	75 - 125	20	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:41:00PM

Units: mg/L

PDS Anal. Date: 2/5/2008 5:46:00PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.984	2.79	2.00	90.2	75 - 117		
Antimony	ND	0.473	0.500	93.2	75 - 117		
Arsenic	0.108	1.97	2.00	93.1	75 - 116		
Barium	0.0533	1.85	2.00	89.7	75 - 116		
Beryllium	ND	0.0459	0.0500	92.3	75 - 111		
Boron	0.345	0.780	0.500	87.0	75 - 130		
Cadmium	ND	0.0350	0.0500	73.0	75 - 113	lowPDS	
Calcium	3.61	12.5	10.0	88.6	75 - 119		
Chromium	ND	0.185	0.200	90.6	75 - 117		
Cobalt	ND	0.452	0.500	90.2	75 - 118		
Copper	ND	0.229	0.250	89.9	75 - 117		
Iron	ND	0.971	1.00	92.9	75 - 121		
Lead	ND	0.455	0.500	90.5	75 - 121		
Magnesium	1.50	10.6	10.0	91.4	75 - 118		
Manganese	ND	0.457	0.500	91.0	75 - 121		
Molybdenum	0.0160	0.481	0.500	93.0	75 - 120		
Nickel	ND	0.455	0.500	90.8	75 - 117		
Potassium	11.5	18.8	10.0	73.6	75 - 110	lowPDS	
Selenium	ND	1.96	2.00	93.6	75 - 117		
Silver	ND	0.237	0.250	95.2	75 - 127		
Sodium	1,220	1,070	10.0	-1,516.8	75 - 113	lowPDS	Note 2
Thallium	ND	0.185	0.200	85.5	75 - 113		
Vanadium	0.0630	0.540	0.500	95.4	75 - 119		
Zinc	0.00809	0.477	0.500	93.8	75 - 120		
Lithium	ND	0.558	0.500	94.8	75 - 120		

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

POST DIGESTION SPIKE REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:51:00PM

Units: mg/L

PDS Anal. Date: 2/5/2008 6:21:00PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag	
Aluminum	0.674	2.33	2.00	82.8	75 - 117		
Antimony	ND	0.433	0.500	85.3	75 - 117		
Arsenic	ND	1.77	2.00	86.4	75 - 116		
Barium	0.0701	1.74	2.00	83.7	75 - 116		
Beryllium	ND	0.0425	0.0500	85.5	75 - 111		
Boron	0.341	0.712	0.500	74.2	75 - 130	lowPDS	
Cadmium	ND	0.0330	0.0500	68.5	75 - 113	lowPDS	
Calcium	3.27	12.6	10.0	93.5	75 - 119		
Chromium	ND	0.172	0.200	84.0	75 - 117		
Cobalt	ND	0.418	0.500	82.7	75 - 118		
Copper	ND	0.219	0.250	87.1	75 - 117		
Iron	ND	1.04	1.00	100.4	75 - 121		
Lead	ND	0.422	0.500	84.6	75 - 121		
Magnesium	1.88	10.4	10.0	85.3	75 - 118		
Manganese	ND	0.429	0.500	85.4	75 - 121		
Molybdenum	0.0127	0.449	0.500	87.2	75 - 120		
Nickel	ND	0.424	0.500	84.9	75 - 117		
Potassium	12.4	18.1	10.0	57.7	75 - 110	lowPDS	
Selenium	ND	1.74	2.00	87.0	75 - 117		
Silver	ND	0.222	0.250	89.9	75 - 127		
Sodium	1,270	996	10.0	-2,766.0	75 - 113	lowPDS	Note 2
Thallium	ND	0.165	0.200	78.9	75 - 113		
Vanadium	0.0313	0.473	0.500	88.3	75 - 119		
Zinc	ND	0.449	0.500	89.5	75 - 120		
Lithium	ND	0.523	0.500	86.7	75 - 120		

SERIAL DILUTION REPORT

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:41:00PM

Units: mg/L

SER DIL. Date: 2/5/2008 5:51:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.984	0.050	0.014	1.04	0.25	5.5	
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	0.108	0.10	0.015	ND	0.50		
Barium	0.0533	0.0100	0.00016	0.0576	0.050	7.7	
Beryllium	ND	0.0010	0.000060	ND	0.0050		
Boron	0.345	0.050	0.0018	0.348	0.25	0.8	
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	3.61	0.10	0.013	3.63	0.50	0.5	
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	ND	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	1.50	0.10	0.012	1.50	0.50	0.0	
Manganese	ND	0.0100	0.00066	ND	0.050		
Molybdenum	0.0160	0.0100	0.0018	ND	0.050		
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	11.5	1.0	0.31	11.7	5.0	1.7	
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	1,220	3.0	0.028	1,100	15	10.3	OUT
Thallium	ND	0.40	0.011	ND	2.0		
Vanadium	0.0630	0.0100	0.00072	0.0681	0.050	7.7	
Zinc	0.00809	0.0050	0.0010	ND	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:51:00PM

Units: mg/L

SER DIL. Date: 2/5/2008 6:26:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205002**

SERIAL DILUTION REPORT

Analysis: SW6010B - ICP - Total

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/19/2008 2:51:00PM

Units: mg/L

SER DIL. Date: 2/5/2008 6:26:00PM

Matrix: Aqueous

Analyte Name	SampResult	PQL.	MDL.	SerialRes.	SerPQL.	RPD	Flag
Aluminum	0.674	0.050	0.014	0.749	0.25	10.5	Note 4
Antimony	ND	0.050	0.0067	ND	0.25		
Arsenic	ND	0.10	0.015	ND	0.50		
Barium	0.0701	0.0100	0.00016	0.0688	0.050	1.8	
Beryllium	ND	0.0010	0.000060	ND	0.0050		
Boron	0.341	0.050	0.0018	0.331	0.25	2.9	
Cadmium	ND	0.0060	0.00051	ND	0.030		
Calcium	3.27	0.10	0.013	3.24	0.50	0.9	
Chromium	ND	0.0100	0.0018	ND	0.050		
Cobalt	ND	0.0050	0.0016	ND	0.025		
Copper	ND	0.0050	0.0019	ND	0.025		
Iron	ND	0.050	0.0027	ND	0.25		
Lead	ND	0.050	0.011	ND	0.25		
Magnesium	1.88	0.10	0.012	1.81	0.50	3.7	
Manganese	ND	0.0100	0.00066	ND	0.050		
Molybdenum	0.0127	0.0100	0.0018	ND	0.050		
Nickel	ND	0.040	0.0027	ND	0.20		
Potassium	12.4	1.0	0.31	11.7	5.0	5.8	
Selenium	ND	0.10	0.026	ND	0.50		
Silver	ND	0.015	0.00066	ND	0.075		
Sodium	1,270	3.0	0.028	1,080	15	16.1	OUT
Thallium	ND	0.40	0.011	ND	2.0		
Vanadium	0.0313	0.0100	0.00072	ND	0.050		Note 4
Zinc	ND	0.0050	0.0010	ND	0.025		
Lithium	ND	0.10	0.00072	ND	0.50		

Prep Batch: **T080205004**

SAMPLE DUPLICATE REPORT

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205004**

SAMPLE DUPLICATE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:59:48PM

DUP Anal. Date: 2/5/2008 5:02:05PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Mercury	ND	ND	0.0	20	

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 5:13:23PM

DUP Anal. Date: 2/5/2008 5:20:14PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Mercury	ND	ND	0.0	20	

LCS/LCSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

MB: T080205004-MB

Prep Date: 2/5/2008

MB Anal. Date: 2/5/2008 4:23:51PM

Units: mg/L

LCS Anal. Date: 2/5/2008 4:26:44PM LCSD Anal. Date: 2/5/2008 4:29:07PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00223	0.00227	0.00200	0.0020	111.5	113.5	1.8	80 - 120	20	

MS/MSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Parent: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:59:48PM

Units: mg/L

MS Anal. Date: 2/5/2008 5:04:18PM MSD Anal. Date: 2/5/2008 5:06:23PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00217	0.00209	0.00200	0.00200	108.5	104.5	3.8	70 - 130	20	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080205004**

MS/MSD REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Parent: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 5:13:23PM

Units: mg/L

MS Anal. Date: 2/5/2008 5:22:59PM MSD Anal. Date: 2/5/2008 5:25:08PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	MSDRes	SPLev	SPDLev	Recov.	MSD Rec.	RPD	Recov Lim	RPDLim	Flag
Mercury	ND	0.00215	0.00209	0.00200	0.00200	107.5	104.5	2.8	70 - 130	20	

POST DIGESTION SPIKE REPORT

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801210-02A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 4:59:48PM

Units: mg/L

PDS Anal. Date: 2/5/2008 5:08:38PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Mercury	ND	0.00211	0.00200	109.4	80 - 120	

Analysis: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

Base Sample: B0801210-04A

Prep Date: 2/5/2008

Samp. Anal. Date: 2/5/2008 5:13:23PM

Units: mg/L

PDS Anal. Date: 2/5/2008 5:27:21PM

Matrix: Aqueous

Analyte Name	SampResult	PDSRes.	SPLev	Recov.	Recov Lim	Flag
Mercury	ND	0.00208	0.00200	109.4	80 - 120	

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080204004**

SAMPLE DUPLICATE REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Base Sample: B0801210-02B

Prep Date: 2/4/2008

Samp. Anal. Date: 2/4/2008 7:48:30PM

DUP Anal. Date: 2/4/2008 8:06:54PM

Units: mg/L

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Fluoride	10.2	10.2	0.0	30	
Chloride	607	609	0.3	30	
Sulfate	349	352	0.9	30	

LCS/LCSD REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

MB: T080204004-MB

Prep Date: 2/4/2008

MB Anal. Date: 2/4/2008 2:54:13PM

Units: mg/L

LCS Anal. Date: 2/4/2008 3:12:36PM LCSD Anal. Date: 2/4/2008 3:31:00PM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Fluoride	ND	2.46	2.43		2.50		97.2	1.2	90 - 110	20	
Chloride	ND	5.15	5.14		5.00		102.8	0.2	90 - 110	20	
Sulfate	ND	37.1	37.1		37.5		98.9	0.0	90 - 110	20	

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Parent: B0801210-02B

Prep Date: 2/4/2008

Samp. Anal. Date: 2/4/2008 7:48:30PM

Units: mg/L

MS Anal. Date: 2/4/2008 8:25:18PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Fluoride	10.2	12.8	2.50	104.0	70 - 130	*NOTE 2*	
Chloride	607	743	125	108.8	70 - 130	*NOTE 2*	
Sulfate	349	1,270	938	98.2	70 - 130		

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Parent: B0801210-04B

Prep Date: 2/4/2008

Samp. Anal. Date: 2/4/2008 9:20:30PM

Units: mg/L

MS Anal. Date: 2/4/2008 9:38:55PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080204004**

MS REPORT

Analysis: Inorganic Anions by Ion Chromatography - Anions by IC

Parent: B0801210-04B

Prep Date: 2/4/2008

Samp. Anal. Date: 2/4/2008 9:20:30PM

Units: mg/L

MS Anal. Date: 2/4/2008 9:38:55PM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim		Flag
Fluoride	4.72	7.14	2.50	96.8	70 - 130		
Chloride	624	757	125	106.4	70 - 130	*NOTE 2*	
Sulfate	285	321	37.5	96.0	70 - 130	*NOTE 2*	

Prep Batch: **T080207003**

SAMPLE DUPLICATE REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Base Sample: B0801210-02B

Prep Date: 2/6/2008

Samp. Anal. Date: 2/12/2008 10:07:15AM

Units: mg/L

DUP Anal. Date: 2/12/2008 10:07:15AM

Matrix: Aqueous

Analyte Name	SampResult	DUPRes.	RPD	RPDLim	Flag
Total Dissolved Solids	3,070	3,050	0.7	20	

LCS/LCSD REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

MB: T080207003-MB

Prep Date: 2/6/2008

MB Anal. Date: 2/12/2008 10:07:15AM

Units: mg/L

LCS Anal. Date: 2/12/2008 10:07:15AM LCSD Anal. Date: 2/12/2008 10:07:15AM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Total Dissolved Solids	ND	797	845	821	821	97.0	102.9	5.8	80 - 120	20	

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801210-02B

Prep Date: 2/6/2008

Samp. Anal. Date: 2/12/2008 10:07:15AM

Units: mg/L

MS Anal. Date: 2/12/2008 10:07:15AM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

Tests Run at: Analytica Environmental Laboratories - Thornton, Colorado

Workorder (SDG): B0801210

Project: Navajo Mine Extension Leaching Study

Project Number:

QUALITY CONTROL REPORT

Prep Batch: **T080207003**

MS REPORT

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801210-02B

Prep Date: 2/6/2008

Samp. Anal. Date: 2/12/2008 10:07:15AM

Units: mg/L

MS Anal. Date: 2/12/2008 10:07:15AM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag
Total Dissolved Solids	3,070	3,890	821	99.8	70 - 130	

Analysis: 160.1 - Total Dissolved Solids dried at 180°C - TDS

Parent: B0801210-04B

Prep Date: 2/6/2008

Samp. Anal. Date: 2/12/2008 10:07:15AM

Units: mg/L

MS Anal. Date: 2/12/2008 10:07:15AM

Matrix: Aqueous

Analyte Name	SampResult	MSRes.	SPLev	Recov.	Recov Lim	Flag
Total Dissolved Solids	3,060	3,930	821	105.9	70 - 130	

Prep Batch: **T080205001**

LCS/LCSD REPORT

Analysis: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

MB: T080205001-MB

Prep Date: 2/4/2008

MB Anal. Date: 2/4/2008 9:52:02AM

Units: mg/L

LCS Anal. Date: 2/4/2008 9:52:02AM LCSD Anal. Date: 2/4/2008 9:52:02AM

Matrix: Aqueous

Analyte Name	SampResult	LCSRes.	SDRes.	SPLev	SPDLev	Recov.	SD Recov	RPD	Recov Lim	RPDLim	Flag
Bicarbonate	ND	24.0	27.0	25.0	25.0	96.0	108.0	11.8	80 - 120	20	
Carbonate	ND	50.0	51.0	50.0	50.0	100.0	102.0	2.0	80 - 120	20	

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

FOOTNOTES TO QC REPORT

Note 1: Results are shown to three significant figures to avoid rounding errors in calculations.

Note 2: If the sample concentration is greater than 4 times the spike level, a recovery is not meaningful, and the result should be used as a replicate. In such cases the spike is not as high as expected random measurement variability of the sample result itself.

Note 3: For sample duplicates, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample and duplicate results are not five times the PQL or greater, then the RPD is not expected to fall within the window shown and the comparison should be made on the basis of the absolute difference. Analytica uses the criterion that the absolute difference should be less than the PQL for water or less than 2XPQL for other matrices.

Note 4: For serial dilutions, if the result is less than the PQL, the duplicate RPD is not applicable. If the sample result is not 50 times the MDL or greater, then the fact that the RPD does not meet the 10% criterion has little signifcance. Otherwise it indicates that a matrix bias may exist at the analytical step.

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,686** **Lab Project Number:** **B0801210**

Prep Date: 2/4/2008

Lab Method Blank Id: T080204004-MB

Prep Batch ID: T080204004

Method: Inorganic Anions by Ion Chromatography - Anions by IC

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080204004-LCS	LCS	080204_014.DXD	2/4/2008 3:12:36PM
T080204004-LCSD	LCSD	080204_015.DXD	2/4/2008 3:31:00PM
B0801210-01B	MB Successive #2	080204_017.DXD	2/4/2008 4:07:47PM
B0801210-02B	Ash Successive #2	080204_018.DXD	2/4/2008 4:26:11PM
B0801210-02B-DUP	DUP	080204_019.DXD	2/4/2008 4:44:34PM
B0801210-02B-MS	MS	080204_020.DXD	2/4/2008 5:02:58PM
B0801210-03B	MB Successive #3	080204_022.DXD	2/4/2008 5:39:45PM
B0801210-04B	Ash Successive #3	080204_023.DXD	2/4/2008 5:58:09PM
B0801210-04B-MS	MS	080204_024.DXD	2/4/2008 6:16:33PM
B0801210-01B	MB Successive #2	080204_028.DXD	2/4/2008 7:30:06PM
B0801210-02B	Ash Successive #2	080204_029.DXD	2/4/2008 7:48:30PM
B0801210-02B-DUP	DUP	080204_030.DXD	2/4/2008 8:06:54PM
B0801210-02B-MS	MS	080204_031.DXD	2/4/2008 8:25:18PM
B0801210-03B	MB Successive #3	080204_033.DXD	2/4/2008 9:02:06PM
B0801210-04B	Ash Successive #3	080204_034.DXD	2/4/2008 9:20:30PM
B0801210-04B-MS	MS	080204_035.DXD	2/4/2008 9:38:55PM

Prep Date: 2/4/2008

Lab Method Blank Id: T080205001-MB

Prep Batch ID: T080205001

Method: 310.1 - Alkalinity, Titrimetric (pH 4.5) - Alkalinity

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801191-04B	Batch QC		2/4/2008 9:52:02AM
B0801210-01B	MB Successive #2		2/4/2008 9:52:02AM
B0801210-02B	Ash Successive #2		2/4/2008 9:52:02AM
B0801210-03B	MB Successive #3		2/4/2008 9:52:02AM
B0801210-04B	Ash Successive #3		2/4/2008 9:52:02AM
T080205001-LCS	LCS		2/4/2008 9:52:02AM
T080205001-LCSD	LCSD		2/4/2008 9:52:02AM
B0801191-04B-DUP	DUP		2/4/2008 9:52:02AM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,686** **Lab Project Number:** **B0801210**

Prep Date: 2/5/2008

Lab Method Blank Id: T080205002-MB

Prep Batch ID: T080205002

Method: SW6010B - ICP - Total

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
T080205002-LCS	LCS	E02058A	2/5/2008 4:32:00PM
T080205002-LCSD	LCSD	E02058A	2/5/2008 4:37:00PM
B0801210-02A-DUP	DUP	E02058A	2/5/2008 4:52:00PM
B0801210-04A-DUP	DUP	E02058A	2/5/2008 6:06:00PM
B0801210-02A-MS	MS	E02058A	2/5/2008 4:57:00PM
B0801210-04A-MS	MS	E02058A	2/5/2008 6:11:00PM
B0801210-02A-MSD	MSD	E02058A	2/5/2008 5:02:00PM
B0801210-04A-MSD	MSD	E02058A	2/5/2008 6:16:00PM
B0801210-02A-PDS	PDS	E02058A	2/5/2008 5:46:00PM
B0801210-04A-PDS	PDS	E02058A	2/5/2008 6:21:00PM
T080205002-LCS	LCS	E02068A	2/6/2008 1:59:00PM
T080205002-LCSD	LCSD	E02068A	2/6/2008 2:04:00PM
B0801210-02A-MS	MS	E02068A	2/6/2008 2:09:00PM
B0801210-04A-MS	MS	E02068A	2/6/2008 2:19:00PM
B0801210-02A-MSD	MSD	E02068A	2/6/2008 2:14:00PM
B0801210-04A-MSD	MSD	E02068A	2/6/2008 2:24:00PM
B0801210-01A	MB Successive #2	E02198A	2/19/2008 2:36:00PM
B0801210-02A	Ash Successive #2	E02198A	2/19/2008 2:41:00PM
B0801210-03A	MB Successive #3	E02198A	2/19/2008 2:46:00PM
B0801210-04A	Ash Successive #3	E02198A	2/19/2008 2:51:00PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,686** **Lab Project Number:** **B0801210**

Prep Date: 2/5/2008

Lab Method Blank Id: T080205004-MB

Prep Batch ID: T080205004

Method: SW7470A - Mercury in Liquid Waste by CVAA - Total Hg

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801197-02A	Batch QC	B020508W.WKS	2/5/2008 4:38:47PM
B0801210-01A	MB Successive #2	B020508W.WKS	2/5/2008 4:57:34PM
B0801210-02A	Ash Successive #2	B020508W.WKS	2/5/2008 4:59:48PM
B0801210-03A	MB Successive #3	B020508W.WKS	2/5/2008 5:11:03PM
B0801210-04A	Ash Successive #3	B020508W.WKS	2/5/2008 5:13:23PM
T080205004-LCS	LCS	B020508W.WKS	2/5/2008 4:26:44PM
T080205004-LCSD	LCSD	B020508W.WKS	2/5/2008 4:29:07PM
B0801197-02A-DUP	DUP	B020508W.WKS	2/5/2008 4:41:14PM
B0801210-02A-DUP	DUP	B020508W.WKS	2/5/2008 5:02:05PM
B0801210-04A-DUP	DUP	B020508W.WKS	2/5/2008 5:20:14PM
B0801197-02A-MS	MS	B020508W.WKS	2/5/2008 4:43:28PM
B0801210-02A-MS	MS	B020508W.WKS	2/5/2008 5:04:18PM
B0801210-04A-MS	MS	B020508W.WKS	2/5/2008 5:22:59PM
B0801197-02A-MSD	MSD	B020508W.WKS	2/5/2008 4:46:03PM
B0801210-02A-MSD	MSD	B020508W.WKS	2/5/2008 5:06:23PM
B0801210-04A-MSD	MSD	B020508W.WKS	2/5/2008 5:25:08PM
B0801197-02A-PDS	PDS	B020508W.WKS	2/5/2008 4:52:53PM
B0801210-02A-PDS	PDS	B020508W.WKS	2/5/2008 5:08:38PM
B0801210-04A-PDS	PDS	B020508W.WKS	2/5/2008 5:27:21PM

Detailed Analytical Report

Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

QC BATCH ASSOCIATIONS - BY METHOD BLANK

Lab Project ID: **83,686** **Lab Project Number:** **B0801210**

Prep Date: 2/6/2008

Lab Method Blank Id: T080207003-MB

Prep Batch ID: T080207003

Method: 160.1 - Total Dissolved Solids dried at 180°C - TDS

This Method blank and sample preparation batch are associated with the following samples, spikes, and duplicates:

SampleNum	ClientSampleName	DataFile	AnalysisDate
B0801210-01B	MB Successive #2		2/12/2008 10:07:15AM
B0801210-02B	Ash Successive #2		2/12/2008 10:07:15AM
B0801210-03B	MB Successive #3		2/12/2008 10:07:15AM
B0801210-04B	Ash Successive #3		2/12/2008 10:07:15AM
T080207003-LCS	LCS		2/12/2008 10:07:15AM
T080207003-LCSD	LCSD		2/12/2008 10:07:15AM
B0801210-02B-DUP	DUP		2/12/2008 10:07:15AM
B0801210-02B-MS	MS		2/12/2008 10:07:15AM
B0801210-04B-MS	MS		2/12/2008 10:07:15AM

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

DATA FLAGS AND DEFINITIONS

The PQL is the Method Quantitation Limit as defined by USACE.
Reporting Limit: Limit below which results are shown as "ND". This may be the PQL, MDL, or a value between. See the report conventions below.

Result Field:

ND = Not Detected at or above the Reporting Limit
NA = Analyte not applicable (see Case Narrative for discussion)

Qualifier Fields:

LOW = Recovery is below Lower Control Limit
HIGH = Recovery , RPD, or other parameter is above Upper Control Limit
E = Reported concentration is above the instrument calibration upper range

Organic Analysis Flags:

B = Analyte was detected in the laboratory method blank
J = Analyte was detected above MDL or Reporting Limit but below the Quant Limit (PQL)

Inorganic Analysis Flags:

J = Analyte was detected above the Reporting Limit but below the Quant Limit (PQL)
W = Post digestion spike did not meet criteria
S = Reported value determined by the Method of Standard Additions (MSA)

Several ways of defining the limit of detection and quantitation are prevalent in the laboratory industry and may appear in Analytica reports. These include the following:

MRL = "minimum reporting level", from the EPA Safe Drinking Water program (SDW)
PQL = "practical quantitation limit", from SW-846
EQL = "estimated quantitation limit", from SW-846
LOQ = "limit of quantitation", from a number of authoritative sources

In Analytica's work, all of these terms have the same meaning, equivalent to the EPA definition of the MRL. This reporting level is supported by a satisfactory calibration data point which is at that level or lower, and also is supported by a method detection limit (MDL) determined by the procedure in 40CFR. The MDL is lower than the MRL and represents an estimate of the level where positive detections have a 99% probability of being real, but where quantitation accuracy is unknown.

The MRL as defined by Analytica is the lowest demonstrated point of known quantitation accuracy.
The MRL should not be confused with the MCL, which is the EPA-defined "maximum contaminant level" allowed for certain regulated targets under specific regulations, such as the National Primary Drinking Water Regulations. Normally, the MRL is set at a level which is much lower than the MCL in order to ensure that levels are well below those limits. Not all target analytes have MCL levels established.

Other Flags may be applied. See Case Narrative for Description

Detailed Analytical Report Analytica Environmental Laboratories, Inc.

Workorder (SDG): B0801210

Project: **Navajo Mine Extension Leaching Study**

Client: **Applied Hydrology Associates, Inc.**

Client Project Number: **none**

REPORTING CONVENTIONS FOR THIS REPORT

B0801210

TestPkgName	Basis	# Sig Figs	Reporting Limit
150.1/150.1 (Aqueous) - pH	As Received	2	Report to PQL
160.1/160.1 (Aqueous) - TDS	As Received	2	Report to PQL
300.0/300.0 (Aqueous) - Anions by IC	As Received	2	Report to PQL
310.1/310.1 (Aqueous) - Alkalinity	As Received	2	Report to PQL
6010B/3010A (Aqueous) - Total	As Received	2	Report to PQL
7470A/7470A (Aqueous) - Total Hg	As Received	2	Report to PQL

Analytica Chain of Custody Form

ANALYTICA GROUP®

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(907) 780-6670 fax

Chain of Custody No: 63254

Client Name & Address: Applied Hydrology Associates, INC

Public Water System (PWS) ID#:

Project Name: Navajo Mine Extension Leaching Study

Section To be Completed by Analytica
Quote ID:
LGN: B0801210
Account #: Cash Credit Card

Report to:
Phone No:
Fax No:
E-mail:

Turnaround Time for Results (TAT)
___ Standard ___ Expedited (< 10 days, prior authorization required) (please specify due date below; add'tl charges may apply)

Requested Due Date for Results:

Invoice to Name & Address:

P.O. or Contract No:

Special Instructions/Comments: Tumbled in house by R.Seeman
Ash Successive leaching Study

Kit Prep/Shipping Charge: $

Requested Analysis/Method

Client Sample Identification / Location	Date Sampled	Time Sampled	Matrix (S-DW-WW-Other)	No. of Containers	6010B/3010A TTL (Lot #: 1101090; Pres: HNO3)	7470A/7470A Hg (Lot #: 1101090; Pres: HNO3)	150.1 pH (Lot #: Pres:)	160.1 TDS (Lot #: Pres:)	300.0 Anions IC (Lot #: Pres:)	310.1 Alk. (Lot #: Pres:)	(Lot #: Pres:)	Field Preserved	Field Filtered	MS/MSD ?
MB Successive #2	1/30/08	11:30	Aq	2	X	X	X	X	X	X		½	⅔	
Ash Successive #2				2	X	X	X	X	X	X				X
MB Successive #3	1/31/08	11:00		2	X	X	X	X	X	X				
Ash Successive #3				2	X	X	X	X	X	X				X

Relinquished by:	Date	Time	Received by:	Date	Time
R.Seeman	1/31/08	15:05	[signature]	1/31/08	15:05
Relinquished by:	Date	Time	Received by:	Date	Time
Relinquished by:	Date	Time	Received by:	Date	Time

Name of Sampler: (printed)

Section To Be Completed by Analytica

	THO	ANC	JNU	FBKS
Condition of Custody Seal?:	—			
Initialed By:	—			
Temp/Loc:	3.0			
Thermo ID#:				
Shipped Via:	Ryan Seeman			

Version 2.0

APPENDIX 11-WW

Navajo Mine Area IV

Groundwater Modeling Report

November 2011

NAVAJO MINE AREA IV.
GROUNDWATER MODELING REPORT

Submitted to:
BHP Navajo Coal Company,
Farmington, New Mexico
November 15, 2011

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1 INTRODUCTION

1.1 BACKGROUND

This report describes the numerical groundwater flow model developed for BHP Navajo Coal Company (BNCC) in support of a previously proposed different mining operation within resource area (Area) IV South of the BNCC coal lease, located on the western flank of the San Juan Structural Basin within the Navajo Nation Indian Reservation, southwest of Farmington, New Mexico. The groundwater flow model also included Area IV North within the model domain so that the affects of coal mining in Area IV North could also be simulated. Consequently, this model has been applied to simulate the affects of BNCC's proposed mining within Area IV North to meet its Pre-2016 fuel sales obligations with Four Corners Power Plant The model can also be applied to simulate the affects of future mining and reclamation within Area IV South and Area V as well as within the portions Area IV North beyond the Pre-2016 mine plan.

The coal seams to be mined include seams 2, 3, 4, 6, 7, and 8 of the Cretaceous age Fruitland Formation. Seams 7 and 8 extend over only a portion of the coal lease. The coal lease area and adjacent area within Area IV North is dominated by badlands and mesas with the Chaco River valley coursing from south to north approximately 1 mile west of the coal lease. The Chaco River flows north into the San Juan River approximately 18 miles north-north-west of the model area. The regional setting for the model area is shown in Figure 1-1. Although the Chaco River drains an area of more than 4,000 square miles, the flow in the river and in tributary drainages is ephemeral in the vicinity of the project site.

The BNCC coal lease at resource areas IV North and IV South is crossed by three arroyos, Cottonwood Arroyo at the north edge of Area IV North, Pinabete Arroyo through Area IV South and No Name Arroyo, which separates Area IV South from Area V. These arroyos flow into the Chaco River but are ephemeral streams that only flow in response to large storm events. Cottonwood Arroyo may experience temporary flows resulting from irrigation channel releases from the Navajo Indian Irrigation Project. Alluvial groundwater is present in the alluvium of both Pinabete and Cottonwood Arroyos, although the saturated thickness is variable and is often insufficient to yield water from the few dug water wells that have been installed for stock water use. Cottonwood Arroyo has a drainage area of approximately 80 square miles and flows from east to west along the north side of Area IV North. Pinabete Arroyo traverses in a northwest direction across Area IV South, and then flows west to the Chaco River. The drainage basin area of Pinabete Arroyo is approximately 60 square miles. The surface water drainage immediately south of Pinabete Arroyo is No Name Arroyo, which separates Area IV South from Area V. A topographic and structural high area exists on the west side of the Area V south of No Name Arroyo.

Groundwater recharge is quite low due to the arid climate. Evaporation rates are high, averaging over 60 inches per year, while precipitation is low, averaging less than 6 inches per year. Most precipitation occurs during several large high intensity precipitation events. Snow rarely accumulates in any significant depth over the site.

Groundwater modeling was performed to support the baseline hydrogeologic characterization and the probable hydrologic consequences (PHC) assessment of proposed mining and reclamation activities. The hydrogeologic units within the BNCC coal lease that could potentially be affected by proposed mining and reclamation include:

- The alluvium of Cottonwood and Pinabete Arroyos
- The Coal Seams of the Fruitland Formation
- The Pictured Cliffs Sandstone, located below the Fruitland Formation No. 2 Coal Seam

Among these units, only the alluvium of Cottonwood and Pinabete Arroyos supply water to wells located within or adjacent to BNCC's Navajo coal lease. The saturated thickness and yield of these alluvial wells is quite low but at times is sufficient to provide stock water via windmill driven pumps at dug wells. The water level in the alluvium varies with precipitation patterns. Alluvial groundwater levels are generally too low to supply water to dug wells in the Cottonwood alluvium west of the coal lease during most years and to dug wells in the Pinabete alluvium within the coal lease during dry years. For example, in the Fall of 2007 the saturated thickness of the Pinabete alluvium was less than 3-feet at monitoring well PA-2 located adjacent to dug well 13R-37. The groundwater quality in the Pinabete and Cottonwood alluvium is also poor with total dissolved solids (TDS), sulfate, fluoride, iron, and manganese concentrations above drinking water standards. Although the groundwater in the alluvium has been used for stock watering, the fluoride, sulfate and TDS concentrations exceed recommended criteria for livestock use (BNCC's Navajo Mine permit application package (PAP) NM-0003F, Chapter 6, Appendix 6.G).

Although, groundwater is also found in the coal units of the Fruitland Formation and in the Pictured Cliffs Sandstone (PCS), which underlies the Fruitland Formation at BNCC coal lease, the yields from these units are quite low and wells are typically pumped dry during testing and well purging for sampling. The water quality in these units is also poor. The sulfate and fluoride concentrations at most monitoring locations exceed recommended criteria for livestock use (Appendix 6.G). Stone and others (1983) state that the Pictured Cliffs Sandstone cannot be considered a major aquifer, and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation.

There are no water supply wells completed in the Fruitland Formation or the PCS within or near the project area. One well, 13-15-1, is located within Area V of BNCC's coal lease. The completion interval for this well is not known but is believed to be a PCS well based on the depth reported by Metric Corporation (1991). The well has not been used for at least 20 years and has been capped and welded shut.

Groundwater models are conceptual descriptions or approximations that describe physical systems using mathematical equations. Groundwater models used for a PHC assessment can range from simple empirical equations to complex numerical computer simulations of groundwater flow and groundwater chemistry. Regardless of the level of complexity, all groundwater models are based on certain simplifying assumptions which typically involve: the direction of flow, geometry of the hydrogeologic units, the heterogeneity or anisotropy of sediments or bedrock within these aquifer units, and the location of boundaries and conditions at these boundaries.

As a result of these assumptions and the uncertainties in the values of parameters and data required by the model, all models are an approximation and not an exact representation of the physical systems being modeled. In order to select and apply an appropriate modeling code it is necessary to:

- consider modeling objectives,
- have a thorough understanding of the physical system with sufficient site-specific data to apply the modeling code, and
- have sufficient data to assess how well the model approximates the groundwater conditions at the Site.

Extensive information on the baseline groundwater conditions at the Navajo Mine is provided in Chapter 6 Navajo Mine PAP. Information specific to Area IV North, Area IV South and Area V is provided in Appendix 6.G while regional groundwater information is also available from the U.S Geological Survey and the New Mexico Bureau of Mines and Mineral Resources Reports, and from the nearby San Juan Mine and CONSOL Energy's Burnham Mine, located outside of Burnham, New Mexico.

1.2 OBJECTIVES AND SCOPE

The first step in developing a groundwater model is to define the objectives of the study. The primary groundwater resource issue related to surface coal mining within Areas IV North and IV South concern the effects of proposed mining and reclamation on the quantity and quality of groundwater in the alluvium of Pinabete Arroyo, Cottonwood Arroyo and the Chaco River that provide potential livestock water supplies. Specific objectives of the groundwater model are as follows:

- The first objective is to provide a better understanding of the baseline groundwater flow systems within and adjacent to the proposed mining locations. .
- The second objective is to provide a better understanding of the likely groundwater changes that may occur during and after mining.

The modeling process involved the following steps:

- development of a conceptual model of groundwater systems within the proposed mine area and adjacent area;
- selection of a numerical code or modeling software capable of representing the conceptual model;
- development of a three-dimensional groundwater flow model using the chosen software;
- calibration of the model such that it is representative of observed conditions; and
- application of the model to support the PHC assessment of proposed mining and reclamation.

This supporting document describes the model development, calibration and sensitivity evaluation, and discusses the application of the model for PHC assessment. Prior to developing the numerical groundwater flow model, it was first necessary to develop a conceptual model of the groundwater flow system. A conceptual groundwater model is a complex hypothesis of the characteristics and functions of a hydrogeologic system, including recharge and discharge relationships, groundwater flow within and between hydrogeologic units and the expected properties of these hydrogeologic units. Section 2 of this report presents the conceptual model, including the description of the model domain and basin hydrogeology. Section 3 describes the model code selection, model setup and application of the model code to the conceptual model. Section 4 describes the model calibration, the steady state baseline simulation results, and the sensitivity evaluations. Section 5 describes the application of the model to simulate the results for a specific mine plan. The mine plan discussed in this section is BNCC's mine plan revision submitted to OSM on February 15, 2011. The revision provides the plans to conduct surface coal mining and reclamation activities within a 704 acre mining block in Area IV North to allow mining to continue through mid-2016 in order to meet mine lease terms with the Navajo Nation and contractual coal tonnage delivery obligations with the Four Corners Power Plant. The results of the simulations described in Section 5 are included in the PHC in Chapter 11 of BNCC's mine permit revision submitted to OSM on February 15, 2011. The calibrated model also provides a tool that can be used for subsequent permit revisions. The modeling results for subsequent mine plan revisions will be provided in the PHC revisions in Chapter 11 of the Navajo Mine Permit Application. References can be found in Section 6 of this report.

2 CONCEPTUAL MODEL

A conceptual model of the groundwater flow system is the foundation on which the numerical model is based. The conceptual model needs to incorporate the major processes and factors controlling the magnitude, rate, and direction of groundwater flow. The groundwater flow systems at a particular site are governed by geology, topography, and groundwater recharge. This section summarizes the conceptual model of the groundwater flow system at the project location. The nature and patterns of groundwater flow, from the locations where water enters the subsurface at a recharge area, to the locations where groundwater discharges, from a groundwater flow system. A combination of groundwater flow systems from local to regional in scale can develop in an area (Toth, 1963). Intermediate and regional systems tend to predominate in arid areas and areas with gentle topography. Local flow systems tend to be dominant in areas with high topographic relief and wetter climates.

Groundwater flow models are used to calculate or simulate the rate and direction of movement of groundwater through geologic units. The simulation of groundwater flow requires a thorough understanding of the hydrogeologic characteristics of the site, including:

- the extent, thickness and characteristics of hydrogeologic units included in the model domain;
- the boundary conditions for the model domain;
- the distribution and magnitude of either groundwater recharge or groundwater discharge, which is needed to characterize the overall water balance of the groundwater flow system; and
- the horizontal and vertical distribution of hydraulic heads throughout the modeled domain, which is needed for model calibration.

2.1 HYDROGEOLOGIC UNITS

The San Juan Basin is a typical asymmetrical, Rocky Mountain basin, with a gently dipping southern flank and a steeply dipping northern flank (Stone et al., 1983). The project site is located along the western flank of the central basin with a northwest trending axis parallel to the Hogback monocline located northwest of the project site. The stratigraphic section in the project area reflects the Late Cretaceous transition of a shallow marine depositional environment to a terrestrial fluvial depositional environment. The four formations encompassing this depositional environment change are (in ascending order): the Lewis Shale, the Pictured Cliffs Sandstone, the Fruitland Formation, and the Kirtland Shale.

The Lewis Shale contains the last purely marine shales deposited in the Upper Cretaceous. It consists of gray to black shale with some interbeds of sandy limestone, brown sandstone, and bentonite. The Pictured Cliffs Sandstone (PCS) conformably overlies and intertongues with the Lewis Shale. This formation consists of both delta-front and barrier-beach sediments and marks the change to a littoral (near-shore) depositional environment. The upper two-thirds of the PCS consists of a generally coarsening upward sequence of light gray, fine to medium grained sandstone while the lower one-third of the formation consists of interbedded shale and sandstone. The total thickness of the PCS is approximately 110 to 120 feet in the model area.

The Fruitland Formation, which conformably overlies the PCS, contains minable coal seams that are the target for proposed surface mining. The coal seams are highly continuous within the coal lease area and are nearly flat lying, with a dip of up to 2 degrees to the east-northeast. Localized pinches, rolls, and occasional faults with minor offsets are encountered. The topography within the project area rises gently from west to east, with the overburden becoming thicker from west to east. The coal seams outcrop or subcrop close to the western limits of the mine lease. The coal resource is burned or washed out beyond the western limit of the mine lease and within portions of the mine lease for some of the upper coal seams. The upper seams typically do not exist within much of the lower topographic surface in the western portions of the coal lease, but come into the sequence on the eastern portion of the lease area where the topography rises and as the strata dip to the east.

Surface soils are thin or nonexistent, and the near surface geology is typically comprised of a layer of weathered shale and sandstone along with unconsolidated eolian sands. Deposits of Quaternary alluvial sediments and unconsolidated eolian sands also occur along the ephemeral stream channels. The unconsolidated surficial materials overlie a competent overburden comprised of shales, sandstones, and siltstones. Within the project area the stratigraphically highest coal seam (Seam 8) occasionally lies directly under the unconsolidated layer. Portions of Seams 8 and 7 within the lease are weathered, and very little of Seam 8 is found within Area V. Overburden depths range from a few feet to over 80 feet. Interburdens and partings are generally composed primarily of soft gray shale, a dark gray siltstone, and carbonaceous shale. Sandstone lenses and stringers with minor thickness are found to a limited extent within the interburden, but shales and siltstones are predominant.

The Kirtland Shale conformably overlies the Fruitland Formation to the east of the coal lease. This formation is divided into two units, the upper shale member, which includes the Farmington Sandstone Member, and the lower shale member. The lower shale member is composed of gray claystone shales that contain a few thin interbeds of siltstone and sandstone. No coal beds exist in the Kirtland Shale (Fasset and Hinds, 1971).

A more thorough description of the regional and local geology of the Navajo Mine SMCRA permit area is provided in Chapters 5 and 6 of the Navajo Mine PAP, with specific information concerning Areas IV North, IV South and V in Appendix 6.G. Based on both regional and site-specific information, the Fruitland Formation and associated coal units and the PCS are unsaturated, or partially saturated, near the outcrop of these units on the west side of Areas IV North, IV South and V of the coal lease, but become saturated to the east and down dip of the outcrop.

One conceptualization of the hydrogeology of the model area is to consider the Fruitland Formation as a single hydrogeologic unit. The single hydrogeologic unit approach was previously proposed by Billings and Associates (1987) for modeling groundwater at the Navajo Mine because of the complexity of the individual coal seams, which often split or pinch out. Kaiser et al (1994) note that "Regionally, the Fruitland Formation is a single hydrologic unit, but compartmentalization is indicated locally by large vertical and lateral pressure gradients." On the more localized scale of Area IV of BNCC's Navajo coal lease, the interbedded strata and coal beds have a significant influence on the hydrogeology of the Fruitland Formation. Although the hydraulic conductivities of the coals are relatively low, they are still considerably higher than those of the interbedded shales, resulting in large vertical potentiometric gradients among the coals within the coal lease. One of the primary hydrogeologic changes to occur as a result of mining is the removal of the coals and the interbedded shales and sandstone strata in the overburden and interburden resulting in more homogeneous and isotropic conditions within the mine backfill. Furthermore, water chemistry has been found to vary among the individual coal units within the Fruitland Formation. Typically, TDS concentrations increase with depth, while sulfate concentrations decrease with depth.

Although the coal geology is complex with multiple coal bed splits and coal beds that pinch out, there is good correlation and spatial continuity for particular coal zones, or seams, within BNCC's Navajo coal lease. These coal seams may feature one coal bed, or they may include splits with multiple coal beds. Within the Navajo coal lease these coal zones, or seams, are numbered sequentially from the bottom coal zone (No. 2) to the uppermost coal in this area, the No 8 coal. The No. 1 coal zone and the No. 5 coal zone are not present within BNCC's Navajo coal lease, while the No. 2, No. 3, No. 4, No. 6, No. 7 and No. 8 coal zones all occur within Areas IV North, IV South and V. For these reasons, the conceptual hydrogeologic model and the numerical groundwater model for the project handles the individual coal zones, or seams, as separate and distinct hydrogeologic units.

The PCS, the first hydrogeologic unit below the Fruitland Formation has been included in the groundwater flow model. The top of the Lewis Shale has been included as the base of the model domain. Generally, a shale zone such as the Lewis Shale would be considered as an impermeable boundary. However, given the low recharge rates at the site, overall low permeability of the Fruitland Formation shales and coals, and the relatively low permeability of the PCS, the flow conditions at the boundary between the PCS and Lewis Shale were found to be significant for calibrating the groundwater flow model.

The delineation of the hydrogeologic units within the model domain was developed from the extensive geologic and groundwater information developed for BNCC's Navajo coal lease. The extent of geologic and groundwater information that is available to support the conceptual and numerical model is more limited beyond the coal lease boundaries. Consequently, information was obtained from a variety of sources to help delineate the hydrogeologic units and define groundwater conditions for the portions of the model domain that are beyond the limits of the coal lease. Information sources included various regional geologic and hydrogeologic reports sited in the references provided at the end of this report, the hydrogeologic data in the Navajo Mine and Burnham Mine Permit Application Packages, and logs from oil and gas wells located within or near the model domain.

2.1.1 Hydraulic Conductivities of Modeled Units

Another element of the conceptual model is to define to the extent possible the properties of these hydrogeolgic units, including hydraulic conductivities and storage characteristics of these hydrogeologic units. The representative range for hydraulic conductivities of individual model layers is provided in Table 2-1. The sources of information used to establish the range of hydraulic conductivities and storage characteristics of modeled hydrogeologic units is provided in Attachment 1. Hydraulic conductivities for the hydrogeologic units were modified during model calibration. Calibrated hydraulic conductivity values are shown in Table 2-1 along with the representative range of values determined from local or regional data.

2.1.2 Storage Coefficient and Specific Yield of Modeled Units

The amount of water an aquifer can yield is described by the storage parameters: specific storage and specific yield. The specific storage of a confined aquifer is the volume of water that a unit volume of the aquifer releases from storage per unit decline in head. Specific storage is a measure of the compressibility of the aquifer matrix and the expansion of water. In unconfined aquifers, changes in storage are controlled by the specific yield and not by the compressibility of the matrix or the water in storage. The specific yield is the volume of water that drains from an unconfined aquifer per unit decline in head. The specific yield is less than the porosity but much larger than specific storage.

Specific storage values for the various hydrogeologic units were obtained from aquifer testing results and from literature values for similar formations in other Rocky Mountain sedimentary basins. The specific storage value was set to 3.8 x 10^{-6} ft^{-1} in the PCS based on the observation well response during a pumping test at PCS well T4-1 (Attachment 1). This specific storage estimate is consistent with the specific storage of approximately 10^{-6} ft^{-1} reported by Lohman (1972, p 53) as a reliable estimate for confined sedimentary bedrock aquifers. Specific storage values were also set to the PCS value of 3.8 x 10^{-6} ft^{-1} for the Fruitland Formation overburden and interburden layers. This value is within the range of 2 x 10^{-5} and 1 x 10^{-6} listed by Bredehoeft et al (1983) for specific storage values determined from laboratory consolidation tests of Cretaceous shale confining layers. Also, it is expected that the specific storage for the sedimentary rock in the Fruitland Formation should be similar to the specific storage values found in the underlying PSC and in the literature for confined sedimentary bedrock aquifers. Specific storage for the coal units was set to 2.8 x 10^{-5} ft^{-1}. The specific storage for the coal was estimated from observation well response during a pumping test of the No. 8 coal seam well at the San Juan Mine (Attachment 1).

Specific yield (under unconfined conditions) was assumed to be similar to estimated effective porosities. Specific yield will always be lower than porosity as some of the groundwater will not drain from the formation since it is held by capillary forces. A specific yield of 20 % was used for the alluvium and overburden and interburden units in the model. A lower specific yield of 0.5 % is used for the coals due to the low effective porosity of the coals (Attachment 1).

2.1.3 Unsaturated Parameters of Modeled Units

Little hard data was available on unsaturated zone parameters in the area of the model domain. It was assumed that high capillary head wetting curves were needed given the arid site climate in the study area.

2.2 MODEL DOMAIN AND BOUNDARY CONDITIONS

An essential part of both the conceptual and numerical models is the representation of the horizontal and vertical boundaries of the hydrogeologic system (the model domain) and the delineation of the hydrogeologic units within the model domain. It is also essential that the hydraulic head or flow conditions be defined for each of the hydrogeologic units along the boundaries of the model domain.

The vertical extent of the hydrogeologic model is from the ground surface to the base of the PCS. A head dependent boundary condition was established through model calibration to represent the Lewis Shale at the base of the PCS.

The horizontal extent of the hydrogeologic model is provided in Figure 1-1. The model domain was established where there are physical boundaries, such as the outcrop of the geologic units west of the project as shown in Figure 1-1. The model domain extended sufficient distances to the east and south of the coal lease where the required assumptions about hydrogeologic conditions at these boundaries are expected to have limited influence on the predicted changes in the groundwater system due to drawdown associated with proposed mine pit advance and recovery following planned backfill sequences as evidenced by minimal drawdown and minimal changes in fluxes at these boundaries. The model domain extended to just north of the Cottonwood Arroyo, near where there are a number of wells to better define the steady state pre-mine conditions at the north boundary.

The boundary conditions at the horizontal model extents were established based on the conceptual model. The outcrop of both the PCS and the Lewis Shale is shown in Figure 1-1 along with the model extents. A no flow boundary condition was designated for the west boundary of the model domain along the outcrop of the PCS/Lewis Shale stratigraphic interface. Since this model is an unsaturated-saturated flow model, saturation to the west extends as far as the model solution determines for the calibrated steady-state pre-mine condition but no further than the physical outcrop boundary, which is defined as a no flow boundary.

The boundary conditions for the PCS on the south, east and north boundaries of the model domain were established based on the conceptual model and the potentiometric surface. The potentiometric surface within the model domain is well characterized from current and historic water level monitoring data from wells completed in the PCS within the vicinity of BNCC's Navajo coal lease and from Burnham Mine monitoring wells to the south of the Navajo coal lease. In addition, the PCS outcrop map in the vicinity indicates a large outcrop area for potential recharge along the Hunter Wash valley south of the model domain as shown in Figure 1-1. It is expected that potentiometric elevations for the PCS along Hunter Wash are close to the elevation of the channel bottom. Down dip to the northeast and along the east side of the model domain, the potentiometric gradient is believed to be from south to north as indicated by Kaiser et al (1994). Localized discharge is expected to occur along the topographic lows where the PCS subcrops beneath the alluvium of the ephemeral streams. The regional potentiometric surface depicted in Figure 1-1 was developed based on all these sources of information.

A constant head boundary has been defined for the PCS based on the potentiometric surface along the north, south and east boundaries as depicted in Figure 3-3. A no flow boundary has been specified along the west boundary. Boundary conditions for the model layers corresponding to the Fruitland Formation Coal Seams were established along the south boundary as depicted in Figure 3-2. Constant head boundary conditions were defined at the locations along the eastern portion of the south boundary based on the potentiometric surface of the PCS. The PCS outcrops along Hunter Wash just south of the model domain and the Fruitland coals are not present along portions of the south boundary. A no flow boundary was assigned to the model layers corresponding to the Fruitland coals along the south boundary where the coal is not present or where the potentiometric surface of the PCS was below the elevation of the coal as shown in Figure 3-2. These boundary conditions are consistent with the conceptual model as areal recharge is the source of the groundwater in the shallow coals near the outcrop. However, there may be some lateral flow from the coals across the eastern segment of the south boundary. The constant head boundary within this segment permits flow to enter the model domain along this segment consistent with the conceptual model.

Constant flux (Cauchy) boundary conditions were established for the coal layers along the north model boundary east of the location where a portion of the south end of Dixon Pit of the Area III mine crosses the boundary as depicted in Figure 3-2. The fluxes for boundary conditions were determined based on the estimated potentiometric gradient and the estimated transmissivities of the coals at these locations. No flow boundary conditions were established for the Fruitland Formation layers along the west and east boundaries and along the north model boundary west of the location where a portion of the south end of Dixon Pit of the Area III mine crosses the boundary. The no flow condition for the Fruitland Formation along this segment of the north boundary represents the conceptual model depiction of the lower Cottonwood valley as a local discharge area with no flow to the north. The conceptual model of no groundwater flow in the Fruitland coals to the north of Cottonwood near the southwest boundary of Area III is supported by the relatively flat potentiometric surface for the No. 8 Coal and the No. 3 Coal over much of Area III as depicted in Figures 6.G-2 and 6.G-3, respectively. The no flow condition for the Fruitland Formation along the segment of the east boundary represents the conceptual model depiction of the general northerly direction of flow in the Fruitland Formation along this boundary. Based on the transient simulations for the Area IV North mine plan, the northern boundary conditions appear to have minimal influence on the predicted changes in the groundwater system due to mining and backfilling.

A constrained constant head boundary was also established where the alluvium of Brimhall Wash, No Name Arroyo, Pinabete Arroyo and Cottonwood Arroyo occur along the western boundary of the model domain as depicted by the Dirichlet (constant head) boundary conditions shown in Figure 3-2. A constrained constant head boundary was also extended into the model layer representing the PCS below the alluvium as depicted by the Dirichlet (constant head) boundary conditions shown in Figure 3-3. The constraint on the boundary was that there could be no inflow to the model domain at the constant head boundary. The constant head was determined based on average depth to alluvial groundwater near the mouth of these ephemeral streams.

Constrained head dependent boundary conditions analogous to drain boundaries were also established along the lower portions of model layer representing the alluvium along Cottonwood Arroyo, Pinabete Arroyo, No Name Arroyo and Brimhall Wash.

2.3 DISTRIBUTION AND MAGNITUDE OF GROUNDWATER RECHARGE

The conceptual model also includes an interpretation of spatial relationships between recharge and discharge and the approximate rates of recharge and discharge, including the groundwater inflows and outflows from the model domain. A critical aspect of hydrogeologic modeling is obtaining a reliable estimate of the magnitude of either groundwater recharge or groundwater discharge in order to constrain the overall water balance.

In hydrogeologic settings where groundwater discharge is primarily at streams, an estimate of discharge can generally be determined from measurement of the baseflow of the streams. However, this method for measuring discharge cannot be applied in arid environments, where groundwater discharge rates are low and insufficient to support baseflow at any time. Recharge rates are quite low at the site due to the arid climate. Annual precipitation averages about six inches (150 mm) per year with most precipitation occurring during several large high intensity precipitation events during the seasonal ‘monsoon’ periods. These generally occur in March and August of each year. Snow rarely accumulates in any significant depth over the project area. Summers are hot with low relative humidity. Evaporation rates are high, averaging over 60 inches per year.

Fortunately, reliable estimates of groundwater recharge rates at the Navajo Mine were obtained from studies conducted by Stone (1984, 1986, and 1987). Recharge estimates for undisturbed areas at the Navajo Mine ranged from 0.002 to 0.09 in/yr and are expected to be higher at surface depressions and impoundments.

“Badlands” topography comprises about half of the drainage basins of Cottonwood Arroyo, Pinabete Arroyo and No Name Arroyo and accounts for the high discharge and flow intensities observed in these ephemeral streams. Little groundwater recharge occurs within the badlands areas, due not only to the low rainfall rates, but also to the high proportion of rainfall that results in runoff. The low permeability of sodic clay soils nearly precludes groundwater recharge within badlands areas.

Groundwater recharge from precipitation and ephemeral stream flow within the project area moves vertically downward through the interbedded shales and coal units of the Fruitland Formation and into the PCS. Where Fruitland Formation coals are saturated, groundwater will flow laterally. Based on information obtained from water levels measured in the coal seam wells and piezometers, the flow directions in the coals within the model domain are toward the north-northeast.

Although the vertical hydraulic conductivities of the interbedded shales in the Fruitland Formation are quite low, recharge rates are lower still. Direct recharge rates measured by chloride mass balance methods on undisturbed areas at the Navajo Mine ranged from 0.002 to 0.09 in/yr, (Stone 1987). The highest recharge rate of 0.09 in/yr was for valley terraces while the lowest recharge rate of 0.002 in/year was for badland areas. Recharge from upland flats averaged 0.03 in/year.

Based on the research by Kearns and Hendricks (1998), aerial recharge is thought to occur during very large precipitation events and during extended wet periods with increasing soil moisture. Recharge is expected to be higher along ephemeral stream channels with saturated alluvium and surface impoundments. Although Stone's research (Stone, 1986 and 1987) did not include recharge estimates for ephemeral stream channels and surface impoundments, he does provide an estimate of an average recharge rate of 0.16 inches per year from depressions within reclaimed mine areas at the Navajo Mine. Recharge of the alluvium along the ephemeral stream channels is dynamic and variable and dependent upon precipitation runoff. Recharge at surface depressions at the mine is also dynamic and variable and also dependent upon precipitation runoff. Thus the estimate was expected to provide a reasonable approximation for the recharge of the alluvium and gave reasonable results during model calibration. The recharge of the alluvium is a very small component of the overall water balance due to the relatively small area of the alluvium in the model domain.

Slopes were calculated based on the U.S. Geological Survey (USGS) digital elevation model (DEM) and Stone's recharge rate estimates for geomorphologic categories were then assigned to various slope ranges in order to estimate spatially varying recharge rates for the groundwater model. These categories, slope ranges, the associated recharge rates from Stone's research, and the associated model recharge rates are provided in Table 2-2.

2.4 POTENTIOMETRIC LEVELS AND GROUNDWATER FLOW

A potentiometric surface map for the PCS within the model domain is provided in Figure 1-1. As indicated on the potentiometric surface map, groundwater flow is from the recharge areas at the outcrops along Hunter Wash in the south toward the regional discharge area to the north and locally toward topographic lows in the stream valleys along the west side of the model domain. Potentiometric data for the No 2, No. 3 and No. 8 coal seams indicate a general potentiometric gradient to the north northeast, although the data are limited and are not sufficient to identify possible local gradients toward topographic lows and drainages.

3 GROUNDWATER MODEL SETUP

The low rate of recharge and the interbedded strata at the site results in large vertical downward potentiometric gradients with perched groundwater zones. One of the primary hydrogeologic changes to occur as a result of mining is the removal of the coal and the interbedded shales and sandstone strata and placement of a more homogeneous post mine backfill. Saturated groundwater flow models, such as MODFLOW, are incapable of handling three-dimensional unconfined situations with several dry model layers separating a water table from perched groundwater overlying low conductivity units. Consequently, in order to meet the modeling objectives, a multi-layer numerical groundwater flow model of the project area was developed using the FEFLOW (Finite Element subsurface FLOW system) software developed and supported by DHI-WASY GmbH, a German research and consulting group specializing in groundwater and surface water hydrology. The software uses a finite element analysis technique to solve the groundwater flow equations for both saturated and unsaturated conditions.

FEFLOW can be efficiently used to describe the spatial and temporal distribution of groundwater quality constituents, to estimate the duration and travel times of these constituents in aquifers and to assist in designing alternatives and effective monitoring schemes. It includes a sophisticated interface with GIS applications such as ArcInfo, ArcView and ArcGIS for ASCII and binary vector and grid formats. FEFLOW is used worldwide as a high-end groundwater modeling tool at universities, research institutions, government agencies and engineering companies.

Although the objective of the groundwater modeling study is to model flow and transport in the saturated zone, given the arid climate and the perched groundwater conditions over much of the study area, a full saturated/unsaturated implementation of FEFLOW was used in modeling.

3.1 MODEL MESH DISCRETIZATION

The model domain was discretized on a triangular mesh pattern as shown in Figure 3-1 to establish a 3D finite element mesh of 6-node triangular prisms. The groundwater flow model domain was established as described in Section 2.2. The element size was chosen to be sufficiently small to capture significant variations in topography, hydrology, and geology but large enough to minimize the model size. The pre- and post- mining steady state model mesh includes additional detail within the coal lease area and the areas of Cottonwood, Pinabete No Name Arroyos and Brimhall Wash. The pre- and post-mining steady state model mesh contains 805,280 elements and 424,821 nodes. The post-mining transient model contains 855,176 elements and 450,660 nodes.

3.2 MODEL LAYERS

The model is discretized vertically into 29 slices corresponding to 28 layers to accommodate the hydrogeologic units of interest. Layers are continuous horizontally across the model. Hydraulic parameters were assigned to each hydrostratigraphic unit through the corresponding model layer. Additional layers are needed in the finite element formulation to accommodate the transition between hydrogeologic units and for the implementation of boundary conditions in the coal layers. Thin (1.0 ft thick) buffer layers were added to reduce the conductivity contrast between the low conductivity overburden and interburden layers and the higher conductivity coals to improve model convergence. These buffer layers were assigned hydraulic properties of the corresponding overburden, or interburden, unit. Table 3-1 summarizes the correlation between model layers and slices and hydrostratigraphic units used in model design.

Implementation of the conceptual hydrogeologic model into the numerical groundwater model for the project includes the individual coal zones or seams as separate and distinct hydrogeologic units. Spatial grids with the elevations of the top of the PCS and the top and bottom of all coal beds within and adjacent to the coal lease were provided by BNCC. Additional data from the Burnham Mine, and surface topography of the PCS outcrop were used to extend the top of the PCS beyond the coal lease area. The individual coal beds were also identified according to coal zone. These data were used to construct the model layers. Additional data from Burnham Mine was used to extend the coal layers to the south. The top and bottom of the individual coal zones were determined from the upper and lower coal bed within the particular seam at individual grid locations. The Lewis Shale is a low conductivity unit that forms the base of the modeled groundwater flow system and was included as a head dependent boundary in the model. The top of the Lewis Shale was assumed to be 120 feet below the top of the PCS. The top surface of the model is based on topography derived from USGS DEMs.

3.3 MODEL BOUNDARY CONDITIONS

The conceptual boundaries discussed in Section 2.2 are implemented in FEFLOW as no flow boundaries, constant head boundaries, constant flux boundaries, and head dependent boundaries. The various boundary conditions in FEFLOW can be constrained by head or flux to represent conceptual boundaries such as drains or streams. The constraints are limitations which result from the requirement that the boundary condition is only valid as long as minimum and/or maximum head or flux bounds are satisfied. If, during a simulation run, the conditions fall below or are exceeded, the constraints are to be assigned as new intermediate boundary conditions. This section is a discussion of the implementation of boundary conditions and constraints in the model.

The boundary locations for a typical model layer and for the PCS are shown on Figure 3-2 and Figure 3-3.

3.3.1 No Flow Boundaries

No flow boundaries are shown on Figures 3-2 and 3-3 at locations along the edge of the model domain where no other boundary conditions are depicted in the Figures. A no flow boundary was set along the west edge of the model corresponding to the outcrop of the PCS/Lewis shale contact. A no flow boundary was also set in the model layers representing the Fruitland Formation along the east edge of the model where this boundary is parallel to the regional groundwater flow direction. A no flow boundary was also set in the model layers representing the Fruitland Formation along the western portion of the north boundary where the Cottonwood alluvium represents a local discharge area. No flow boundary conditions were also assigned to the model layers corresponding to the Fruitland coals along the south boundary where the coal is not present or where the potentiometric surface of the PCS was below the elevation of the coal as shown in Figure 3-2.

3.3.2 Recharge

Recharge in FEFLOW can be treated as a constant flux boundary condition with a constraint that allows flow only into the model, or as a flow into top layer of the model. Constrained boundary conditions can add significantly to the computational time to run the model, so the simplified flow into the top of the model was chosen to represent recharge. The distribution of recharge boundaries is shown on Figure 3-4.

3.3.3 Stream Boundaries

The ephemeral streams (Cottonwood Arroyo, Pinabete Arroyo, No Name Arroyo, and Brimhall Wash) and tributaries are represented as head dependent (Cauchy) boundary conditions constrained such that the boundary removes water when the groundwater elevation is greater than a specified reference head, but that no flow in to the groundwater system is contributed by the boundary. When constrained this way the boundary acts similar to a MODFLOW drain boundary. Drain conductance is specified as a leakage coefficient and was set to a value of 10^{-4}/day. Stream boundaries are shown on Figure 3-2.

3.3.4 Head Dependent (Cauchy) Boundaries

During initial model calibration it became clear that the boundary between the PCS and the Lewis Shale needed to account for vertical flow to support model calibration. Head dependent, or Cauchy, boundary conditions were assigned to each finite element node at the base of model to simulate flow between the PCS and Lewis Shale. These boundary conditions were unconstrained to allow flow into or out of the base of the model.

An effort was made to examine alternate conceptual models for this boundary condition. Several configurations of reference head and leakage coefficient for the boundary conditions were examined to represent the potentiometric surface of the Lewis Shale and vertical hydraulic conductivity between the PCS and the Lewis Shale, respectively. For example, the reference head was first set as the elevation of the base of the PCS with a constant leakage coefficient. Other conceptual models examined included a reference head with a constant slope from south to north and a linear increase in leakage coefficient from west to east.

In the final calibrated model, the reference head is a damped surface based on the elevation of the top of the PCS, and the leakage coefficient varies in space, generally decreasing with the depth to the top of the PCS. The damped reference head surface for the head dependent boundary conditions was determined by choosing a reference elevation contour of the top of the PCS and smoothing the highs and lows in the PCS top based on this reference contour. The final calibrated leakage coefficient is higher on the west side of the model where the PCS is shallower and decreases as the PCS dips to the east. The reference head surface and the distribution of leakage coefficient for the head dependent boundary conditions are shown on Figure 3-5 and Figure 3-6, respectively. The modeling of vertical leakage to the Lewis Shale is developed through model calibrations. It is, however, consistent with the conceptual model of low rates of vertical flow through the shales in the Fruitland and the PCS as well as in the Lewis Shale. These shales exhibit low vertical hydraulic conductivities and the hydraulic conductivity would be expected to decrease with depth due to consolidation.

3.3.5 Constant Head (Dirichlet) Boundaries

Constant head, or Dirichlet, boundaries were assigned at finite element nodes where the four main streams intersect the west model boundary. These boundary conditions are constrained by setting a maximum flux constraint equal to zero. With the maximum flux constrained to zero, the boundary condition can only remove water from the model representing stream flow out of the model domain. The locations of these boundaries are shown on Figure 3-2.

Unconstrained constant head boundaries were also assigned along the south edges of the model domain in the layers corresponding to the Fruitland Formation coal seams. These boundaries were assigned the potentiometric head of the PCS and were assigned where the potentiometric head of the PCS was above the bottom of the specific model layers.

In the model layers corresponding to the PCS, constant head boundaries were assigned along the entire lengths of the south, east and north edges of the model domain. The constant head boundaries along the north boundary are constrained such that groundwater can only flow out of the model domain. These boundaries are shown on Figure 3-2 and 3-3.

3.3.6 Flux (Neumann) Boundaries

Constant flux, or Neumann, boundaries were assigned along portions of the north model boundary in layers representing the Fruitland Formation coal seams to represent groundwater flow out of the model domain. Fluxes were determined from regional groundwater gradients and hydraulic conductivities of the individual model layers. The locations of the flux boundary conditions are shown on Figure 3-2, and the constant fluxes assigned to the boundaries in individual layers are shown in Table 3-2.

3.4 UNSATURATED ZONE FLOW IMPLEMENTATION

FEFLOW utilizes a full implementation of Richard's Equation for solving saturated/unsaturated flow problems. The modified Van Genuchten parametric relationship for capillary pressure head and relative conductivity was used to model unsaturated zone flow.

4 MODEL CALIBRATION AND SENSITIVITY ANALYSIS

In multilayer groundwater models, the hydraulic parameters (mainly hydraulic conductivity) of the model layers and boundary conditions (mainly recharge, potentiometric heads, and leakage coefficients) are adjusted during model calibration in order to obtain a better match with observed heads and potentiometric gradients. Model calibration is necessary because hydraulic parameters obtained from well tests, regional studies, or literature values for similar hydrogeologic units are, at best, order of magnitude estimates of the average hydraulic conductivity and storage properties of the hydrogeologic unit on the scale of the model. With reliable estimates for the expected magnitude of either groundwater recharge or groundwater discharge and estimates for the expected upper and lower bounds for hydraulic conductivities of the hydrogeologic units, the model can be constrained during model calibration to arrive at a model that is an acceptable representation of the hydrogeologic system.

Model calibration can also serve to revise the conceptual model of the groundwater system and provide a better assessment of the properties of hydrogeologic units on a regional scale that cannot be obtained solely from local pumping test results. Model calibration is assumed to be achieved once the model reasonably simulates the interpreted groundwater flow conditions in the area of interest using input values that are within the range of measured or estimated values. The primary measures of model calibration are the match between the measured groundwater potentiometric surface ("heads") and the model's predicted values at the same location. Other considerations in arriving at an acceptable calibrated model included any model predicted locations of surface saturation and comparison of modeled potentiometric surfaces with potentiometric surfaces developed for the conceptual model. The data used in model calibration and the calibration results are discussed in this section.

4.1 CALIBRATION TARGETS

The calibration targets for the model were measured groundwater elevations in monitoring wells within individual coal seams, in the alluvium and in the PCS. Surface saturation and groundwater potentiometric surfaces were also used as a general guide in model calibration. Table 4-1 lists the calibration wells, formation, model layer, observed potentiometric head, and the calibrated model potentiometric head. The locations of the calibration wells are shown on Figure 4-1.

4.2 STEADY STATE MODEL CALIBRATION

Model calibration was performed by running the model repeatedly with the steady state boundary conditions and using a range of values for model parameters. In order to better match the observed head calibration targets, several model input parameters were varied within acceptable ranges. These parameters included hydraulic conductivity, leakage coefficient for drain and stream boundaries, recharge, and reference head and leakage coefficient for the head dependent boundary condition at the base of the model. Unsaturated zone wetting curve parameters were also varied during model calibration. The final calibrated regional PCS potentiometric surface is shown in Figure 4-2, and the calculated vs. observed heads for all calibration wells is shown in Figure 4-3 and in Table 4-1.

4.3 STEADY STATE MODEL RESULTS

Detailed discussions of the steady-state baseline modeling results are presented in Appendix 6.G of the Navajo Mine PAP. Transient simulation results are dependent upon the specific mine plan being simulated and are included in the PHC assessment supporting the mine permit application. Selected model results are presented below.

4.3.1 Mass Balance and Groundwater Budget

The model mass balance was reviewed as part of the steady state model calibration. The mass balance is the difference between the inflow into the model and the outflow (discharge) from the model. The overall model mass balance difference is 0.24 %. A low mass balance difference is indicative of a lack of numerical issues with the model and that the model is run with adequately small convergence criteria. Various authors recommend that the mass balance difference should be less than 0.1% for saturated groundwater flow models (Konikow 1996) and less than 1% for variably saturated groundwater flow models (USGS 2000).

4.3.2 Potentiometric Surface Contour Maps

The model calibrated PCS potentiometric surface is shown on Figure 4-2. The modeled potentiometric surfaces for the No. 3 Coal and the No. 8 Coal are shown on Figures 6.G-2 and 6.G-3 in Appendix 6.G of the Navajo Mine PAP. The modeled pre-mining potentiometric surfaces generally follow the conceptual model. The modeled steady state results and recharge rates are consistent with the measurements or estimates obtained from baseline monitoring as previously discussed. However, the modeled potentiometric surfaces extend beyond the limits that could be depicted from measurements at monitoring wells and piezometers. For example, the results for the No. 3 Coal in Figure 6.G-2 in Appendix 6.G show groundwater flow toward the topographic lows along the west side of the model domain in the valleys of No Name Arroyo, Pinabete Arroyo, Brimhall Wash, and Cottonwood Arroyo. These results could not be determined from potentiometric measurements alone, which indicate a general potentiometric gradient to the north northeast in the No. 3 coal. A detailed discussion of the steady state model potentiometry is found in Appendix 6.G.

4.4 STEADY STATE MODEL SENSITIVITY ANALYSIS

A sensitivity analysis was performed after model calibration to determine the affect on model calibration of changes in the calibrated model parameters. The model parameters included in the sensitivity analysis were the hydraulic conductivities of the alluvium, the coals, the overburden and interburden, and the PCS; the recharge rate; and the leakage coefficient of the head dependent boundary condition at the base of the PCS. The steady state model was run varying the individual parameters over the ranges shown in Table 4-2. In addition to the formal sensitivity analysis, the effect of other model parameters was noted during model calibration. The results of both of these efforts are discussed in this section. Plots of calculated vs. observed heads resulting from the sensitivity runs are shown in Figures 4-4 through 4-21. The plots show the effect that varying of individual model parameters has on the model calibration.

Figures 4-4 and 4-5 show the results of varying the hydraulic conductivity of the PCS over the range of one-half the calibrated value to twice the calibrated value. A hydraulic conductivity for the PCS of one-half the calibrated value, results in over prediction of most of the head values particularly in the higher head locations as shown in Figure 4-4. A hydraulic conductivity for the PCS of twice the calibrated value does not indicate a particular bias in the head predictions as shown in Figure 4-4 but does result in more scatter in the prediction as indicated by the higher mean absolute (MA) residual. The results show that modeled potentiometric heads in the PCS are somewhat sensitive to the hydraulic conductivity of the PCS, and that the potentiometric heads in the Fruitland Coals are less sensitive to this parameter.

During model calibration it was noted that predicted results were not very sensitive to the horizontal hydraulic conductivity of the lower coals within the calibration range but the results were more sensitive to the horizontal hydraulic conductivity of the upper coals. A hydraulic conductivity for the upper coals of five times the calibrated value results in more scatter as shown in Figure 4-6. The results show that modeled potentiometric heads in the alluvium and the upper coal are very sensitive to the increase in the horizontal hydraulic conductivity of the upper coals. A hydraulic conductivity for the upper coals of half the calibrated value as shown in Figure 4-7 also results in more scatter in the prediction, although the mean absolute (MA) residual is better than the results in Figure 4-6. The results in Figure 4-7 show that modeled potentiometric heads in the alluvium are particularly sensitive to the decrease in the horizontal hydraulic conductivity of the upper coals.

Weathered coals were identified in the upper coal seams (No. 6, No. 7 and No. 8) in the geologic model. Model calibration improved when these weathered coals were assigned a hydraulic conductivity one order of magnitude greater than the unweathered coal. Figure 4-8 provides the sensitivity results performed with the weathered coal hydraulic conductivity equal to that of the unweathered coal. The plot shows much greater scatter in the head prediction in comparison with the calibration results with an MA residual of 25.5 feet in comparison with 11.4 feet for the calibrated model. The results show that modeled potentiometric heads in the PCS and the alluvium are highly sensitive to the hydraulic conductivity of the weathered coals and that the heads in the coals are less sensitive to this parameter. This result is most likely due to the fact that the weathered coals are nearest to the formation outcrops near the alluvium.

During model calibration, the predicted results were found to be sensitive to the vertical hydraulic conductivities of the interburden layers. In particular, a vertical hydraulic conductivity of 1.0 x 10^{-6} ft/day (Kx/Kz = 500) was needed for the interburden layer between the No. 6 coal and the No. 4 coal in order simulate the large vertical head gradients between the upper coal seams and the lower coal seams. Sensitivity model runs were made with Kz for this interburden zone (layer 14) adjusted to 5 x 10^{-6} ft/day (Kx/Kz = 100) and to 5 x 10^{-7} ft/day (Kx/Kz = 1,000). These results are provided in Figures 4-9 and 4-10 respectively, and show that the results are highly sensitive to the vertical hydraulic conductivity of the interburden layer separating the upper coals from the lower coals, particularly the predicted heads in the alluvium and the upper coals units. The calibration error increased as the Kz was increased or decreased from the calibrated value but the error was higher with the decrease in the vertical hydraulic conductivity to 5 x 10^{-7} ft/day.

Sensitivity runs were made with vertical hydraulic conductivity, Kz, of the interburden layers separating the upper coals (No. 6, No. 7 and No. 8 coals) decreased from 5.0 x 10^{-6} ft/day (Kx/Kz=100) to 2.0 x 10^{-7} ft/day (Kx/Kz=2,500) as shown in Figure 4-11. Figure 4-12 provides the plot of predicted versus observed head with the vertical hydraulic conductivity, Kz, of the interburden layers separating the upper coals (No. 6, No. 7 and No. 8 coals) increased from 5.0 x 10^{-6} ft/day (Kx/Kz=100) to 2.5 x 10^{-5} ft/day (Kx/Kz=20). These plots show the model calibration to be much less sensitive to these changes in the Kx/Kz ratios of the interburden within the upper coals in comparison with the Kz separating the upper coals from the lower coals.

The model calibration was even less sensitive to the Kz of the interburden layers between the lower coals (No. 2, No. 3 and No. 4 coals). Figure 4-13 shows the relative minor decrease in the MA residual when the Kz of the interburden layers between the lower coals is decreased from 2.0 x 10^{-5} ft/day (Kx/Kz=25) to 2.0 x 10^{-7} ft/day (Kx/Kz=2,500).

Figures 4-14 through 4-16 show the results of varying the hydraulic conductivity of alluvium in Cottonwood Wash, Pinabete Arroyo, No Name Arroyo, and Brimhall Wash. The results show that the modeled potentiometric heads in the coal layers are highly sensitive to the hydraulic conductivity of the alluvium. The heads in the PCS are also sensitive to this parameter, but less so than the heads in the coals. The best calibration was with a hydraulic conductivity for the alluvium of 156 ft/day, which is above the hydraulic conductivity of the alluvium expected from aquifer test information provided in Attachment 1. Despite the relatively fine mesh depicted in

Figure 3-1, the alluvium is often represented by a width of one or two elements along the length the alluvium. The finite element calculation essentially averages the hydraulic conductivity from elements adjacent to the nodes to calculate the head at the node. This averaging occurs in both the horizontal and vertical dimensions. Due to this averaging effect, a higher hydraulic conductivity needs to be assigned to the elements representing alluvium to compensate for the lower hydraulic conductivity of the adjacent elements or a finer mesh is needed to transition between the alluvium and the adjacent bedrock. However, model predictions would not necessarily be more reliable with further mesh refinement because a hydraulic conductivity needed for model simulation is developed from model calibration. Furthermore, further mesh refinement would be of limited value given that depth and extent of the alluvium varies are defined approximately and would be difficult to identify for a fine mesh without a considerable amount of additional drilling information.

During the model calibration process it became evident that the calibration was also highly sensitive to the reference head and the leakage coefficient of the head dependent boundary at the base of the model which represents groundwater interaction between the PCS and the Lewis Shale. The reference head of this boundary condition represents the potentiometric head in the Lewis Shale, and the leakage coefficient is a function of the vertical hydraulic conductivities and thicknesses of the two formations. The effect of these parameters on model calibration appears to be highly coupled, therefore, only the leakage coefficient was varied in the sensitivity analysis. In the calibrated model, the leakage coefficient ranged over the model domain from $4x10^{-9}$/day to $3x10^{-8}$/day (Figure 3-6). In the sensitivity analysis, the leakage coefficient was ranged from one-half to twice the calibrated value. These results are shown in Figures 4-17 and 4-18, respectively. An additional sensitivity run was made with a constant leakage coefficient of $3x10^{-8}$/day as shown in Figure 4-19. The residual plots resulting from varying the leakage coefficient of the head dependent boundary at the base of the model show that the model calibration is highly sensitive to this parameter.

In addition to the sensitivity runs discussed above, model calibration runs revealed a high sensitivity to the recharge rates of the various surface characterizations in Table 2-2 (particularly, the upland flat recharge rate). Figures 4-20 and 4-21 show plots of the results of varying the recharge rates in the model from 0.8 to 1.2 times the calibrated values. The recharge parameters are the main parameters that control flow into the groundwater system over the model domain. Hence, the model calibration is very sensitive to these model parameters. Nevertheless, the best model calibration results, as measured by the Root Mean Squared error (RMS) of residuals between predicted heads and measured heads, included the recharge estimates that were consistent with Stone's measurements of recharge at Navajo Mine. Also, the location and extent of surface saturation was sensitive to the estimated recharge. There are essentially no areas of surface saturation within the model domain so that the location and extent of surface saturation predicted by the steady state model was also used to support model calibration. Thus, the final calibrated model, in which model parameters and recharge estimates were within the range determined from site measurement or relevant literature data, was selected from the calibration results that best satisfied measures of goodness of fit based on both RMS error of modeled and measured heads and the extent of surface saturation predicted by the calibrated model.

4.5 TRANSIENT MODEL SENSITIVITY ANALYSIS

The calibrated steady state model is applied to simulate the transient response to mining. This application requires that the storage characteristics of the hydrogeologic units within the model domain be defined. It also assumes that the transient behavior can be simulated adequately without transient model calibration. As mining progresses the observations of drawdown at monitoring wells will provide the transient response that can be used to revise the model calibration for future predictions if previous predictions are off. Thus, with limited observations from the model domain as mining progresses, confidence in model predictions for long-term predictions will improve.

The groundwater drawdown and recovery resulting from mining and reclamation was simulated using the FEFLOW default specific storage value of 10^{-4} per foot and default specific yield of 0.2 and using the specific storage values and specific yield best estimate values for the various units as determined in Attachment 1 (Base). Figure 4-22 shows the differences in the drawdown and recovery in the backfill and in the PCS at the two locations Y3 and Y5 that result using the FEFLOW default values and the Base estimates for the various units. The Y3 and Y5 locations are shown in Figure 4-23 and represent locations within the year-3 mine pit and the year-5 mine pit. The results in Figure 4-22 show that the FEFLOW default values simulate less drawdown but slower rates of recovery in both the PCS and the mine backfill in comparison with the Base or best estimates. The drawdown and recovery response also varies spatially with greater drawdown at the Y3 location relative to the Y5 location.

In addition, the sensitivity analysis of the extent of drawdown to changes in specific storage and specific yield were assessed using the FEFLOW default values and the Base estimates determined from the best estimates of specific storage and specific yield for the various units in Attachment 1. The maximum extent of the 5 foot drawdown for the No 8 coal for the two simulations is shown in Figure 4-23. These results show that the drawdown extent in the upper coals is not particularly sensitive to changes in the specific storage and specific yield However the drawdown extent in the deeper coals and in the PCS is more sensitive to the changes in specific storage and specific yield as shown in Figures 4-24 and 4-25, respectively

4.6 MODEL LIMITATIONS AND USES

As with any model of a complex physical system, the groundwater model has limitations and uncertainties. Simplifying assumptions must be made to model the complex hydrogeologic system. In particular, the hydrogeologic units within the model domain have been represented as homogeneous and isotropic. Geologic environments are never homogeneous and isotropic. However, such assumptions are required because it is not possible to define hydraulic conductivities, specific storage, specific yield, porosity and other properties spatially within all the hydrogeologic units within the model domain.

The groundwater model assumes that Darcy's law and the equations of flow through porous media apply to the strata at the site. However, almost all the bedrock sedimentary deposits and coals within the model domain have low matrix permeability and are fractured. Groundwater flow is typically through fractures, bedding-plane partings, and coal cleats and to a much lesser degree through the intergranular pores. Low permeability units (such as the claystones, the shales and in many cases the sandstones) also exert significant control on groundwater flow. The facies, fractures and hydrogeologic properties of these units all vary spatially. At best, the properties of particular hydrogeologic units can be determined from site testing and adjusted during model calibration to arrive at a model that adequately represents the general behavior of the hydrogeologic system.

Model calibration produces a non unique solution and there are a number of calibrations that could be selected on the basis of comparable measures of head residuals. Furthermore, it would have been possible to arrive at a better calibration by spatially varying the hydraulic conductivities for the various hydrogeologic units within the model domain. However, adjustments to improve calibration were not performed unless there was supporting geologic information for such spatial adjustment. The geologic model provided a fairly clear delineation between the weathered coals and the non-weathered coals. As such, the delineated weathered coals were the only locations, where the hydrogeologic properties were adjusted spatially during model calibration to values that were different from the corresponding coal unit.

The hydrogeologic unit within the model domain that is believed to include the greatest uncertainty in the model simulations is the alluvium within the valleys of Cottonwood, Pinabete and Brimhall. Part of this uncertainty is due to the difficulties in delineating the extent and depth of alluvium and representing that delineation by the finite element mesh. Also, the baseline information shows that the groundwater within the alluvium is not at steady state as is assumed in the calibration of the steady state model. Groundwater flows, groundwater levels and groundwater recharge within the alluvium varies seasonally and from year to year. Perched conditions also occur within some segments of the alluvium as indicated by the well nest adjacent to Pinabete Arroyo. All of these conditions add to the uncertainty in the predictions within the alluvium based on the calibrated steady-state groundwater model.

Despite these limitations, the model provides a better understanding of the hydrogeologic system and the nature of the changes in the system that might occur as a result of mining and reclamation. The model predictions are essentially scientific hypotheses that will be re-examined as mining and reclamation proceed. The model is a useful tool for evaluating the possible extent and magnitude of changes in the hydrogeologic system that might occur in response to proposed mining and reclamation. The model is also useful in identifying the time frames that might be associated with these changes. These results provide better insight into the locations and frequency of monitoring that can be used to confirm or modify the PHC predictions.

Groundwater monitoring has been performed at various locations within the vicinity of the site over the past forty years. These monitoring results show very little change in the hydrogeologic conditions in the bedrock units over these time frames. Transient model simulations also show that the response in the bedrock units beyond the direct impact area of mining is very slow and damped. Nevertheless, model predictions far beyond the historic monitoring period need to be considered in the context of other changes that might be influencing the hydrogeologic system in the long-term to avoid false confidence in model predictions far into the future.

5 SIMULATION OF PROPOSED MINING AND RECLAMATION

5.1 STEADY STATE POST MINING CONDITIONS

For the PHC modeling scenario, mine backfill properties were added to the mined out area associated with the Area IV North mine plan. The overburden and interburden material placed in the mine pit as backfill will have higher porosity and hydraulic conductivity than the pre-mine interbedded sedimentary deposits of the Fruitland Formation. Laboratory measurements of pre-mine overburden core indicate porosity values of about 0.35 while porosity of mine spoils is on the order of 0.40. These laboratory porosity measurements are consistent with the swell factor of 12% estimated based on experience in mining the same formation at the Navajo Mine. The higher porosity will result in higher hydraulic conductivity in comparison with the pre-mine interburden and overburden material (Van Voast, 1974).

A detailed discussion of the steady state model simulation results for post-mining conditions following proposed mining within Area IV North is presented in Section 11.6.2.4 of the Navajo Mine PAP. Comparison of the steady state pre-mine and post-mining groundwater model results show the changes in the groundwater flow patterns and rates that are expected to occur in the long-term following mining. These results support the quantitative assessments of the potential changes in regional or local aquifers resulting from mining. In particular, these effects include the removal of the interbedded coal, shales and sandstone strata and replacement with a relatively homogeneous and isotropic spoil backfill and the increase in recharge rates for reclaimed surfaces. The steady state pre-mine groundwater model simulates a large decline in heads with depth in the Fruitland Formation, including the occurrence of perched groundwater zones. After mining, the simulated steady state heads in the mine spoil are much more uniform with depth, although there is still a slight downward gradient and downward flow. Also, the perched groundwater that occurs under pre-mine conditions within the mine area is eliminated within and near the spoil backfill under long-term steady state conditions following mining. Both the pre-mine and post-mine steady state groundwater flow models show a flow component from Area IV North toward the topographic low elevations along Cottonwood Arroyo in the PCS and in the Fruitland Formation coals. The rate of groundwater flow toward these topographic lows increases for post-mining conditions due to the increase in recharge rate within the reclaimed mine areas.

5.2 TRANSIENT MODEL SIMULATIONS

For the transient simulations of proposed mining operations in Area IV North, detailed mine progression plans were lumped into one-year time increments with constant head boundaries set to the base of mining in all mined out layers over the area covered by the specific one-year time increment (i.e. for a one-year time increment, the entire area of the one-year plan was simulated as dewatered over the one year increment). The proposed plan for pit advance within Area IV North from year 2011 to year 2016 is shown in Figure 11-39 in Chapter 11 of the Navajo Mine PAP. The transient model was run for 500 years after the completion of mining to simulate post-mining transient behavior. A recharge rate of 0.10 in/year was used for mine spoils in the transient modeling until final reclamation, after which the long-term recharge rate of 0.04 in/year was used for reclaimed areas in the transient model. This recharge rate of 0.10 in/year used for mine backfill and initial reclamation in the transient simulations represents an average rate for the mine backfill in various stages of reclamation and is based on the average between Stone's estimate of 0.16 in/year for depressions during mine reclamation and the 0.04 in/year for final reclamation.

5.2.1 Transient Model Parameters

The area covering the one-year increment being mined was assigned hydraulic properties to simulate "air" in the open pit. The specific yield and specific storage in these areas were set equal to 1, and hydraulic conductivity was set equal to 8,640 ft/d. As one increment ended and the next was started, mine backfill hydraulic parameters were added to the model over the area of the previous one-year increment. As discussed in Section 5.1, swelling of mine backfill is accompanied by an increase porosity and permeability, therefore, hydraulic conductivity and storage properties were increased in the transient simulations compared with those used in the steady state pre- mining runs. Mine backfill properties are shown in Table 5-1. The hydraulic conductivity of 0.0113 ft/day ($4.0\text{x}10^{-6}$ cm/sec) estimated from laboratory tests on Navajo Mine spoils was used as a lower bound estimate for mine spoils to provide more conservative estimates of water recovery rates in mine spoils.

5.2.2 Initial Conditions

The head and saturation distributions from the pre-mining steady state simulation were used as initial conditions for the first one-year transient run in the mine plan. Subsequent one-year transient runs used the final result of the prior year run as initial conditions. At the conclusion of the proposed Area IV North mine plan, the final mine area was assigned backfill properties and a post mining transient simulation was run for 500 years to simulate rebound in groundwater levels in the mine backfill.

5.2.3 Transient Model Results

The results of the transient mining simulations are discussed in Section 11.6.2.4 of the Navajo Mine PAP. The transient modeling results presented in Section 11.6.2.4 of the Navajo Mine PAP show the slow rate of spoils resaturation as well as the rate of drawdown and recovery in the coals and PCS adjacent to mining.

5.3 MASS TRANSPORT MODEL SIMULATIONS

The FEFLOW software used for groundwater flow modeling also includes features that simulate conservative and reactive transport. The FEFLOW transport routines were applied to simulate the transport of TDS as a conservative constituent from mine spoil materials that are planned for backfilling of mine pits. TDS was selected for transport modeling based on analysis of constituents in spoil monitoring wells and spoil leaching tests as described in Section 11.6.2.4.3 of the Navajo Mine PAP. TDS transport modeling simulations were performed using a lower bound source concentration of 3,550 mg/l and an upper bound TDS concentration of 11,850 mg/l. TDS was assumed to behave conservatively, that is with no attenuation due to adsorption or chemical transformation.

The transport model solves advection-dispersion equations of transport processes in groundwater flow. Natural background concentrations were not included in the transport modeling because the objective of the transport modeling is to simulate the direction and rate of transport of modeled constituents from the mine spoils, including the magnitude of attenuation due to dispersion. Mass transport simulations were run for 500 years after the completion of mining assuming that the TDS source concentrations remain constant throughout the 500-year transport modeling period. The 500-year transport simulation was performed using the post-mine steady-state groundwater flow conditions as the initial condition for transport modeling. Experience from other surface mining operations as well as the successive leaching test results indicate that the concentrations of TDS are expected to decline over time with leaching of the mine spoils. A 500-year simulation period was considered reasonable for modeling the fate and transport from a constant TDS source concentration in the backfill. After 500 years it is expected that the source concentrations in the mine backfill will decline as groundwater flows through the mine backfill and flushes salts that may have been concentrated in the mine spoils as a result of weathering and evaporation during mining and backfilling operations.

5.3.1 Initial Conditions

The results of the steady state post-mining flow simulation were used as the initial flow condition for the transport simulations.

5.3.2 Mass Transport Boundaries

Transport runs for TDS were performed assuming that the source concentrations in mine spoils remained constant throughout the 500-year transport modeling period. Constant concentration boundary conditions were assigned to mine backfill for the runs simulating constant leaching to groundwater over time. These constant concentration boundary conditions were assigned concentrations equal to the initial source concentrations as described above.

5.4 MASS TRANSPORT MODEL RESULTS

Mass transport modeling results for the PHC for the proposed mine area in resource Area IV North are presented in Section 11.6.2.4.3 of the Navajo Mine PAP. The transport simulations based on the assumption that source concentrations remain constant throughout the 500-year simulation period show a substantial reduction in concentrations due to dispersion and mixing. Transport modeling results show that lateral migration of groundwater flow and constituents from the mine backfill in Area IV North is primarily vertically downward to the PCS and laterally toward the alluvium and topographic lows along Cottonwood Arroyo.

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TABLES

NORWEST
CORPORATION

TABLE 2-1. HYDRAULIC CONDUCTIVITY OF MODEL LAYERS AND CORRESPONDING HYDROSTRATIGRAPHIC UNITS

Formation	Estimated Kx Range		Calibrated Results			Comment
	Kx (ft/d)	Kx (ft/d)	Kx (ft/d)	Kx/Kz	Kx[1] (ft/d)	
Alluvium	5.13E+01	1.15E+01	1.56E+02			
No Name Alluvium			3.11E+01			
Weathered Overburden			5.02E-03	1		
Overburden	1.43E-03	9.64E-04	1.00E-03	10		
S8 Coal	6.00E-02	4.00E-03	1.25E-02	125	1.25E-01	Kz of weathered coal 5.0E-02
Interburden	8.64E-03	2.80E-05	5.01E-04	100		
S7 Coal	8.00E-03	2.00E-03	2.49E-03	2.5	2.49E-02	Kz of weathered coal 1.0E-02
Interburden	8.64E-03	2.80E-05	5.01E-04	100		
S6 Coal	2. 0E-03	1.0E-04	1.88E-03	2.5	1.88E-02	Kz of weathered coal 7.5E-03
Interburden	8.64E-03	2.80E-05	5.01E-04	500		
S4 Coal	2.0E-03	1.0E-0	1.88E-03	2.5		
Interburden	8.64E-03	2.80E-05	5.01E-04	25		
S3 Coal	2.0E-03	1.0E-04	4.99E-03	5		
Interburden	8.64E-03	2.80E-05	5.01E-04	25		
S2 Coal	2.0E-03	1.0E-04	1.25E-03	2.5		
Interburden	8.64E-03	2.80E-05	5.01E-04	25		
Pictured Cliffs Sandstone	4.41E-02	1.00E-04	1.00E-02	1		

[1] **calibrated Kx for weathered coals**

TABLE 2-2. RECHARGE VALUES AND SURFACE CHARACTERIZATION

Surface Characterization	Recharge Range[1] (in/yr)	Mean Recharge[1] (in/yr)	Modeled Recharge (in/yr)
Badlands	0.002 to 0.01	0.006	
Slopes > 5%			0.002
Slopes: 2 to 5%			0.01
Upland Flat	.02 to 0.05	0.03	
Upland Flat (slope<1%)			0.03
Upland (Slope 1 to 2%)			0.02
Alluvial Valley	0.09	0.09	0.09
Mine Backfill			0.04

[1]From Stone, W. J. 1987. Phase-III Recharge Study at Navajo Mine

TABLE 3-1 MODEL LAYERS AND CORRESPONDING HYDROSTRATIGRAPHIC UNITS

Layer	Slice	Formation
1	1	Alluvium and Weathered Overburden
2,3	2,3	Overburden
4	4	S8 Coal
5,6,7	5,6,7	Interburden
8	8	S7 Coal
9,10,11	9,10,11	Interburden
12	12	S6 Coal
13,14,15	13,14,15	Interburden
16	16	S4 Coal
17,18,19	17,18,19	Interburden
20	20	S3 Coal
21,22,23	21,22,23	Interburden
24	24	S2 Coal
25,26	25,26	Interburden
27,28	27,28,29	Pictured Cliffs Sandstone

TABLE 3-2. FLUXES ASSIGNED TO CONSTANT FLUX BOUNDARY CONDITIONS

Model Layer	Coal Seam	Constant Flux (ft/d)
4	#8	$1.704\text{x}10^{-4}$
8	#7	$8.52\text{x}10^{-6}$
12	#6	$6.375\text{x}10^{-5}$
16	#4	$6.375\text{x}10^{-5}$
20	#3	$8.52\text{x}10^{-5}$
24	#2	$4.25\text{x}10^{-6}$

TABLE 4-1. CALIBRATION DATA

Well	Formation	Model Layer	Observed Head	Calibrated Head	Residual
QACW-2B	Alluvium	1	5235.20	5224.97	-10.23
PA-1	Alluvium	1	5340.81	5319.97	-20.84
PA-2	Alluvium	1	5422.73	5403.40	-19.33
KF2007-01	#8 Coal	4	5392.01	5403.41	11.40
KF84-22A	#8 Coal	4	5270.49	5258.15	-12.34
VWP2007-02	#8 Coal	4	5393.67	5403.45	9.78
KF84-21C	#7 Coal	8	5273.98	5240.47	-33.51
KF84-22B	#7 Coal	8	5268.95	5256.52	-12.43
VWP2007-02	#7 Coal	8	5370.81	5389.16	18.35
KF84-22C	#6 Coal	12	5257.20	5255.42	-1.78
VWP2007-01	#6 Coal	12	5329.88	5347.48	17.60
KF84-22D	#3 Coal	20	5248.20	5249.50	1.30
KF-98-02	#3 Coal	20	5354.47	5364.56	10.09
KF-98-03	#3 Coal	20	5291.94	5327.26	35.32
VWP2007-01	#3 Coal	20	5278.56	5281.84	3.27
VWP2007-02	#3 Coal	20	5287.85	5325.76	37.92
KF-98-04	#3 Coal	20	5288.48	5301.90	13.42
KF84-21A	#2 Coal	24	5240.95	5243.31	2.36
KF84-22E	#2 Coal	24	5246.90	5249.37	2.47
VWP2007-01	#2 Coal	24	5273.37	5281.64	8.27
VWP2007-02	#2 Coal	24	5291.09	5325.54	34.45
VWP2007-03	#2 Coal	24	5357.60	5362.06	4.46
VWP2007-5	#2 Coal	24	5410.61	5421.95	11.35
GM-19	PCS	28	5265.00	5272.31	7.31
GM-20	PCS	28	5333.00	5312.87	-20.13
GM-21	PCS	28	5428.00	5439.27	11.27
GM-29	PCS	28	5305.00	5310.11	5.11
GM-30A	PCS	28	5387.00	5385.22	-1.78
KPC2007-01	PCS	28	5262.00	5280.46	18.46
KPC2007-02	PCS	28	5351.90	5360.50	8.60
KPC2007-03	PCS	28	5336.52	5326.88	-9.64
KPC-98-01	PCS	28	5288.31	5271.78	-16.53
T4-1	PCS	28	5385.85	5385.29	-0.56
T4-2	PCS	28	5385.20	5385.31	0.11
O-1	PCS	28	5422.00	5426.77	4.77
13-7-2	PCS	28	5402.00	5410.29	8.29

Well	Formation	Model Layer	Observed Head	Calibrated Head	Residual
P-1	PCS	28	5430.00	5439.69	9.69
VWP2007-01	PCS	28	5268.30	5280.44	12.14
VWP2007-02	PCS	28	5296.81	5325.25	28.44
VWP2007-4	PCS	28	5397.48	5404.55	7.07
VWP2007-5	PCS	28	5411.26	5419.03	7.77
GM-28	PCS	28	5265.00	5251.82	-13.18

TABLE 4-2.
Model Parameters Varied in Sensitivity Analysis of Steady State Model

Model Parameter	Calibrated Value	Sensitivity Analysis Range
Alluvium Kx	155 ft/d	31 to 187 ft/d
Upper Coals (#6, #7 and #8) Kx	Variable	Calibrated Value x 5, Calibrated Value / 2
Upper Coal Interburden Kx/Kz Ratio	100/1	20/1 to 2,500/1
Lower Coal Interburden Kx/Kz Ratio	25/1	25/1 to 2,500/1
Interburden between Upper and Lower Coals Kx/Kz Ratio	500/1	100/1 to 1000/1
PCS Kx	0.01 ft/d	0.005 to 0.02 ft/d
Leakage Coefficient of Head Dependent Boundary at Base of Model	Variable	3×10^{-4}/day, Calibrated Value x 2, Calibrated Value / 2
Kx of Weathered Coal	Variable	Kx same as unweathered
Recharge	Variable	Calibrated Values x 0.8 Calibrated Values x 1.2

TABLE 5-1.
RECHARGE RATES AND HYDRAULIC PROPERTIES OF MINE SPOILS FOR POST-MINE GROUNDWATER MODEL

Surface Characterization	Recharge Range[1] (in/yr)	Mean Recharge[1] (in/yr)	Modeled Recharge (in/yr)
Reclaimed Areas	0.01 to 0.23	0.04	
Reclaimed Depression Areas		0.16	
Reclaimed Areas-Transient			0.1
Reclaimed Areas-Steady State			0.04
Alluvium- Pre-Mine and Reclaimed	0.09		0.09
Pre-Mine Surfaces	0.002 to 0.04		0.02

Reclamation Materials	Porosity (%)	Ksat (cm/sec)	Ksat (ft/day)
Surface Mine Spoils (L1)	40.6	2.0E-04	0.563
Mine Spoils <L1	40.6	2.0E-05	0.0563
Geometric Mean of Mine Spoils in Northern Great Plains (Rehm et al, 1980)		8.0E-05	0.2268
Lab Tests of Navajo Mine Spoil Samples	40.6	4.0E-06	0.0113

[1] Estimates from Stone (1987)

FIGURES

FIGURE 1-1. PICTURED CLIFFS SANDSTONE CONCEPTUAL GROUNDWATER MODEL

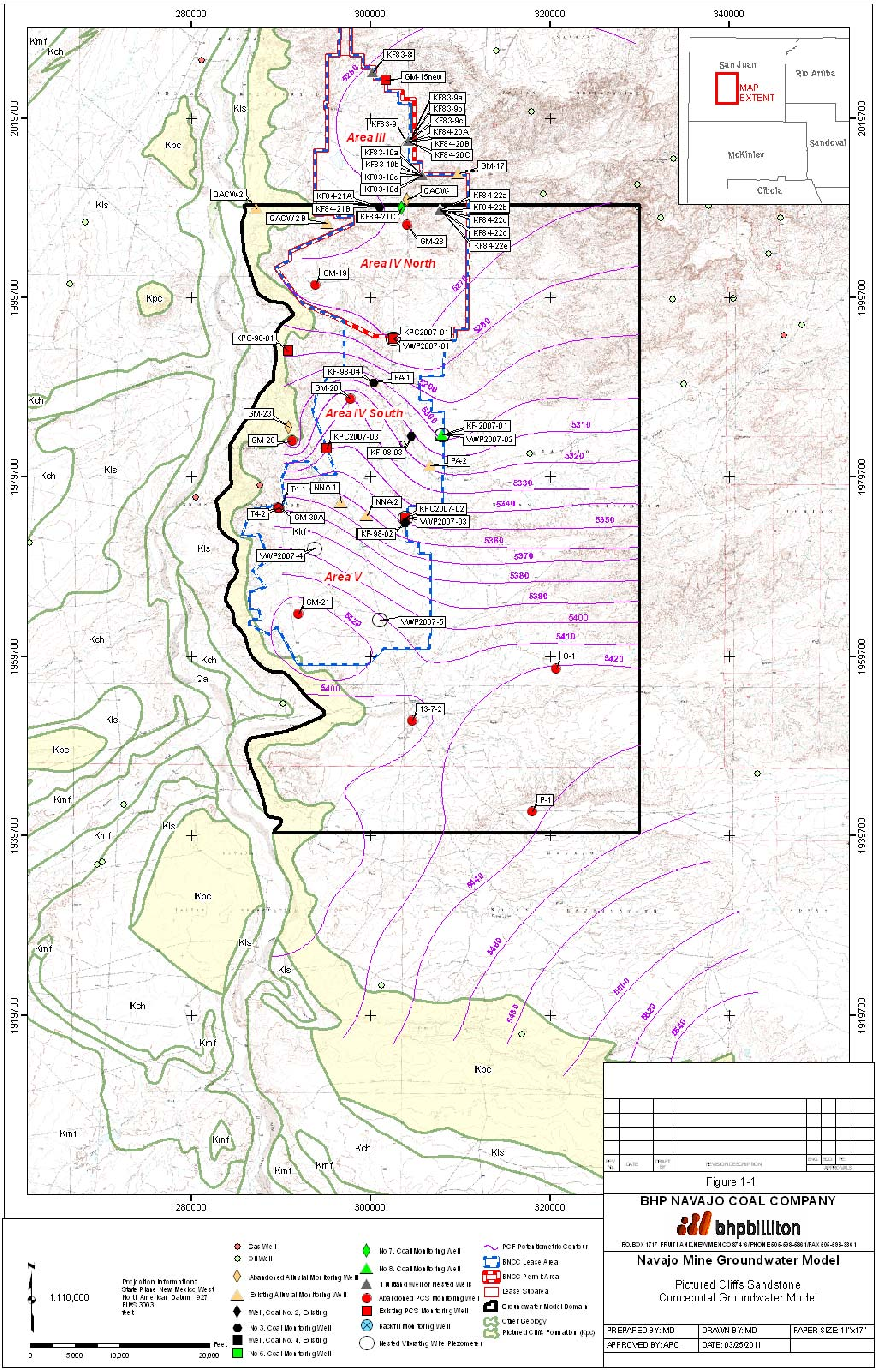

FIGURE 3-1. MODEL DOMAIN AND MESH DISCRETIZATION

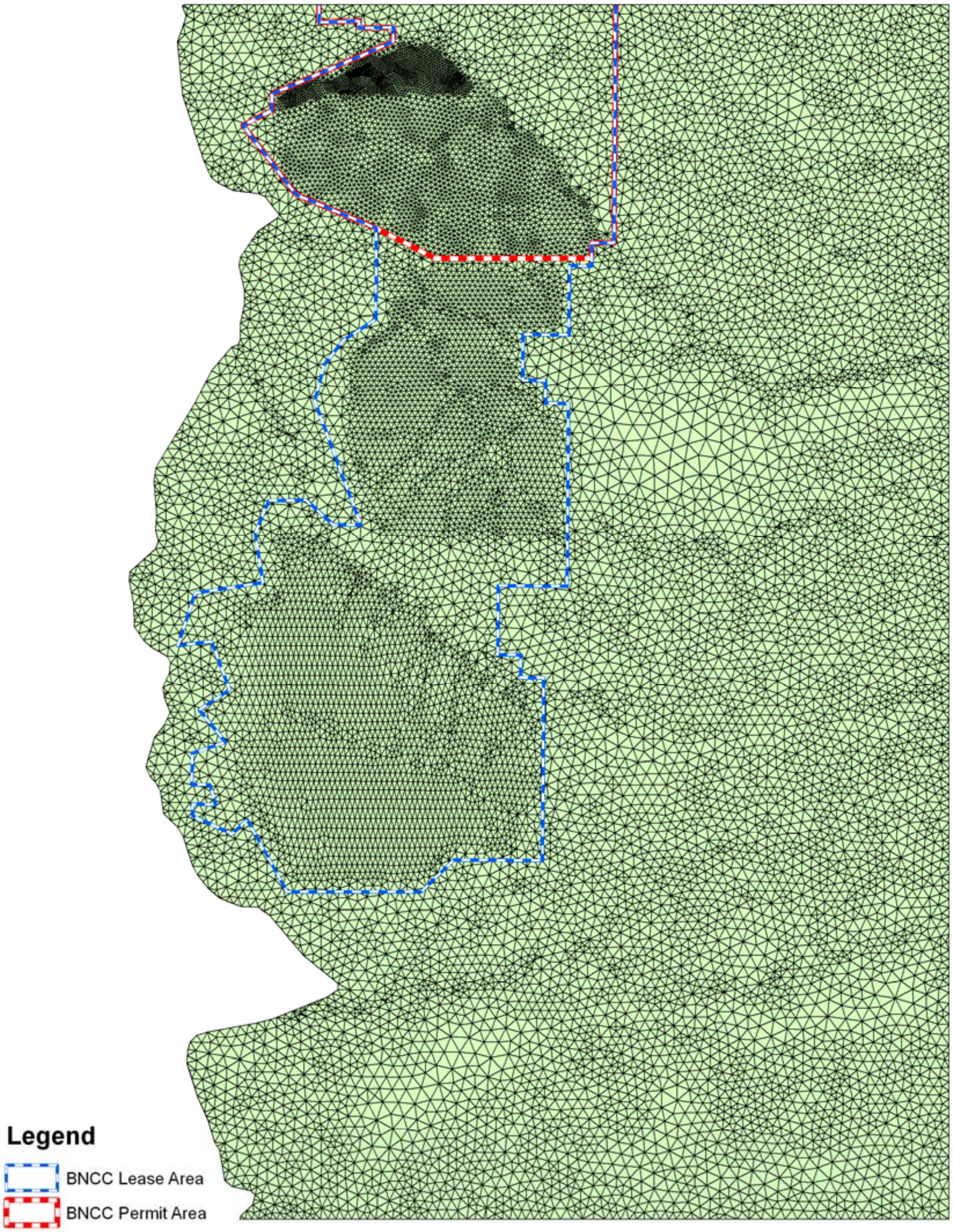

FIGURE 3-2. LOCATIONS OF BOUNDARY CONDITIONS - FRUITLAND AND ALLUVIAL MODEL LAYERS

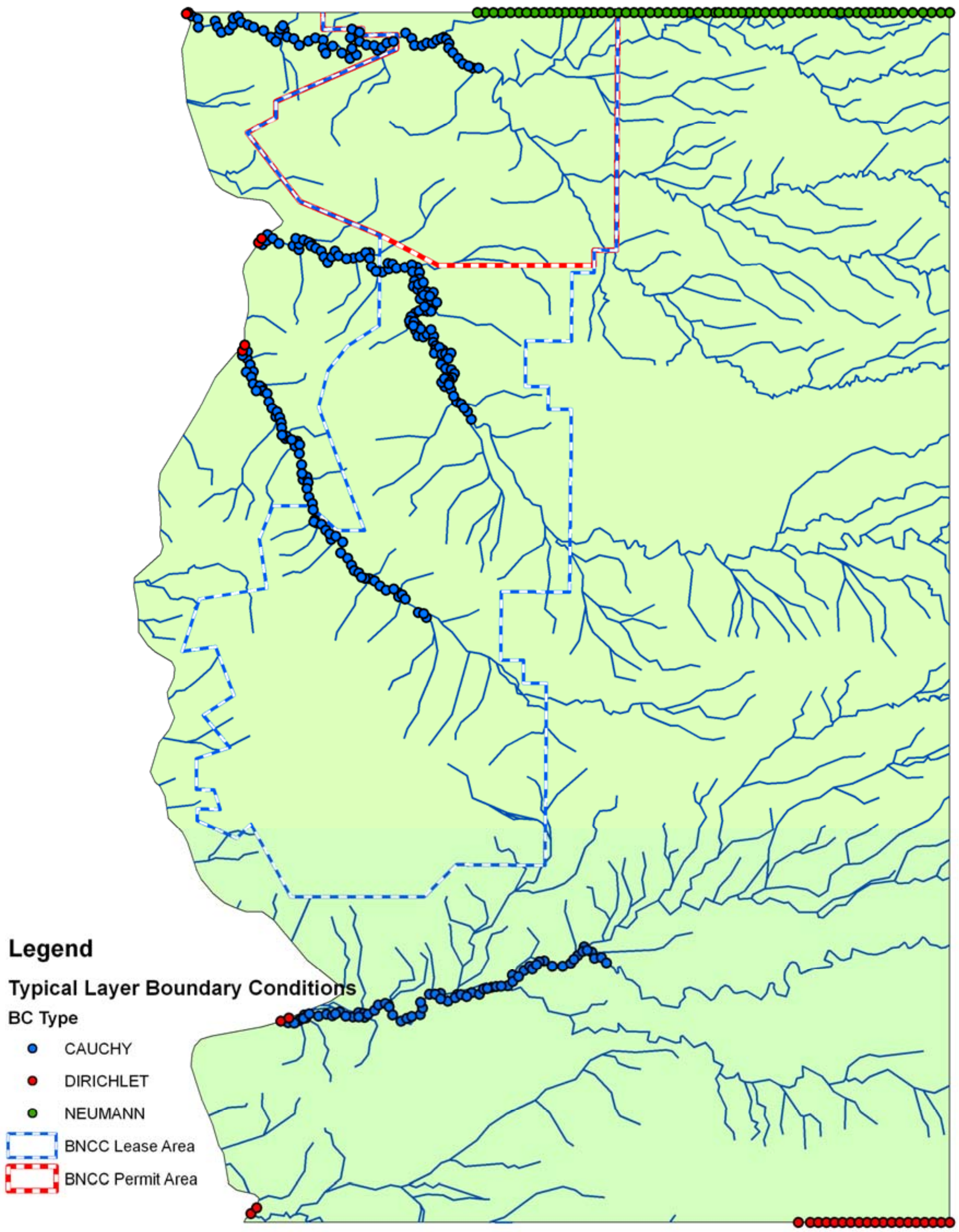

FIGURE 3-3. LOCATIONS OF BOUNDARY CONDITIONS - PCS

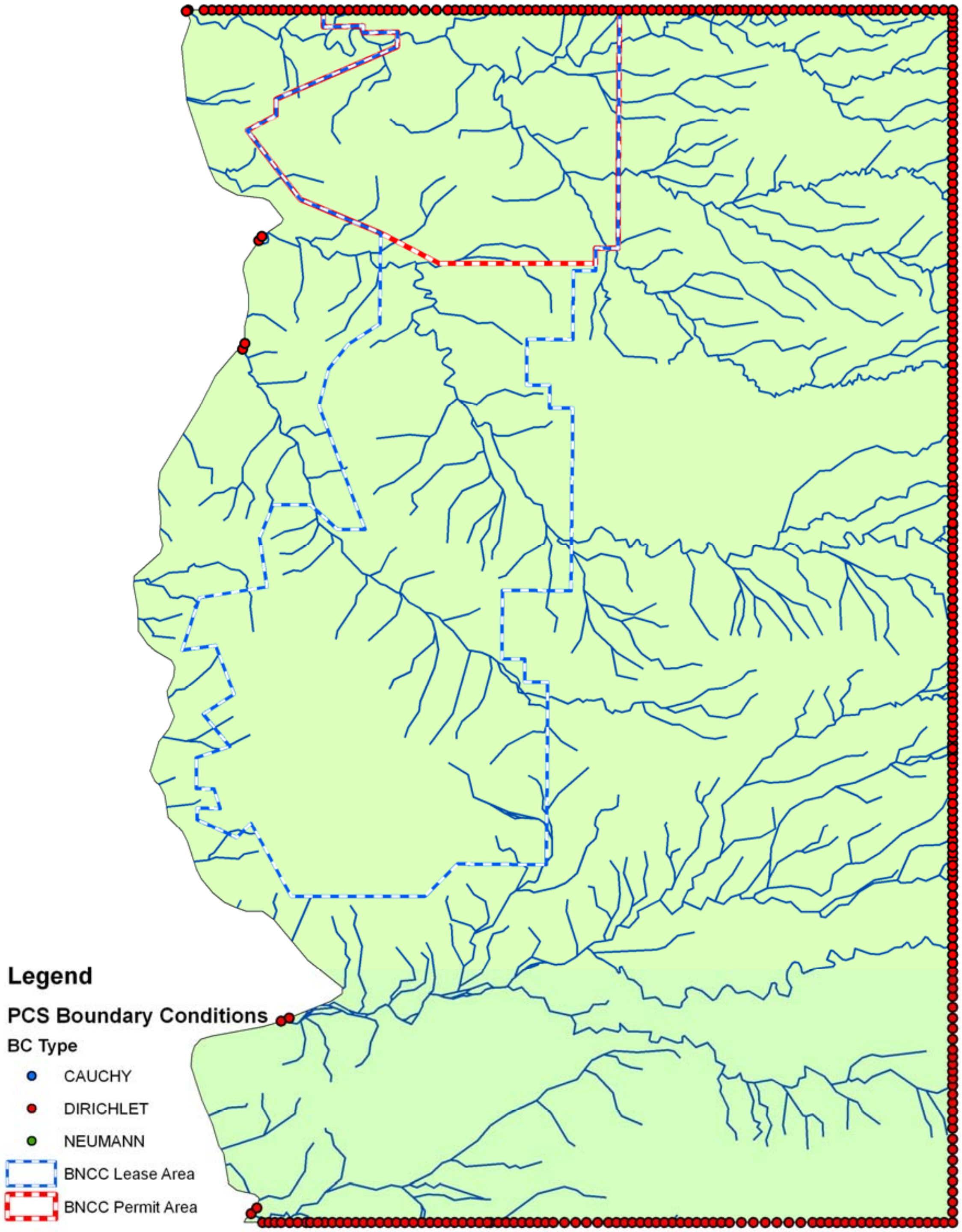

FIGURE 3-4. RECHARGE DISTRIBUTION

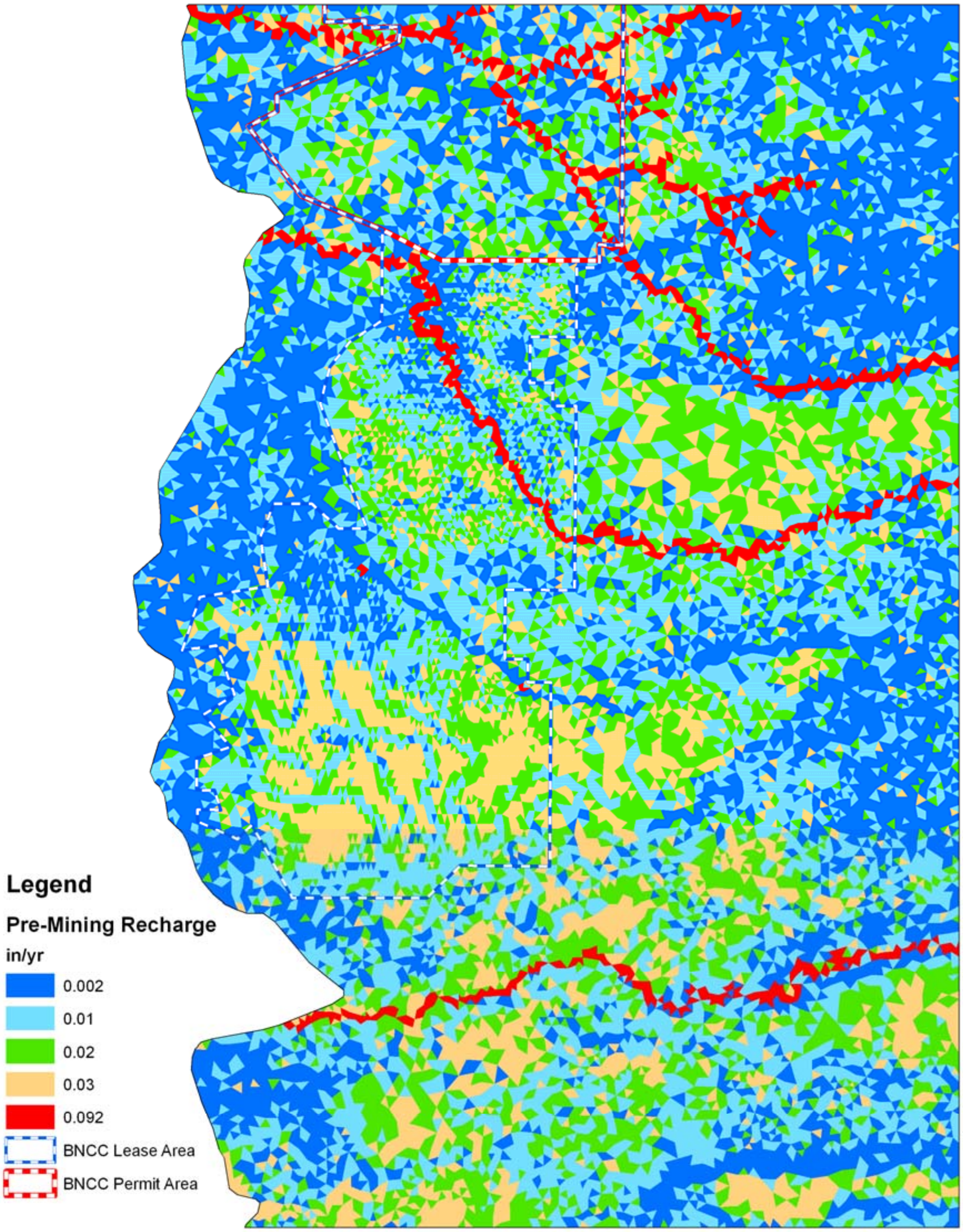

FIGURE 3-5. HEAD DEPENDENT BOUNDARY CONDITIONS - REFERENCE HEAD

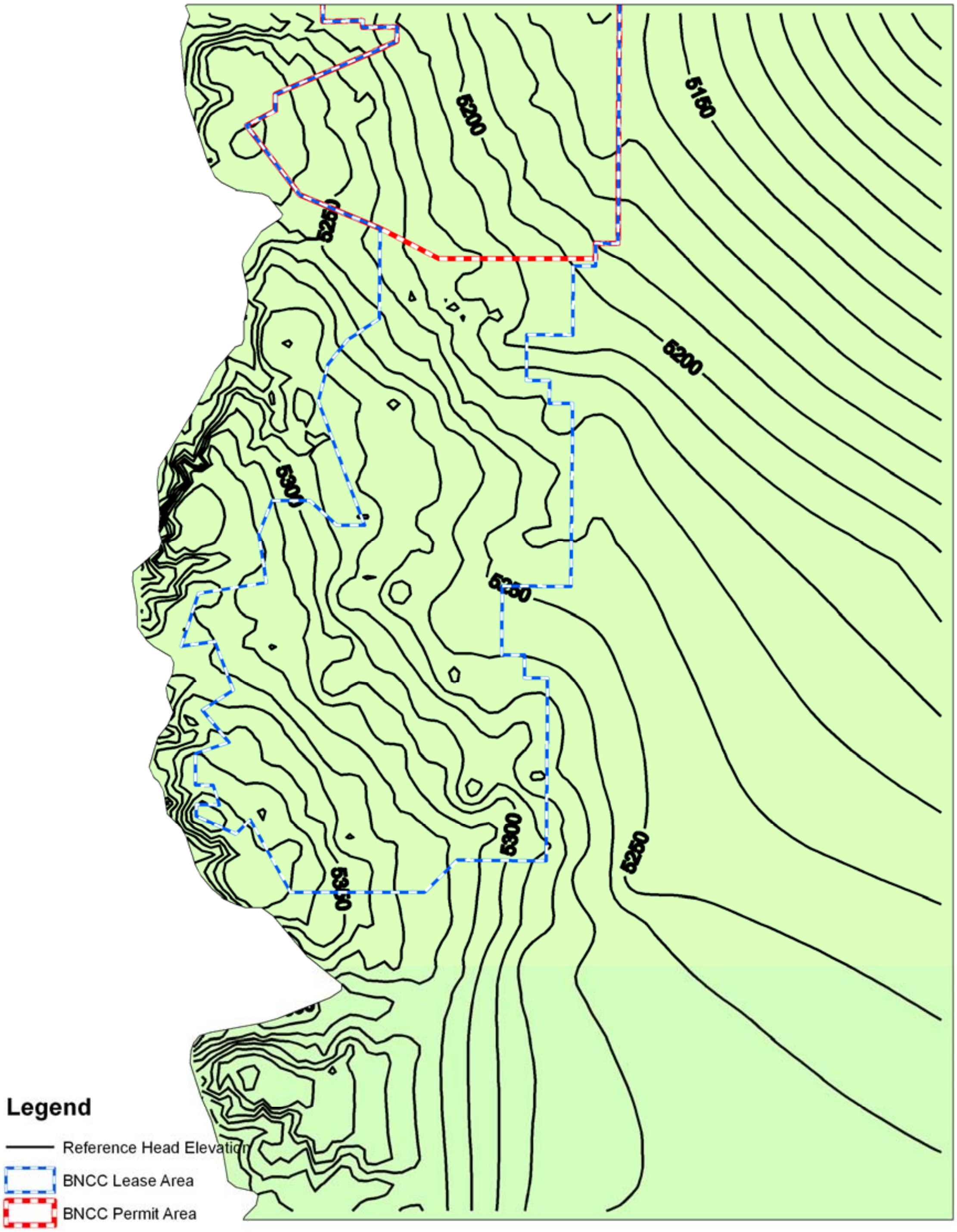

FIGURE 3-6. HEAD DEPENDENT BOUNDARY CONDTIONS - LEAKAGE COEFFICIENT

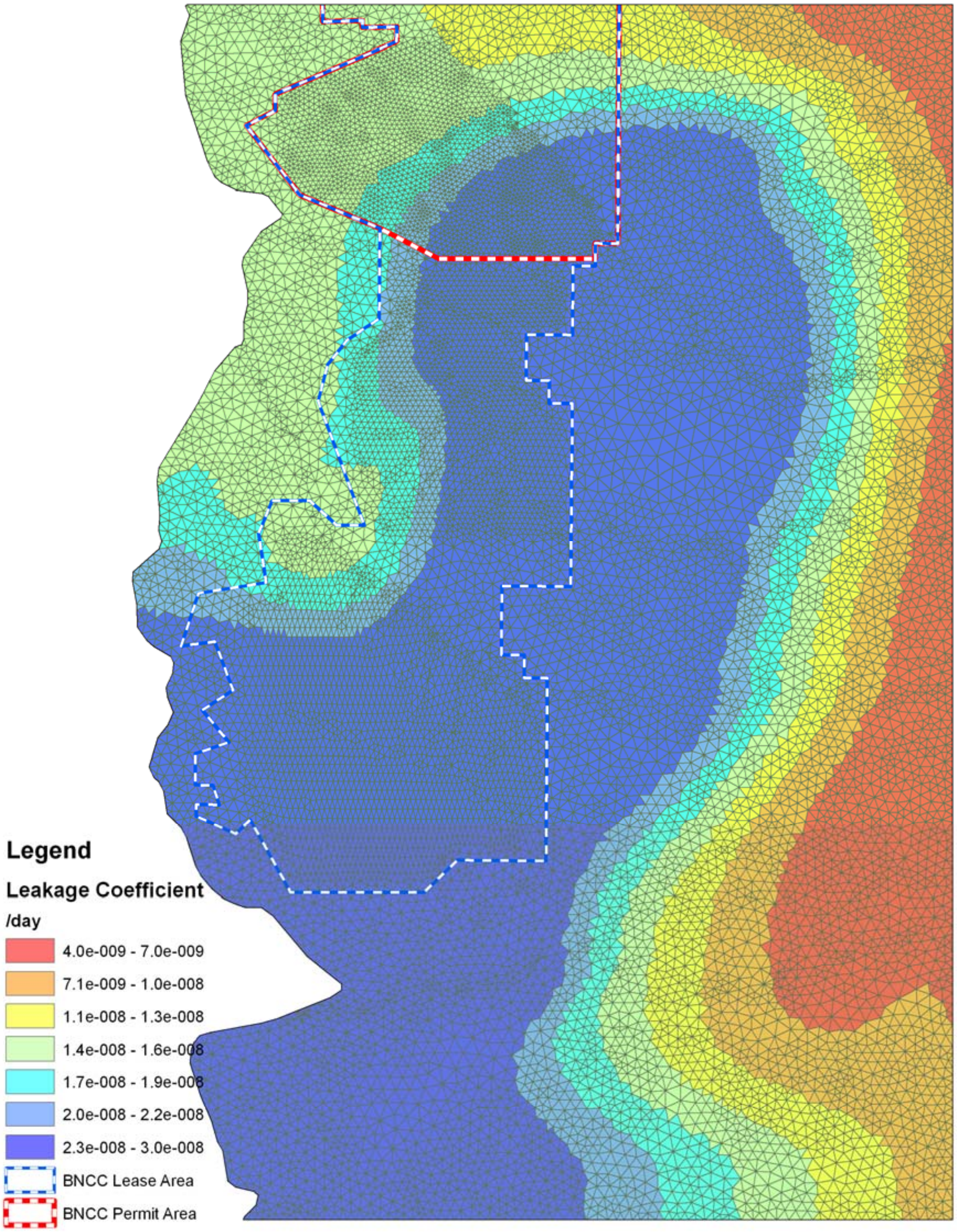

FIGURE 4-1. CALIBRATION WELL LOCATIONS

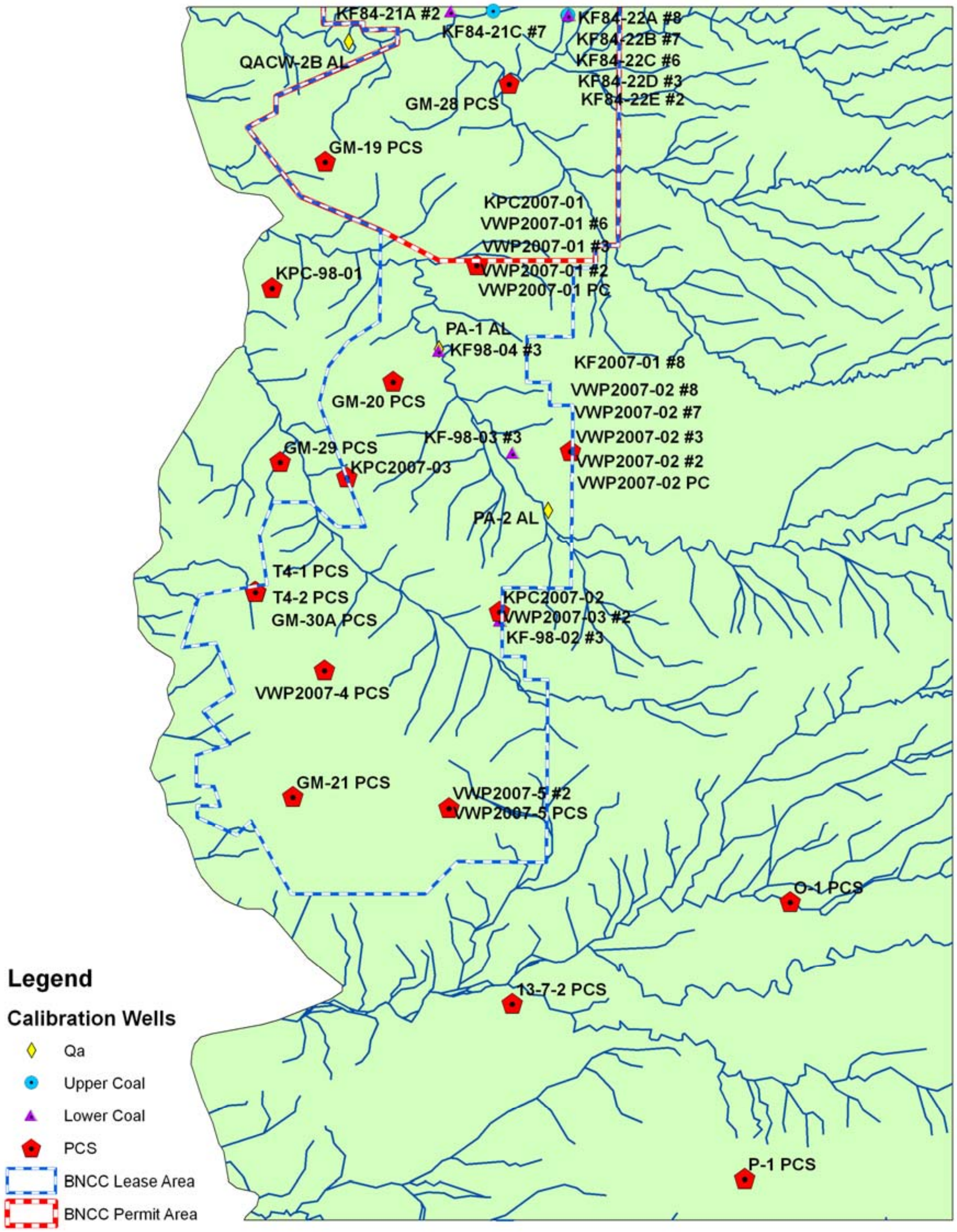

FIGURE 4-2. CALIBRATED PCS POTENTIOMETRIC SURFACE

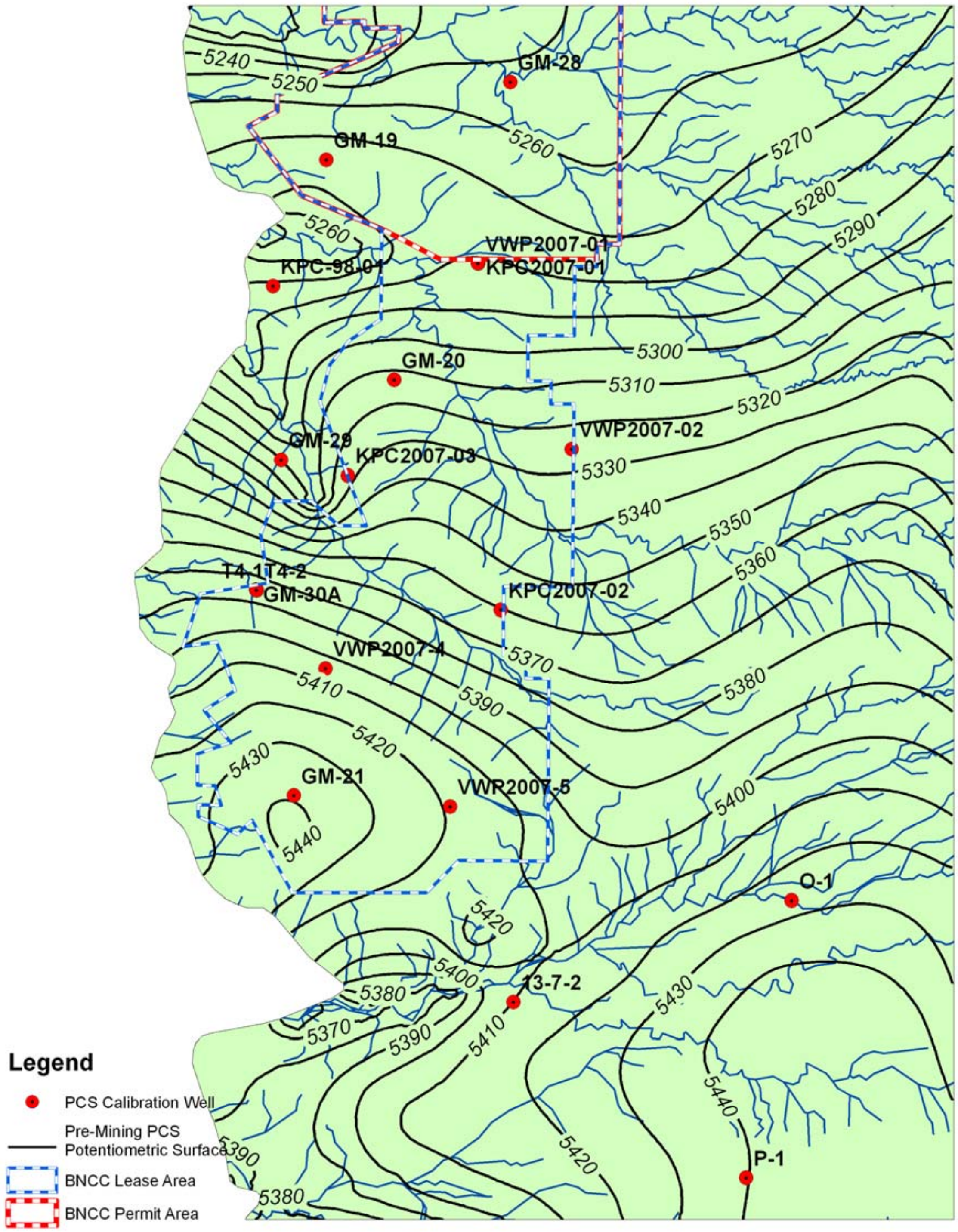

FIGURE 4-3. MODEL CALIBRATION - CALCULATED VS. OBSERVED HEADS

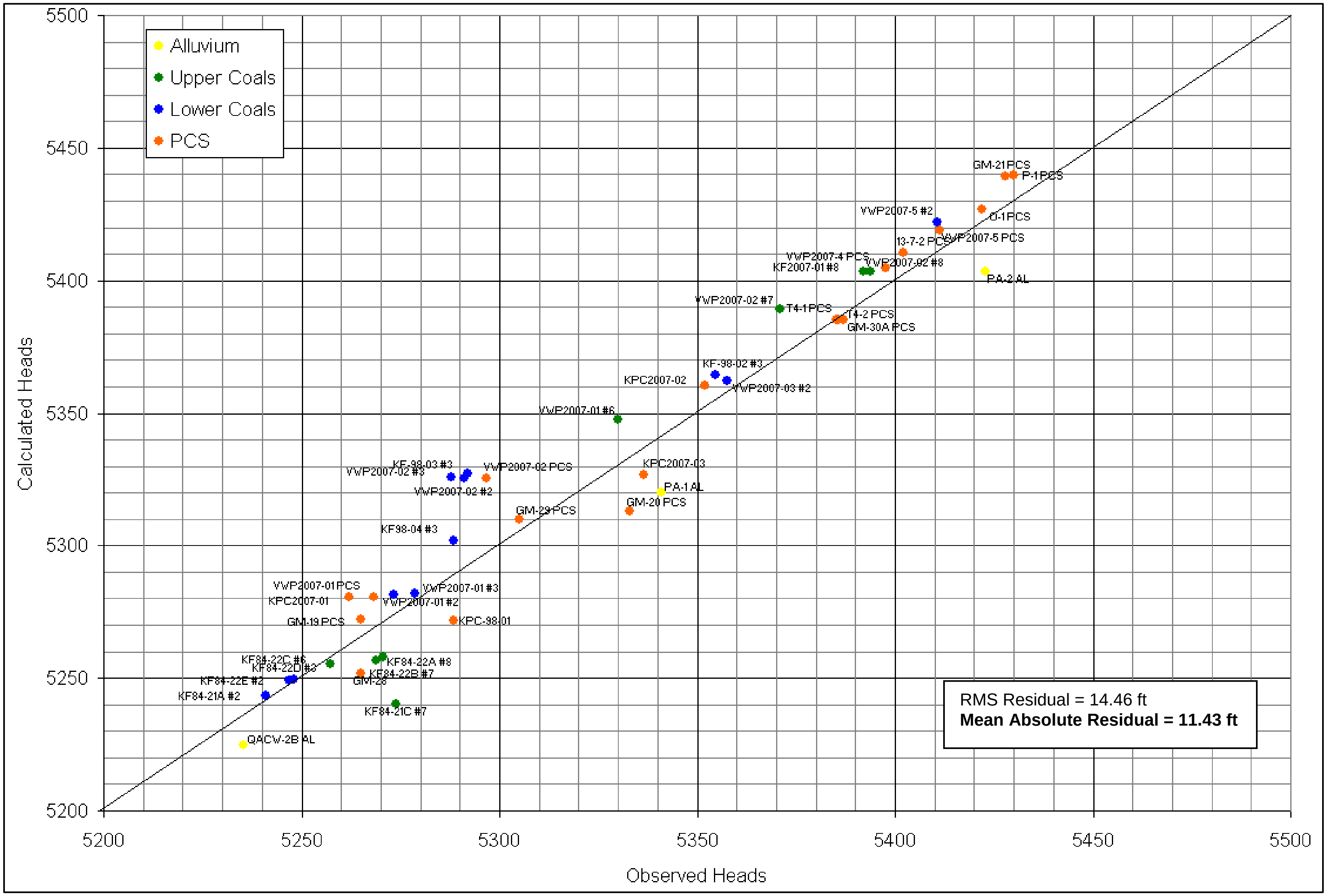

FIGURE 4-4. Sensitivity Analysis - Calculated vs. Observed Heads - K_{PCS}=0.005 ft/d

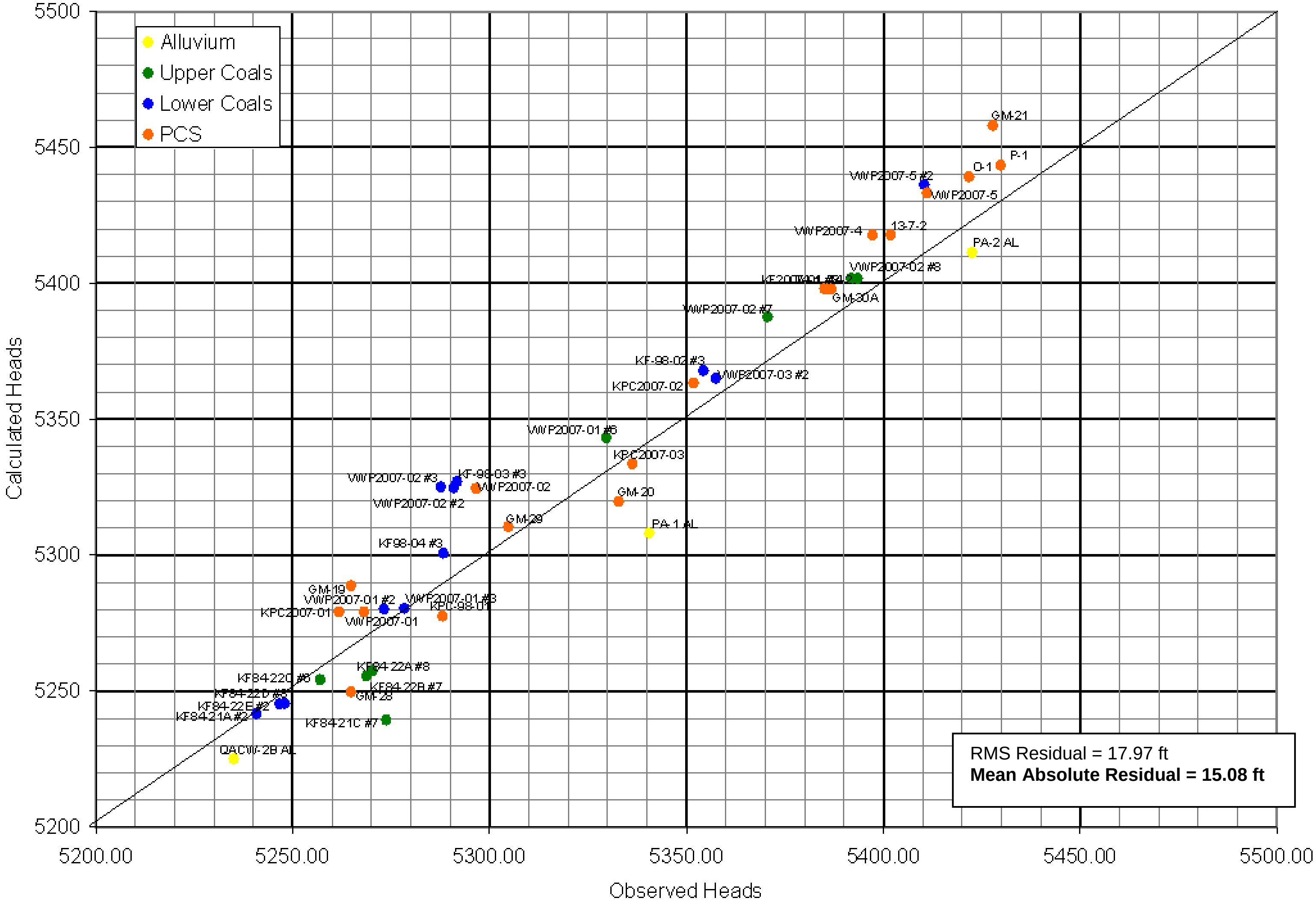

Figure 4-5. Sensitivity Analysis - Calculated vs. Observed Heads - KPCS=0.02 ft/d

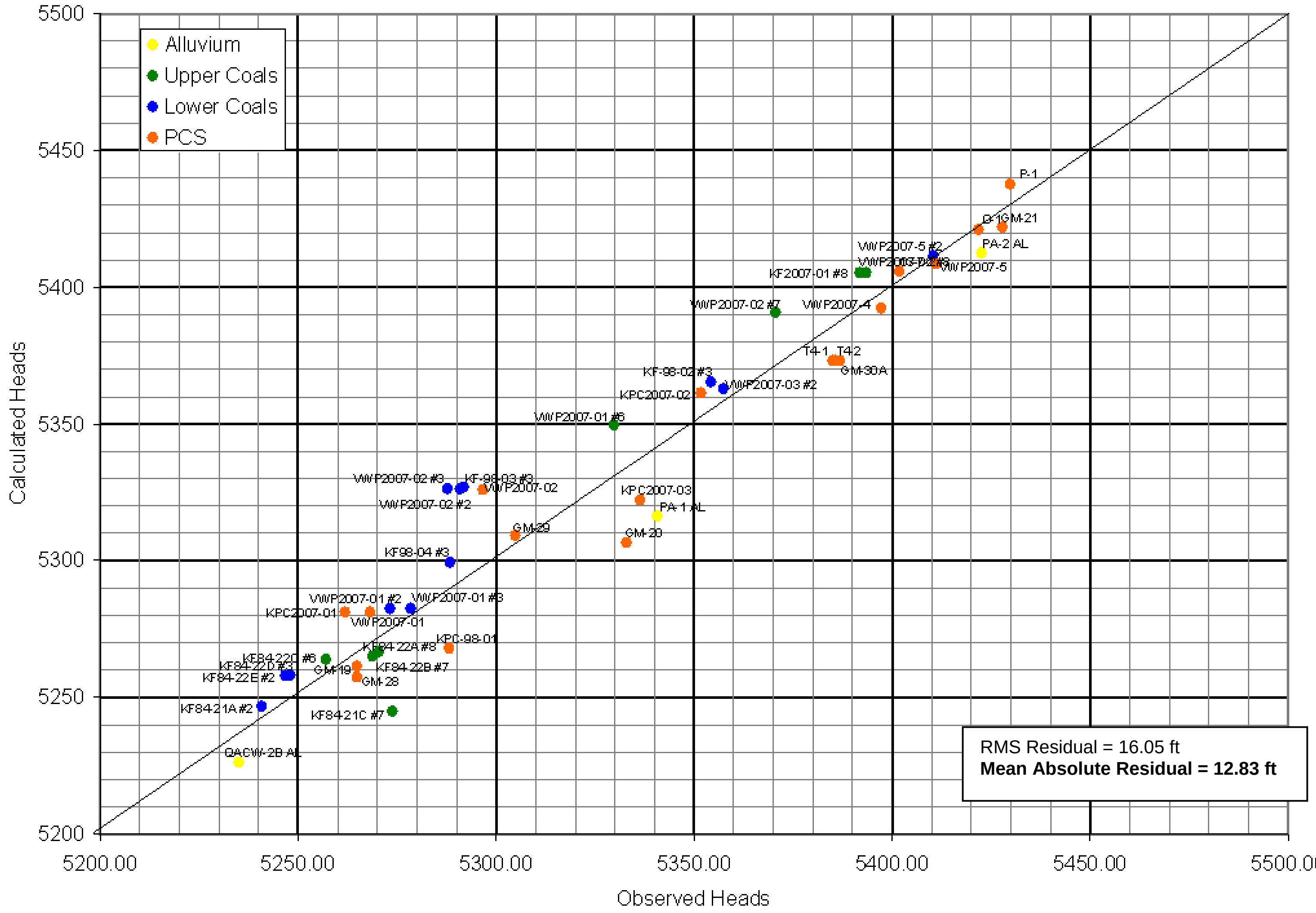

FIGURE 4-6. Sensitivity Analysis - Calculated vs. Observed Heads – Kx of upper coals X5

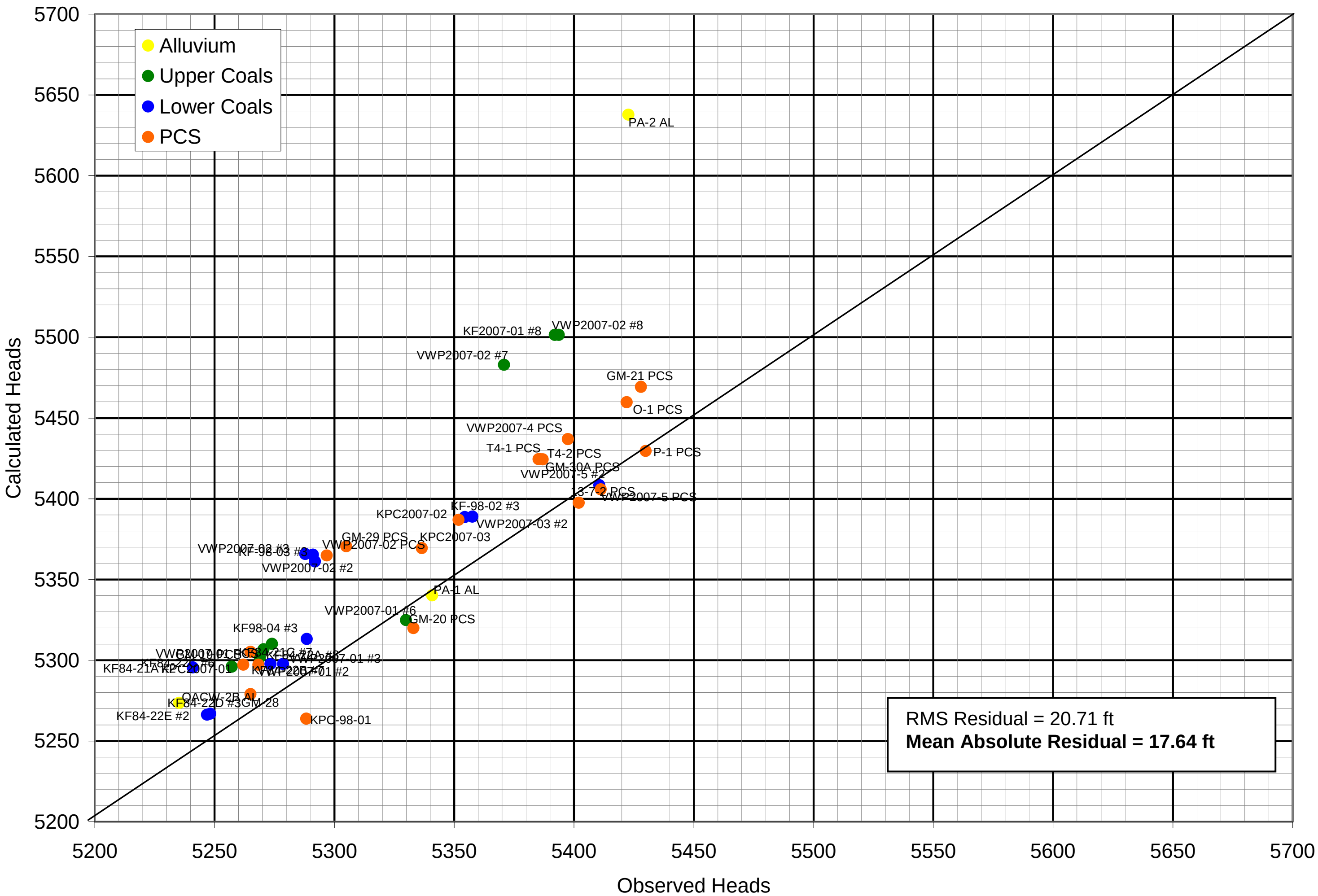

FIGURE 4-7. Sensitivity Analysis - Calculated vs. Observed Heads – Kx of upper coals /2

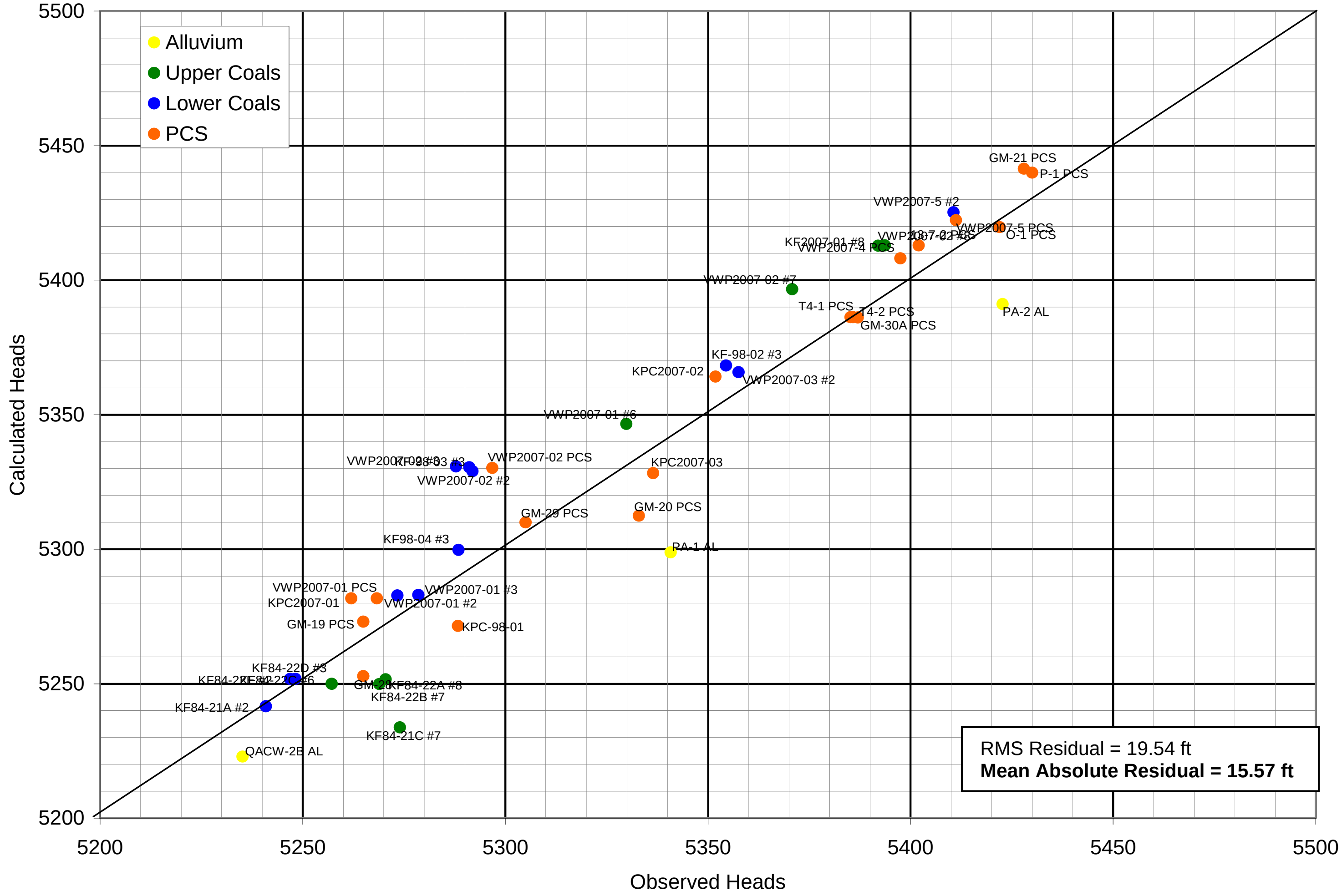

FIGURE 4-8. Sensitivity Analysis - Calculated vs. Observed Heads - $K_{\text{weathered coal}}$=$K_{\text{unweathered coal}}$

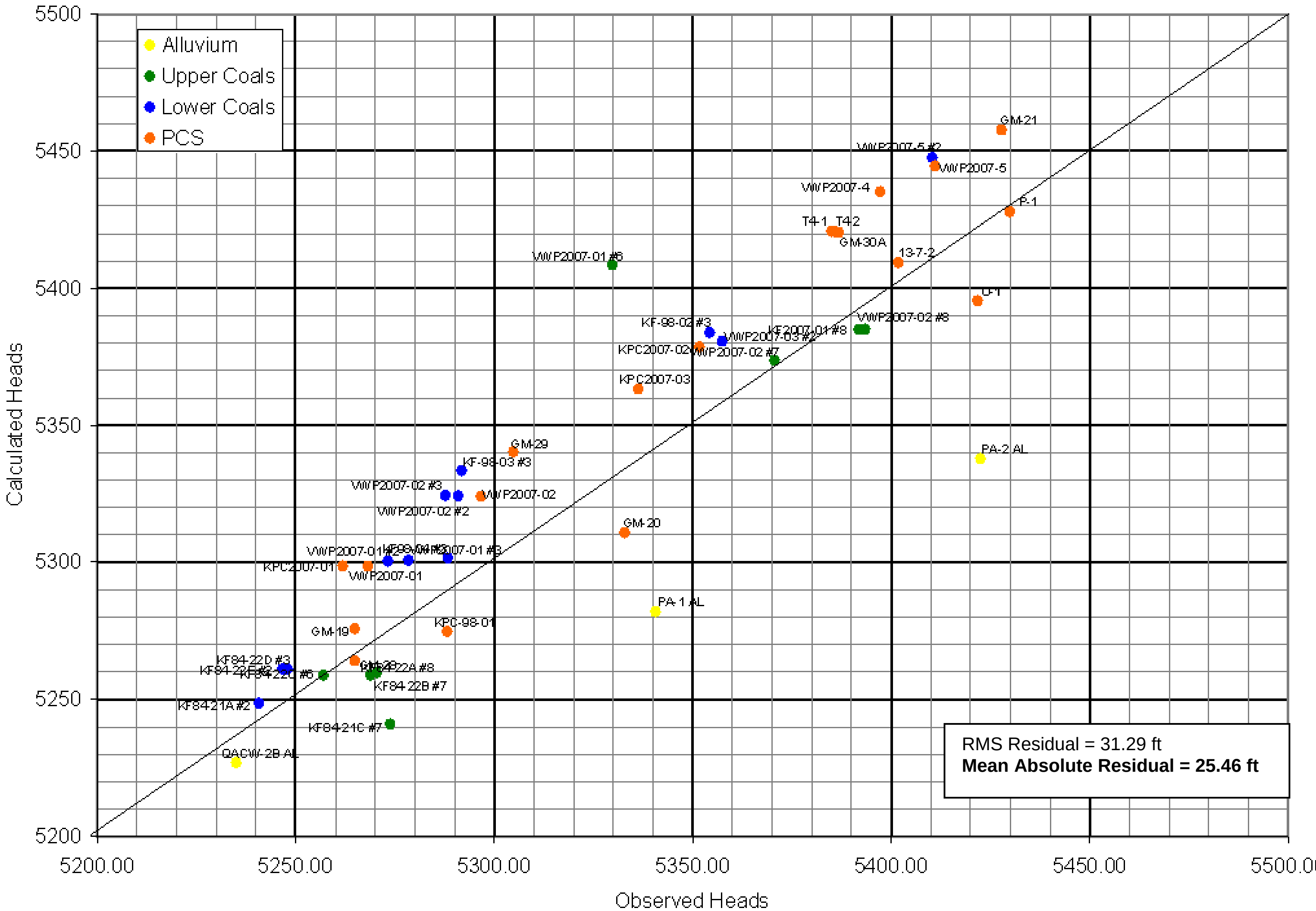

FIGURE 4-9. Sensitivity Analysis - Calculated vs. Observed Heads - Kz_{14}=5x10^{-6} ft/d (Kx/Kz=100)

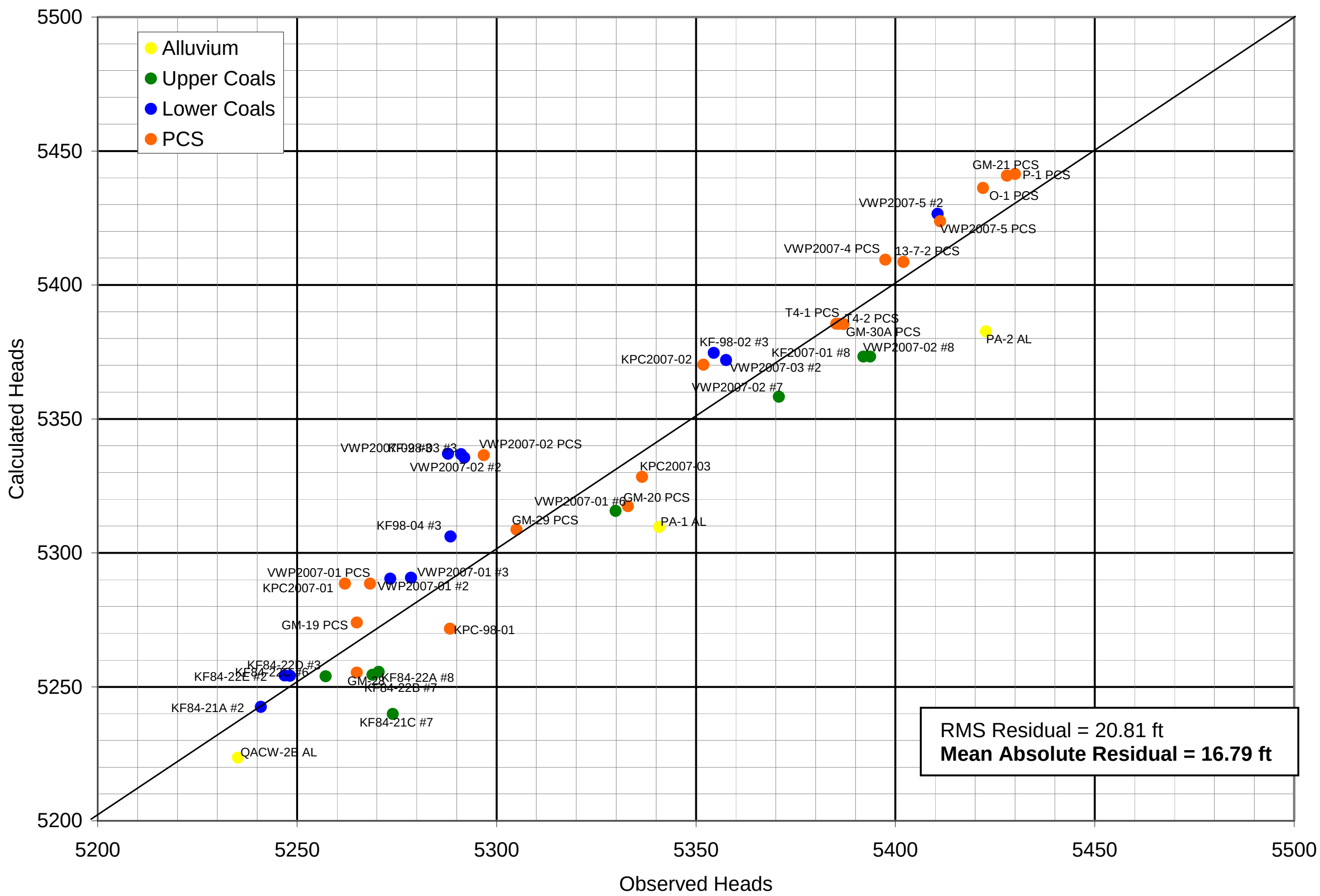

FIGURE 4-10. Sensitivity Analysis - Calculated vs. Observed Heads - Kz_{14}=5x10^{-7} ft/d (Kx/Kz=1,000)

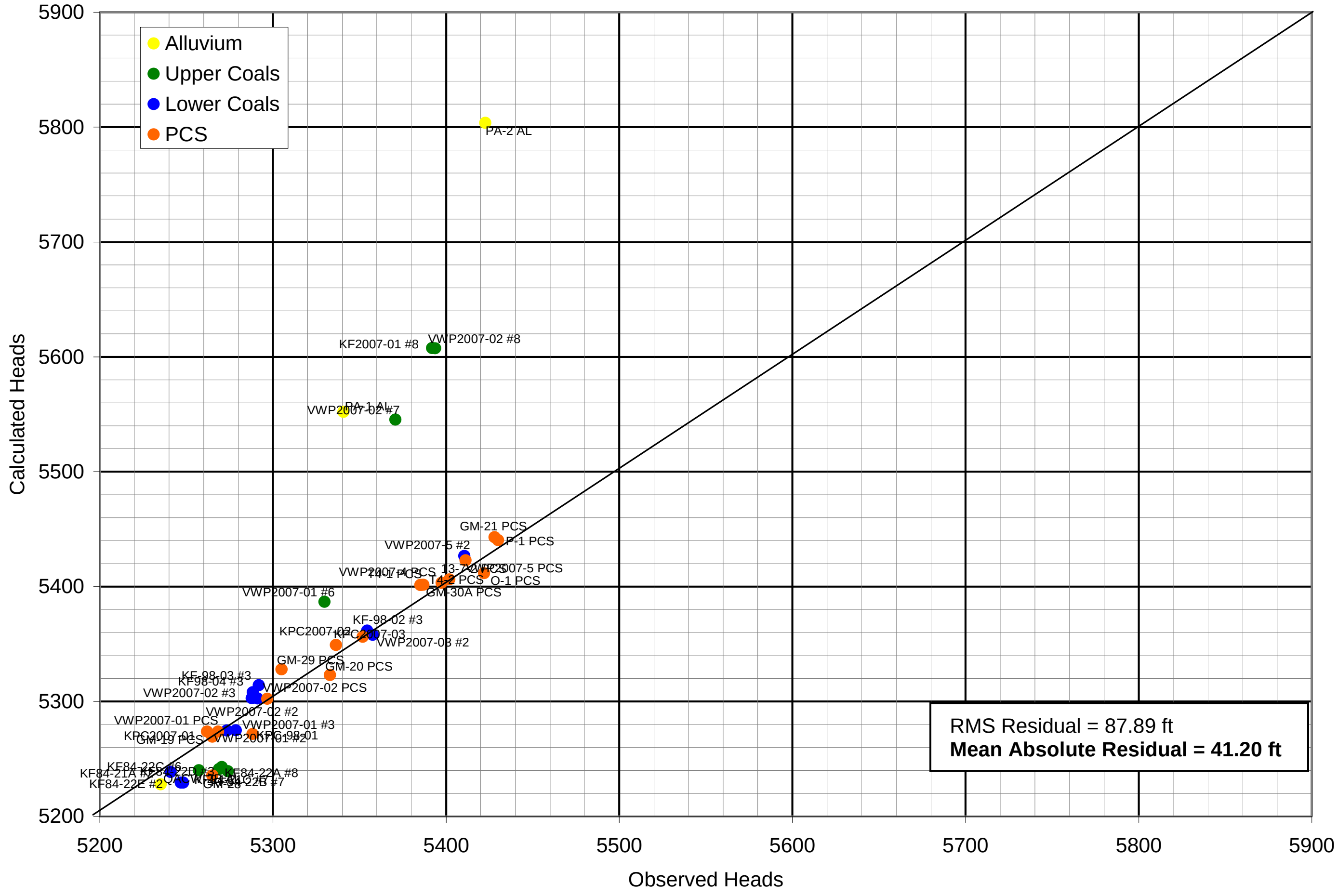

FIGURE 4-11. Sensitivity Analysis - Calculated vs. Observed Heads - $Kz_{UpperIB}$=2x10^{-7} ft/d (Kx/Kz=2,500)

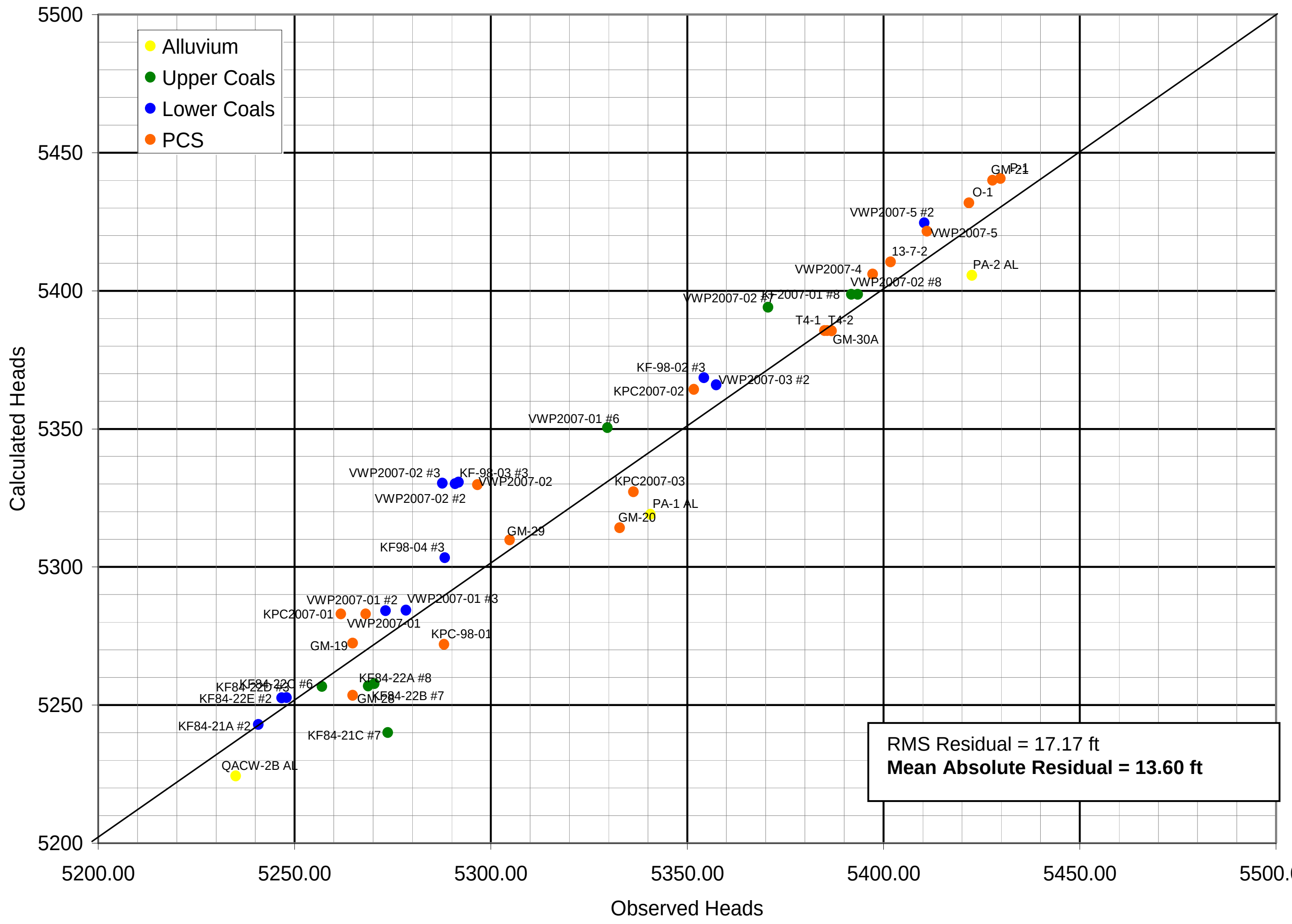

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FIGURE 4-12. Sensitivity Analysis - Calculated vs. Observed Heads - $Kz_{UpperIB}=2.5x10^{-5}$ ft/d (Kx/Kz=20)

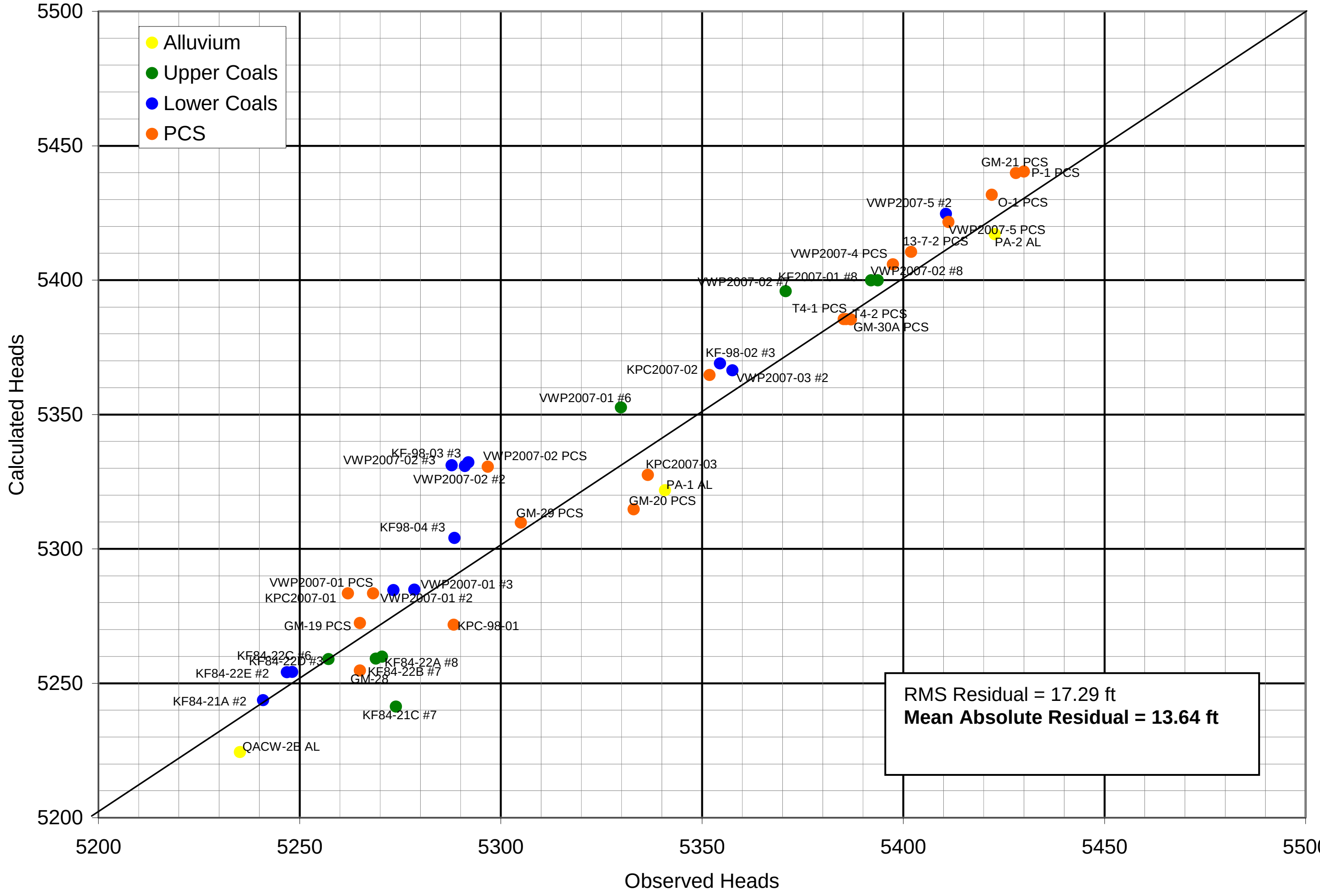


FIGURE 4-13. Sensitivity Analysis - Calculated vs. Observed Heads - $Kz_{LowerIB}$=2x10^{-7} ft/d (Kx/Kz=2,500)

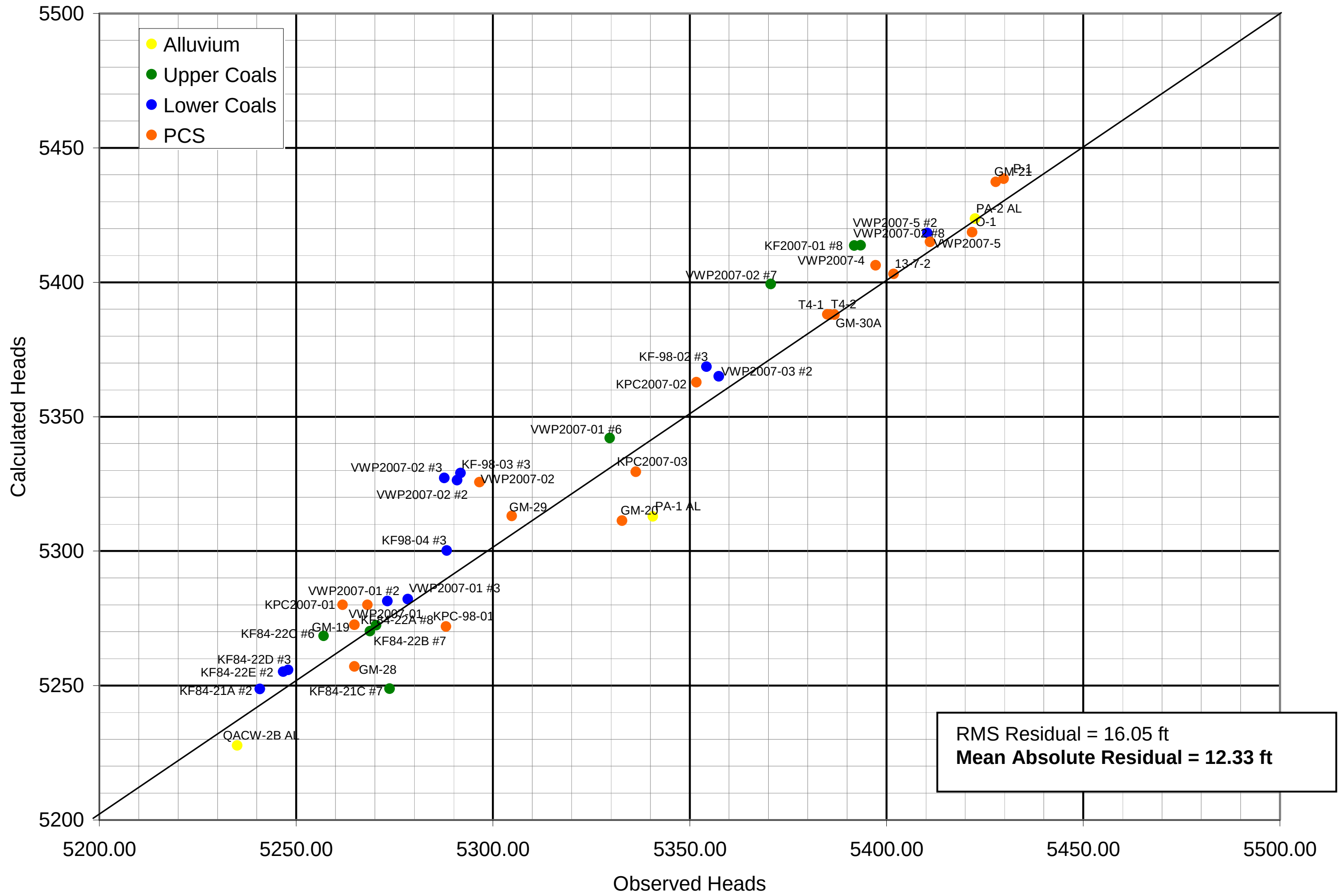


Figure 4-14. Sensitivity Analysis - Calculated vs. Observed Heads - K_{al}=31 ft/d

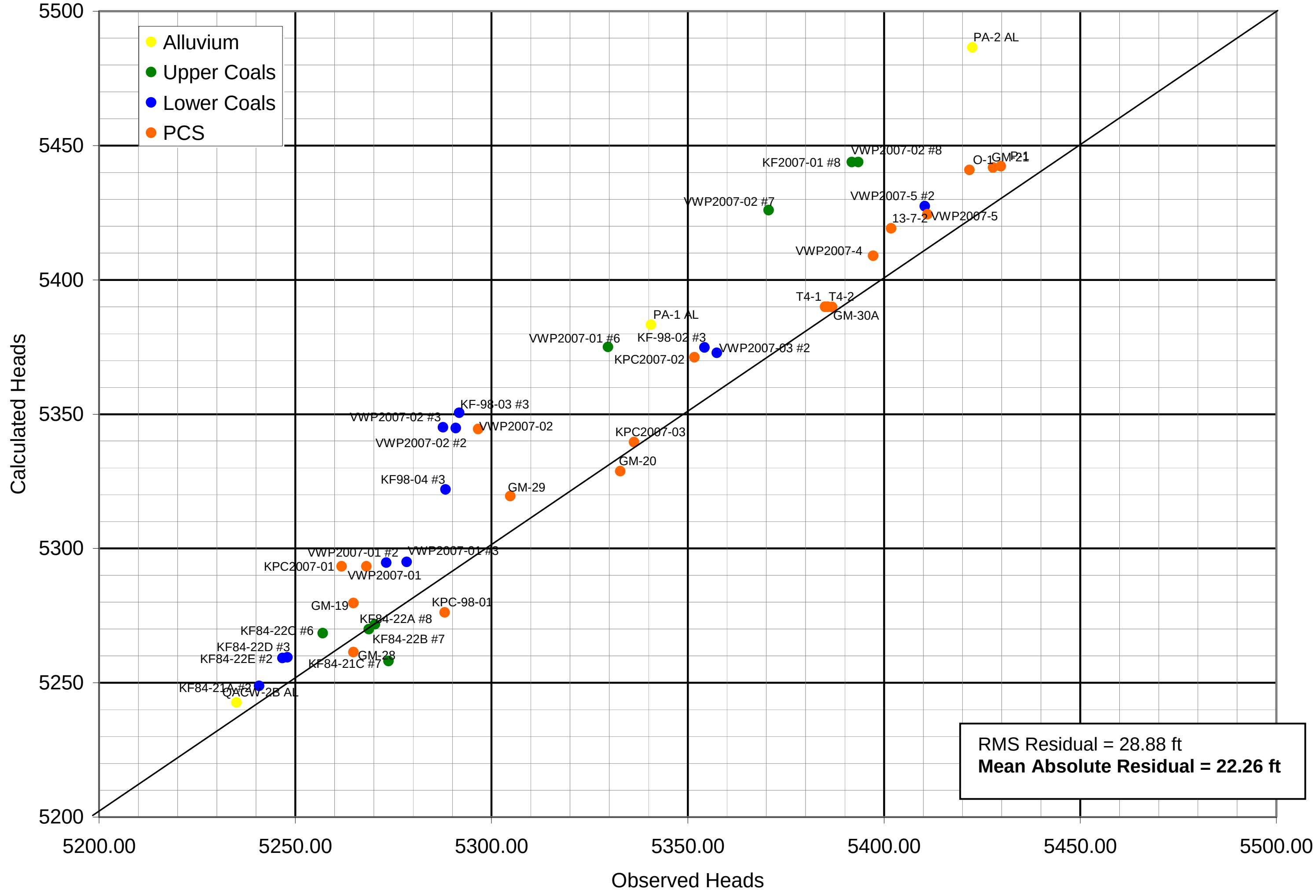


Figure 4-15. Sensitivity Analysis - Calculated vs. Observed Heads - K_{al}=62 ft/d

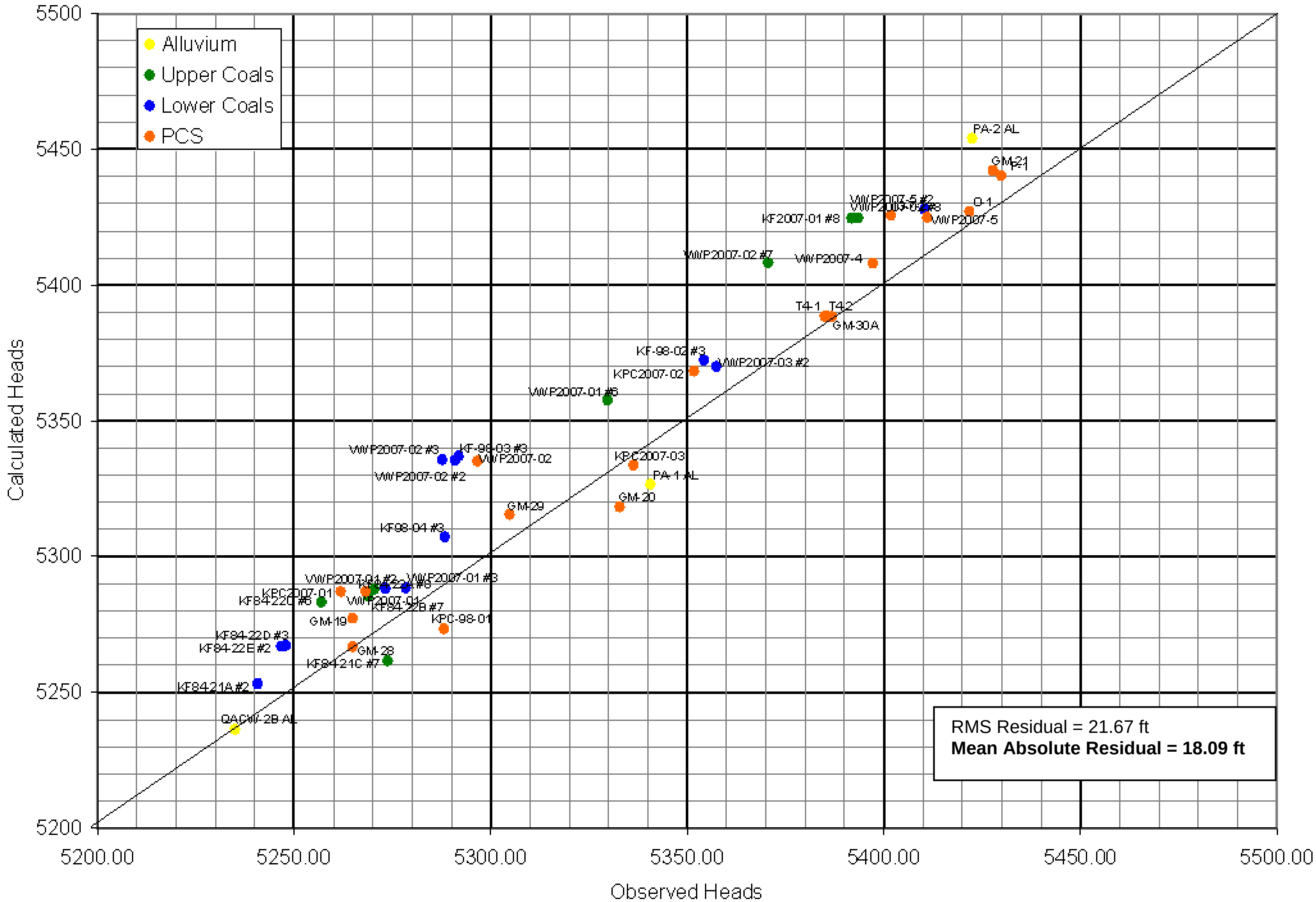


Figure 4-16. Sensitivity Analysis - Calculated vs. Observed Heads - K_{al}=187 ft/d

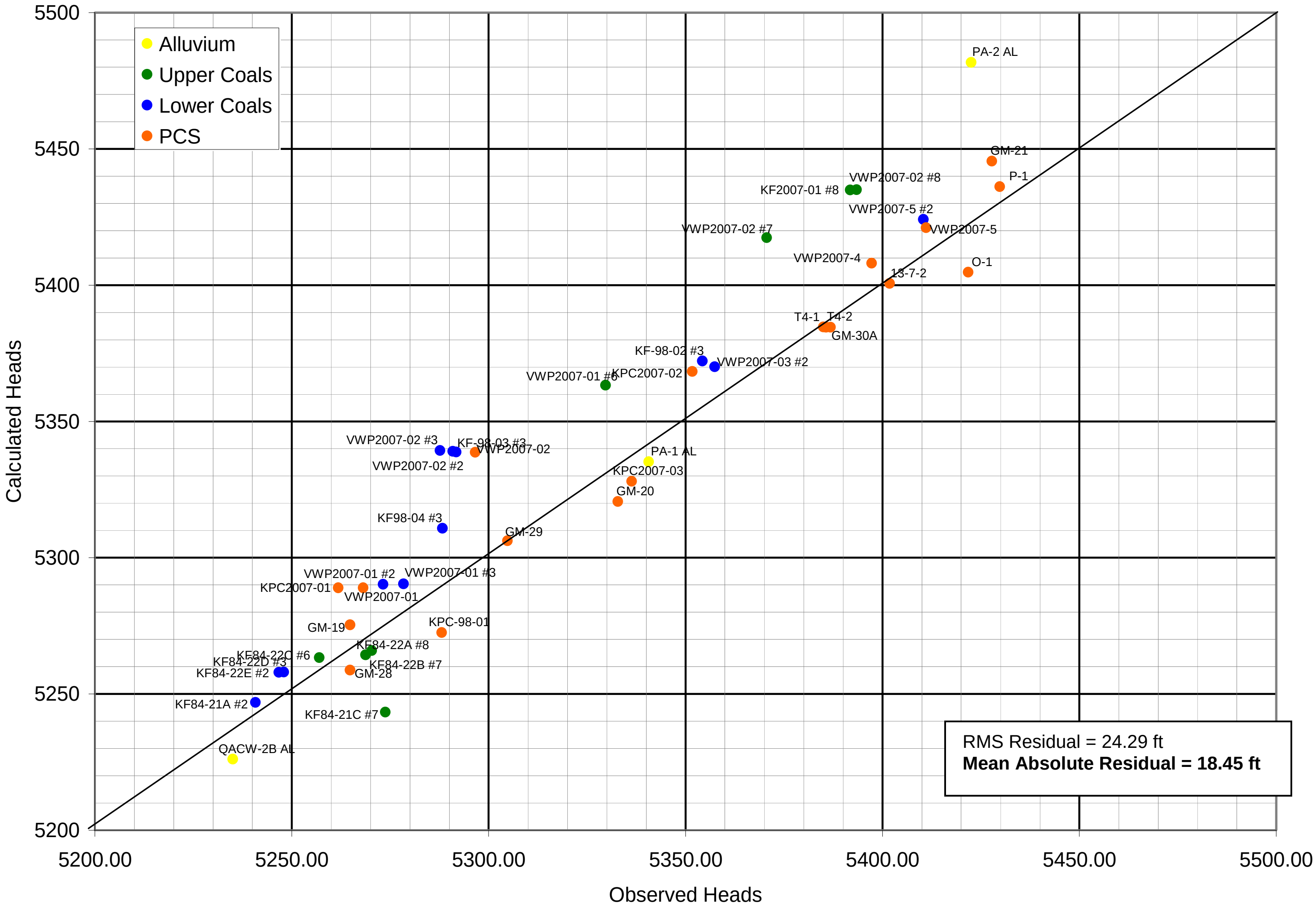


Figure 4-17. Sensitivity Analysis - Calculated vs. Observed Heads - Leakage Coefficient = 1/2 Calibrated Value

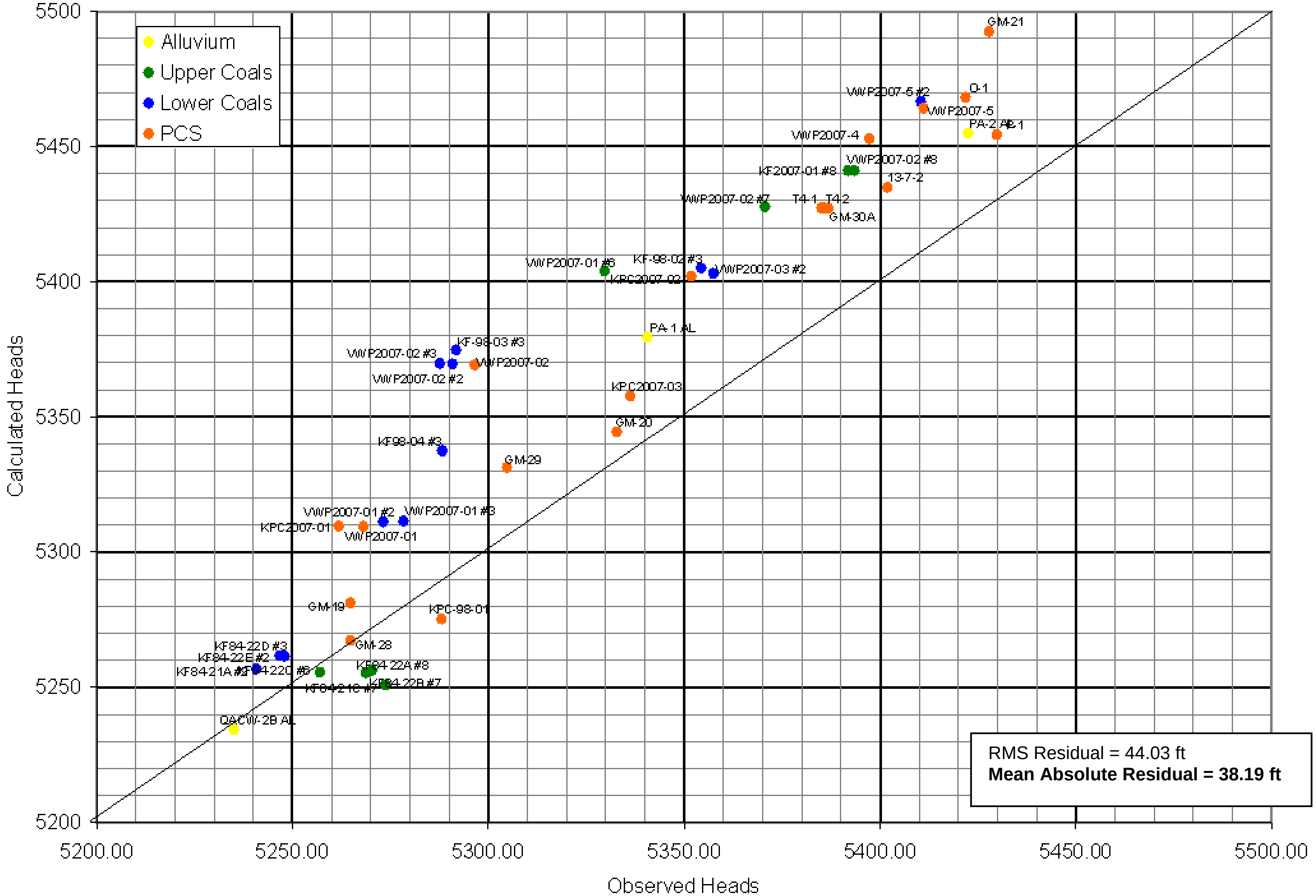


Figure 4-18. Sensitivity Analysis - Calculated vs. Observed Heads - Leakage Coefficient = 2x Calibrated Value

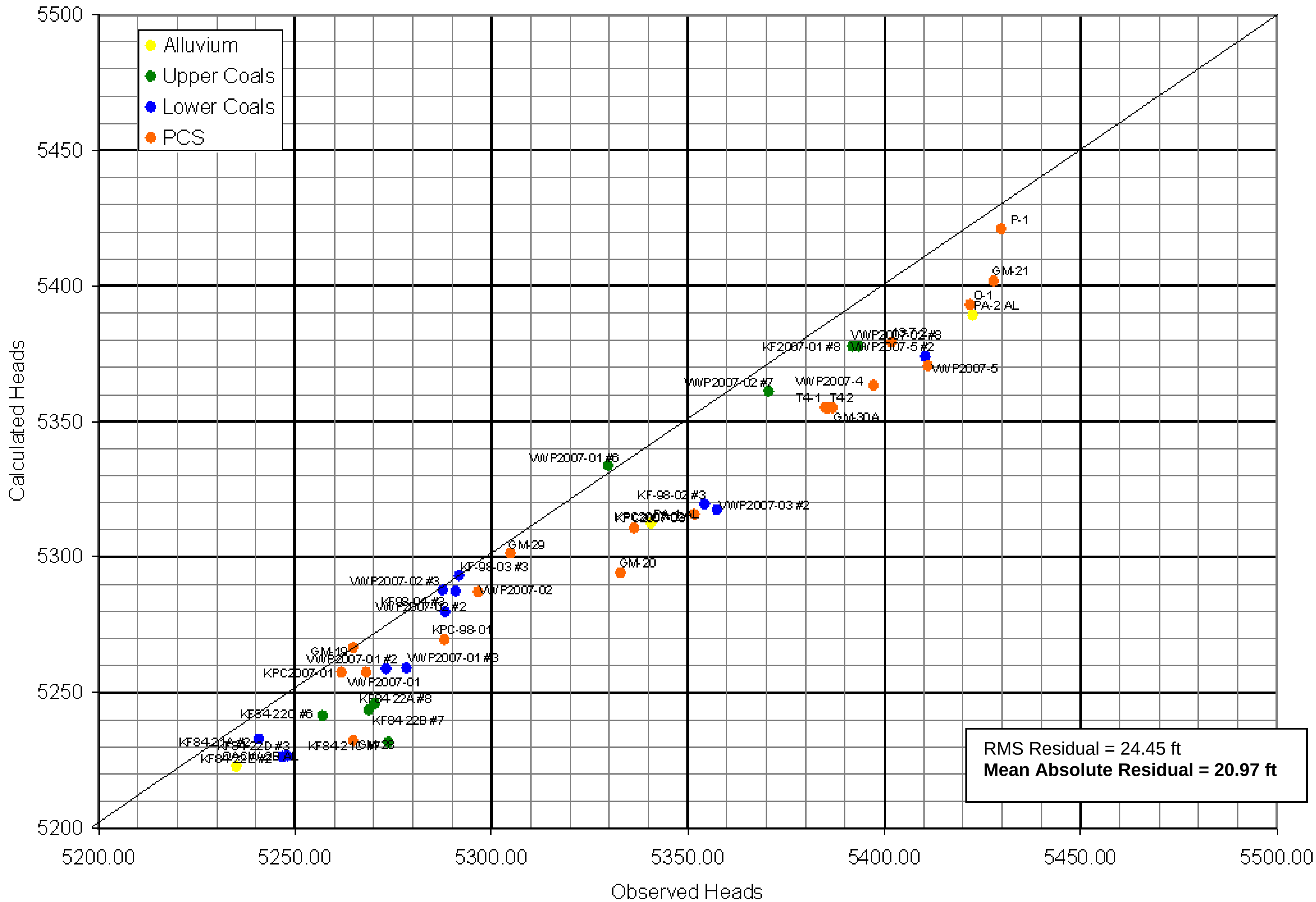


Figure 4-19. Sensitivity Analysis - Calculated vs. Observed Heads - Leakage Coefficient=3x10^{-4}/d

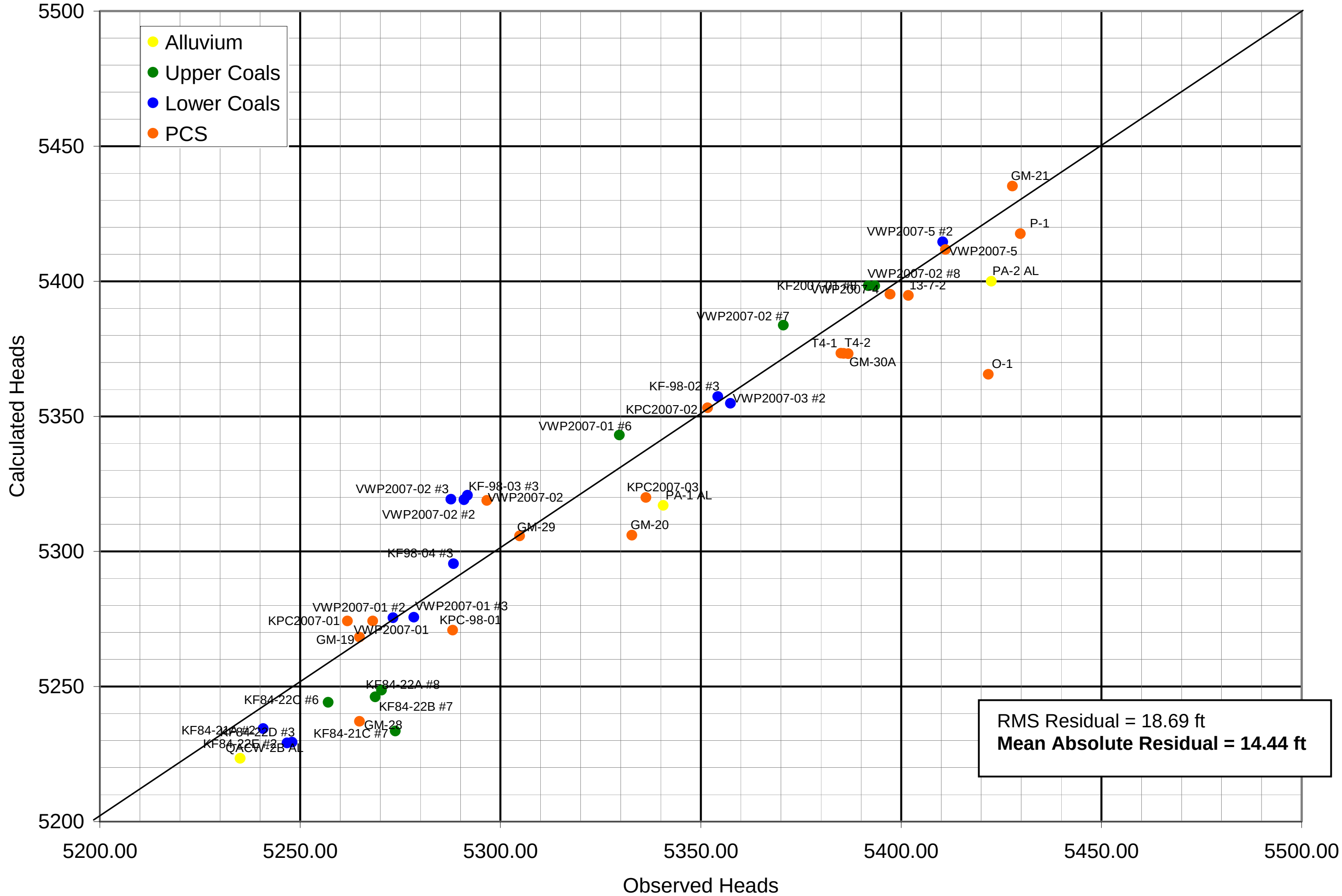


Figure 4-20. Sensitivity Analysis - Calculated vs. Observed Heads - Recharge = 0.8 x Calibrated Value

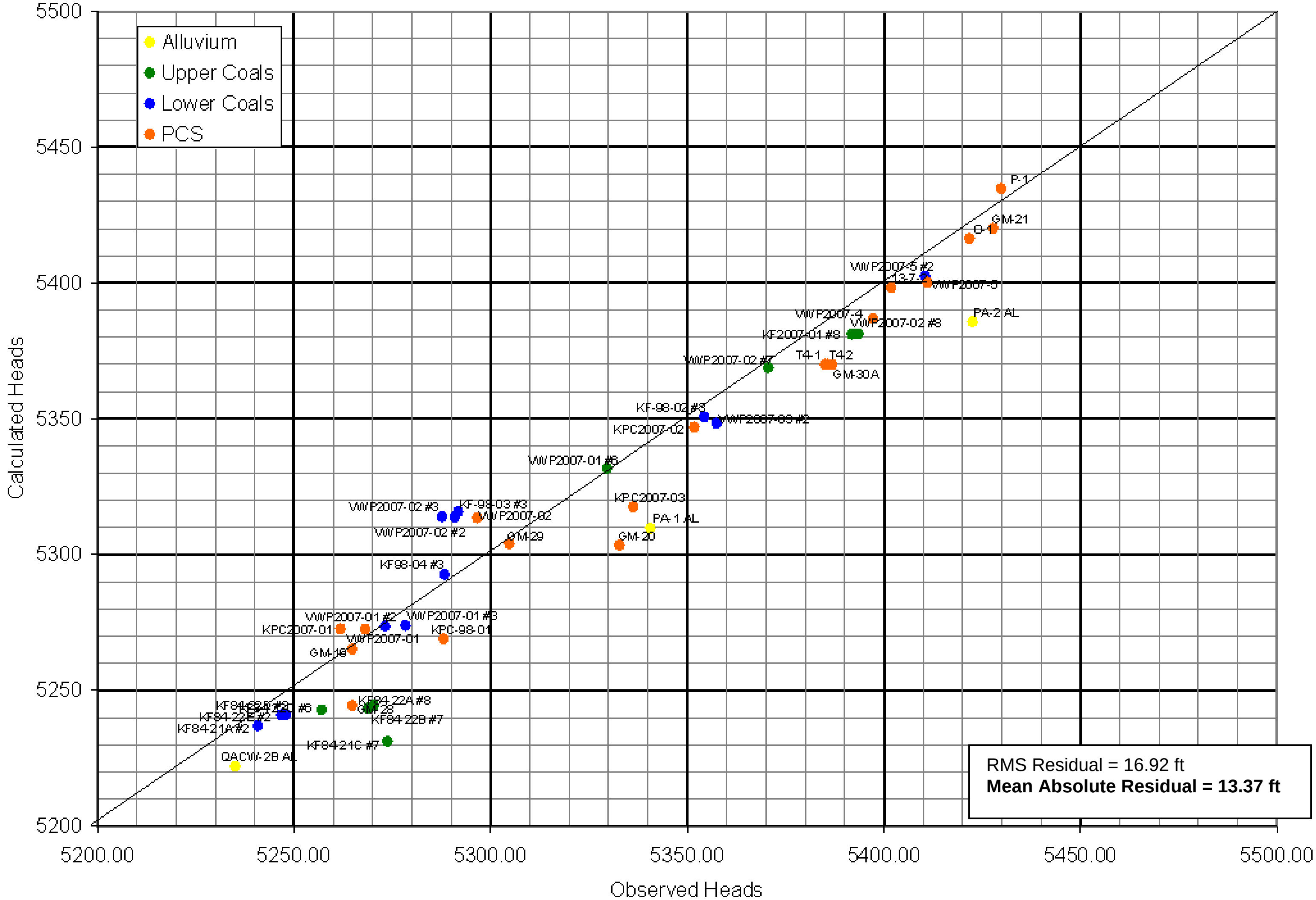


Figure 4-21. Sensitivity Analysis - Calculated vs. Observed Heads - Recharge = 1.2 x Calibrated Value

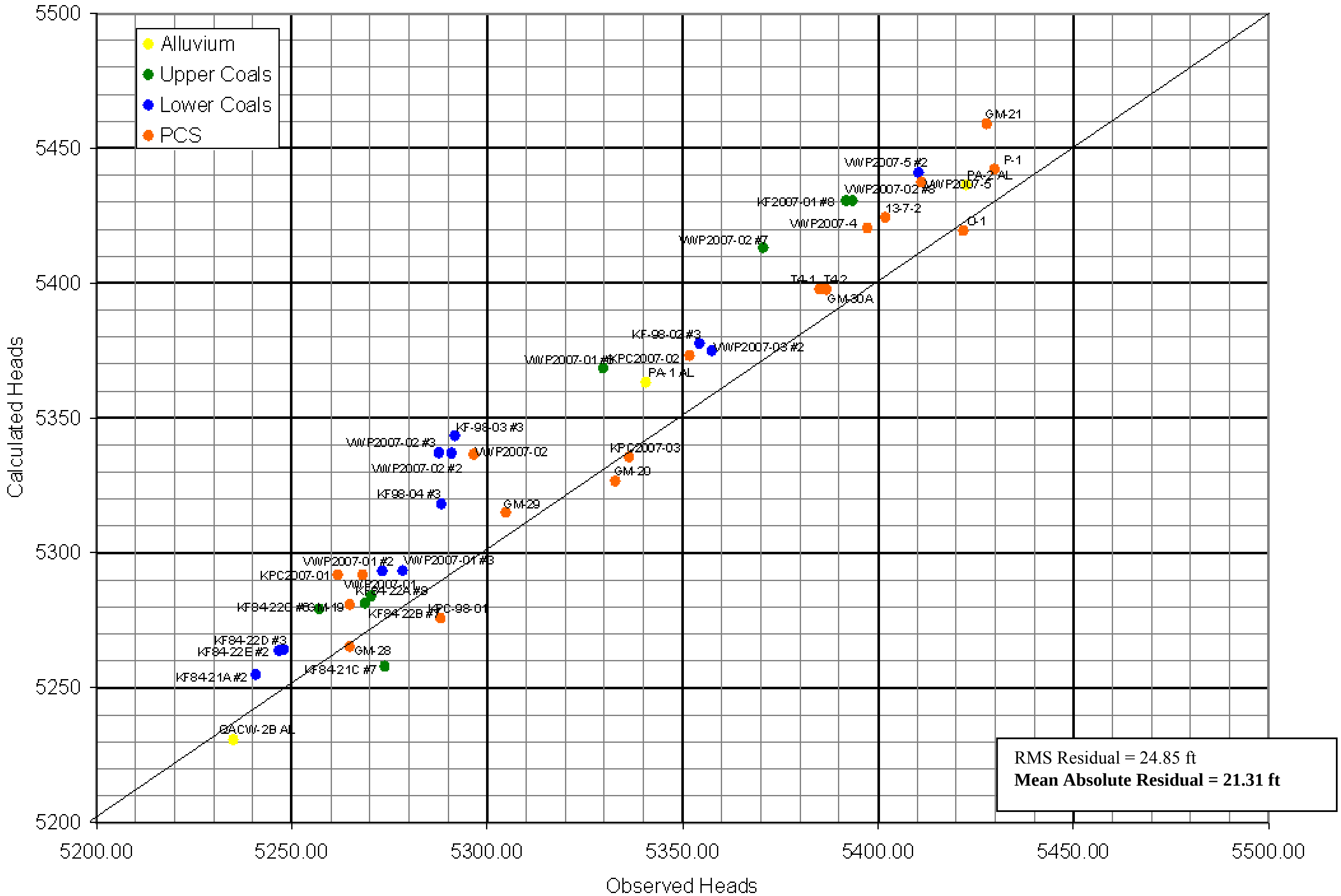


Figure 4-22. Drawdown and Recovery-Sensitivity Results Default Ss versus Base Ss

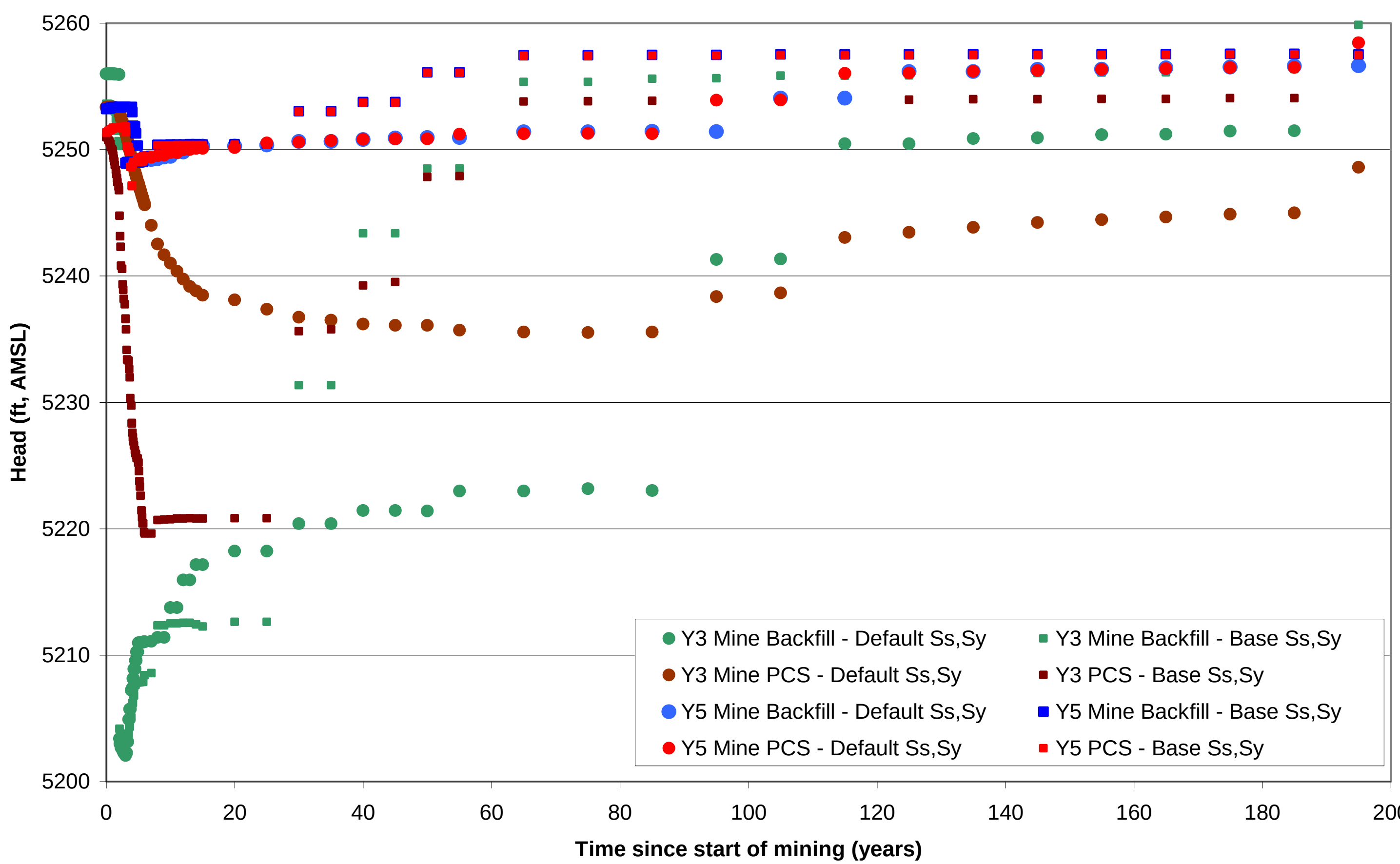
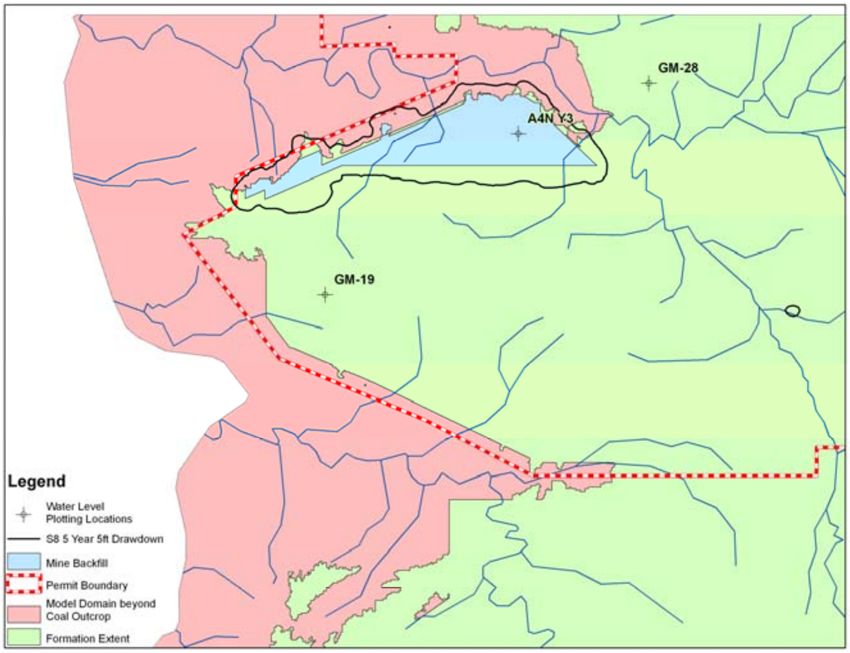


Figure 4-23. Maximum 5-foot Drawdown in No. 8 Coal –Sensitivity Results

Default Ss & Sy



Base Ss & Sy

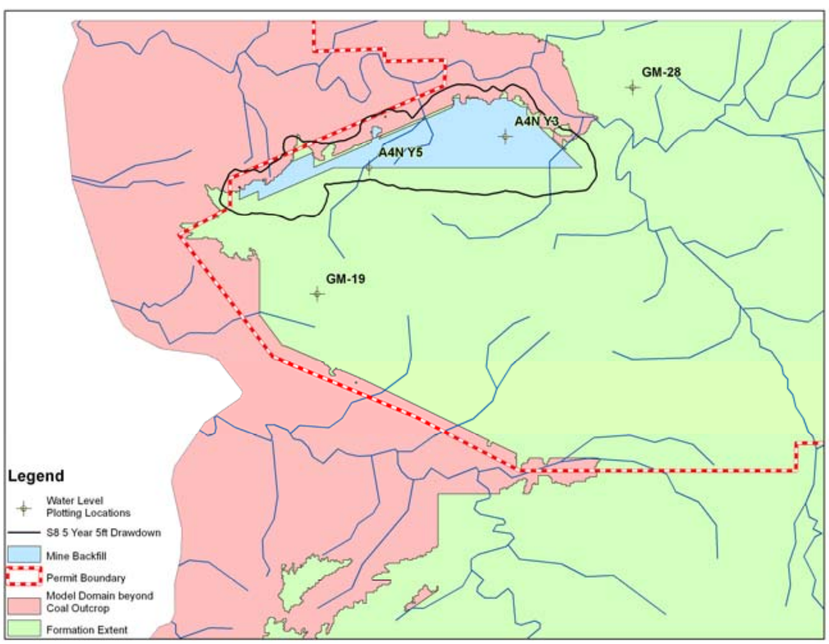
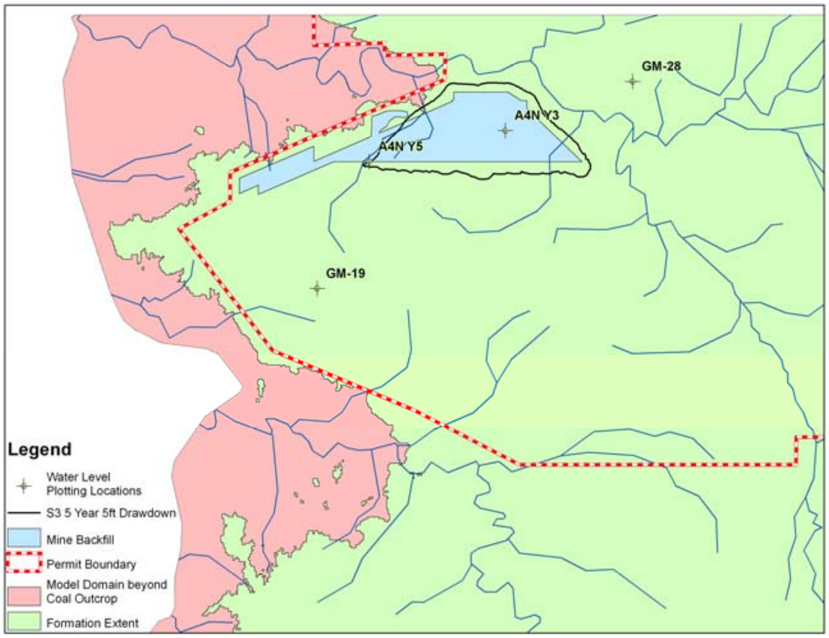


Figure 4-24. Maximum 5-foot Drawdown in No. 3 Coal –Sensitivity Results

Default Ss



Base Ss

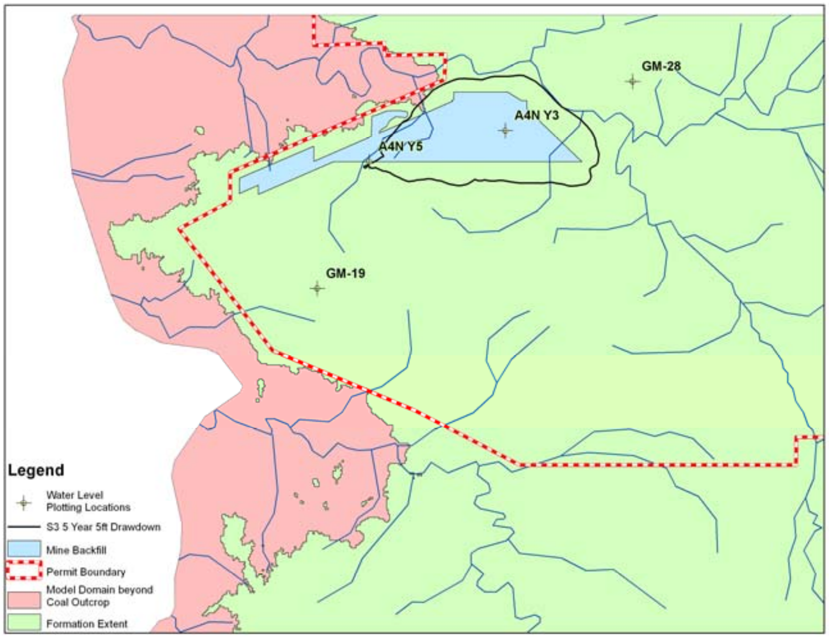
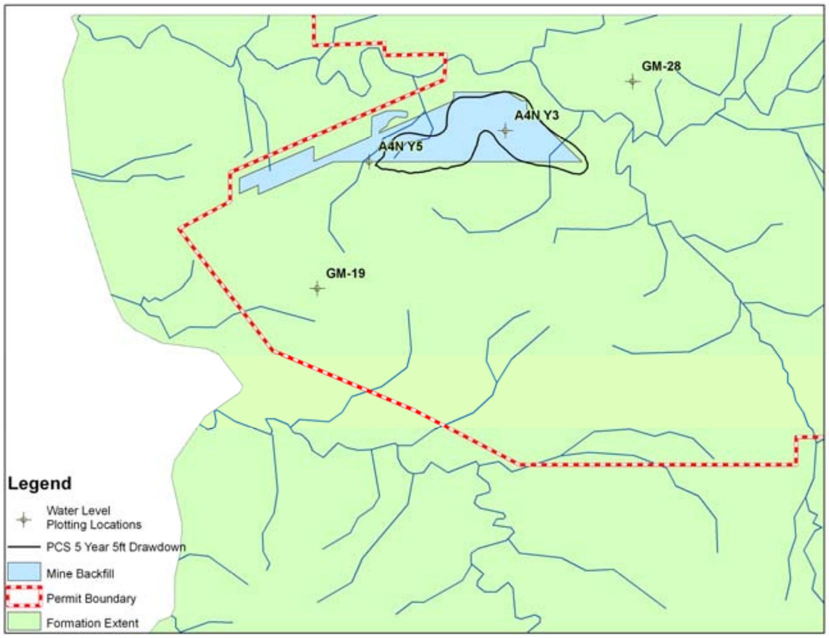
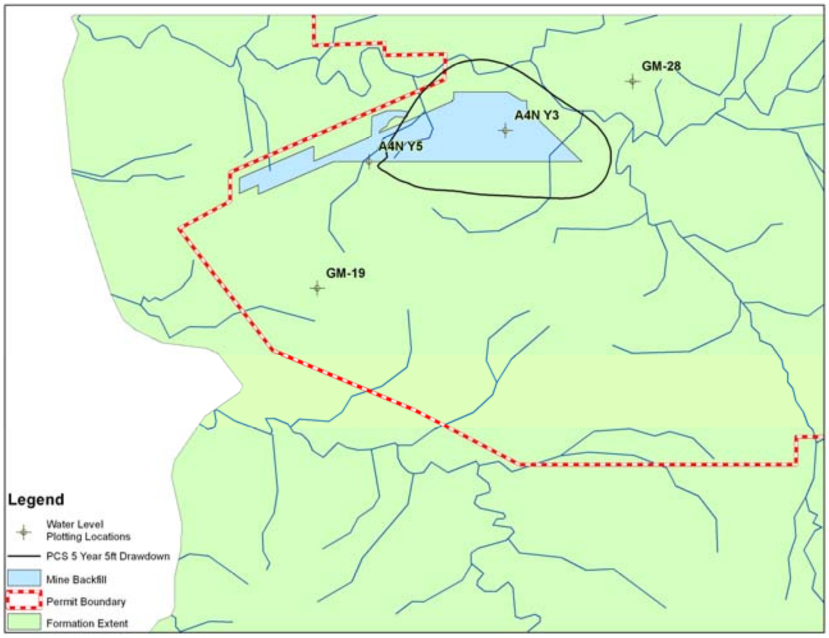


Figure 4-25. Maximum 5-foot Drawdown in PCS –Sensitivity Results

Default Ss



Base Ss



ATTACHMENT 1

HYDRAULIC CONDUCTIVITY AND STORAGE CHARACTERISTICS OF MODELED HYDROGEOLOGIC UNITS

Pinabete and Cottonwood Alluvium

The estimated range in hydraulic conductivities for the alluvial fill deposits within the valley bottoms of Cottonwood and Pinabete Arroyos within the model domain were obtained from constant rate pumping tests performed on wells PA-1 and PA-2 completed in Pinabete Alluvium within Area IV South on May 16, 1998. The test results are summarized in Table 6.G-4 in Appendix 6.G of the Navajo Mine permit application package (BNCC, 2011). These results indicate a hydraulic conductivity of 51.3 ft/day (1.8 x10-2 cm/sec) for well PA-1 and a hydraulic conductivity of 11.5 ft/day (4.1 x10-3 cm/sec) for well PA-2. Tests were not conducted on wells in Cottonwood Arroyo because wells were dry or had limited saturation insufficient for aquifer testing. However, the hydraulic conductivities for the Cottonwood Alluvium should be similar to that alluvial deposits along Pinabete Arroyo because the alluvial materials in the two arroyos are similar, ranging from fine-grained wind blown sand to coarse-grained sands and gravels.

Kernodele (1996) notes that the specific yield for the alluvium in the San Juan Basin would be in the range from 0.1 to 0.25 and that tests for specific storage have been performed because the alluvium is unconfined. The FEFLOW default specific yield of 0.2 is within the range indicated by Kernodele and has been used to represent the alluvium in the transient simulations. Physically, specific storage is a measure of the compressibility of the aquifer matrix and the expansion of water. In unconfined aquifers, changes in storage are controlled by the specific yield and not by the compressibility of the matrix or the water in storage.

Pictured Cliffs Sandstone

The hydraulic conductivities for the Pictured Cliffs Sandstone (PCS) from aquifer tests performed within the model domain are summarized in Table 6.G-11 in Appendix 6.G of the Navajo Mine permit application package (BNCC, 2011). Well KPC-98-01 was installed in 1998 near the PCS outcrop at the location west of Navajo Mine lease Area IV South. In 2007, wells KPC2007-01, KPC2007-02, and KPC2007-03 were completed in the PCS at locations around the perimeter of Area IV South. Water yields from these monitoring wells completed in the PCS at the Navajo Mine lease are quite low. Two of the PCS wells were quickly pumped or bailed dry during conventional sampling. The yield from one of the PCS wells was sufficient to sustain a rate of about 0.4 gallons per minute (gpm) during a constant rate pumping test. The fourth PCS monitoring well was pumped dry after about 140 minutes during a constant-rate pumping test at a rate of about 1 gpm.

An aquifer test was conducted by Science Application Inc. (1979) at well T4-1 installed in the PCS near the western side of the Navajo Mine Area V lease. The drawdown and recovery measurements were recorded at the pumped well, at observation well GM30A located 55.8 ft from the pumping well, and at observation well T4-2 located 12.5 ft from the pumping well. The top of the PCS is approximately 146 ft blow ground surface at the test location while the static water level was at a depth of 134 ft, demonstrating confined conditions at the test location. The results of this aquifer test are summarized in the attached table, along with the results of tests performed at the PCS monitoring wells installed within or adjacent to Area IV South.

The hydraulic conductivity from the recovery response at well GM-30A from the pumping test at the PCS well T4-1 was 0.0016 ft/day (5.6 x 10^{-7} cm/sec). The storage coefficient determined from the observation well response at GM-30A was 3.4 x 10^{-4}. A specific storage of 3.9 x 10^{-6} per foot is estimated based on the estimated PCS aquifer thickness of 84 feet at the test well location. The hydraulic conductivity estimate for the PCS of 0.02 ft/day (7.0 x 10^{-6} cm/sec) was obtained from the test at monitoring well KPC-98-01, located west of the Navajo Mine Area IV South coal lease. The PCS is unconfined at this location. The results for this well are consistent with the aquifer test results of 0.032 ft/day (1.1 x 10^{-5} cm/sec) from a slug test at Well O-1 completed in the PCS at the Burnham Mine but higher than the range from 0.0 to 0.0001 ft/day (2.6 x 10^{-6} to 3.5 10^{-8} cm/sec) obtained from the slug tests at the three other PCS monitoring wells at the Navajo Mine as summarized in the attached.

Pumping test results for the PCS monitoring well O-1 in the PAP for the Burnham Mine are on file in the library of the OSM in Denver. In this well test, pumping at a relatively high rate of 18.3 gpm could be sustained for only 8.7 minutes when most of the well-bore storage water was removed and the test had to be terminated. Although the results were interpreted in the Burnham Mine PAP as a pumping test, this approach is not correct due to the predominant influence of well-bore storage. Consequently, the well test results have been reinterpreted as a slug test in the attached table. Slug test results indicate a hydraulic conductivity of 0.032 ft/day (1.1 x 10^{-5} cm/sec).

There is no information in the literature concerning the specific yield for the PCS and little information concerning specific yield of sandstone aquifers. The specific yield is the storage parameter that applies only to the unconfined portion of the aquifer. Normally this is where the aquifer is shallow and often weathered. Johnson (1967) provides specific yield values ranging from about 0.1 to 0.3 for fine sands and sands. The New Mexico State Engineer (2010) provides specific yield estimates of 0.14 and 0.25 for well tests in the Mesa Verde Group. The Mesa Verde Group is comprised of inter bedded sedimentary deposits of sandstones, siltstones, shales and coals not unlike the Fruitland Formation and the PCS. Consequently, the FEFLOW default specific yield of 0.2 is within the range indicated by the Mesa Verde tests and has been used to represent both the PCS and the interburden and overburden sedimentary layers in the Fruitland Formation.

Summary of Pictured Cliffs Sandstone Aquifer Test Results

Well	Well Depth (ft)	Test type	Transmissivity (ft^2/day)	Hydraulic conductivity (ft/day)	Hydraulic conductivity (cm/sec)	Saturated thickness (ft)	Storage coefficient
KPC-98-01	125.7	0.4 gpm pumping test	0.79	0.020	7.1E-06	39	NA
KPC2007-01	208.84	0.95 gpm, Theis analysis	0.576	0.0074	2.6E-06	78	NA
KPC2007-03	138.4	Bower and Rice	0.04	0.004	1.4E-06	10	NA
		Horslev slug test	0.9	0.09	3.2E-05	10	NA
Pumping test well T4-1	228	0.15 gpm pumping	0.1203	0.0014	4.9E-07	84	0.00032
Recovery test well GM-30A	191.6	Theis recovery	0.1337	0.0016	5.6E-07	84	0.00034
O-1[1]	414	Cooper slug test	2.7300	0.0321	1.1E-05	85	NA
		Horslev slug test	3.7500	0.0441	1.6E-05	85	NA

[1] Burnham Mine well pumped dry in 8.7 minutes at 18.3 gpm. Re-interpreted as a slug test

Fruitland Coals

The hydraulic conductivities for the Fruitland Formation coal zones have been obtained from aquifer tests performed within the model domain as summarized in Table 6.G-8 in Appendix 6.G of the Navajo Mine permit application package (BNCC, 2011) and from tests performed at Fruitland coal wells at Navajo Mine as summarized in Table 6-1 in the Navajo Mine permit application package (BNCC, 2011). The results of these aquifer tests are summarized in the attached table, including a description of the relevant coal unit tested. The upper coal units, #8 and #7 have higher hydraulic conductivities than the lower coal units. Test information is sufficient to establish a range for the hydraulic conductivities for the No. 8 coal, the No. 7 coal, and the No. 3 coal. Only one test result was found for the No. 6 coal, the No. 4 coal, and the No. 2 coal. These tests were within the range found for the No. 3 coal. Thus the range of hydraulic conductivity for the No. 3 coal is also used for all the lower coal seams. All of these tests were single well tests, which do not provide estimates of confined storage coefficients for the coals.

A storage coefficient estimate of 4.2 x 10^{-4} was reported in the Western Coal Company (1979) permit application for the San Juan Underground Mine Project. The thickness of the coal zone tested and the specific storage were not listed. However, the thickness of No. 8 coal unit at San Juan Mine averages about 15 feet, resulting in an approximate specific storage value of 2.8 x 10^{-5} per foot. A storage coefficient estimate of 1 x 10^{-5} was also obtained by Neimczyk and Walters (1980) using a single well step-test of Fruitland coal well GT-2 located east of the San Juan Mine. Based on an estimated 14.3 feet of coal in the test well, the specific storage of the coal is approximately of 3.9 x 10^{-6} per foot. The specific storage estimates determined from these tests for the Fruitland No. 8 coal are within the range of 1 x 10^{-3} to 3 x 10^{-7} per foot determined from fourteen pump tests of coal referenced by Rehm et al (1980). The average specific storage from these fourteen tests was 3 x 10^{-5} per foot, which is almost the same as the estimate for the No. 8 coal reported for the San Juan Underground Mine Project.

A lower specific yield of 0.5 % is used for the coals due to the low effective porosity of the coals. This specific yield value is consistent with the median value of 0.4% for coal was found in a comprehensive review of aquifer characteristics from pumping tests conducted in support of plans for coal mining and reclamation in the Powder River Basin (Applied Hydrology Associates and Greystone Environmental Consultants (2002).

Fruitland Overburden and Interburden

Laboratory tests of two samples of unconsolidated overburden material at the Navajo Mine found hydraulic conductivity values of 1.43 x 10^{-3} ft/day (5 x 10^{-7} cm/sec) and 9.64 x 10^{-4} ft/day (3.4 x 10^{-7} cm/sec). Frenzel and Lyford (1982) utilized literature estimates based on descriptions of the geology to estimate the horizontal hydraulic conductivity values for confining beds ranging from 8.64 x 10^{-3} ft/day to 8.64 x 10^{-4} ft/day. Vertical hydraulic conductivity values for the confining beds were estimated from model calibration and ranged from 5 x 10^{-6} ft/day to 8.64 x 10^{-8} ft/day and were generally 10^{-4} times lower than the horizontal hydraulic conductivities. Model calibration was very sensitive to the ratio.

Summary of Aquifer Test Results For Fruitland Coals

Well	Coal seam	Elevation (ft)	Well depth (ft)	Test type	Transmissivity (ft^2/day)	Hydraulic conductivity (ft/day)	Hydraulic conductivity (cm/sec)	Saturated thickness
Kf-98-02	#3	5505.89	216.5	Displacement Test	0.0010	0.0001	4.6E-08	7.5
Kf-98-03	#3	5423.45	133.9	Bailed Recovery Test	0.010	0.002	7.1E-07	5
Kf-98-04	#3	5351.80	64.8	Bailed Recovery Test	0.010	0.001	3.5E-07	10
Kf84-22D	#3	5124.20	220	MCWhorter Recovery	0.01	0.002	7.1E-07	5.0
Kpc2007-01	#8	5352.97	118	Papadopulos-Cooper Pumping Test	1.398	0.056	2.0E-05	25
SJKF84#3	#8	4990.18	120	MCWhorter Recovery	0.71	0.04	1.4E-05	18.0
SJKF84#4	#8	5046.67	71	MCWhorter Recovery	1.03	0.06	2.1E-05	18.0
SJKF84#5	#8	5092.00	180	MCWhorter Recovery	0.07	0.004	1.4E-06	18.0
KF84-20(d)	#7	5213.92	190	MCWhorter Recovery	0.01	0.002	7.1E-07	5.0
Kf84-21C	#7	5219.66	75	MCWhorter Recovery	0.04	0.008	2.8E-06	5.0
Kf84-22B	#7	5204.10	140	MCWhorter Recovery	0.02	0.003	1.1E-06	5.0
Kf84-22C	#4-6	5142.50	202	MCWhorter Recovery	0.01	0.0014	4.9E-07	7.0
Kf84-20A	#2	5163.78	240	MCWhorter Recovery	0.009	0.001	3.5E-07	10.0
Kf84-22E	#2	5107.80	237	MCWhorter Recovery	0.01	0.001	3.5E-07	10.0

Most estimates of vertical hydraulic conductivities of confining units, such as the Fruitland Formation interburden, are obtained indirectly by model calibration. Kaiser et al (1994) performed regional hydrogeologic modeling of the Fruitland Formation and overlying and underlying formations. They found that large ratios of horizontal to vertical hydraulic conductivity (kh/kv) on the order of (1000/1) were required to simulate observed heads. The New Mexico Office of the State Engineer Aquifer Test Index provides an estimate of the vertical hydraulic conductivity of 1 x 10^{-5} ft/day for a confining zone in the Brushy Basin Shale member of the Morrison Formation based on a long-term pumping test at well 16u162 located in the San Juan Basin in T27N, R13W, Sec 16 about 13 miles east of the Navajo Mine.

Mine Spoils

Based upon laboratory determinations in Appendix 11-K of the Navajo Mine permit application package (BNCC, 2011), the hydraulic conductivity or permeability of the backfilled spoil will be on the order of 1.13 x 10^{-2} ft/day (4 x 10^{-6} cm/sec). Laboratory tests are thought to provide a lower bound estimate of hydraulic conductivity of mine spoils. Saturated spoils are not found in the Navajo Mine permit area that could be assessed with a well test. However, some of the mine spoil in the pre-law Bitsui Pit is saturated. Well tests have not been performed on these saturated spoils but future testing plans are being considered. In the mean time, the geometric mean of mine spoils of 2.268 x 10^{-1} ft/day (8 x 10^{-5} cm/sec) obtained from tests on mine spoils at a number of mines in the Northern Great Plains (Rehm et al, 1980) provides information on the expected hydraulic properties of mine spoil. Laboratory tests of mine spoils in Appendix 11-K also indicate that mine spoils will have a porosity of about 40%.

A hydraulic conductivity value of 5.63 x 10^{-2} ft/day has been used in the post-reclamation model for the mine spoils in the backfill below 10 ft of the final reclaimed surface at Area IV North. This estimate of hydraulic conductivity for mine spoils was between the average of 1.13 x 10^{-2} ft/day estimated from laboratory tests on five mine spoil samples from the Navajo Mine (Physical Testing Laboratory Data provided in Appendix 11-K) and the estimate of 2.27 x 10^{-1} ft/day obtained by Rehm et al. (1980) from the geometric mean of 40 hydraulic conductivity values measured for mine spoils in the Northern Great Plains. A hydraulic conductivity value of 5.63 x 10^{-1} ft/day has been used to represent the model layer for the upper 10 ft within the mine backfill, which will be comprised of weathered spoil and topdressing material.