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November 5, 2007

Mr. John Tinger
United States Environmental Protection Agency
Region IX (WTR-5)
75 Hawthorne Street
San Francisco, California 94105

Re: National Pollutant Discharge Elimination System (NPDES) Permit NN0028193 – BHP Navajo Coal Company – Navajo Mine

Dear Mr. Tinger:

BHP Navajo Coal Company ("BNCC") appreciates this opportunity to submit this response to the March 2, 2007 letter of comments submitted by the San Juan Citizens Alliance, Dinè Citizens Against Ruining our Environment, and the Clean Air Task Force (collectively the "Citizens Alliance"). This letter begins with an introduction and summary of BNCC's responses to the Citizens Alliance's comments (Part I). The letter then provides more detailed responses to individual comments (Part II).

There are three attachments to this letter. Attachment 1 is a technical report, prepared by Norwest Applied Hydrology -- "Technical Review of a Report Prepared by D.A. Zimmerman (2005) Entitled: ***A Preliminary Evaluation of Potential For Surface Water Quality Impacts From Fly Ash Disposal at the Navajo Mine, New Mexico*"** (the "Norwest Report"). The Norwest Report was prepared at the request of BNCC to review and respond to the May 23, 2005 report prepared by D.A. Zimmerman and used in the Citizens Alliance letter of comments. ("Zimmerman Report"). Attachment 2 is the Supplemental Groundwater Monitoring Study ("SGS") of BNCC, which is on file with OSM as Appendix 11-MM of BNCC's Permit Application Package. Attachment 3 is the Probable Hydrologic Consequences ("PHC") study of BNCC that accompanied BNCC's Permit Application Package to OSM. Chapter 11.6. This letter and all its attachments are for inclusion in the administrative record.

I. INTRODUCTION AND SUMMARY OF RESPONSES

BNCC's NPDES Permit No. NN0028193 ("NPDES Permit") should be renewed as proposed by EPA in its Notice of Proposed Action. EPA first issued an NPDES permit for Navajo Mine in 1977. The terms of the proposed renewal of the NPDES Permit are quite similar to the terms of the NPDES permit that it renews and the terms of the NPDES permits that came before it.[1] The NPDES permit concerns rarely used outfalls for surface drainage at Navajo Mine.

The Citizens Alliance letter of comment focuses on coal combustion wastes ("CCBs). CCBs have been placed subsurface in mine pit backfills at Navajo Mine since 1971 and regulated under regulatory regimes other than the Clean Water Act. The Clean Water Act's NPDES permitting requirements never applied to the CCBs because surface drainage does not mingle with the CCBs buried subsurface at Navajo Mine. The buried CCBs are outside of any jurisdictional water, and do not result in discharge of a pollutant from the CCBs to any jurisdictional water. No significant change in these circumstances has occurred since the last issuance of the NPDES Permit, and the Citizens Alliance's effort now to alter and greatly expand the scope of the proposed NPDES Permit renewal terms in order to address its recent concerns about CCBs buried subsurface at Navajo Mine is without basis and should be rejected.

The Citizens Alliance's request that the NPDES Permit be expanded to regulate various aspects of subsurface disposal of CCBs seems to be based largely, on the Zimmerman Report, which was prepared in 2005. The Zimmerman Report was funded by environmental groups to respond to information presented by BNCC and the Office of Surface Mining ("OSM") at a National Academy of Sciences meeting in December 2004 concerning coal combustion residue.[2] The Zimmerman Report was conducted with an incomplete data set, and it provides inadequate basis for the conclusions it reaches and for the effluent limits and permit conditions the Citizens Alliance seek. Summarized below are several primary points in response to the letter of comments and Zimmerman Report. More detail is presented in Part 2 of this letter.

Contrary to inferences drawn by the Zimmerman Report, existence of higher constituent concentrations downstream from the mine than upstream should not be attributed to disposal of CCBs at the mine. The Citizens Alliance uses that report to infer that because data from Chaco River show higher concentrations of certain constituents downstream of the mine than upstream, the difference

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[1] The proposed permit renewal incorporates recent regulatory changes that are not central to the Citizens Alliance position, but otherwise it does not change the previous permit significantly.

[2] Although the Zimmerman Report states in its introduction that it "was undertaken to support" a National Research Council ("NRC") study, and its cover prominently references the National Academy of Sciences ("NAS"), the report was not commissioned or adopted by either NRC or NAS. In fact the comprehensive 2006 report of the National Research Council, Managing Coal Combustion Residues in Mines, observed that environmental impacts described by the Zimmerman Report and others "have not withstood the scrutiny of review by the scientific and/or regulatory communities" and therefore "are not explicitly discussed in this report." p. 82

should be attributed to an unidentified and unproven discharge from Navajo Mine. The attached Norwest Report demonstrates that EPA should reject that blanket assumption because the upstream and downstream data used by Citizens Alliance is incomplete and does not support their assumption. Moreover, the Norwest Report concludes that the difference in concentrations is due to natural factors.

There is no discharge from CCBs at Navajo Mine to any jurisdictional water. First, BNCC does not place CCBs in jurisdictional waters; they are placed in dry subsurface pits outside of jurisdictional waters. Second, because CCBs are buried in subsurface pits, no surface runoff from CCBs has or could reach jurisdictional waters. Third, even if pollutants in ground water with a connection to jurisdictional waters were in some circumstances regulated by the Clean Water Act, the Navajo Mine does not present such circumstances. The Citizens Alliance fails to demonstrate contamination of ground water acquifers resulting from placement of CCBs in mine pits at Navajo Mine or any hydrologic connection between CCB placement locations and any surface waters, including Bitsui Wash, Chinde Wash, or the Chaco River. To the contrary, data in the Norwest Report indicates the absence of any contamination or such hydrologic connection.

II. RESPONSES TO CITIZENS ALLIANCE COMMENTS

A. BNCC's Subsurface Placement of CCBs Has Not Caused An Increase in TDS, Sulfate, Boron or Selenium in the Chaco River or Bitsui Wash

Both the Zimmerman Report and the Citizens Alliance letter attempt to link increased levels of sulfates in water collected at downstream monitoring stations to disposal of CCBs at the Navajo Mine. The Norwest Report establishes that those efforts ignore several physical realities.

1. Leachates from CCBs have low concentrations of soluble sulfates relative to sulfates in alluvial ground water and ground water in mine backfill, and therefore an increase in sulfate concentrations is not an indicator of contamination by CCBs.

2. Sulfate levels in the region commonly increase as water moves through watersheds of arid and semi-arid lands due to the dissolution of naturally occurring sulfate-bearing minerals, such as gypsum. Thus, surface water in the Chaco Basin will typically demonstrate increased levels of sulfate in the lower reaches of the watershed. Evaporation also contributes to increased sulfate concentrations in the lower reaches.

3. CCBs are buried in subsurface pits, surrounded by overburden and not exposed to surface runoff.

Below, these circumstances are discussed in greater detail.

1. Chaco River: The Citizens Alliance's claim that "historic reporting" indicates that concentrations of TDS, sulfate, boron and selenium are increasing to a statistically significant degree in the Chaco River from points upstream of the Navajo Mine to points downstream of the mine is not supportable. The Citizens Alliance relies upon a discussion in the Zimmerman Report to suggest that such downstream increases in concentrations are the result of CCBs disposal at the mine. That link between constituent concentrations and disposal of CCBs at the mine is erroneous for several reasons.

First, the Zimmerman Report seems to confuse the burying of CCBs for mine backfill at the Navajo Mine with the use of surface impoundments by Arizona Public Service for the CCBs from Four Corners Power Plant Units 1 – 3 (e.g., "...fly ash is piled unprotected and left in mountains...," p. 21). The Power Plant is not the subject of this NPDES permit. It and its operators are distinct from Navajo Mine and BNCC. BNCC does not place CCBs in surface impoundments. Instead, as described in the Norwest Report, BNCC places CCBs in subsurface pits on the mine site. Those pits are located in subsurface strata that dip to the east, away from the Chaco River, at levels well below the alluvium. Norwest Report, p. 35. The CCBs are encased in low permeability overburden and are capped with at least ten (10) feet of low permeability cover material before being covered with topsoil. Moreover, major drainages in the reclaimed areas are not routed over the CCB backfill areas. Thus, the CCB are not exposed to surface water runoff at the Navajo Mine, and it is therefore unnecessary and improper to include in the renewal of Permit No. NN0028193 the monitoring and effluent limitation requirements that the Citizens Alliance requests. Norwest Report, pp. 5, 8-9.

Second, water quality data does not indicate that disposal of CCBs at Navajo Mine is causing concentrations of water quality constituents in washes near Navajo Mine to increase. In preparing its report, Norwest Applied Hydrology ("Norwest") has undertaken a thorough review of the publicly available data available through the OSM Library in Denver, Colorado concerning the hydrology and geology at Navajo Mine.[3] Norwest Report, pp. 7-9. Norwest concludes that there is no cause and effect relationship between disposal of CCBs at Navajo Mine and water quality in the Chaco River based in part on its more comprehensive review of the publicly available data on Navajo Mine in the OSM library and on data contained in the Zimmerman Report. The Norwest Report states:

> No information or data presented in the Zimmerman Report indicates a cause and effect relationship between CCBs disposal operations at the Four Corners Generating Station or the placement of CCBs in mine backfill at the Navajo Mine and the water quality in the Chaco River. In fact, hydrologic information and observations at the Navajo Mine indicate that CCBs in mine backfill at the Navajo Mine has not impacted

[3] Although this public information is available through OSM, the Zimmerman Report neglects to use it. That Report's elaborate explanation (pp. 6-10) about why its data is "insufficient" is not only questionable argument for a scientific report, but it also ignores information at OSM that the report fails to use.

> water quality in the Chaco River. CCBs at the Navajo Mine are placed in mine pits that are excavated in subsurface strata that dip to the east, away from the Chaco River. These mine pits are well below the elevations of the alluvium of any tributaries to the Chaco River that cross the Navajo Mine lease. At the northern portion of the mine, any ground water associated with CCB placement in the Watson, Bitsui, Dodge, Custer and Bighan Pits cannot flow to the west toward the Chaco River because of the ten to twenty-five foot thick shale layer separating the bottom of the pit from the Pictured Cliffs Sandstone (PCS) and the higher ground water levels in the PCS due to the influence of Morgan Lake which preclude such a pathway.

Norwest Report, p. 34.

Norwest concludes that the "statistical analysis of water quality monitoring data provided in the Zimmerman Report does not demonstrate a cause and effect relationship between water quality constituents in the Chaco River and the presence of either the Navajo Mine to the east along the lower segment of the Chaco River or the past disposal of CCBs in surface impoundments at the FCGS." Norwest Report at p. 34. As the Norwest Report explains,

> Furthermore, the statistical analysis of water quality monitoring data provided in the Zimmerman Report does not demonstrate a cause and effect relationship between water quality constituents in the Chaco River and the presence of either the Navajo Mine to the east along the lower segment of the Chaco River or the past disposal of CCBs in surface impoundments at the FCGS. The Zimmerman report includes a statistical analysis of TDS, sulfate, boron, and selenium concentrations of surface water quality monitoring stations located along the Chaco River and a number of its tributaries. The statistical analysis consists of separating the data from the stations into the two groups outlined in Figure 12 of the Zimmerman Report. A copy of that figure has been provided in the report as Figure 13.
>
> As shown on Figure 13 of the report, the downstream stations are primarily locations along the perennial flow segment of the Chaco River and include one station on Chinde Wash that is influenced by NAPI irrigation return flows. The upstream stations consist of locations along the ephemeral flow segment of the Chaco River and locations within tributary segments, many of which are in the headwaters. Given this grouping of stations, it is to be expected that soluble water quality constituents, such as TDS, sulfate, selenium and boron, would be higher at stations near the mouth of the drainage basin. Similar trends occur throughout most drainage basins in the semi-arid portions of the

> western United States. The reason for the increase is that soluble constituents increase in the downstream direction due to the dissolution of soluble salts and the concentrating effects of evapotranspiration.
>
> Furthermore, baseflow from regional ground water generally increases in the lower portions of a drainage basin. Regional ground water flow in the lower portions of drainage basins typically has much higher concentrations of salts than local ground water flow systems in the upper portion of drainage basins. Thus, the cause of the increase in soluble water quality constituents at the downstream segment is unrelated to CCB placement in pits at Navajo Mine or Four Corners Generating Station. This natural downstream increase in the concentration of salts occurs in the Chaco River. In fact, the grouping of stations for statistical analysis in the Zimmerman Report specifically separates the intermittent and perennial flow stations within the downstream segment of the Chaco River basin from the other stations. As a result, the data from the downstream stations reflect the higher soluble salts in regional ground water discharge, which only occurs within the downstream segment referred to in the Zimmerman Report.

Norwest Report at pp 33-34.

2. Bitsui Wash: The Citizens Alliance also contends that levels of sulfate, TDS, and boron monitored in the surface waters of Bitsui Wash by the Navajo Nation EPA downstream of the CCBs placed in Bitsui Pit have risen, "indicating the CCBs are the source of the degradation in the Wash." Citizens Alliance Letter at p. 2. In fact, however, the Norwest Report establishes that "average TDS, sulfate and boron concentrations decreased at the surface water monitoring station NB-2 on Bitsui Wash down gradient of the mine in comparison with the concentrations observed at the surface water monitoring station NB-1 on Bitsui Wash up gradient of the mine." Norwest Report at p. 33. As the Norwest Report explains:

> The Zimmerman Report concedes that "the data from only 5 of the 7 monitoring stations listed in Table 7-7 of the PAP were reviewed." The other two stations, NB-1 and NB-2, are located on Bitsui Wash. As shown in Table 4, the data from these stations show that the mine does not result in increased TDS concentrations at the station downstream of the mine. Under natural conditions, Bitsui Wash would flow ephemerally during times of high precipitation. However, due to the existence of NAPI and its associated irrigation return flows, this stream flows intermittently at both monitoring stations. NB-1 is located upstream of the mining at the Bitsui Pit before SMCRA regulation was implemented and there is no mining disturbance located upstream of this station. NB-2 is located downstream of Bitsui Pit and receives precipitation runoff

> from areas of historic mining that predates SMCRA. The water quality summaries for these two stations in Table 4 shows that the average concentrations of TDS, sulfate and boron actually decrease at the station NB-2, located downstream of mining, in comparison with the station NB-1 located upstream of mining.

Norwest Report at 32. Moreover, the NPDES Permit outfalls are not at Bitsui Wash; Bitsui Wash is unrelated to the NPDES Permit.

3. CCB Disposal Operations Do Not Require an NPDES Permit. The Norwest Report establishes not only that there is no correlation between disposal of CCBs and constituents in nearby washes, but it also supports that disposal of CCBs at Navajo Mine falls outside the proper scope of an NPDES permit. Generally speaking, an NPDES permit is not necessary for an activity that does not involve the discharge of a pollutant from a point source into navigable waters. Clean Water Act, §§ 301(a) and 402. The only discharges that have occurred at Navajo Mine have been permitted under the existing Section 402 permit. They have been infrequent and have met NPDES effluent limits. These discharges have occurred in locations unrelated to CCB disposal.

The Norwest Report establishes that CCB disposal operations do not result in a discharge of a pollutant from a point source into navigable waters.

1. The CCBs are deposited outside of jurisdictional waters.

2. There is no surface runoff across the CCBs; they are buried in pits.

3. Not only is there no surface connection between CCBs and the adjacent washes, there is no ground water connection resulting in a discharge of a pollutant. The Norwest Report validates the conclusion that CCBs have not caused ground water contamination.

4. Furthermore, Norwest validates that constituents found in ash, have not entered nearby jurisdictional water through ground water.

B. Additional Monitoring for Arsenic, Cadmium, and Lead Is Neither Necessary nor Appropriate.

The Citizens Alliance premises its request that EPA include "water-quality based effluent limits for arsenic, cadmium and lead in NPDES permit NN0028193" on the assumption that these constituents are "rising to harmful levels in the Shumway Arroyo alluvium" as a result of placement of CCBs in pits. The Norwest Report and the extensive documentation on file with the OSM concerning the Navajo Mine lease area demonstrate that the Citizens Alliance's premise is invalid in several respects:

1. The Shumway Arroyo is not at Navajo Mine; it is near San Juan Mine, which is located approximately 13 miles to the north, on the north side of the San Juan River. The allegations about a connection between CCBs and the Shumway Arroyo are not relevant to Navajo Mine.

2. As described above, the CCBs at Navajo Mine are placed in locations and at depths that prevent any groundwater that may come into contact with the CCBs from reaching surface water. ***See, e.g.*** Norwest Report at p. 30 ("These mine pits are well below the elevations of the alluvium of any tributaries to the Chaco River that cross the Navajo Mine lease. At the northern portion of the mine, any ground water associated with CCBs placement in the Watson, Bitsui, Dodge, Custer and Bighan Pits cannot flow to the west toward the Chaco River because of the ten to twenty-five foot thick shale layer separating the bottom of the pit from the Pictured Cliffs Sandstone. . . . Norwest Report, p. 35 ")

3. The mine spoils around the CCBs placed at the Navajo Mine retard migration in groundwater of the contaminants of concern as demonstrated in the Norwest Report, the Supplemental Groundwater Study, leach studies on file with OSM, and other records. ***See, e.g.***, Norwest Report; p. 26.

4. The extensive monitoring data on file with OSM establishes that the CCBs placed at the mine are not impacting groundwater. As the Norwest Report summarized:

> The Zimmerman Report concludes its review of the SGS with the statement that the SGS does not conclusively demonstrate that CCB disposal activities have a negligible impact on off-lease surface and ground water quality. The report also questions how the results of the SGS, a local scale study at Bitsui Pit, can be used to support the statement that CCB disposal has negligible impact on regional ground water quality. The question fails to recognize that the study focused on the Bitsui Pit because of the pit and CCB saturated from nearby NAPI irrigation and the potential for off-site migration of ground water from the mine backfill. CCB were placed in the Bitsui Pit prior to SMCRA and prior to NAPI irrigation. The Bitsui Pit is the only location at the mine where CCBs are placed in a backfilled mine pit where significant levels of saturation subsequently developed. Furthermore, concurrent with the SGS at the Bitsui Pit, monitoring wells were also completed in the CCB disposal locations within the Watson, Custer and Doby pits. All but the Watson-4 well were dry. Saturation in the Watson-4 well was limited to about 1 to 2 feet above the base of the mine pit. The limited saturation in Watson-4 well and the dry condition in the downgradient Watson-1 well demonstrate that CCB disposal at these pits has negligible contact with or impact on regional ground water.

Norwest Report at p. 24.

In light of the Norwest Report conclusions, the Citizens Alliance's request for additional monitoring is contrary to the Clean Water Act. In the absence of any credible connection between disposal of CCBs in buried pits and a discharge of a pollutant to a navigable water, the requested permit conditions for enhanced monitoring should be rejected as beyond the appropriate scope of an NPDES permit. The Citizens Alliance would have EPA essentially assume jurisdiction over regulation of CCBs disposal operations well outside of jurisdictional waters, despite the absence of credible evidence tying disposal of CCBs to the proper subject of an NPDES permit – the discharge of pollutant from a point source into jurisdictional waters. OSM has been regulating mine disposal of CCBs in pits. It also has issued an advanced notice of proposed rulemaking to propose new regulations pertaining to placement of coal combustion byproducts at surface mines. 72 Fed. Reg. 12026-12030 (March 14, 2007).

The Citizens Alliance also relies upon a January 3, 1994 Guidance Memorandum from the West Virginia Office of Mining and Reclamation entitled "Disposal and Utilization of Coal Ash on Surface Mining Operations" as precedent to support its claim that EPA should establish additional effluent characterization, monitoring and limits for this permit. The Guidance Memorandum was issued more than 5 years before the EPA studies and final regulatory determination concerning CCBs. EPA should not premise its permitting decisions on a state document from West Virginia, inapplicable to New Mexico.

D. The Citizen Alliance's Request for Further Characterization of CCBs Are Unnecessary and Should be Denied.

The Citizens Alliance request that EPA require additional characterization of the CCBs being placed at Navajo Mine is unnecessary for several reasons. First, extensive work has already been undertaken to characterize the CCBs. Both the Supplemental Groundwater Study and the Probable Hydrologic Consequences study, both of which accompany BNCC's application to OSM, already provide detailed analysis of the constituents and leach characteristics of the CCBs. Copies of both of those documents are attached to this letter as Attachments 2 and 3, respectively. The Supplemental Groundwater Study was thoroughly reviewed by both OSM and the Navajo Nation EPA as part of BNCC's significant mine permit revision to permit CCBs placement. That mine permit revision was approved after a determination was made that CCBs placement is an environmentally sound practice that would comply with all applicable environmental standards and requirements.

Second, as described above, long term monitoring of pits containing CCBs at the Navajo Mine demonstrates that only one pit, Bitsui Pit, contains CCBs with significant moisture content. The monitoring further demonstrates that CCBs placement does not have an impact on groundwater or surface water in the area.

Once again, BNCC appreciates the opportunity to provide this response to the comments concerning the renewal of NPDES permit NN0028193. Please feel free to raise any questions you may have.

Very truly,

Kent Applegate

Kent Applegate

cc: Charles Roybal

ATTACHMENT 1

Norwest Report

TECHNICAL REVIEW OF A REPORT PREPARED BY D. A. ZIMMERMAN (2005) ENTITLED: "*A PRELIMINARY EVALUATION OF POTENTIAL FOR SURFACE WATER QUALITY IMPACTS FROM FLY ASH DISPOSAL AT THE NAVAJO MINE, NEW MEXICO*."

Submitted to:
BHP NAVAJO COAL COMPANY

October 22, 2007

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BNCC – BHP Navajo Coal Company

CCB – Coal Combustion Byproducts

DFD – Doby French Drain

EIA - Environmental Impact Assessment

EIS – Environmental Impact Statement

FCGS – Four Corners Generating Station

NAH – Norwest Applied Hydrology

NAPI – Navajo Agricultural Products Industry

OSM – Office of Surface Mining

PAP – Permit Application Package

PCS – Pictured Cliffs Sandstone

PHC – Probable Hydrologic Consequences

SGS – Supplemental Groundwater Study

SMCRA – Surface Mining Control and Reclamation Action

SWL – Static Water Level

TDS – Total Dissolved Solids

1 INTRODUCTION

Norwest Applied Hydrology ("NAH") prepared this report at the request of BHP Navajo Coal Company ("BNCC") to provide a technical review and response to the report by D.A Zimmerman entitled "A Preliminary Evaluation of Potential for Surface Water Quality Impacts from Fly Ash Disposal at the Navajo Mine, New Mexico 2005" (the "Zimmerman Report"). The Zimmerman Report's stated objective was an evaluation of the adequacy of the data and legitimacy of the conclusions in BNCC's December 7, 2004 presentation to the National Academy of Sciences (NAS) Committee on Mine Placement of Coal Combustion Waste entitled "Placement of Coal Combustion Byproducts (CCB) at New Mexico Coal Operations."

BNCC's Presentation to NAS concluded that placement of CCBs in mined out areas is an environmentally sound practice in Northwestern New Mexico based on the following reasons:

- CCBs are placed in locations within the pit that are generally dry or free of ground water in accordance with the approved SMCRA permit.
- The spoil or backfilling material is generally silty or clayey and provides a natural barrier to water movement into or out of the CCB materials placed within the backfill.
- CCB materials are chemically similar to backfill material encountered at the mine.
- CCB placement plans and engineering controls, including covering with sufficient material to prevent plant roots and surface water from directly coming into contact with CCBs. are reviewed, approved and monitored by regulatory authorities.
- Mine site placement of CCB reduces total land disturbance and eliminates offsite transport and disposal.
- No significant impacts to the environment are predicted.
- CCB placement is heavily regulated and monitoring is required until final bond release.

BNCC's Presentation to NAS also included the results of a monitoring study of CCBs placed in a mine pit in the northern portion of the mine referred to as the Bitsui Pit. The Bitsui Pit was mined in the 1960s and CCBs were placed in the Bitsui Pit during backfilling of the pit in the 1970's. The study was performed because saturation conditions developed in this pit as a result of irrigation activity by NAPI, which began at locations adjacent to the Bitsui Pit in the early 1980s. This study showed that even where groundwater is present, the water quality of leachate from the ash is similar to that of water that contacts only backfill and both ash and backfill waters have TDS levels similar to baseline.

The Zimmerman Report takes issue with BNCC's conclusion that no significant impacts to the environment are predicted or expected as a result of CCB placement at the Navajo Mine. Based on what he conceded was a limited data review, Zimmerman advances interpretations and reaches conclusions that he asserts warrant further investigation. In this report, NAH has investigated in greater depth using relevant publicly available information from the Navajo Mine and Office of Surface Mining (OSM) files the conclusions in the BHP presentation and the alternate interpretations and conclusions provided in the Zimmerman Report.

2 EXECUTIVE SUMMARY

The Zimmerman Report's assertions that BHP's monitoring data in the vicinity of Bitsui Pit indicate "ash-constituent migration toward the mine-permit boundary" and that CCB disposal practices have already adversely impacted the water quality in the Chaco River are not supported by the voluminous, publicly available data. This report provides the data and interpretations that refute these assertions.

The Zimmerman Report accuses BNCC of making misleading and/or unsupported statements to the NAS Committee and specifically references the statement that "groundwater is very saline with total dissolved solids typically > 10,000 mg/l toward the basin interior and > 25,000 mg/l to the east" as an example. However, it is clear from the baseline ground water data presented in the PAP that the ground water in the coals of the Fruitland Formation within and near the Navajo coal lease is very saline. The median TDS concentration for all coal wells within the lease is over 8,000 mg/l and TDS concentrations increase to levels greater than 40,000 mg/l within distances of a mile or less in the coal downgradient of the lease boundary. Thus, the statement by BNCC is neither misleading nor unsupported. On the contrary, the Zimmerman Report suggestion that a TDS value of 2,345 mg/l is representative of baseline conditions for the Fruitland Formation near the mine is misleading and unsupported.

The Zimmerman Report improperly relies upon surface water quality data from the San Juan River that is impounded in Morgan Lake and from Gallegos Canyon 18 miles to the east to draw conclusions about ground water quality impacts associated with subsurface disposal of CCBs at Navajo Mine. First, neither of those surface water sources are representative of the ground water in the vicinity of the Navajo Mine. Second, the Zimmerman Reports' attempt to link increasing surface water sulfate levels to placement of CCBs in backfill at Navajo mine is unsupported by the data. Both the leaching tests and the ground water monitoring results obtained by BNCC demonstrate that sulfates are at lower concentrations in CCBs than in the native overburden rock that has been used to backfill the mine pits. It is quite unlikely that CCB placement at the mine causes increased sulfate levels.

Third, ground water studies and ground water monitoring in the only CCB placement areas that have been exposed to ground water infiltration demonstrate that CCB leachates at the Bitsui and Watson Pits do not materially impact ground water quality. BNCC has conducted ground water studies and monitoring at these pits that were mined and backfilled prior to SMCRA and were not included in BNCCs past or current SMCRA permits. The Zimmerman Report questions how a local scale study at Bitsui Pit can be used to support the statement that CCB disposal has negligible impact on regional ground water quality. This question fails to recognize that the study focused on the Bitsui Pit because this is the only location at the Navajo mine where CCBs have been placed in a backfilled mine pit where significant levels of saturation have developed. Some saturation has also developed within the backfill of the Dodge Pit due to NAPI irrigation return flow seepage along the highwall at the northeast side of the pit, but CCBs were not placed within the saturated portion of this pit. Monitoring wells were also completed in CCB disposal locations within the Watson, Custer and Doby pits. All but the Watson-4 well were dry and the saturation in the Watson-4 well was limited to about 1 to 2 feet above the base of the mine pit. These data demonstrate the dry condition of CCB placement at all locations but the Bitsui and Watson Pits. Furthermore, the limited saturation in the Watson–4 well and the dry condition in the downgradient Watson-1 well demonstrate that CCB disposal at the Watson Pit has negligible contact with or impact on ground water.

The Supplemental Groundwater Study (SGS) included as Appendix 11-MM of the PAP concludes that "ash burial and potential ash affected groundwater does not impact the water quality or quantity significantly as to change the designated use or classification of groundwater or surface water." The SGS found that regional ground water use of the Fruitland Formation is virtually nonexistent due to poor water quality and poor water yield. This statement is supported by studies completed by the US Geological Survey and by Office of Surface Mining. The baseline monitoring data obtained by BNCC also shows that ground water quality in the Fruitland coals and Pictured Cliffs Sandstone within the mine lease is poor, with TDS concentrations typically greater than 5,000 mg/l. Further down dip the baseline ground water TDS concentrations typically exceed concentrations of 30,000 mg/l, which is not suitable for any use due to the very high TDS.

The Zimmerman Report erroneously concludes that mine water leachates are the cause for the increase in TDS and sulfate observed at the Chinde Arroyo monitoring station downstream of the mine in comparison with the monitoring station on Chinde Arroyo upstream of the mine. While an increase in TDS and sulfate has been observed, the increase is the result of the concentrating influences of evapotranspiration loss from the wetlands areas associated with the Chinde Diversion and NAPI irrigation return flows entering the Chinde Diversion. There are no contributions of surface flows or ground water seepage from the mine area to the Chinde Diversion as the Zimmerman Report suggests.

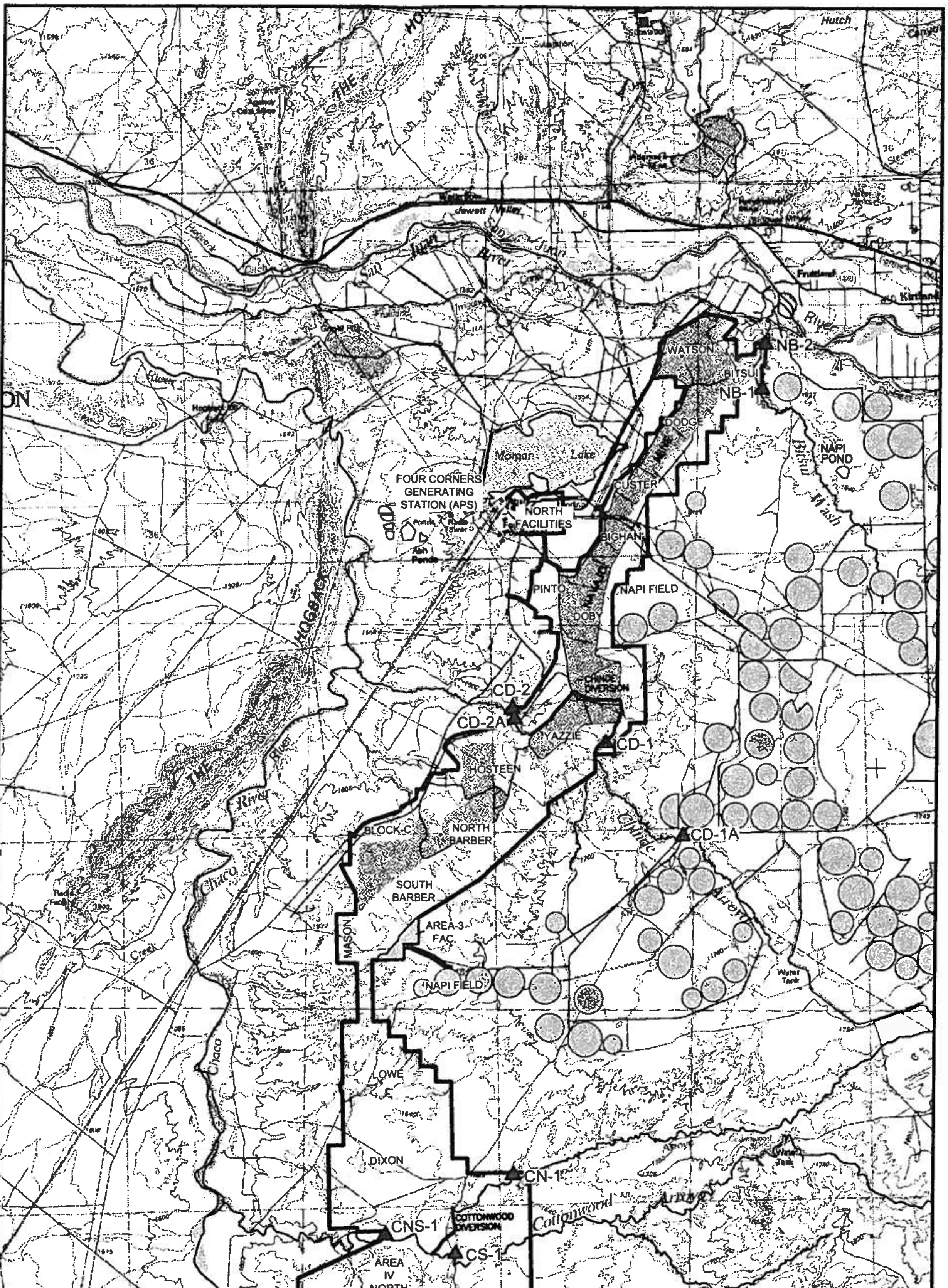
Finally, the conclusion in the Zimmerman Report that an increase in soluble water quality constituents along the lower perennial flow segment of the Chaco River strongly suggests that mining and CCB disposal practices at the mine have already adversely impacted the quality of the Chaco River is both misleading and unsupported. Increasing TDS and sulfate concentrations are a natural occurrence in drainage basins located within the semiarid west, particularly when comparing data high in the watershed to data much further downstream. The increase is typically due to the dissolution of soluble salts and the concentrating effects of evapotranspiration. The statistical comparisons demonstrate no cause and effect relationship between CCB placement at the mine and water quality in the Chaco River.

3 BACKGROUND

Navajo Mine is a large surface coal mine located in northwest New Mexico. Navajo Mine has been operated since 1963 to supply the Four Corners Generating Station, a mine mouth Generating Station. Navajo mine is on a mining lease from the Navajo Nation, the boundaries of which are shown on Map 1. Map 1 also shows the locations of the Four Corners Generating Station. The mine currently supplies about 8.5 million tons of coal to the Four Corners Generating Station, a 2,040-megawatt power plant. Morgan Lake, a large surface impoundment shown on Map 1, supplies water to both the Navajo Mine and the Four Corners Generating Station. The water supply for Morgan Lake is pumped from the San Juan River located north of the lake as shown in Map 1.

Various surface water features are shown on Map 1 including the segment of the Chaco River located to the west of the Navajo Mine and the Four Corners Generating Station. The drainage basin area for the Chaco River is over 4,350 square miles and only the segment near its mouth at the confluence with the San Juan River is shown. Chinde Arroyo and Cottonwood Arroyo, shown on Map 1, are major tributaries to the Chaco River that pass through the Navajo Mine lease. Diversions constructed to route Chinde Arroyo and Cottonwood Arroyo around mining and reclamation operations are also shown on Map 1. Bitsui Wash, which passes through the northwest portion of the lease and flows to the San Juan River, is also shown on Map 1. BNCC has established surface water monitoring stations on these tributaries at the locations shown on Map 1.

CCBs from generating units 1, 2, and 3 at the Four Corners Generating Station (FCGS) have been managed and disposed in ash ponds located on the power plant site as shown in Map 1. Those ash ponds are not under the control of BNCC and are not the subject of the BNCC presentation to NAS. Since 1971, CCBs from generating units 4 and 5 have been placed in mine pit backfills at Navajo Mine. Initial authorization for mine placement of CCBs was approved by the Navajo Nation and the United States Department of the Interior. These CCBs are the mineral constituents that remain following combustion of the coal and consist primarily of inert constituents including silicon dioxide, aluminum oxide, and calcium sulfite. The volume of CCBs placed within the backfilled mine pits is approximately 1.6 million tons per year or about 3% of the total volume of material used to backfill the pits. The remaining backfill material is the overburden and interburden materials removed during mining of the coal. The CCBs were placed at discrete locations in the Bitsui and Watson Pits during backfilling of these pits in the 1970s. The CCBs were covered with backfill material to isolate the CCBs from plant roots or surface water.



LEGEND

- ▲ Stream Monitoring Location
- Navajo Mine Lease Boundary
- SOUTH BARBER Mine Pit
- Ash Pond
- NAPI Irrigation Plots
- Diversion

8000' 0 8000'

SCALE IN FEET

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NORWEST
Applied Hydrology

BHP BILLITON
Navajo Mine
New Mexico

MAP 1

AHA | Oct 18, 2007
JLS | As Shown

SW Monitor Wells UTM12M USGS Topo.dwg

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The Bitsui and Watson Pits were mined in the mid 1960s and backfilled in the 1970s. The location of the mine pits at the Navajo Mine are shown on Map 1. Mining, CCB placement and backfilling of the Bitsui and Watson pits was completed before the promulgation of regulations under the Surface Mining Control and Reclamation Act of 1977 (SMCRA). CCB placement within these mine pits also preceded the Navajo Agricultural Products Industry (NAPI) irrigation activities which began in the area in the early 1980s. The NAPI irrigation plots located to the east of the Navajo Mine are also outlined in Map 1.

Following the adoption of SMCRA regulations, mining and reclamation activities within the Navajo Mine Permit Area, including the placement of CCBs, has been regulated by the Office of Surface Mining (OSM). The OSM regulations require permit approval for all mining and reclamation activity. Permit applications must describe the premining environmental conditions and land uses; provide the detailed plans for all aspects of mining and reclamation; describe how mining and reclamation operations will be conducted and implemented to meet the SMCRA performance standards for protection of the environment; and include a plan for post mining land use that describes how reclamation will maintain the designated land use. SMCRA also requires that mining companies post a bond sufficient to cover the cost of reclaiming the site. The bond ensures that the mining site will be reclaimed even if the company goes out of business or fails to complete reclamation in accordance with the permit. The OSM also performs inspection to ensure that mining and reclamation operations are being conducted in accordance with the approved permit.

A very large number of reports, studies and correspondence have been generated over the 44 year period since mining operations at the Navajo Mine began in 1963. Regulations, monitoring technology and protocols, operating procedures, and documentation and reporting requirements have changed considerably over this time period. Hydrologic studies and monitoring well completions at the mine started in the early 1970's long before the SMCRA regulations were adopted. Hydrologic studies and monitoring expanded under the OSM regulations. The monitoring well construction information and monitoring data are scattered throughout numerous reports given the long-history and numerous hydrologic studies that have been conducted at the mine. Some of wells have been mined out or plugged and abandoned. Virtually all of the "relevant" information concerning hydrology, water quality and placement of CCBs at the Navajo Mine is also on file at the OSM library in Denver, where the public is free to browse the files and can pay a nominal fee to make copies of relevant information.

The U.S. Bureau of Reclamation issued the first Environmental Impact Statement (EIS) for the mine in 1976 for the "Proposed Modification of Four Corners Generating Station and Navajo Mine, San Juan County, New Mexico." Ground water information was developed in support of this EIS. Science and Engineering Resources, Inc. prepared several reports that described the relevant ground water studies developed in support of this EIS as well as another EIS issued in 1976 by the US Bureau of Reclamation for the "Proposed Western Gasification Company (WESCO) Coal Gasification Expansion of Navajo Mine by Utah International Inc. San Juan

County, New Mexico." Copies of all the relevant draft and final EIS documents are on file in the OSM library.

Arizona Public Service Company, BHP, and its predecessor Utah International have also conducted a number of environmental assessments of the CCBs that have been placed within backfill as part of mine reclamation operations. A 1974 report by Woodward-Envicon, Inc. entitled "Trace Element Study for the Four Corners Generating Station and the Navajo Mine" included a study of trace elements in CCBs. This study also examined trace element concentrations in various environmental receptors in the vicinity of the mine and generating station, including, air, water, soil, plants, fish and terrestrial animals. Subsequently, a study entitled "A Laboratory Investigation of Processing and Handling Options of Fly Ash and FGD Sludge from the Four Corners Generating Station" was completed by Radian Corporation in 1981. This report studied the leachate properties of fly ash, FGD sludge and ash blends and found that the leachate quality of all CCBs were nontoxic as related to RCRA guidelines.

Since SMCRA became law, BNCC has developed mining and reclamation plans as part of the Permit Application Package (PAP) and periodic revisions and updates that are submitted to the OSM for approval. These submittals have included baseline hydrology monitoring and characterization, hydrologic monitoring programs for operations and reclamation, hydrologic reclamation plans and assessments of the probable hydrologic consequences (PHC) of proposed mining. The geologic and hydrologic information and monitoring results describe the site-specific conditions and provide the foundation for the PHC determination. Of course, 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, a considerable amount of surface and ground water monitoring has been conducted in both of these areas as well as for the current and proposed expansions within Areas III and IV. These data and interpretations have been included in the PAP documents and related correspondence that has been submitted to the OSM. All of this data is publicly available through the OSM library.

Approvals have been obtained from OSM to continue the placement of CCBs in mine pit backfill at the Navajo Mine. These CCBs are placed back in the mined out pit, in order to achieve the restoration of approximate original contour and are typically surrounded above and below with the overburden that was removed in mining the coal. It is important to realize that CCB disposal practices and associated baseline monitoring and hydrogeologic characterization has changed considerably since the completion of mining of the Bitsui Pit in the mid 1960's. The SMCRA regulations also mandate that all aspects of mining protect the hydrologic balance with respect to the quality and quantity of water both during and after mining.

To ensure protection of the hydrologic balance with respect to CCB use as backfill at the Navajo Mine, the OSM has reviewed and approved the plans developed by BNCC for CCB disposal. These plans include descriptions of the physical and chemical properties of the CCB materials; the proposed disposal locations; the volumes and rates of disposal; a depiction of the final surface configuration; the schedule, type and depth of cover; the plans for fugitive dust control; and the probable hydrologic consequences (PHC) resulting from the proposed use of CCBs as mine backfill. The performance standards under the approved plan require covering the CCBs with spoil and avoiding placement beneath drainages to prevent the CCBs from being exposed at the surface and to prevent plant roots and surface water from directly coming into contact with the buried CCBs. Since the Bitsui Pit became saturated due to NAPI irrigation, BNCC has also avoided the CCB placement in mine pits that are expected to become saturated as a result of NAPI irrigation or other sources. Observational information, including the locations and magnitude of any ground water seeps at active mine pits, predictions from hydrogeologic interpretations and models, and locations for post mining drainages are all used to select the locations most suitable for CCB placement.

Also, BNCC has completed detailed studies of the constituents leached from CCBs and of the hydrology of the mine with respect to CCB disposal locations in support of the CCB disposal plans and the PHC determination. These studies have included a 1984 study and report by IT Corporation entitled "Laboratory Assessment of Ground Water Quality Impacts from Ash Disposal at the Navajo Mine." This report and a related report by IT Corporation entitled "Ground Water Leachate Transport Studies to Assess Ground Water Quality Impacts of Ash Disposal at the Navajo Mine" were included in the PAP along with the Plans for CCB placement and cover. Subsequent studies were also completed under the OSM permitting process, including:

- A 1986 study of the "Effects of Fly Ash Burial on Selenium Content of Vegetation at San Juan and Navajo Mine at Farmington, New Mexico"
- A 1987 "Rooting Depth Study Atriplex canescens" concerning required depth of overburden cover over CCBs placed in mine backfill at the Navajo Mine
- A 1993 "Fly Ash Disposal, Supplemental Groundwater Monitoring Plan" for CCBs placed in mine backfill at the Navajo Mine
- A "Supplemental Groundwater Study, November 1996 through March 1998" (APPENDIX 11-MM of the PAP)

The purpose of the Supplemental Groundwater Study (SGS) was to investigate possible impacts to ground water from previous CCB disposal at Navajo Mine. The investigation was accomplished by installing six ground water-monitoring wells within mine backfill and CCB disposal areas in the Bitsui Pit. The Bitsui Pit is in the northeastern portion of the mine lease area, as shown on Map 1. 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 Navajo Agricultural Products Industry (NAPI") east of the mine lease, and
- The saturated CCBs at the Bitsui Pit are closest to the San Juan River of the CCBs that have been placed in mined out areas of the Navajo Mine.

4 TOPICS OF STUDY

Based on a "very limited data review and analysis," the Zimmerman Report offers alternate interpretations and conclusions concerning the following subjects:

1. CCB disposal at and monitoring of the Bitsui Pit,
2. surface water quality monitoring on Chinde Wash and Cottonwood Wash, and
3. surface water quality information from the Chaco River Basin.

In contrast, this report provides a more detailed review and evaluation of these interpretations and conclusions based upon investigations of the historic CCB disposal at the Navajo Mine; the studies of CCB properties and leachate characteristics; the considerable amount of geologic, ground water and surface water information provided in the PAP; and the recent monitoring performed at Navajo Mine.

5 BITSUI PIT ASH DISPOSAL DATA AND INTERPRETATIONS

The Zimmerman Report questions some of the interpretations provided in both BNCC's presentation to the NAS and in the SGS (Appendix 11-MM of the PAP) related to the current ground water conditions associated with historic CCB placement at the Bitsui Pit. The PHC provided in the PAP addresses the potential adverse effects of CCB disposal on ground water quality. These results were summarized in BNCC's presentation to the NAS committee in December 2004. Those presentations described the CCB disposal process and summarized data. All of BNCC's detailed studies and investigations supporting the summary could not be included and presented to the NAS in the limited time allowed for the presentation. Zimmerman attempts to refute the statement in the BNCC presentation to the NAS that the baseline ground water near the mine and the Bitsui Pit is very saline with TDS typically greater than 10,000 mg/l. He insinuates that the BHP statement is misleading and that that these TDS values are derived exclusively from deep wells that have no relationship to background values in the vicinity.

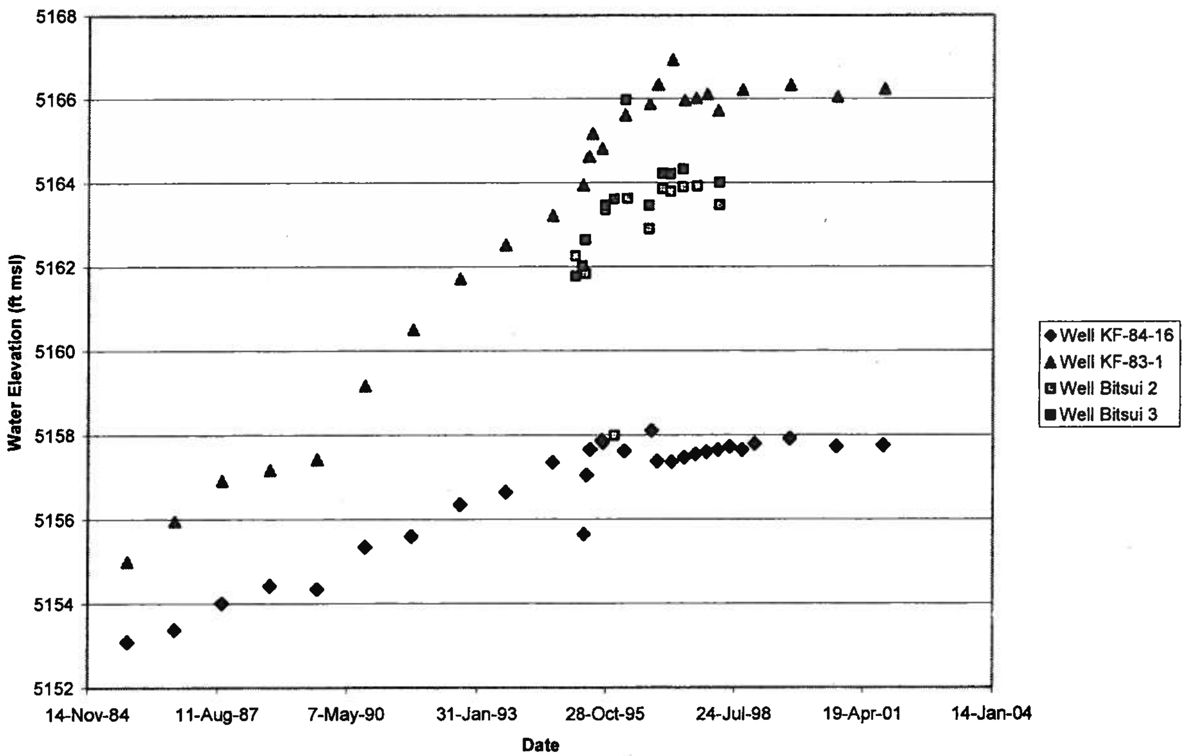
The Bitsui Pit is located along the north end of the mine as shown in Map 1 and Figure 2. The Bitsui Pit was mined in 1964-1965 and was backfilled in the mid-1970s. Some of the backfill in this area consisted of CCBs from the Four Corners Generating Station. CCBs were placed at discrete locations within 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 in Figure 2. Irrigation activity by NAPI 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 Figure 2. NAPI irrigation has had a significant influence on both nearby ground water elevations and flow directions.

As indicated in the "Cumulative Hydrologic Impact Assessment" completed for the Office of Surface Mining by Kamen Tempo (February 1984), ground water yields from the Friutland Formation and the Pictured Cliffs Sandstone in the vicinity of the Navajo Mine are extremely low due to limited saturation and very low permeability. Also, Myers and Villanueva in the US Geological Survey, Water Resources Investigations Report 85-4251 (1986) provide the result of water quality monitoring, which demonstrate the overall poor water quality in the Fruitland Formation in Northwestern New Mexico. This study also shows that the general gradient for ground water movement in the Fruitland Formation and the Pictured Cliffs Sandstone (PCS) in the vicinity of the Navajo Mine Lease is north toward the San Juan River, although ground water flow directions can change locally.

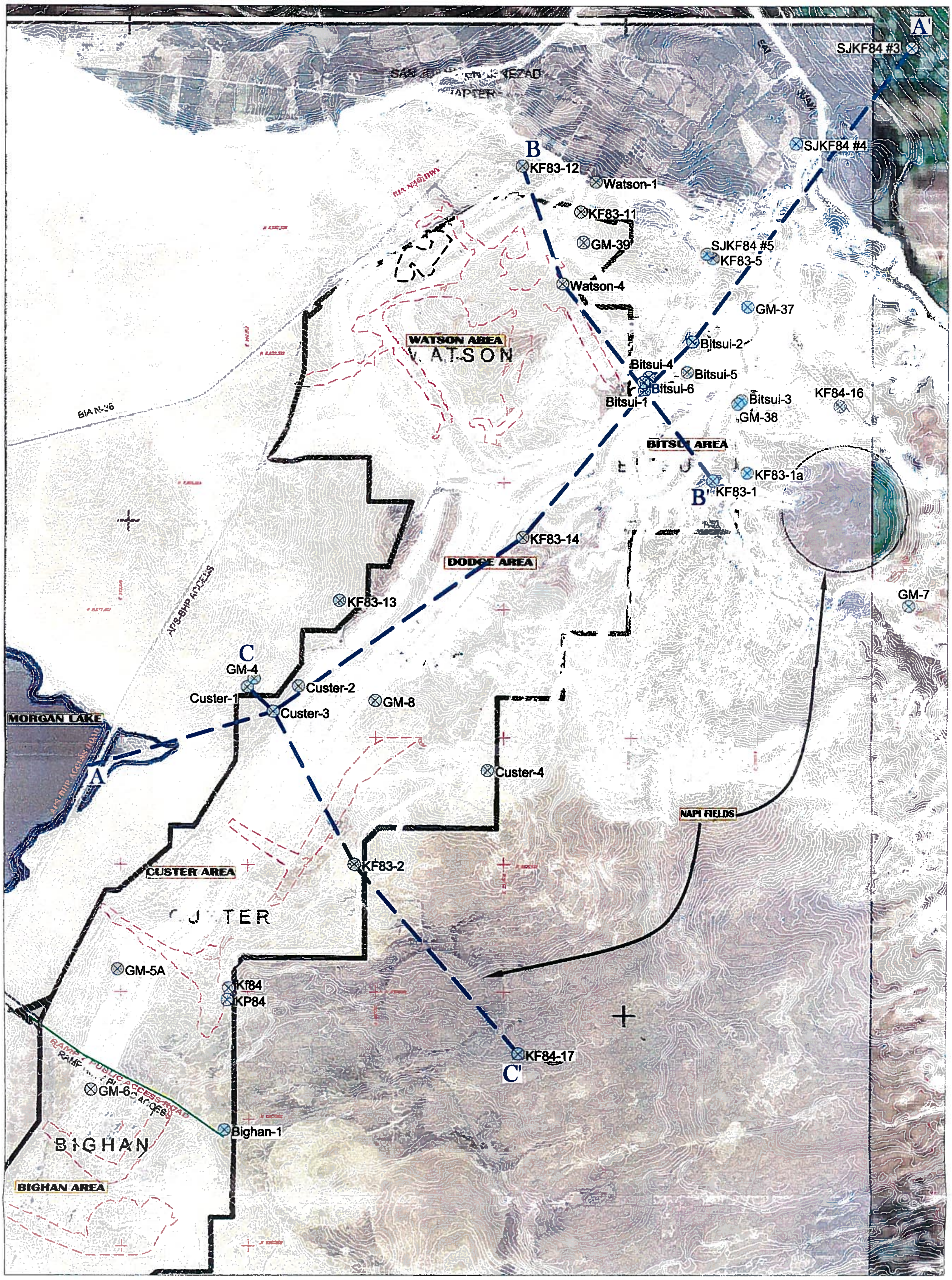
5.1 BASELINE WATER QUALITY AND THE SOURCE OF WATER IN THE BITSUI PIT

Navajo Mine has been monitoring static water level (SWL) and collecting 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 1. 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 Figure 2. The Bitsui 3 well is completed in the No. 8 coal seam east of the Bitsui Pit but west of the well KF 84-16. The Bitsui 2 well is completed in the No. 8 coal seam immediately north of the Bitsui Pit as shown in Figure 2. Water elevations have appeared to increase in both the Bitsui 2 and 3 wells, but they were installed in 1995 so the trend prior to that date is uncertain. SWL in these four wells appears to have reached an equilibrium stage with relatively little change in SWL since 1996, as indicated in Figure 1.

Figure 1. Water Elevations in Coal Monitoring Wells in the Vicinity of the Bitsui Pit



The rise in water levels is associated with NAPI irrigation recharging the Bitsui Pit and the coal. Observations of ground water seepage from the Fruitland Formation along the highwall at the northeast end of the Dodge Pit adjacent to and southwest of the backfilled Bitsui Pit supported this conclusion. 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 Map 1. These sources of water from NAPI irrigation return flows are sufficient to migrate down gradient and saturate the backfilled Bitsui Pit.



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LEGEND

⊗ Monitoring Well

Ash Boundary

2000' 0 2000'

SCALE IN FEET

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NORWEST

BHP Billiton
Navajo Mine
New Mexico

FIGURE 2
AREA 1 MONITORING WELL LOCATIONS

DESIGN:	AHA	DATE:	Jul 26, 2007	Layer Manager:	
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DRAWING:	_Wells & Fruitland Contours NM-W.dwg				

The Zimmerman Report argues that the source of the recharge water for the Bitsui Pit and the nearby coal wells is recharge from Morgan Lake and from the nearby NAPI irrigation, although the relative amount of water from each source is unknown. As shown on Figure 2, Morgan Lake is well to the southwest of the Bitsui Pit. The Zimmerman report argues that the NAPI irrigation water is not the likely source of TDS in the Bitsui Pit or in well KF-83-1 because lower TDS concentrations have been observed at a surface monitoring station in Gallegos Canyon, located below a NAPI irrigation site 18 miles to the east. However, it is incongruous to use surface water data downstream of an irrigation site situated within different geologic conditions 18 miles east as an analog of baseline water quality for either NAPI irrigation return flows in the vicinity of the mine or for baseline water quality of the source water for the Bitsui Pit. The Zimmerman Report tries to discredit the use of data from well KF-83-1 to represent background water quality in the Fruitland coal and uses the term "misleading" for BNCC's statement to the NAS committee that "groundwater is very saline" The Zimmerman Report then refers to an average TDS concentration of 2345 mg/l as representative of local ground water based on a USGS regional study within the entire San Juan Structural Basin. Again it is incongruous to use an average TDS from data across a wide region, much of it from water supply aquifers within recharge areas at much higher elevations, as representative of baseline TDS in ground water in the vicinity of the mine, especially given the considerable amount of publicly available ground water baseline data available in the PAP for the Navajo Mine. These baseline data show that the BNCC's statement to the NAS is valid and well supported.

The ground water monitoring data from the Navajo Mine shows that baseline ground water in the coals is very saline. Baseline water quality information for the Fruitland coals are summarized in Table 1. This table shows median baseline concentrations measured at the coal wells monitored at the Navajo Mine. The median TDS concentration for all coal wells within the coal lease is over 8,000 mg/l and TDS concentrations increase to levels greater than 40,000 mg/l within distances of a mile or less in the coal downdip of the lease boundary. The median baseline TDS concentration in <u>all of the Fruitland coal wells</u> exceeds the 2,345 mg/l value provided in the Zimmerman Report claims is representative of the baseline concentration for the Fruitland Formation.

The publicly available ground water data also establishes that baseline ground water in the alluvium upstream of the mine is very saline. Baseline water quality information for the alluvium is included in Appendix 6-C of the PAP. Maximum TDS and sulfate concentrations of 10,060 and 6,568 mg/l, respectively, were observed in three baseline samples from well GM-9 completed in the Chinde alluvium east and upgradient of the mine. TDS as high as 16,000 mg/l and maximum sulfate concentrations of 9,810 mg/l were observed in well GM-17 completed in the alluvium of the North Fork of Cottonwood Creek east of the Navajo mine lease. Lower TDS and sulfate concentrations were observed in wells completed in the alluvium of the main stem of Cottonwood downgradient (north) of the Navajo Mine lease. Table 2 was also provided in the PAP to show the range of baseline water quality constituent concentrations in the Pictured Cliffs Sandstone within close proximity to the Navajo Mine lease area. Although the water quality concentrations vary, the results show that the quality is either unsuitable for use or, in some areas, unsuitable for all but limited livestock use.

Table 1. Baseline Water Quality of Fruitland Coals at Navajo Mine

Location	Well	EC	TDS (mg/L)	SO4 (mg/L)	Na (mg/L)	B (mg/L)
Baseline Fruitland Coals within coal lease	KF84-18A	22900	13450	19	4660	0.72
	KF84-18B	15850	9640	15	3365	0.74
	KF84-20A	12775	7280	20	2690	0.56
	KF84-20B	8100	6660	172	904	0.13
	KF84-20C	4370	2640	37	1040	0.42
	KF84-21A	14200	8120	64	3090	0.61
	KF84-22A	6560	4650	2245	1600	0.26
	KF84-22B	10900	6005	7	2230	0.39
	KF84-21C	12600	8505	184	2858	0.63
	KF84-22C	12000	8035	10	2716	0.46
	KF84-22D	13000	8610	10	2866	0.50
	KF84-22E	12800	8275	44	2890	0.56
	Mean	12171	7656	236	2576	0.50
	Median	12688	8078	28	2787	0.53
Baseline No. 8 Coal downgradient of coal lease	SJKF#2	46500	43035	10	13456	1.23
	SJKF#3	53000	50810	10	15632	1.43
	SJKF#4	10400	7370	10	2642	1.57
	Mean	36633	33738	10	10577	1.41
	Median	46500	43035	10	13456	1.43

Table 2. Baseline Water Quality of the Pictured Cliffs Sandstone

	Range
Total Dissolved Solids	5200 mg/l to 16960 mg/l
Chloride	170 mg/l to 9000 mg/l
Sodium	1330 mg/l to 6100mg/l
Sulfate	1100 mg/l to 4750 mg/l
pH	6.8 to 9.1

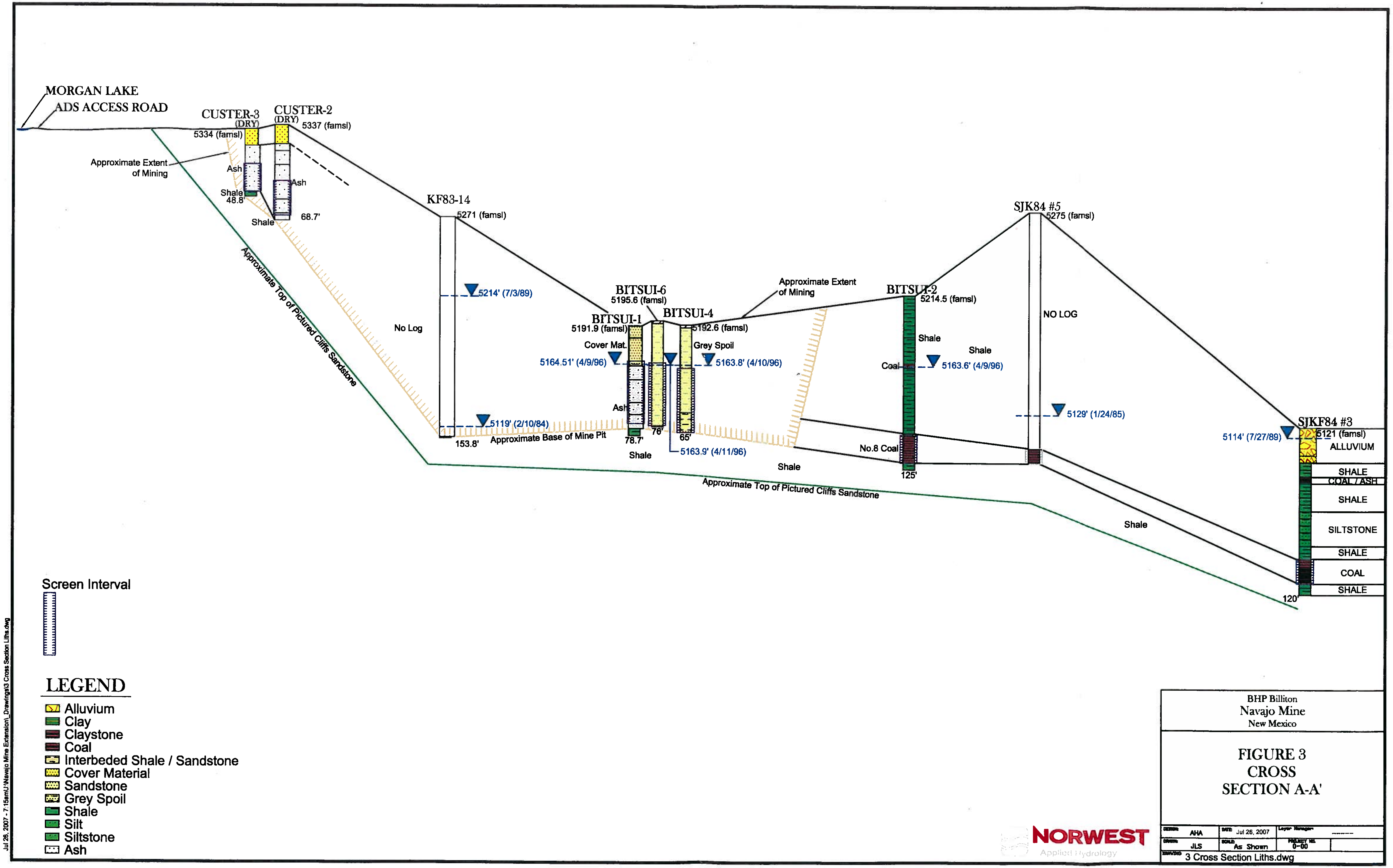
As discussed earlier, BNCC has over many years completed a number of ground water studies and performed ground water monitoring in support of its mining and reclamation activities. Furthermore, BNCC has conducted ground water studies and monitoring at the Bitsui and Watson Pits that were mined and backfilled prior to SMCRA and are not included in BNCCs past or current permits from the Office of Surface Mining. The SGS, which was undertaken in 1995, focused on the Bitsui Pit because of the suspected saturation caused by the nearby NAPI irrigation. Wells were installed to evaluate the potential for off-site migration of ground water impacted by CCBs or by mine backfill. Other wells were installed during the mid -1990s to monitor back fill and CCB disposal 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, KF-83-1 and KF-84-16 were monitored for static water levels and water quality on a quarterly basis from 1995 through 1998 and then annually. These wells are shown in Figure 2 along with other monitoring wells in the vicinity

Three geologic sections through selected monitoring well locations were prepared to examine ground water conditions in three dimensions. The locations of the sections are shown in Figure 2 and the geologic sections are provided in Figures 3, 4 and 5. Measured water levels in monitoring wells are shown on the sections.

These geologic sections show no influence from Morgan Lake with no saturation of pit spoils and CCBs in the adjacent Custer Pit. The wells completed in the CCBs of the Custer Pit remained dry. 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 was sufficient to sample in order to characterize CCB leachate at a location that is not influenced by NAPI irrigation.

Saturated conditions also developed within the backfill of the Dodge Pit as indicated by the water level rise in spoil well KF-83-14. The water source for saturation of both the Dodge Pit and the Bitsui Pit is from NAPI irrigation and not from Morgan Lake. Morgan Lake overlies the Pictured Cliffs Sandstone. Water elevations in spoil well KF-83-14 are higher than the water elevations in the Pictured Cliffs Sandstone well GM-4 located between well KF-83-14 and Morgan Lake as shown in Figure 1. Thus, the current potentiometric levels do not support ground water flows from Morgan Lake to the Dodge Pit or to Bitsui Pit which is located further from Morgan Lake. Also, the Custer Pit and ramps that are closer to Morgan Lake 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 Pictured Cliffs Sandstone (see CHAPTER 6 of the PAP) acts to isolate the mine pits from ground water in the Pictured Cliffs Sandstone. 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 significantly below the projected potentiometric levels in the Pictured Cliffs Formation. Furthermore, as mentioned previously, ground water inflow was observed along the highwall of the Dodge Pit in the vicinity of the NAPI irrigation sites.



MORGAN LAKE
ADS ACCESS ROAD
CUSTER-3 (DRY)
5334 (famsl)
CUSTER-2 (DRY)
5337 (famsl)
Approximate Extent of Mining
Ash
Shale
48.8'
Ash
Shale
68.7'
Approximate Top of Pictured Cliffs Sandstone
KF83-14
5271 (famsl)
5214' (7/3/89)
No Log
5119' (2/10/84)
153.8'
Approximate Base of Mine Pit
BITSUI-6
5195.6 (famsl)
BITSUI-1
5191.9 (famsl)
Cover Mat.
5164.51' (4/9/96)
Ash
78.7'
76'
Shale
BITSUI-4
5192.6 (famsl)
Grey Spoil
5163.8' (4/10/96)
65'
5163.9' (4/11/96)
Approximate Extent of Mining
BITSUI-2
5214.5 (famsl)
Shale
Shale
Coal
5163.6' (4/9/96)
No.8 Coal
125'
Shale
Approximate Top of Pictured Cliffs Sandstone
SJK84 #5
5275 (famsl)
NO LOG
5129' (1/24/85)
Shale
SJKF84 #3
5121 (famsl)
5114' (7/27/89)
ALLUVIUM
SHALE
COAL / ASH
SHALE
SILTSTONE
SHALE
COAL
SHALE
120'
Screen Interval
LEGEND
Alluvium
Clay
Claystone
Coal
Interbeded Shale / Sandstone
Cover Material
Sandstone
Grey Spoil
Shale
Silt
Siltstone
Ash
NORWEST
Applied Hydrology
BHP Billiton
Navajo Mine
New Mexico
FIGURE 3
CROSS
SECTION A-A'
AHA
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As Shown
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3 Cross Section Liths.dwg
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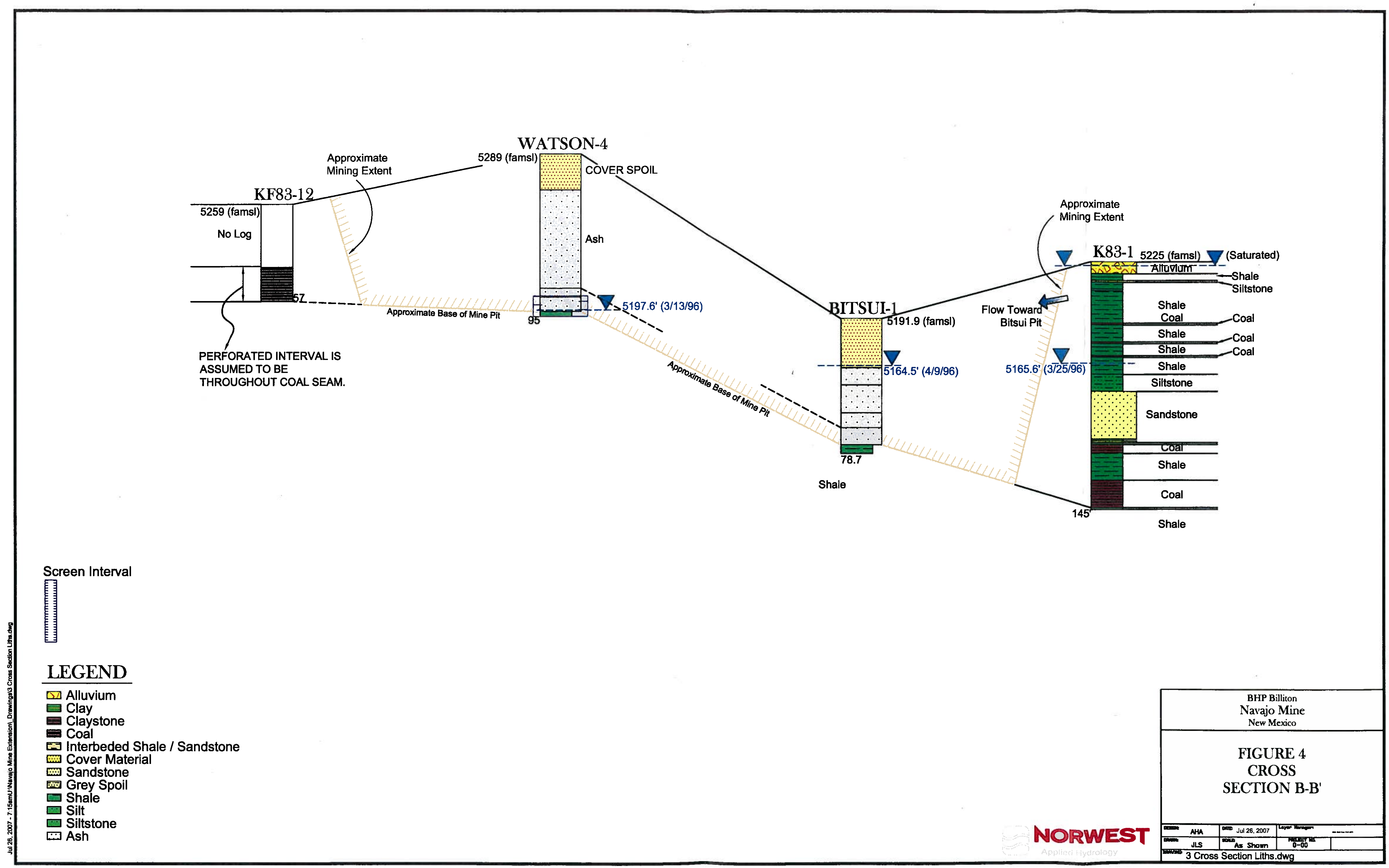
KF83-12
5259 (famsl)
No Log
57
PERFORATED INTERVAL IS ASSUMED TO BE THROUGHOUT COAL SEAM.
Approximate Mining Extent
Approximate Base of Mine Pit
WATSON-4
5289 (famsl)
COVER SPOIL
Ash
95
5197.6' (3/13/96)
Approximate Base of Mine Pit
BITSUI-1
5191.9 (famsl)
5164.5' (4/9/96)
78.7
Shale
Flow Toward Bitsui Pit
5165.6' (3/25/96)
Approximate Mining Extent
K83-1
5225 (famsl)
(Saturated)
Alluvium
Shale
Siltstone
Shale
Coal
Coal
Shale
Coal
Shale
Coal
Shale
Siltstone
Sandstone
Coal
Shale
Coal
145
Shale
Screen Interval
LEGEND
Alluvium
Clay
Claystone
Coal
Interbeded Shale / Sandstone
Cover Material
Sandstone
Grey Spoil
Shale
Silt
Siltstone
Ash
BHP Billiton
Navajo Mine
New Mexico
FIGURE 4
CROSS
SECTION B-B'
AHA
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As Shown
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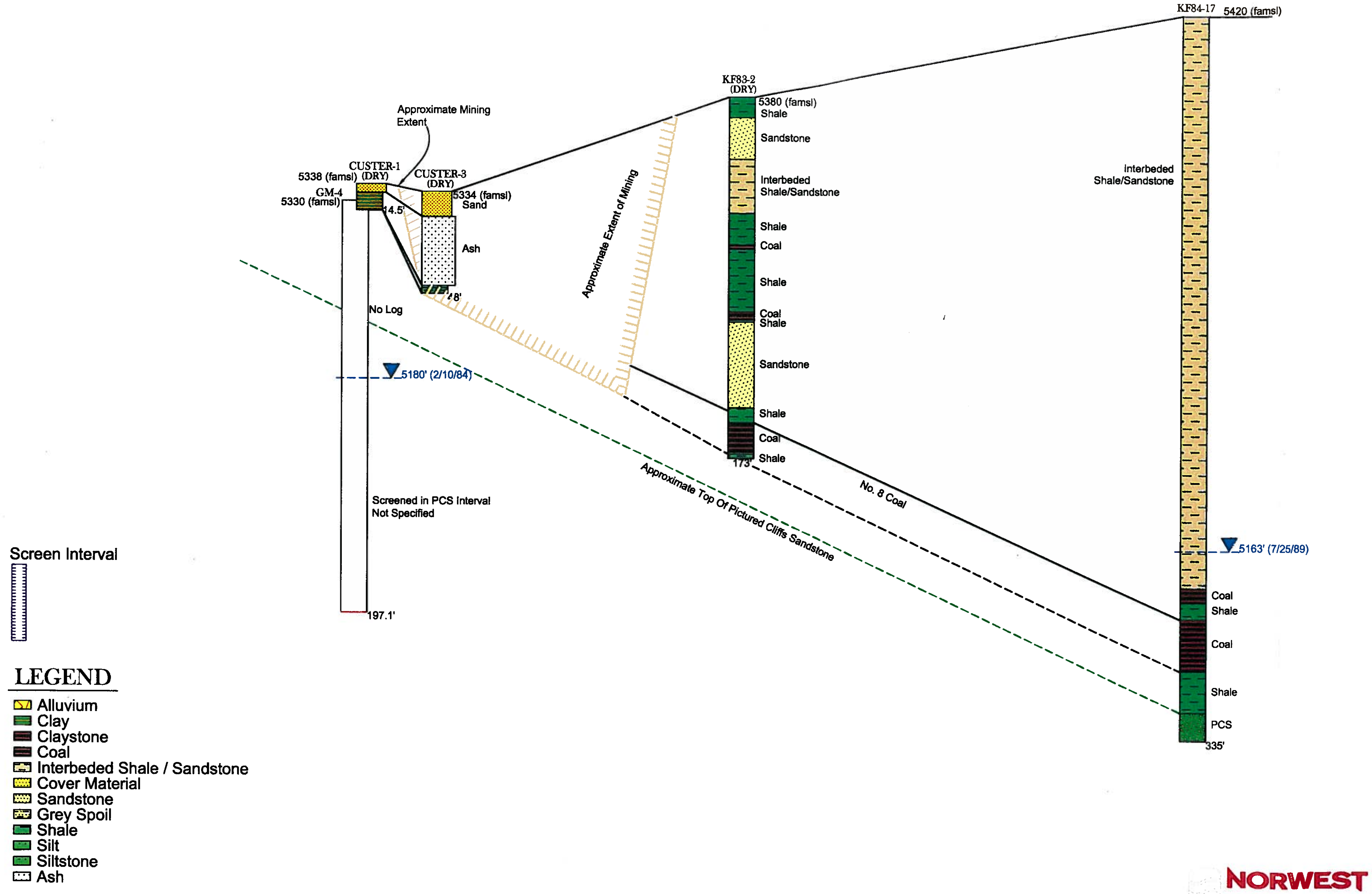

BHP Billiton
Navajo Mine
New Mexico

FIGURE 5
CROSS
SECTION C-C'

NORWEST Applied Hydrology

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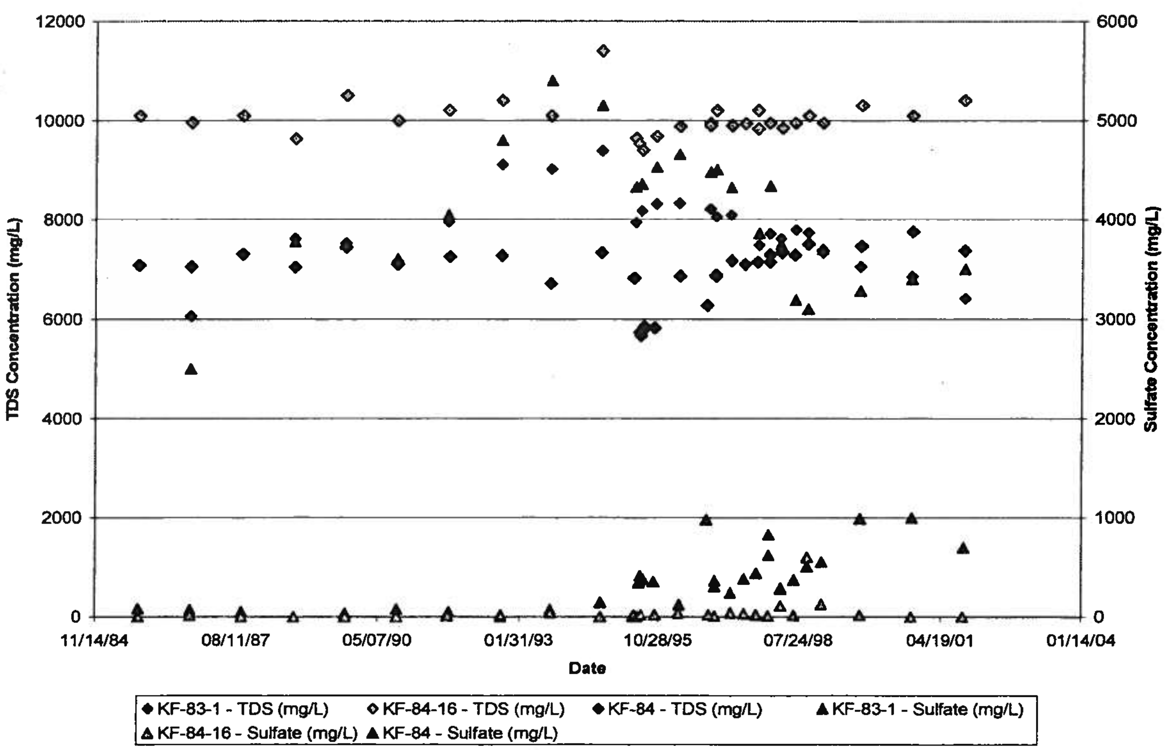
5.2 WATER QUALITY INFLUENCES FROM MINE SPOILS AND CCB DISPOSAL

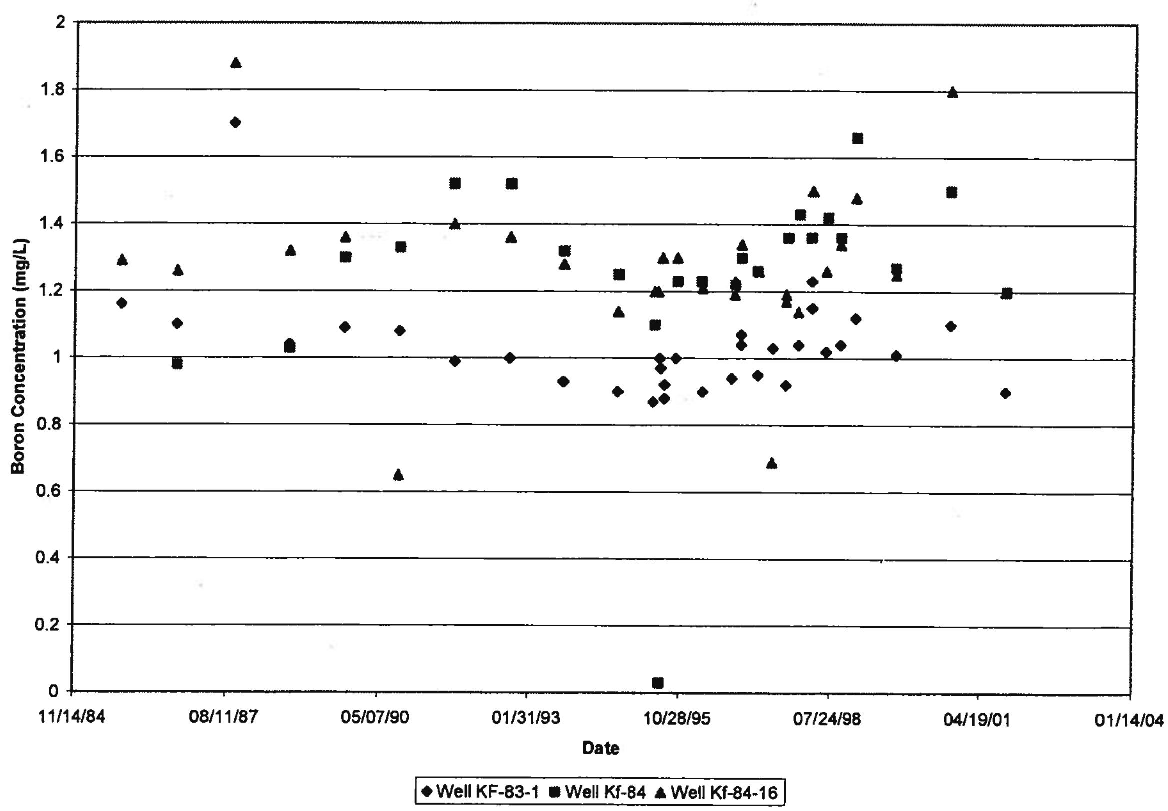
The Zimmerman Report's assertions that ash leachate may be migrating down gradient and that "because the buried ash is covered with spoil and water is present and moving through it, water quality will deteriorate with higher levels of sulphate," are not supported by the data. Figure 5 in the Zimmerman Report shows time series plots of TDS and sulfate concentrations for well KF-83-1. The report claims that there is a "strong increasing trend" in both TDS and sulfate concentrations in the well during the period from 1995 to 1999. While an increase in sulfate appears in these data, the data do not show an increasing trend in TDS concentrations. In fact, decrease in TDS concentrations actually occurred in 1995 corresponding with the more frequent quarterly sampling as shown in Figure 6. This decrease in TDS corresponds with an increase in sulfate concentrations in the same samples. Subsequently, the TDS concentrations returned to their pre-1995 levels while the sulfate concentration remained higher than the pre-1995 concentrations.

Figure 6. Time Series of TDS and Sulfate in Coal Wells Located Near the Bitsui and Bighan Pits.



The increase in sulfate in the ground water in the adjacent coal well KF-83-1 that occurred in 1995 reflects some influence of water that has been in contact with overburden and migrated from the Bitsui Pit. Overburden, rather than CCBs, is the likely cause of increased sulfate concentrations. Pit water migration from Bitsui Pit to this coal well may have been enhanced by purging of the coal well conducted for sampling. Purging of a coal well generally increases hydraulic gradients toward the well. Coals are especially sensitive to these well purging influences due to the very low cleat (fracture) porosity. Although sulfate levels have increased in this well, TDS levels have not increased as Zimmerman implied. Furthermore, the very low concentrations of sulfate prior to 1995 show wells has not been "tainted by many years of leaching through the mine" as stated in the Zimmerman Report. In fact, the water quality is consistent with the coal baseline water quality provided in Table 1. Furthermore, the data do not support the Zimmerman Report's suggestion that ground water that is impacted by CCBs is migrating from the mine pit. Boron, a constituent at elevated concentrations in CCB leachate, shows no concentration change in well KF-83-1 or in the other coal wells as demonstrated in Figure 7. Very high concentrations of boron may be an indicator of CCB leachate but high sulfate is not.

Figure 7. Time Series of Boron Concentrations in Coal Wells Located Near the Bitsui and Bighan Pits.



TDS and sulfate concentrations in the coal well Kf84-16 are relatively constant as indicated in Figure 6. TDS concentrations in Well Kf84-16, located 1,400 feet to the east of the Bitsui Pit are much higher in comparison with coal wells Kf-84 and Kf-83-1 consistent with the higher baseline TDS concentrations observed in the coals further down dip within the basin. Boron concentrations in well Kf-84-16 show no change over time as demonstrated in Figure 7.

No. 8 coal seam well Kf-84 is located near the highwall adjacent to the Bighan Pit as shown in Figure 2. Sulfate concentrations are much higher in this well in comparison with coal wells Kf-84-16 and Kf-83-1. The TDS concentrations increased in the mid 1990's, but have recently returned to concentration levels consistent with earlier values and with coal well Kf-83-1. Boron concentrations in this well show no apparent time trend as indicated in Figure 7. All of the boron concentrations observed in well Kf-84 are consistent with values observed at the other coal wells, Kf-83-1 and Kf-84-16, with the exception of a 0.03 concentration outlier detected in the sample collected on June 22, 1995. This value is believed to be a transcription error and is not representative of the variation in boron concentration at this well. These monitoring results show that during resaturation of mine backfills, sulfate concentrations can reach levels comparable to if not higher than in the baseline overburden and alluvium, which are much higher than the baseline concentrations in most of the coal wells. An increase in sulfate concentrations in a coal well located near a backfilled mine pit is generally an indication of some influence of spoil water. However, it is not an indication of any influence from CCBs. An increase in boron concentrations could be an indication of possible migration of CCB constituents, although boron is also present in coal water, spoil water and alluvial/overburden water. Nevertheless, the absence of any increasing boron concentration trend occurring along with the increase in sulfate shows no migration from CCB placement locations. TDS levels have remained at or near baseline concentrations in these coal wells located near the backfilled mine pits and have not increased as implied by Zimmerman.

The Zimmerman Report also errs in theorizing that the high TDS concentrations observed in spoil monitoring wells Bitsui-4 and Bitsui-6 are due to the influence of CCB disposal in the Bitsui Pit. The report postulates a theory that molecular diffusion can account for the migration of CCB constituents into adjacent mine spoils, but provides no calculations to test the plausibility of this theory. Wells Bitsui-4 and Bitsui-6 are completed in the Bitsui Pit mine backfill approximately 280 feet and 170 feet, respectively, north of "ash" monitoring well Bitsui 1 as shown in Figure 2 and in the geologic section in Figure 3. Surface 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 results of time series plots of TDS, sulfate and boron concentrations from the Bitsui monitoring wells and the Watson Pit ash well (Watson-4) are provided in Figures 8, 9 and 10, respectively. The results show similar TDS concentrations in the ash well Bitsui-1 and in mine backfill wells Bitsui-4 and Bitsui-6 and much lower TDS concentrations in the coal wells, Bitsui 2 and Bitsui 3. 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 ash well refute Zimmerman's assertion that the high TDS observed in spoil monitoring wells Bitsui-4 and Bitsui-6 is due to influences from CCB disposal.

The sulfate concentration plots in Figure 9 show highest levels in the mine backfill wells Bitsui-4, and Bitsui-6 and slightly lower levels in the ash well Bitsui-1 and spoil well Bitsui 5. The lowest sulfate concentrations appear in the coal wells Bitsui 2 and Bitsui 3. The sulfate concentrations observed in the Watson-4 as well are much lower than the concentrations observed in the backfill wells, but are higher than the concentrations observed in the coal wells. No. 8 coal seam wells Bitsui-2 and Bitsui-3 are located near the former highwall adjacent to the backfilled Bitsui Pit. Sulfate concentrations increased in coal well Bitsui-2, indicating likely influence of mine backfill water in this well. However, sulfate concentrations have decreased in coal well Bitsui-3, indicating a lack of recent influence from spoil water. At the same time, TDS concentrations have remained essentially constant in both of the coal wells, demonstrating that the influence of spoil water has not changed the overall salinity of the coal immediately downgradient of the mine pit.

Figure 8. TDS Concentrations in Bitsui and Watson Wells

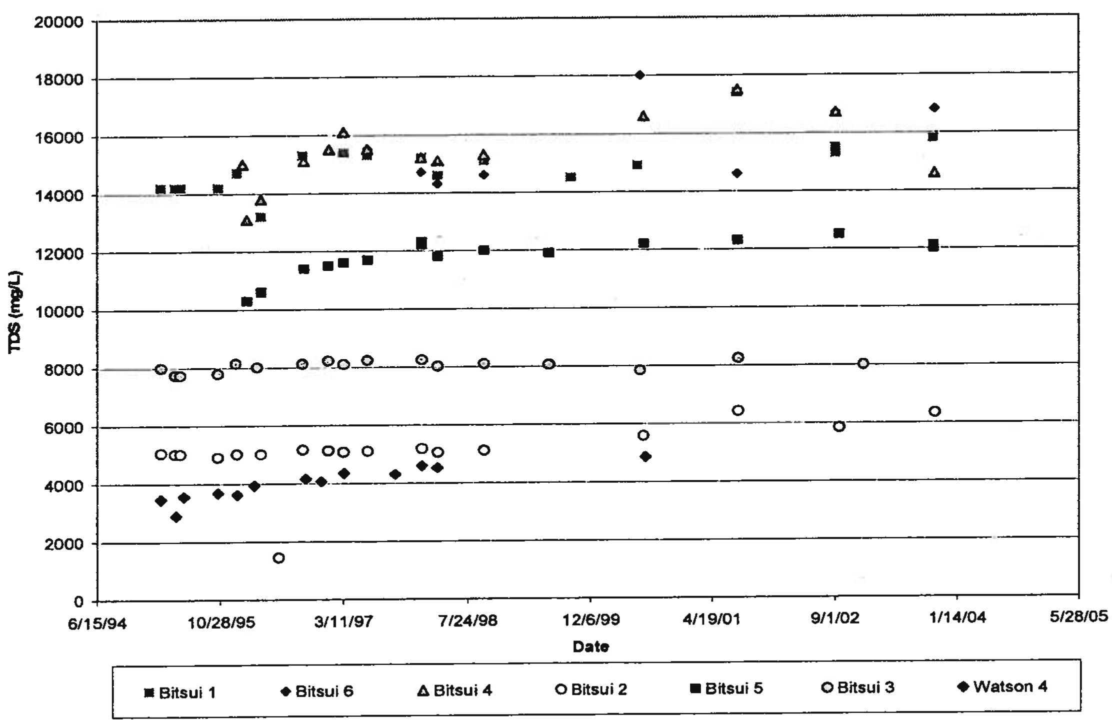
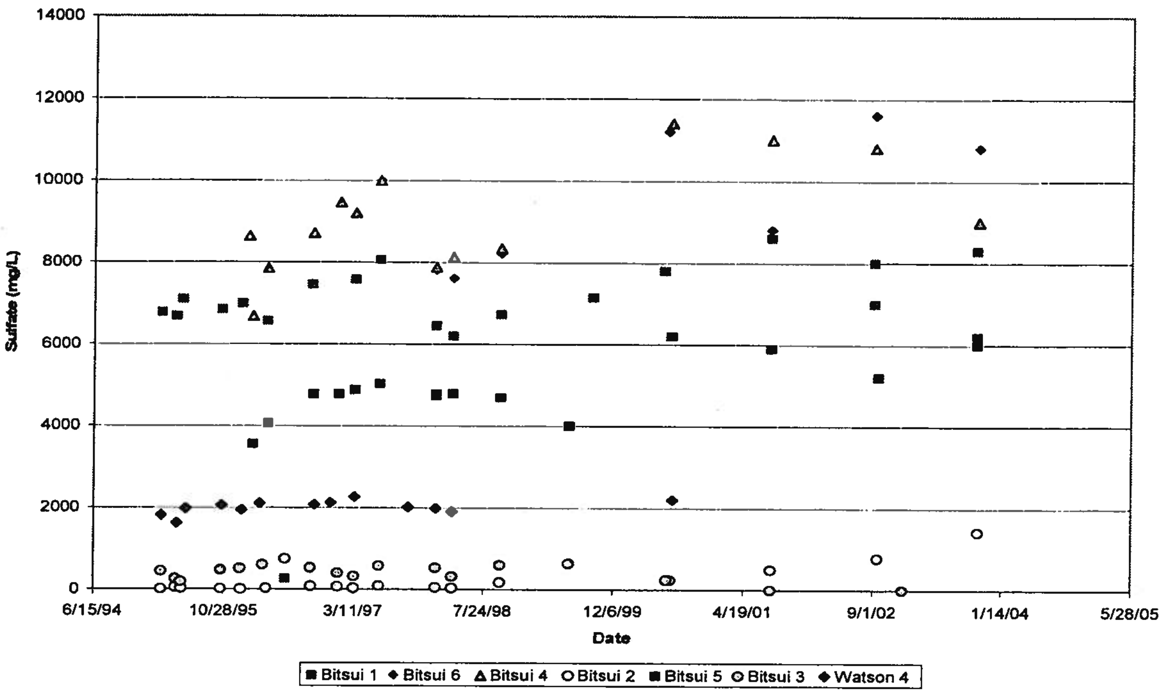
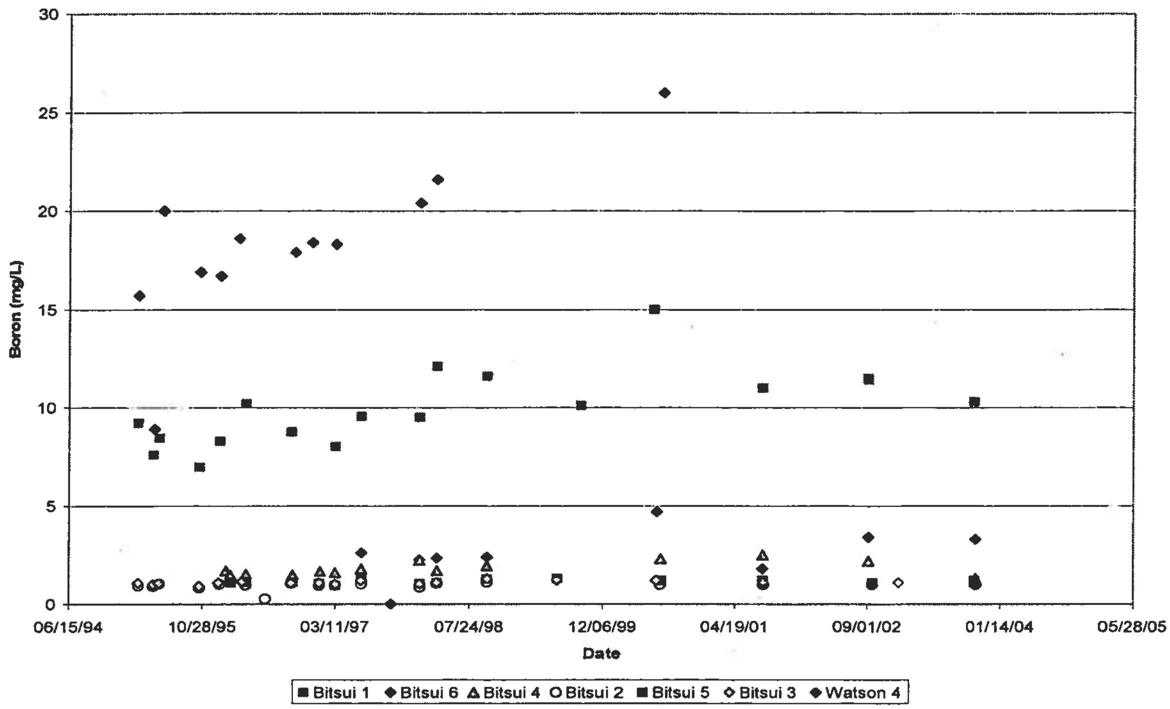


Figure 9. Sulfate Concentrations in Bitsui and Watson Wells



The boron concentrations plotted in Figure 10 show highest levels in the Watson-4 ash 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 coal wells are much lower and consistent with the boron concentrations observed in other coal wells as shown in Figure 7. The boron concentrations in the Bitsui ash well, Bitsui 1, are significantly higher than the coal wells, but much lower than the concentrations observed in the Watson-4 ash well. On the other hand, the sulfate in Bitsui 1 was similar to the sulfate in the backfill wells. This suggests that the water in Bitsui 1 may be a mixture of spoil water and leachate from CCBs. The boron concentrations in the mine backfill wells Bitsui 4 and Bitsui 5 are similar to the concentrations observed in the coals and do not show any influence from CCBs. Boron concentrations in well Bitsui 6 have increased during the period from 1995 through 2000 and have since stabilized at a concentration between that in the ash well Bitsui 1 and the backfill well Bitsui 5, indicating possible influence of ground water from the ash at this location in the backfill adjacent to the ash.

Figure 10. Boron Concentrations in Bitsui and Watson Wells



The Zimmerman Report concludes its review of the SGS with the statement that the SGS does not conclusively demonstrate that CCB disposal activities have a negligible impact on off-lease surface and ground water quality. The report also questions how the results of the SGS, a local scale study at Bitsui Pit, can be used to support the statement that CCB disposal has negligible impact on regional ground water quality. This question fails to recognize that the study focused on the Bitsui Pit because of the pit and CCB saturated from nearby NAPI irrigation and the potential for off-site migration of ground water from the mine backfill. CCB were placed in the Bitsui Pit prior to SMCRA and prior to NAPI irrigation. The Bitsui Pit is the only location at the mine where CCBs are placed in a backfilled mine pit where significant levels of saturation subsequently developed. Furthermore, concurrent with the SGS at the Bitsui Pit, monitoring wells were also completed in CCB disposal locations within the Watson, Custer and Doby pits. All but the Watson-4 well were dry. Saturation in the Watson-4 well was limited to about 1 to 2 feet above the base of the mine pit. The limited saturation in the Watson-4 well and the dry condition in the downgradient Watson-1 well demonstrate that CCB disposal at these pits has negligible contact with or impact on regional ground water.

The SGS concludes that "Ash burial and potential ash affected groundwater does not impact the water quality or quantity significantly as to change the designated use or classification of groundwater or surface water." (APPENDIX 11-MM of the PAP, p 17). Based on my review of the data, this statement is supported by the Bitsui Pit monitoring data. Ground water in the

Fruitland coals and Pictured Cliffs Sandstone very close to the outcrop is generally unsuitable for any use, except perhaps marginal livestock watering in some locations. Further down dip the baseline ground water TDS concentrations typically exceed concentrations of 30,000 mg/l as indicated by monitoring wells in the vicinity of the Navajo Mine coal lease and a study by Simpson (2006) entitled "Characterization of Produced Groundwater within the San Juan Basin" New Mexico Bureau of Geology and Mineral Resources, Open-file Report 499. This ground water is not suitable for any use due to high TDS and is normally injected into deep aquifers as waste when produced for oil and gas or coal bed methane operations.

Boron, an indicator of ground water that is impacted by CCBs, increases in backfill well Bitsui-6 located adjacent to the CCBs placed in the Bitsui Pit but not in any of the downgradient coal wells. Also, as shown in Table 4 provided in Section 5 of this report, average TDS, sulfate and boron concentrations decreased at the surface water monitoring station NB-2 on Bitsui Wash down gradient of the mine in comparison with the concentrations observed at the surface water monitoring station NB-1 on Bitsui Wash up gradient of the mine. All of these data establish that CCB disposal, even when in contact with ground water, does not materially impact ground water quality in the vicinity of the Navajo Mine.

5.3 LEACHATE AND ATTENUATION STUDIES

The ground water quality monitoring results presented in the previous section are largely consistent with the results of leaching and attenuation studies summarized in Table 3 taken from Table 11-14C of the PAP. These tests were conducted using samples of CCB materials and mine rock spoil (pit backfill material). Tests were performed using surface water samples from Chinde Arroyo as one leaching fluid and composite coal water samples from seams 4 and 6 as the other leaching fluid. Constituent results from each of these fluid samples prior to leaching are included in Table 3. Fluid samples of NAPI irrigation return water were not included in the tests.

Table 3 also provides a comparison of the concentrations in the surface and ground water samples used in the leaching test with the concentrations in these fluids after leaching through different mixtures of spoil and CCBs. The results in Table 3 show that the concentrations of TDS and sulfate in the CCB leachate samples were lower than for the samples leached from mine spoils. These results were consistent for both the surface and ground water leaching fluids. These leaching test results are consistent with the relatively low TDS and sulfate observed in the Watson-4 ash well samples. The TDS concentrations in the spoil wells and ash well completed in the Bitsui pit are consistent with the leaching test results for ground water. Although, TDS concentrations appear slightly higher in spoil water in comparison with the baseline TDS concentrations in the coal on lease, these concentrations are lower than the TDS concentrations observed in the coals off lease in the direction of ground water flow. The leach studies and the observations in the Bitsui Pit show that mine spoils are capable of retarding the migration in ground water of metals such as barium, iron, and selenium.

Table 3. Selective Results of Batch Leach Tests
(Table 11-14c in the Navajo Mine PAP)

Comparison of leaching water (surface water from Chinde Wash and ground water 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	Sulfate	Fe	Mn	B	Se	As	Cd
Surface Water from Chinde Wash	7.8	1,900	230	280	15	1,200	0.45	0.08	0.31	<0.001	<0.001	<0.001
SW Leachate:												
Spoils S-4	7.8	4,600	640	850	43	2,700	0.06	0.7	<0.5	0.20	0.002	<0.001
Spoils S-5	8.2	3,500	320	750	27	2,300	0.02	0.26	<0.5	0.018	0.002	<0.001
Fly Ash	12.2	2,000	290	380	16	590	0.02	0.02	1.0	0.09	0.009	<0.001
Bottom Ash	8.5	2,000	260	330	22	940	0.03	0.07	<0.5	0.046	<0.001	<0.001
Ash w/ S-4	7.7	5,300	670	850	37	3,200	0.02	1.4	<0.5	0.018	<0.003	<0.001
Ash w/ S-5	8.1	4,500	550	800	29	3,000	0.08	0.39	<0.5	0.010	<0.003	<0.001
Ground water - coals 4 & 6 (Composite #4)	8.2	9,800	140	3,500	5,200	120	0.15	0.03	0.53	0.011	0.015	0.001
GW Leachate:												
Spoils S-4	7.8	12,000	730	3,200	5,500	2,700	0.06	0.7	<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	0.018	0.002	<0.001
Fly Ash	12	10,000	520	3,000	5,600	320	0.02	0.02	6.2	0.22	0.017	<0.001
Bottom Ash	8.5	8,700	170	3,500	5,500	170	0.03	0.07	0.6	0.020	<0.001	<0.001
Ash w/ S-4	7.9	12,000	790	3,100	5,700	2,000	0.04	1.3	<0.5	0.016	0.009	<0.001
Ash w/ S-5	7.9	12,000	740	3,700	5,600	2,000	0.09	0.64	0.9	0.009	0.008	<0.001

6 INTERPRETATION OF NAVAJO MINE SURFACE WATER MONITORING DATA

The Zimmerman Report refers to Table 7-7 of the PAP (see Table 4 below) and erroneously suggests that mine leachate has entered Chinde Wash because TDS and sulfate concentrations increase between the Chinde Wash monitoring stations upstream of the mine and monitoring stations that are downstream of the mine. The Zimmerman Report refers to the monitoring stations on Cottonwood Wash and suggests that the lack of any increase in TDS and sulfate between the monitoring stations upstream and downstream of the mine on Cottonwood Wash provides further evidence that the increase in sulfate and TDS on Chinde "are indicators of environmental impact from the mine."

The increase in concentrations in Chinde Wash noted in the Zimmerman Report is not associated with either mine leachate or CCB placement at the mine. Instead, the increased concentrations are largely due to loss of water in these drainages. Synoptic monitoring conducted within segmented reaches of Chinde Wash and the Chinde Diversion shows that there is water loss in the Chinde Wash and the Chinde Diversion. It appears that most of the loss is associated with the Segment 3 containing the large wetlands and salt cedar thickets. The water loss is primarily due to evapotranspiration and to a lesser extent due to seepage near the Yazzie highwall immediately below the wetland area at the head of the diversion. The effect of the large evapotranspiration loss associated with the large and densely vegetated wetland areas is a concentration of salts in the remaining water. The concentration influences of evapotranspiration together with the higher TDS levels in contributions from NAPI irrigation return flows explain the increase in average TDS and sulfate at CD-2A in comparison with station CD-1A shown in Table 4 (Table 7-7 of the PAP).

The Zimmerman Report states that "no field trips were made during this study." When assumptions are made without field observations and topographic information, misinterpretations can arise. I have visited all the locations highlighted in Figure 8b of the Zimmerman Report several times during the period from 1988 to 1998 in conjunction with several projects related to design modifications for the Chinde Diversion. There is a levee or dyke that was constructed to direct flows in Chinde Wash into the diversion channel that was constructed around the Yazzie Pit. This diversion is indicated by the blue line between the "?" on the photo in Figure 11 (Figure 8b in the Zimmerman Report) and station CD-2A.

Table 4. Average water quality parameters at surface water stations at the Navajo Mine
(Table 7-7 in the Navajo Mine PAP)

Parameter	NB-1	NB-2	CD-1	CD-2	CD-1A	CD-2A	CN-1	CS-1	CNS-1
pH (S.U.)	7.6	7.8	7.7	7.7	8.13	8.21	7.99	8.14	8.17
# of Observations	24	55	218	55	31	20	28	12	19
Total Dissolved Solids (mg/l)	1862	1558	1231	1090	1157	1458	976	652	639
Total Suspended Solids (mg/l)	32211	26613	6995	26845	167.2	111.7	114919	74009	97282
Total Settleable Solids (mg/l)	240	439	81	233	0.3	0.2	311.6	85.5	133.2
Total Sediment (mg/l)							123097	79420	85247
Conductivity (ų mhos/cm)	2361	2069	1618	1873	1713	2162	1298	1728	861
Boron (mg/l)	0.41	0.32	0.18	0.16	0.35	0.27	0.07	0.14	0.08
Calcium (mg/l)	105.37	67.36	85.56	81.93	69.53	195.76	57.73	43.4	38.92
Chloride (mg/l)	115.99	97	40.69	92.02	61.45	73.5	29.37	21.25	16.89
Fluoride (mg/l)	0.91	0.97	0.98	0.79	1.76	1.15	0.83	0.68	0.74
Iron (mg/l)	0.77	1.46	0.35	0.68	0.21	0.23	3.59	7.54	6.65
Total Iron (mg/l)	63.78	211.44	24.79	74.73	1.39	1.99	669.6	540.2	181.55
Magnesium (mg/l)	19.19	13.76	20	14.33	17.67	26.33	7.61	5.46	4.22
Manganese (mg/l)	0.13	0.24	0.13	0.21	0.3	0.05	0.17	0.44	0.38
Total Manganese (mg/l)	0.82	2.23	0.32	0.9	0.42	1.1	14.48	11.01	5.84
Potassium (mg/l)	9.1	8.3	5.36	7.87	2.62	6.92	5.49	6.9	5.25
Selenium (mg/l)	0.005	0.007	0.004	0.003	0.005	0.005	0.006	0.003	0.003
Sulfate (mg/l)	1020.43	789.16	702.75	552.1	532.61	823.65	515.15	279.9	276.74
Sodium (mg/l)	464.71	412.76	277.54	248.8	239.54	358.76	239.74	166.2	169.37
Bicarbonate (mg/l)	141.77	182.96	127.82	149.6	281.45	265.1	167.7	189.3	191.66
Carbonate (mg/l)	0	0.72	0.52	0.29	7.84	4.6	0.65	1.13	6.84

*CD-1A & CD-2A are the remaining active sample points (3/04).

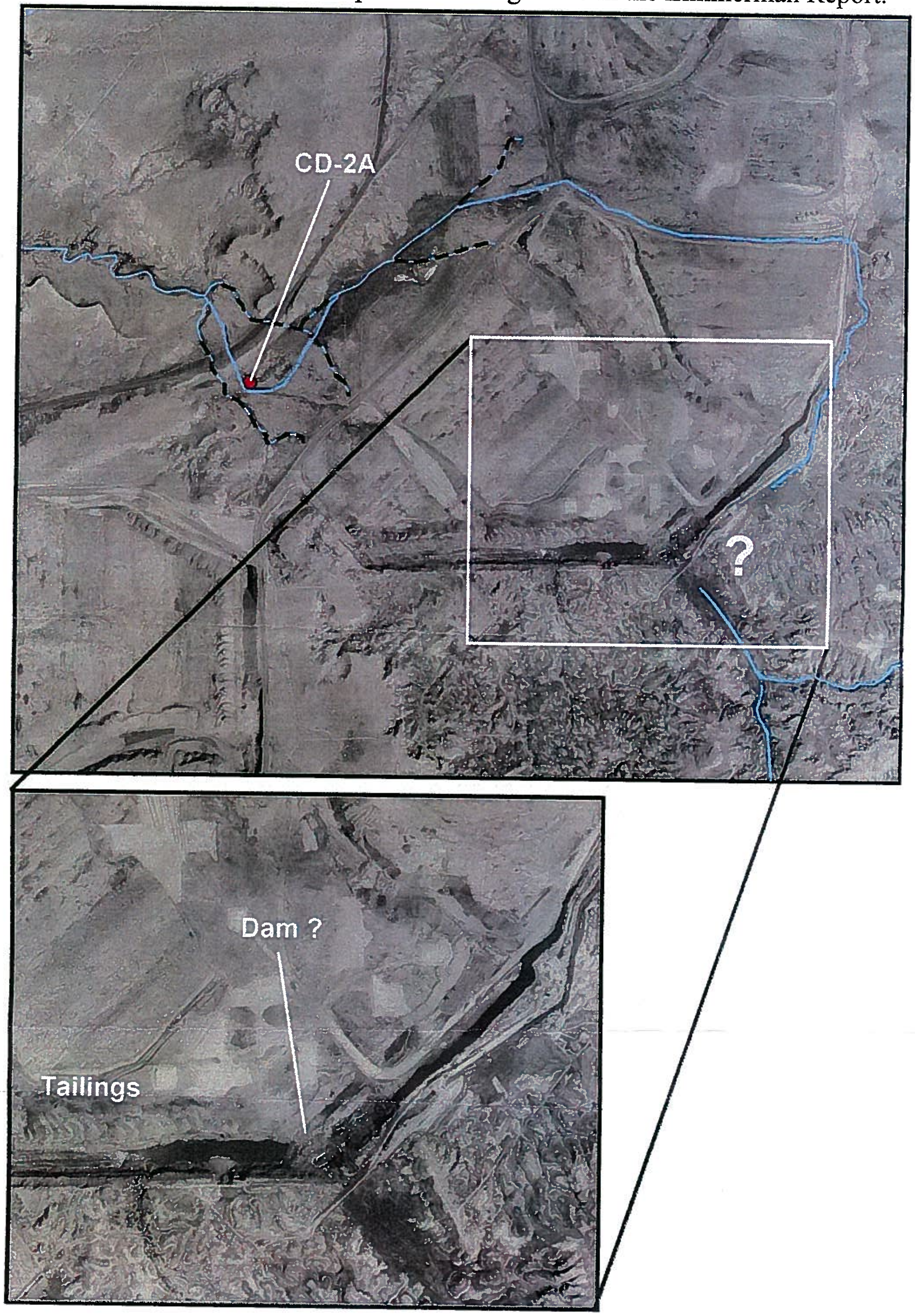
In the photograph, the levee appears as a light linear feature below and to the right of the arrow pointing to "Dam?" in the photo inset. The "Dam?" referred to in the photograph is the ungraded

Yazzie Pit backfill. The standing water adjacent to and to the left of the ungraded backfill in the photograph is water that has seeped from the Chinde Diversion and accumulated in a low point that has not yet been graded. This water is topographically below the Chinde Diversion. Thus, it is not possible for water from the mine to seep into the Chinde Diversion. In fact, the potential for seepage is the opposite. There is a limited amount of seepage from the Chinde Diversion toward the backfilled Yazzie Pit. The Chinde Diversion routes flow to the north along the east side of the backfilled Yazzie Pit. It then bends to the west and flows between the backfilled Yazzie and Doby Pits. The Yazzie Pit remained dry during mining and reclamation, and a monitoring well installed in the backfill of the Doby Pit adjacent to and north of the Chinde Diversion has remained dry.

A very large wetland and extensive growth of salt cedar has developed within Chinde Wash immediately east of the mine in conjunction with the levee or dyke that routes Chinde Wash into the diversion channel. Chinde Wash was originally an ephemeral stream but now exhibits perennial flow due to irrigation return flows and seepage with short term peak flows caused by precipitation and discharge from the NAPI Ojo Amarillo canal. The Cottonwood Arroyo is not impacted by perennial flows. Discharge events in Cottonwood Arroyo are highly variable and are over quickly. There are no wetlands or ponds within the diversion or the channel segment between the two monitoring stations. Thus, there is little opportunity for evaporation losses to occur between these two stations during these short-period events so TDS concentrations would not be expected to change significantly between the two monitoring stations on Cottonwood Arroyo.

The wetland areas associated with the Chinde Diversion on the other hand have resulted in substantial losses of surface flows between monitoring stations CD-1A and CD-2A shown on Figure 12. The results of a gain/loss study conducted within this segment of the Chinde Wash and Chinde Diversion from April 1999 through March 2000 are discussed in Chapter 11 of the PAP. The synoptic and continuous surface water monitoring data collected during this monitoring year have documented a loss of flow along Chinde Wash and the Chinde Diversion. 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 spill. Similar instances of flow volume decreases between CD-1A and CD-2A occurred throughout the year, such as on July 1, 1999 in which CD-1A recorded 11.11 acre-feet of volume and CD-2A recorded only 0.82 of volume for the same NAPI operational spill.

Figure 11. Annotated aerial photo from Figure 8b in the Zimmerman Report.



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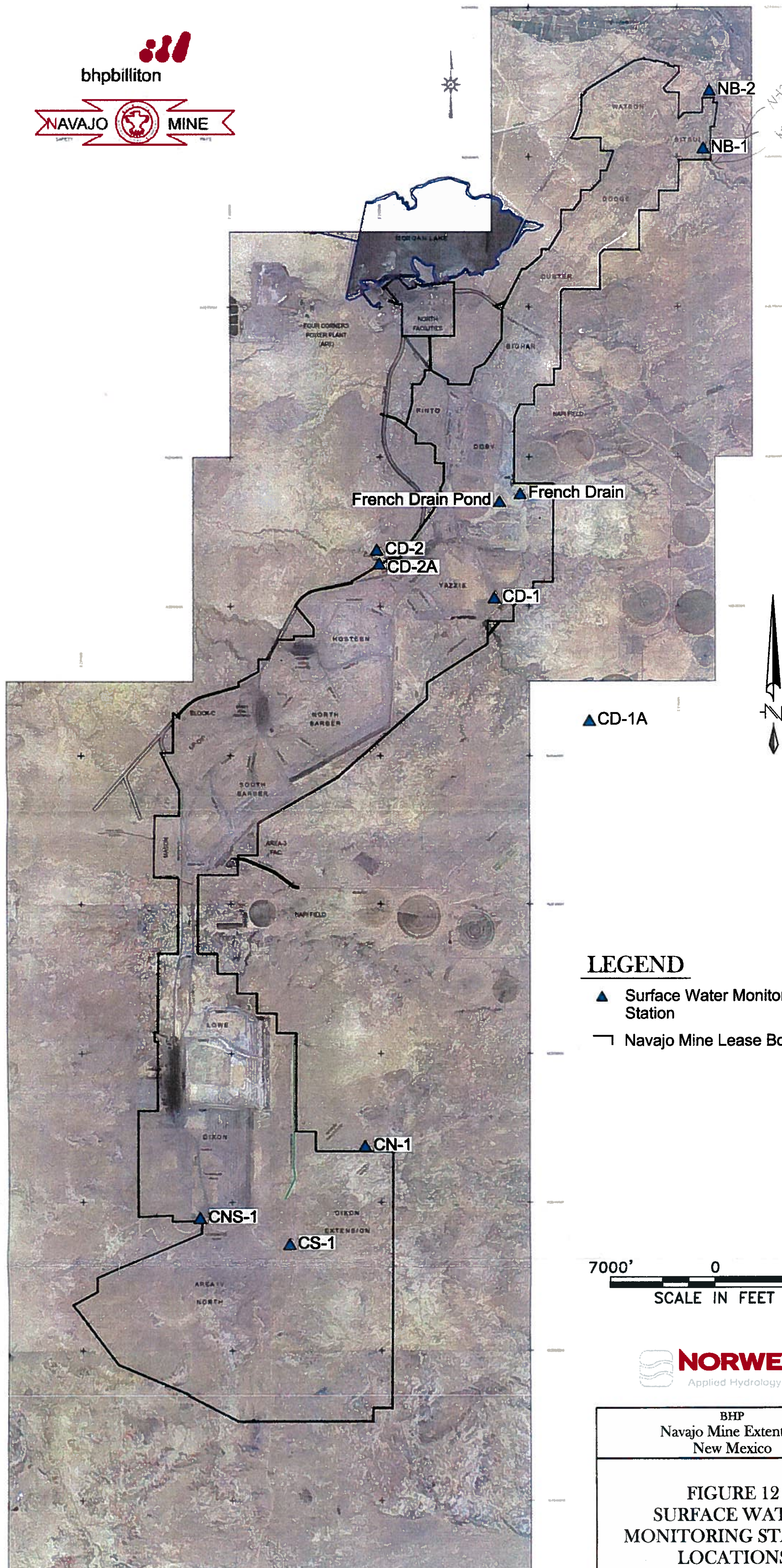
NAVAJO MINE



LEGEND

▲ Surface Water Monitoring Station

Navajo Mine Lease Boundary

7000' 0 7000'
SCALE IN FEET

NORWEST
Applied Hydrology

BHP
Navajo Mine Extention
New Mexico

FIGURE 12
SURFACE WATER
MONITORING STATION
LOCATIONS

DESIGN: AHA	DATE: Jul 26, 2007	Layer Manager:	
DRAWN: JLS	SCALE: As Shown	PROJECT NO. 0-00	
DRAWING: SW- Monitoring Station.dwg			

The Zimmerman Report ignores significant data in the PAP which demonstrates that Zimmerman's theory that mine leachate has entered Chinde Wash is not plausible. At page 17, The Zimmerman report notes that concentrations of TDS and sulfate increase in the Chinde monitoring station downstream of the mine in comparison with the concentrations at the monitoring station upstream of the mine. Given that concentrations of these constituents have not increased at the downstream station on Cottonwood Arroyo in comparison with the upstream station, Zimmerman theorizes that mine leachate has entered Chine Wash. Data in the publicly available PAP shows that this theory is not plausible. For instance, Section 11.6.3.3.1 and the associated Appendix 11-OO of the PAP, clearly demonstrate that mine leachate cannot migrate into Chinde Wash, but rather that seepage is in the opposite direction from the wetland area at the Chinde Diversion toward the Yazzie pit. This section of the PAP also documents the significant loss of water due to evapotranspiration, which accounts for an increase in TDS and sulfate concentrations downstream on Chinde. While the wetland is present due to construction of the diversion for mining, the wetland is believed to provide beneficial use for birds and wildlife.

The Zimmerman Report concedes that "the data from only 5 of the 7 monitoring stations listed in Table 7-7 of the PAP were reviewed." The other two stations, NB-1 and NB-2, are located on Bitsui Wash. As shown in Table 4, the data from these stations show that the mine does not result in increased TDS concentrations at the station downstream of the mine. Under natural conditions, Bitsui Wash would flow ephemerally during times of high precipitation. However, due to the existence of NAPI and its associated irrigation return flows, this stream flows intermittently at both monitoring stations. NB-1 is located upstream of the mining that occurred at the Bitsui Pit before SMCRA regulation was implemented and there is no mining disturbance located upstream of this station. NB-2 is located downstream of Bitsui Pit and receives precipitation runoff from areas of historic mining that predates SMCRA. The water quality summaries for these two stations in Table 4 show that the average concentrations of TDS, sulfate and boron actually decrease at the station NB-2, located downstream of mining, in comparison with the station NB-1 located upstream of mining.

7 CHACO RIVER SURFACE WATER QUALITY DATA AND INTERPRETATIONS

The Zimmerman Report confuses the placement of CCBs as mine backfill at Navajo Mine with the placement of CCBs by Arizona Public Service Company in surface impoundments at the Four Corners Generating Station. The Four Corners Generating Station (FCGS) and the associated ash ponds are located northwest of most of the mine lease as shown on Map 1. The Zimmerman Report refers to data and issues associated with the ash ponds at the FCGS that are irrelevant to CCB placement in mine backfill. The subject of the National Academy of Sciences Committee study and BNCC's presentation to this Committee was mine placement of coal combustion byproducts and not CCB disposal in surface impoundments and pits at generating stations. The surface impoundment facilities at FCGS shown in photographs and referred to in the Zimmerman report are not under the control of BNCC and do not represent mine backfill operations that were under review by the NAS.

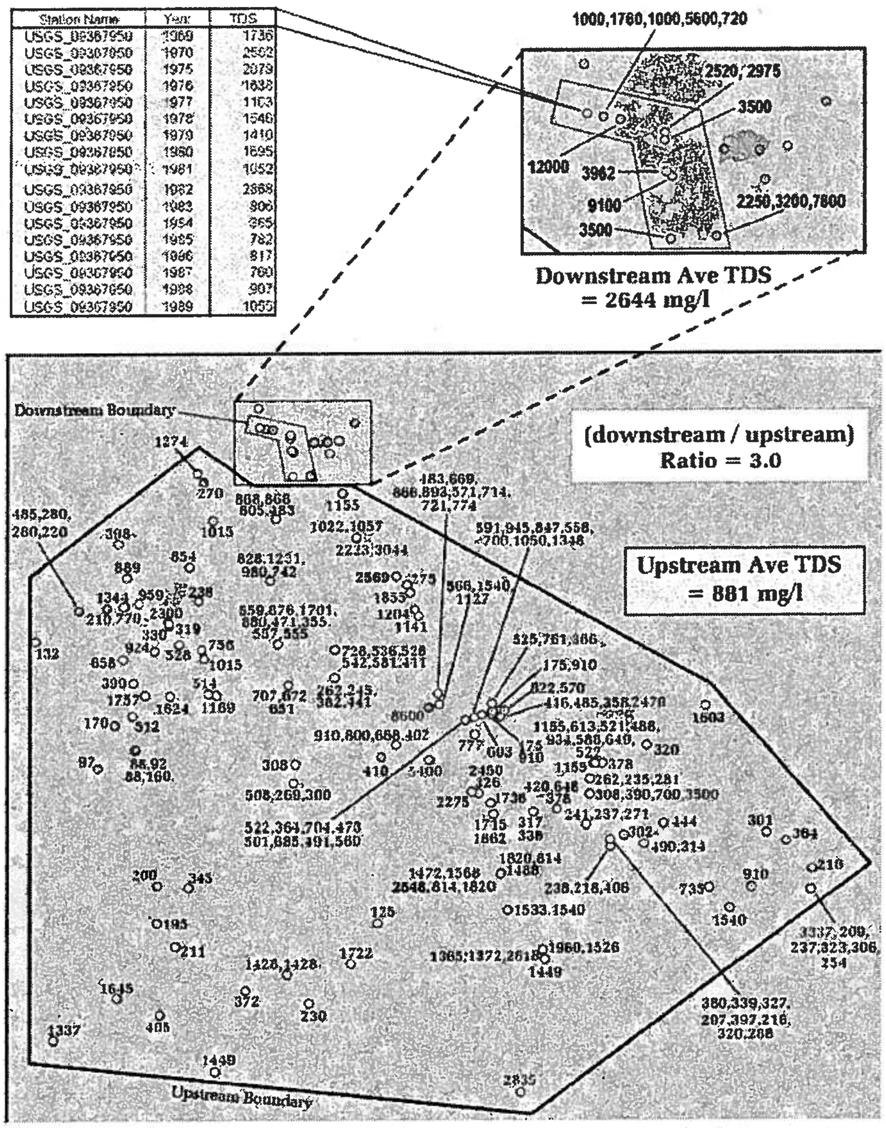
Furthermore, the statistical analysis of water quality monitoring data provided in the Zimmerman Report does not demonstrate a cause and effect relationship between water quality constituents in the Chaco River and the presence of either the Navajo Mine to the east along the lower segment of the Chaco River or the past disposal of CCBs in surface impoundments at the FCGS. The Zimmerman Report includes a statistical analysis of TDS, sulfate, boron and selenium concentrations of surface water quality monitoring stations located along the Chaco River and a number of its tributaries. The statistical analysis consists of separating the data from the stations into the two groups outlined in Figure 12 of the Zimmerman Report. A copy of that figure has been provided in this report as Figure 13.

As shown on Figure 13 of this report, the downstream stations are primarily locations along the perennial flow segment of the Chaco River and include one station on Chinde Wash that is influenced by NAPI irrigation return flows. The upstream stations consist of locations along the ephemeral flow segment of the Chaco River and locations within tributary segments, many of which are in the headwaters. Given this grouping of stations, it is to be expected that soluble water quality constituents, such as TDS, sulfate, selenium and boron, would be higher at stations near the mouth of the drainage basin. Similar trends occur throughout most drainage basins in the semi-arid portions of the western United States. The reason for the increase is that soluble constituents increase in the downstream direction due to the dissolution of soluble salts and the concentrating effects of evapotranspiration. Furthermore, baseflow from regional ground water, generally increase in the lower portions of a drainage basin. Regional ground water flow in the lower portions of drainage basins typically has much higher concentrations of salts than local ground water flow systems in the upper portion of drainage basins. Thus, the cause of the increase in soluble water quality constituents at the downstream segment is unrelated to CCB placement in pits at Navajo Mine or Four Corners Generating Station. This natural downstream increase in the concentration of salts occurs in the Chaco River. In fact, the grouping of stations for statistical analysis in the Zimmerman Report specifically separates the intermittent and perennial flow stations within the downstream segment of the Chaco River basin from the other stations. As a result, the data from the downstream stations reflect the higher soluble salts in regional ground water discharge, which only occurs within the downstream segment referred to in the Zimmerman Report.

No information or data presented in the Zimmerman Report indicates a cause and effect relationship between CCBs disposal operations at the Four Corners Generating Station or the placement of CCBs in mine backfill at the Navajo Mine and the water quality in the Chaco River. In fact, hydrologic information and observations at the Navajo Mine indicate that CCBs in mine backfill at the Navajo Mine has not impacted water quality in the Chaco River. CCBs at the Navajo Mine are placed in mine pits that are excavated in subsurface strata that dip to the east, away from the Chaco River. These mine pits are well below the elevations of the alluvium of any tributaries to the Chaco River that cross the Navajo Mine lease. At the northern portion of the mine, any ground water associated with CCB placement in the Watson, Bitsui, Dodge, Custer and Bighan Pits cannot flow to the west toward the Chaco River because of the ten to twenty-five foot thick shale layer separating the bottom of the pit from the Pictured Cliffs Sandstone (PCS) and the higher ground water levels in the PCS due to the influence of Morgan Lake which preclude such a pathway.

CCBs have also been placed in the Doby Pit further to the south of Morgan Lake but the installation of the Doby French Drain prevents NAPI irrigation return flows from reaching this pit, preventing saturation of CCBs placed within the backfill in this pit. CCBs have also been placed in the Pinto Pit located adjacent to the Doby Pit, but this pit is dry and not subject to any influence from NAPI irrigation. The elevation at the base of the Pinto Pit is such that any ground water in the Fruitland Formation would flow toward the pit. The fact that the pit has remained dry is an indication of the lack of ground water in the Fruitland Formation and the alluvium in the vicinity of the mine pits at locations where NAPI irrigation is not in the immediate proximity to provide a source of ground water recharge.

Figure 13. Map of Water Quality Monitoring Stations, Figure 12 from the Zimmerman Report



Station Name	Year	TDS
USGS_09367950	1969	1736
USGS_09367950	1970	2562
USGS_09367950	1975	2079
USGS_09367950	1976	1638
USGS_09367950	1977	1103
USGS_09367950	1978	1546
USGS_09367950	1979	1410
USGS_09367950	1980	1695
USGS_09367950	1981	1052
USGS_09367950	1982	2868
USGS_09367950	1983	906
USGS_09367950	1984	365
USGS_09367950	1985	782
USGS_09367950	1986	817
USGS_09367950	1987	760
USGS_09367950	1988	907
USGS_09367950	1989	1055

Figure 12. Map of water quality monitoring stations with TDS values plotted. Note that use of average values for USGS station 09367950 biases to the low side, the overall downstream average (see red line and plotted points in Figure 10).

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8 SUMMARY AND CONCLUSIONS

The Zimmerman Report accuses BNCC of making misleading and/or unsupported statements to the NAS Committee and specifically references the statement that "groundwater is very saline with total dissolved solids typically > 10,000 mg/l toward the basin interior and > 25,000 mg/l to the east" as an example (Zimmerman Report, p 15). However, it is clear from the baseline ground water data presented in the PAP that the ground water in the coals of the Fruitland Formation within and near the Navajo coal lease is very saline. The median TDS concentration for all coal wells within the lease is over 8,000 mg/l and TDS concentrations increase to levels greater than 40,000 mg/l within distances of a mile or less in the coal downgradient of the lease boundary. Thus, the statement by BNCC is neither misleading nor unsupported. On the contrary, the Zimmerman Report suggestion that a TDS value of 2,345 mg/l is representative baseline conditions for the Fruitland Formation near the mine is misleading and unsupported.

The Zimmerman Report includes surface water quality data from the San Juan River that is impounded in Morgan Lake and from Gallegos Canyon 18 miles to the east. It improperly uses these data to draw conclusions about ground water quality impacts associated with subsurface disposal of CCBs at Navajo Mine. Neither of these water sources are representative of the ground water entering the Bitsui Pit.

The Zimmerman Report also attempts to link increasing sulfate levels to placement of CCBs in backfill at mine. However, both the leaching tests and the ground water samples from the Watson-4 ash well and the Bitsui monitoring wells demonstrate that soluble sulfates are at lower concentrations in CCBs than in the native overburden rock that has been used to backfill the mine pits. Boron is a better indicator of CCB influence, and boron concentrations are relatively constant.

The Zimmerman Report erroneously concludes that mine leachate has caused the increases in sulfate and TDS observed in the Chinde Arroyo monitoring station downstream of the mine. On the contrary, the increases in TDS and sulfate are the result of the following circumstances:

- The dissolution of soluble salts as Chinde Arroyo flows through several miles of badlands below station CD-1A. Soluble salts are concentrated by the large evapotranspiration loss from the wetlands area at the start of the Chide Diversion as documented by the gain loss study included in the PAP.
- NAPI irrigation return flows also enter the Chinde Arroyo between the two stations, which may also contribute to the increase in soluble salts observed at the downstream station.

Contrary to the assertion in the Zimmerman Report, there are no contributions of surface flows, seepage or mine leachate from the mine area to the Chinde Diversion. The Yazzie and Doby Pits, located adjacent to the Chinde Diversion, remained dry during mining and reclamation, and a monitoring well installed in the backfill of the Doby Pit has remained dry. Thus, the hydraulic gradients are from Chinde Diversion toward the adjacent mine pits.

Also, the Zimmerman Report asserts that the increase in soluble water quality constituents along the lower perennial flow segment of the Chaco River strongly suggests that CCB disposal practices at the mine have already adversely impacted the quality of the Chaco River. The conclusion is based on the observation of an increase in soluble constituents near the mouth of the drainage. Increasing concentrations are a natural occurrence in drainage basins located within the semiarid west, particularly when comparing data high in the watershed to data much further downstream. The increase is typically due to the dissolution of soluble salts and the concentrating effects of evapotranspiration. The statistical comparisons demonstrate no cause and effect relationship between CCB placement at the mine and water quality in the Chaco River. In fact, as discussed in the previous section, the available hydrologic information and observations indicate that CCBs placed in mine backfill at the Navajo Mine has not impacted water quality in the Chaco River.

ATTACHMENT 2

Supplemental Groundwater Study

APPENDIX 11-MM

SUPPLEMENTAL GROUNDWATER MONITORING STUDY

- **NOVEMBER 1996**
- **THROUGH MARCH 1998**

SUPPLEMENTAL GROUNDWATER

STUDY

November 1996

BHP Minerals
Navajo Mine
Fruitland, New Mexico

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EXECUTIVE SUMMARY

The results of the Supplemental Groundwater Study concluded that the burial of ash in saturated post mined pits has an negligible impact on human health and the environment. The study determined that the probable hydrological consequence of ash disposal and ash generated leachate upon the groundwater quality is insignificant. Ash burial and potential ash affected groundwater does not impact the water quality or quantity significantly as to change the designated use or classification of the groundwater or surface water. The conclusions of the Supplemental Groundwater Study support and strengthen the previous results of Chapter 11, Section 6.0, Probable Hydraulic Consequences and APPENDIX 11-K, Leach Study of the Navajo Mine's NM-0003D Permit Application Package.

BHP Navajo Mine implemented a Supplemental Groundwater Study to evaluate the hydraulic consequences of ash disposal in mined out pits. This Supplemental Groundwater Study was executed in two phases; Phase One, a detection investigation, and Phase Two, an assessment investigation. Three new monitoring wells were installed for each phase. The goal for the Supplementary Groundwater Study was to determine the impacts of ash disposal on human health and the environment.

The Supplemental Groundwater Study was designed using the hydrogeologic characteristics provided in Chapter 11, Section 6.0, Probable Hydraulic Consequences and APPENDIX 11-K, Leach Study of the Navajo Mine's NM-0003D Permit Application Package.

The Supplemental Groundwater Study determined that Boron was an indicator parameter of ash affected groundwater. Boron was found to be present only in the groundwater directly saturating the ash. Migration of this constituent or other typical ash leachate constituents away from the pit boundary was not detected in the groundwater downgradient of the ash. The attenuation of Boron and other leachate constituents of ash appears to be caused by the absorption and/or precipitation of the constituents in solution. Boron as well as other ash constituents were determined to attenuate in solution in bench leachate tests performed as part of the Leach Study.

The results from this study support BHP's conclusions that ash disposal has a negligible impact on regional groundwater quality and human health and the environment.

The findings of the Supplemental Groundwater Study are consistent with United States Environmental Protection Agency's (EPA) 1988 Report to Congress, Wastes from the Combustion of Coal by Electric Utility Power Plants, demonstrating that these wastes do not exhibit hazardous characteristics under current the Resource Conservation Recovery Act regulations. EPA does not intend to regulate fly ash, bottom ash, or flew gas desulfurization wastes under Subtitle C. EPA's tentative conclusion is that current waste management practices appear to be adequate for protecting human health and the environment.

1.0 INTRODUCTION

The purpose of the Supplemental Groundwater Study (SGS) was to address OSM's concerns related to the impact of ash disposal on groundwater quality. This report summarizes the results of the SGS and supports BHP's conclusion that ash disposal has a negligible impact on the regional groundwater quality. In order to address Deficiency 1a of OSM's September 2, 1992, deficiency letter, requiring additional hydrogeologic information, BHP proposed a Supplemental Groundwater Monitoring Plan to OSM. In their letter of August 18, 1993, OSM stated that the proposed Supplemental Groundwater Monitoring Plan was in line with OSM's recommendations and BHP must implement the proposed plan. The Supplemental Groundwater Monitoring Plan was implemented as the SGS.

The results of the SGS were determined from two groundwater characterization phases. The objective of the first phase was to detect potential ash constituents in the groundwater. The objectives of the second phase were the following: 1) to delineate the extent of constiuent migration closer to the buried ash based on hydrogeologic information gained from Phase One; 2) further support the conclusions presented in Chapter 11, Section 11.6, Probable Hydraulic Consequences (PHC) and APPENDIX 11-K, Leach Study of the Navajo Mine's NM-0003D Permit Application Package (PAP); and 3) further define the hydrogeologic conditions in the Bitsui A area of the mine.

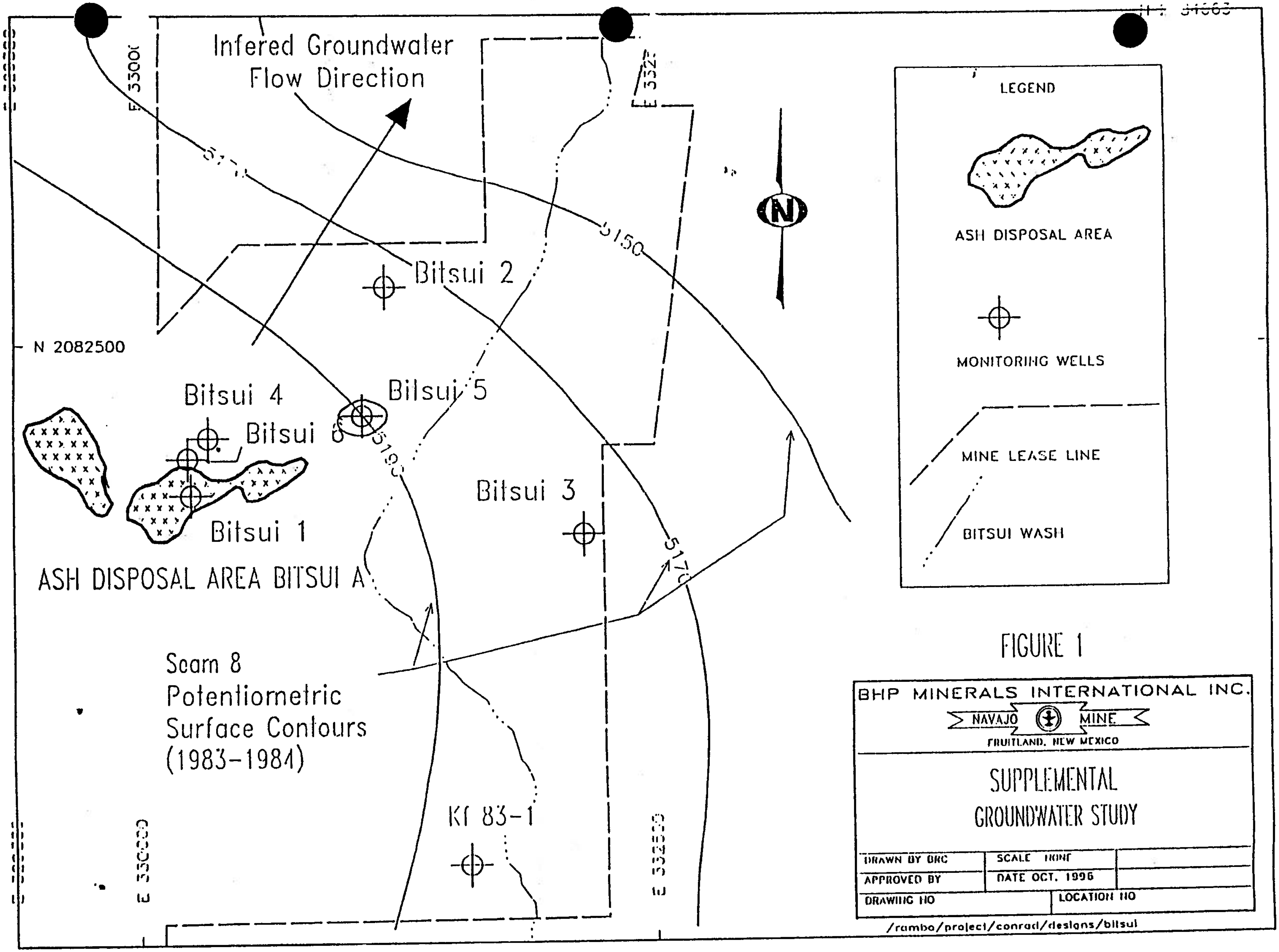
2.0 GROUNDWATER MONITORING STUDY

2.1 Objective

The objective of the SGS was to demonstrate that the disposal of ash in post mine pits is an acceptable management practice and that the impact to human health and the environment is negligible. To meet this objective the SGS was designed to optimize the potential for detecting ash leachate at the Navajo Mine and any off-lease migration of the leachate. In addition, the monitoring system was designed to further characterize the hydrologic regime, support previous hydrogeologic studies performed, and assess any potential risks to human health and the environment.

The objective of Phase One included the installation of three monitoring wells to: 1) to determine if groundwater is present in the Bitsui A area and if the ash is saturated. If groundwater is present, determine its characteristics (i.e., direction and gradient). 2) confirm whether or not leachate is generated and migrating off-lease; 3) determine the effect, if any, the leachate has on groundwater quality and any impacts which may result from these changes.

The Phase One study was designed using hydrogeologic information from the Navajo Mine's PAP, Chapter 6, Groundwater Hydrology . The program included the installation of three monitoring wells (i.e., Wells Bitsui 1, 2, and 3) and focused directly in the Bitsui A area, in the northern part of the mine lease (FIGURE 1). The study focused on establishing a groundwater detection monitoring program that would be able to detect potential ash leachate constituents migrating away from the Bitsui A area towards the San Juan River Valley aquifer to the North.



Infered Groundwaler Flow Direction
N 2082500
E 330000
E 332500
5150
5170
5190
Bitsui 1
Bitsui 2
Bitsui 3
Bitsui 4
Bitsui 5
Bitsui 6
Kf 83-1
ASH DISPOSAL AREA BITSUI A
Seam 8 Potentiometric Surface Contours (1983-1984)
N
LEGEND
ASH DISPOSAL AREA
MONITORING WELLS
MINE LEASE LINE
BITSUI WASH
BHP MINERALS INTERNATIONAL INC.
NAVAJO MINE
FRUITLAND, NEW MEXICO
SUPPLEMENTAL GROUNDWATER STUDY
DRAWN BY DRC
SCALE NONE
APPROVED BY
DATE OCT. 1996
DRAWING NO
LOCATION NO
/rambo/project/conrad/designs/bitsui

FIGURE 1

Phase Two of the SGS was implemented to meet the following objectives: 1) optimize the potential for early detection of ash leachate constituents; 2) further enhanced BHP's understanding of the fate and transport of ash leachate indicator parameters identified in Phase One; 3) define the extent of ash leachate constituent migration; and 4) test the findings and assumptions made in the Leach Study and the PHC of the Navajo Mine's PAP.

The second phase was designed using the hydrogeologic information gained from Phase One and the hydrogeologic information presented in the PHC and the Leach Study of the Navajo Mine PAP. This phase focused on determining the extent to which ash related constituents if any, may have migrated away from the ash disposal area. The Phase Two study also established an enhanced groundwater detection monitoring program, located closer to the ash disposal area, to facilitate the early detection of potential ash leachate constituents. Phase Two included the installation of three wells, Bitsui 4, 5, and 6.

2.2 Background

As mentioned, the SGS focused on the Bitsui A area of the mine located in the prelaw jurisdictional area of the northeastern section of the mine (FIGURE 1). The geologic formations disturbed by mining activities in the Bitsui A area include the Cretaceous Fruitland Formation and associated No. 8 Coal Seam and the overlying Quaternary eolian and alluvial formations. The baseline geology and groundwater quality and quantity information used when designing the SGS was found in the Navajo Mine's PAP, Chapters 5, Geology and Chapter 6, Groundwater Hydrology.

The area designated as Bitsui A was believed to be a location having a high probability of containing power plant ash placed below the potentiometric surface of the No. 8 Coal Seam. This area was chosen for the groundwater characterization because of the probable saturated conditions, and it is the closest (i.e., worst case scenario) ash management area to the San Juan River Valley. The San Juan River alluvial aquifer has the potential to receive water from the Bitsui A area

In general, the hydrogeologic regime of the Bitsui A area is characterized by one water bearing formation, the No. 8 Coal Seam, with varying degrees of saturation separated by hydrologically tight mudstones, sandstones, clays, and shales within the Fruitland Formation.

The hydrogeologic properties of the No. 8 Coal Seam were obtained from groundwater aquifer test information presented in Chapter 11, Section 11.6, Probable Hydrological Consequences (PHC) and Chapter 6, Groundwater Hydrology Groundwater Hydrology of the PAP. The No. 8 Coal Seam is characterized as the zone of the greatest hydrogeologic conductivity. Generally, the groundwater velocity of the No. 8 Coal Seam was found to be no greater than 0.076 feet per day. The groundwater production from the Fruitland Formation and the associated coal seams very minor and it is not considered an aquifer. The groundwater quality in the coal seams of the Fruitland Formation is naturally poor and water production is very minor. Consequently, regional use is virtually nonexistent because of the poor water quality and quantity.

The Fruitland Formation is overlain in selected areas by an unconfined Quaternary eolian and alluvial sand, silt, and gravel formation. The Quaternary deposits vary in thickness and are unsaturated to the west of the Bitsui Wash and saturated by agricultural return flows to the east of the wash. Underlying the Fruitland Formation is the Pictured Cliffs Sandstone, a very low water yielding fine grained clean marine sandstone. There is approximately 60 feet of the Fruitland Formation separating the upper Quaternary deposits and the No. 8 Coal Seam, therefore no hydrologic connection between the water within coal seam and the overlying Quaternary formation exists. Similarly, downward migration of water from the coal seam to the Pictured Cliffs Sandstone is blocked by the lower section of the Fruitland Formation.

Background studies evaluating ash leaching potential and constituent migration were conducted prior to the SGS. The Leach Study, was used as a source of information relating to the geochemical interactions that potentially take place between spoils, fly ash, bottom ash, sludge/fly ash, coal and the groundwater. The fate and transport assessment of ash constituents and the potential impacts to the groundwater quality on downgradient receptors (i.e., San Juan Valley aquifer) due to ash disposal were evaluated using the Leachate Study.

3.0 GROUNDWATER MONITORING

3.1 Monitoring Well Locations

Phase One of the SGS consisted of the installation of three monitoring wells, Bitsui 1, 2, and 3 in the Bitsui A area (FIGURE 1). Well Bitsui-1 was located directly within the boundary of the ash disposal area. This well was completed down to the old pit floor and monitors the saturated thickness of the ash. Wells Bitsui-2 and Bitsui-3 are located downgradient from Bitsui-1 and are completed at a similar depth to Bitsui-1, at the bottom of the No. 8 Coal Seam in the Fruitland Formation. Wells Bitsui-2 and Bitsui-3 are located in an undisturbed area between the ash and the northeastern and east lease boundaries. The three wells were located so that they form an approximate equilateral triangle in order to assess the groundwater flow direction and gradient. The well locations and depths were based on hydrogeologic information provided in the PAP Chapter 6, Groundwater Hydrology.

After reviewing the sampling and analysis results from the Phase One wells and the hydrogeologic and geochemical information provided in the Leach Study, and the PHC three wells, Bitsui 4, 5, and 6 were installed as part of Phase Two. These wells were used to determine if leachate is migrating away from the Bitsui area and to what extent. The wells also provide for the early detection of potential migration of leachate constituents. Wells Bitsui-4 and Bitsui-6 were located sufficiently within the distance a constituent would travel freely in solution in 20 years (i.e., estimated time since ash burial) based on the groundwater velocity of 0.076 ft/day. Well Bitsui-5 was located to assess groundwater movement towards the Bitsui Wash. The location of these wells and the Bitsui 1, 2 and 3 wells are indicated on FIGURE 1.

Background groundwater quality data was obtained from Well Kf83-1. This well is part of the Navajo Mine's annual groundwater monitoring program Chapter 6, Groundwater Hydrology. Well Kf83-1 is located upgradient so that its water quality was not affected by ash disposal in the Bitsui A area. A Piper trilinear plot of the three detection wells Bitsui 1, 2, 3 and the background well KF83-1 is provided in APPENDIX D-2. The plot shows that the water quality between the background well and the downgradient detection wells is similar and therefore the wells are monitoring the same water bearing formation (i.e., No. 8 Coal Seam).

The location of the down gradient monitoring wells (i.e., Wells Bitsui-2, 3, 4, 5, and 6) in the Bitsui A area of the mine are in compliance with the requirements of 40 CFR 264.79. The wells are located so that they intercept the potential leachate migration pathway from the ash disposal area in the Bitsui A area.

3.2 Well Construction

The wells installed in Phase One were two inch diameter wells. The wells installed in Phase Two were four inch diameter wells. Both the Phase One and Phase Two wells were constructed of PVC well casing with sand packed screened intervals and bentonite grout annular spaces. The screened interval for all the wells is at the depth of the No. 8 Coal Seam. This is considered the potential groundwater pathway within the Fruitland Formation for ash leachate affected groundwater. The wells were completed as above ground wells with locking steel protective outer casings.

Boring logs and well construction diagrams are presented in APPENDIX A. The monitoring wells were completed in July 1994 for Phase One and in October 1995 for Phase Two.

3.3 Sampling and Analysis

Static water level measurements to the nearest 0.01 foot were documented prior to each water sampling event. EPA groundwater sample collection guidance and management procedures were followed for the collection, transport, and preservation of collected samples.

The laboratory analysis performed on the samples followed EPA approved procedures found in Standard Methods for the Examination of Water and Waste Water by the Joint Editorial Board, American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 18th edition. The Quality Assurance Quality Control Program in Appendix 27-E of Navajo Mine's NM-0003C PAP was followed.

3.4 Parameter Selection

The parameters listed in TABLE 1 were used for sample analysis. The parameter list was developed based on the identification of potential sources of contaminants to the groundwater specifically as a result of ash disposal. The results of the Leach Study were considered in selection of the parameters. Major ions were included in the list for an ion balance as a quality control measure.

TABLE 1

GROUNDWATER QUALITY PARAMETERS

Water Level	Iron, dissolved
pH	Manganese, total
Total Dissolved Solids	Manganese, dissolved
Conductivity	Aluminum
Calcium	Arsenic
Magnesium	Barium
Sodium	Beryllium
Potassium	Boron
Carbonate	Cadmium
Bicarbonate	Copper
Sulfate	Lead
Chloride	Mercury
Fluoride	Selenium
Nitrate	Silver
Nitrite	Silica
Phosphate	Sulfide
Iron, total	Zinc

3.5 Sampling Frequency

The three Phase One detection monitoring wells were sampled five times. The background well (i.e., Kf83-1) is part of the PAP annual monitoring program and data was provided from five sampling events. The Phase Two assessment wells were sampled two times.

3.6 Data Analysis

The groundwater laboratory data generated was entered into the Navajo Mine's database for analytical review (APPENDIX D). The data from well Bitsui -1 installed in ash was used to identify ash leachate indicator parameters. The data collected from the five remaining wells were analyzed to detect potential ash leachate parameters and determine the extent of leachate migration. Statistical analyses of mean, standard deviation, coefficient of variation, and time verse concentration graphs were reviewed to characterize the water quality, identify trends, detect leachate constituents, and identify problems with the laboratory data.

The groundwater analysis results are summarized in APPENDIX D-1 and the complete lab data reports are provided in APPENDIX D-4. The mean, standard deviation, coefficient of variance, and range were calculated for each parameter and are provided in APPENDIX D-3. The data from these sampling events is provided electronically in the format specified for the Office of Surface Mining's Coal Permit and Reclamation Database (APPENDIX D-5).

4.0 RESULTS AND CONCLUSIONS

4.1 Results

The hydrogeologic data collected during the SGS provided potentiometric surface maps, hydrologic gradients, direction of groundwater flow, and groundwater quality information. This information supported previous work completed by Navajo Mine including, baseline hydrogeology, the PHC section, and the Leach Study. The Phase One wells were used to determine the groundwater flow direction, groundwater quantity and quality, hydrologic gradient, and the potentiometric surface. The field potentiometric surface measurements from the Phase One wells are presented in TABLE 2. The potentiometric maps constructed from these measurements are presented in FIGURES 2 through 6 of APPENDIX C. The potentiometric surface maps constructed using the Phase One well information show the groundwater flow direction in the area to be generally in a northeast direction. This is consistent with the flow directions shown in FIGURE 1, for the No. 8 Coal Seam and the direction used in the PHC and Leach Study.

The hydraulic gradients determined using the Phase One wells ranged from 0.0007 ft/ft to 0.0009 ft/ft. This is consistent with the baseline groundwater information provided in the PAP Chapter 6, Groundwater Hydrology. This gradient range is also consistent with the groundwater velocity of 0.076 feet per day stated in Chapter 11, PHC, Section 11.6. These hydrologic characteristics were also used in the Leach Study. The potentiometeric map constructed from measurements collected on March 1, 1995, shows the groundwater flow direction towards the east. This is a result of an error in field measurements.

TABLE 2

NAVAJO MINE
POTENTIOMETRIC SURFACE DATA

WELL	MEASURING POINT ELEVATION (ft)	DATE	DEPTH TO WATER (ft)	WATER LEVEL ELEVATION (ft)
Bitsui 1	5194.76	2/17/95	32.17	5162.59
		3/1/95	32.10	5162.66
		4/27/95	31.90	5162.86
		5/19/95	31.85	5162.91
		10/18/95	30.19	5164.57
Bitsui 2	5217.32	2/17/95	55.92	5161.4[illegible]
		3/2/95	55.07	5162.25
		4/27/95	55.47	5161.85
		5/19/95	55.48	5161.84
		10/18/95	53.96	5163.36
Bitsui 3	5235.97	2/17/95	74.06	5161.91
		3/1/95	74.18	5161.79
		4/27/95	73.94	5162.03
		5/18/95	73.32	5162.65
		10/18/95	72.50	5163.47

A total of five groundwater samples were collected for laboratory analysis from the Phase One wells. The Phase Two wells were sampled two times. The results are presented in APPENDIX D-1 and complete lab data reports are provided in APPENDIX D-4. The statistical analysis performed for each parameter is provided in APPENDIX D-3. The data from these sampling events is provided electronically in the format specified for the Office of Surface Mining's Coal Permit and Reclamation Database (APPENDIX D-5).

The water quality analyses for well Bitsui-1, completed in the ash, exhibit elevated levels of Boron (i.e., mean concentration 8.10 mg/l). These levels were greater than the Boron concentrations found in composite groundwater samples collected as part of the Leach Study (i.e., mean concentration 0.43 mg/l) shown in TABLE 27.B2 (reproduced in APPENDIX B), the downgradient detection wells, and the background well Kf83-1 (i.e., 0.95 mg/l mean concentration). Two graphs are provided in APPENDIX D-6 comparing Boron levels between background, ash, and downgradient wells. The background well Kf83-1 is located upgradient so that its water quality was not affected by ash disposal in the Bitsui A area.

A Piper trilinear plot of the three detection wells Bitsui 1, 2, 3 and the background well KF83-1 is provided in APPENDIX D-2. The plot shows similar water quality between the background well and the downgradient detection wells. Therefore the wells are monitoring the same water bearing formation (i.e., No. 8 Coal Seam).

It was also noted that selenium and arsenic were elevated slightly above detection limits in Bitsui-1 when compared to Bitsui-2 and Bitsui-3 and the background water quality. These two parameters, along with Boron, were used as indicator parameters of leachate formation and transport.

The Boron concentrations detected in Bitsui-1 (i.e., mean concentration 8.10 mg/l), are less than the Boron concentrations detected in the fly ash leached with composite groundwater (i.e., mean concentration 11.1 mg/l) as shown in TABLE 27.B20 from the Leach Study (reproduced in APPENDIX B). This data indicates that the groundwater at well Bitsui-1 has elevated Boron due to contact with the buried ash. However, the Boron levels are less than those predicted by the Leach Study. The downgradient wells Bitsui-2, 3, 4, 5, and 6 completed within the potential extent of the groundwater migration pathway downgradient from the Bitsui A area did not show elevated Boron levels. These monitoring results indicate that Boron as well as other constituents are being attenuated and therefore have not migrated downgradient away from the ash burial location at the same rate as the groundwater. The fact that the Boron levels in well Bitsui-1 are less than those predicted in the Leach Study and are not detected in downgradient detection wells supports the attenuation conclusions of the Leach Study.

While dissolved sodium and sulfate in groundwater are not of particular concern from a water quality perspective, it can be noted from the groundwater quality data collected that those two parameters are elevated in the samples from well Bitsui-1. It can also be noted that sodium and sulfate in well Bitsui-1 are elevated above levels predicted in the Leach Study for fly ash leached with composite groundwater as shown in TABLE 27.B2 in APPENDIX B.

The source of the elevated sodium and sulfate appears to be the spoil material that surrounds the ash at the Bitsui-1 well location. TABLES 27.B15 through 27.B19 (combined in the Leach Study NM-0003D PAP APPENDIX 11-K) show elevated sodium and sulfate levels for spoil materials leached with composite groundwater.

5.0 Conclusions

The conclusion of the SGS is that burial of ash in saturated post mined pits has an negligible impact on human health and the environment. The SGS determined that the probable hydrological consequence of ash disposal and ash generated leachate upon the groundwater quality is insignificant. Ash burial and potential ash affected groundwater does not impact the water quality or quantity significantly as to change the designated use or classification of the groundwater or surface water. These conclusions are consistent with the conclusions of the Leach Study, and the predictions stated in the PHC in the PAP.

The information provided in the Leach Study and the PHC were used to design the SGS, including hydrogeologic and geochemical characteristics, the placement of the wells, and the selection of the water quality parameters. In turn, the results of the SGS supported and strengthened the conclusions made in the Leach Study and PHC. The PHC assumed the rate of movement of the groundwater to be 0.076 ft/day. Based on this flow velocity, the shortest time of travel for leach affected groundwater from the northern most portion of the mine to the San Juan River was estimated to be approximately 200 years. Using a groundwater velocity of approximately 2.6 times the 0.076 ft/day rate and the downgradient historical boundary of ash disposal in the Bitsui A area, a worst case well was installed (i.e., Well Bitsui-6), 40 feet downgradient at the same elevation as the No. 8 Coal Seam . The groundwater sample results from the Bitsui - 6 detection well, as well as the other five detection wells showed no evidence of ash leachate constituent migration. The very slow rate of migration (i.e., less than 40 feet) of potential ash leachate constituents (i.e., Boron, Arsenic, and Selenium) within the time period of approximately the 20 years since the start of ash disposal supports the Leach Study attenuation conclusions.

The results of the Leach Study concluded that the migration of ash leachate constituents may not occur or, if so, at a slower rate than the groundwater velocity. The Leach Study's bench leach tests concluded that the rate of selected constituent migration would be attenuated and would be significantly less than the groundwater velocity of 0.076 ft/day. The failure to detect ash leachate constituents in the downgradient wells above background concentrations supports the attenuation conclusions. The Leach Study determined that the reason for the attenuation of the ash constituents included the absorption and/or precipitation of the constituents from the leachate. The study also predicted that the quality of the groundwater would be expected to generally increase (i.e., metal concentrations usually decrease while sulfate levels increase) when the groundwater is exposed to spoil. Moreover, as the groundwater travels through the water bearing formations (i.e., coal seams) additional attenuation would occur, further reducing migration of constituents and the impact on groundwater quality.

The PHC section of the PAP predicted that the impacts from ash disposal to the hydrologic regime and specifically the San Juan River water, would be so small as to be undetectable. This prediction was based on the baseline hydrogeologic characteristics of the water bearing formation (i.e., No. 8 Coal Seam) and the San Juan River alluvial aquifer and the attenuation determinations made in the Leach Study. Based on the hydrogeologic aquifer tests performed on the Fruitland Formation and the associated No. 8 Coal Seam the PHC concluded that the contribution of leachate affected groundwater to the large storage capacities of the San Juan Valley alluvial aquifer would be undetectable. Moreover, impacts to surface from water contributions of leachate affected groundwater from the Fruitland Formation to the San Juan River using the mean annual flow in San Juan River would be a ratio of 0.000074 to 1.0. The impact of ash affected groundwater on the San Juan River water quality using these results is so small as to be unmeasurable.

The information and conclusions provided in the SGS, PHC, and the Leach Study provide the technical documentation necessary to show that no significant impacts are observed from ash disposal on the quality and quantity of groundwater at the Navajo Mine. Moreover, The findings of the Supplemental Groundwater Study are consistent with United States Environmental Protection Agency's (EPA) 1988 Report to Congress, Wastes from the Combustion of Coal by Electric Utility Power Plants, demonstrating that these wastes do not exhibit hazardous characteristics under current the Resource Conservation Recovery Act regulations. Including, EPA's tentative conclusion that current waste management practices appear to be adequate for protecting human health and the environment.

APPENDIX A
WELL LOGS AND WELL CONSTRUCTION DIAGRAMS

November 1996

BHP Minerals
Navajo Mine
Fruitland

NAVAJO MINE

PROJECT: SGS Phase One , BHP Minerals Navajo Mine
AREA: BITSUI A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Metric Corp.
DRILLER: Rogers & Company Inc.

BORING NUMBER: Bitsui-1
TOTAL DEPTH: 78.7'
LOGGER: Phil Eerry, Metric Corp.
NORTHING: 2,081,799.4
EASTING: 330,254.5
COLLAR ELEVATION: 5191.92
DATE COLLARED: June 15,1994
DATE BOTTOMED: June 15,1994

FORMATION RECORD

Interval	Thickness	Description
0.0-8.7	8.7	Brownish gray (5YR 4/1) sandy clay with some granule and pabble gravel.
8.7-28.7	20	Brownish gray (5YR 4/1) sandy clay with some granule gravel.
28.7-38.7	10	Light olive gray (5Y6/1) sandy clay with siliceous bottom ash.
38.7-55.0	16.3	Light olive gray (5Y6/1) siliceous bottom ash and sandy fly ash.
55.0-63.7	8.7	Light gray (N7) fly ash.
63.7-73.7	10	Light olive gray (5Y 6/1) siliceous bottom ash and sandy fly ash.
73.7-78.7	5.0	Olive gray (5Y 4/1) shale .

REMARKS:

NAVAJO MINE

PROJECT: SGS Phase One. BHP Minerals Navajo Mine
AREA: BITSUI A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Metric Corp.
DRILLER: Rogers & Company Inc.

BORING NUMBER: Bitsui-2
TOTAL DEPTH: 125.0'
LOGGER: Phil Eerry, Metric Corp.
NORTHING: 2,082,771.6
EASTING: 331,198.7
COLLAR ELEVATION: 5,214.5
DATE COLLARED: July 13,1994
DATE BOTTOMED: July 13,1994

FORMATION RECORD

Interval	Thickness	Description
0.0-5.0	5.0	Pale yellowish brown (10YR 6/2) weathered shale.
5.0-10.0	5.0	Dark yellowish brown (10YR 4/2) weathered shale.
10.0-30.0	20.0	Pale yellowish brown (10YR 6/2) weathered shale.
30.0-40.0	10.0	Dark yellowish brown (10YR 4/2) weathered shale.
40.0-49.0	9.0	Light olive gray (5Y 6/1) weathered shale.
49.0-52.0	3.0	Black (N1) coal.
52.0-56.0	4.0	Light olive gray (5Y 6/1) weathered shale.
56.0-95.0	39.0	Light olive gray (5Y 6/1) friable shale.
95.0-99.0	4.0	Pale yellowish brown (10YR 6/2) friable shale.
99.0-120.0	21.0	Grayish black (N2) coal.
120.0-125.0	5.0	Olive gray (5Y 4/1) friable shale.

REMARKS:

NAVAJO MINE

PROJECT: SGS Phase One, BHP Minerals Navajo mine
AREA: BITSUI A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Metric Corp.
DRILLER: Rogers & Company Inc.

BORING NUMBER: Bitsui-3
TOTAL DEPTH: 175.0'
LOGGER: Phil Berry, Metric Corp.
NORTHING: 2,081,610.5
EASTING: 332,157.1
COLLAR ELEVATION: 5,233.8.5
DATE COLLARED: July 14,1994
DATE BOTTOMED: July 14,1994

FORMATION RECORD

Interval	Thickness	Description
0.0-13	13.0	Pale yellowish brown (10YR 6/2) poorly sorted.
		subangular to subrounded, very fine sand to vary course
		sand
13.0-25.0	12.0	Grayish orange (10YR 7/4) medium sorted subrounded.
		fine to medium sand.
25.0-35.0	10.0	Grayish orange (10YR 7/4) poorly sorted, subrounded
		very fine sand to granule gravel.
35.0-62.0	27.0	Light olive gray (5Y 6/1) weathered shale.
62.0-63.0	1.0	Olive gray (5 Y 4/1) carbonaceous shale.
63.0-68.0	5.0	Light olive gray (5Y i6/1) weathered shale.
68.0-69.0	1.0	Olive gray (5Y 4/1) carbonaceous shale.
69.0-78.0	9.0	Light olive gray (5Y 6/1) weathered shale.
78.0-80.0	2.0	Black (N1) coal.
80.0-100.0	20.0	Light olive gray (5Y 6/1) friable shale.
100.0-133.0	33.0	Olive gray (5Y 4/1) friable shale.
133.0-140.0	7.0	Grayish black (N2) coal.
140.0-148.0	8.0	Olive gray (5Y 4/1) friable shale.
148.0-152.0	4.0	Black (N1) coal.
152.0-157.0	5.0	Olive black (5Y 2/1) shale.
157.0-170.0	13.0	Black (N1) coal.
170.0-175.0	5.0	Olive gray (5Y 4/1) shale.

REMARKS:

NAVAJO MINE

PROJECT: SGS Phase Two, BHP Minerals Navajo Mine
AREA: BITSUI A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Philip Environment
DRILLER: Mike Donohue

HOLE NUMBER: Bitsui-4
TOTAL DEPTH: 63.0'
LOGGER:
NORTHING: 2,082,065.3
EASTING: 330,339.5
COLLAR ELEVATION: 5,192.6
DATE COLLARED: 26-Jan-1996
DATE BOTTOMED: 25-Jan-1996

FORMATION RECORD

Interval	Thickness	Description
0.0-2.0	2.0	Tan topsoil material mostly silly sand, very loose.
2.0-24.0	22.0	Gray spoil, shale and sandstone.
24.0-63	39.0	Gray spoil shale and sandstone material.
63.0		Bottom of hole.

REMARKS:

DATE PREPARED: Feb. 03-96

PREPARED BY: K. valdez

NAVAJO MINE

PROJECT: GSG Phase Two. BHP Minerals Navajo Mine
AREA: BITSUI A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Philip Environment
DRILLER: Mike Donohue

HOLE NUMBER: Bitsui-5
TOTAL DEPTH: 63.0'
LOGGER: KEROY VALDEZ
NORTHING: 2,082,169.5
EASTING: 331,089.2
COLLAR ELEVATION: 5,181.1
DATE COLLARED: 26-Jan-1996
DATE BOTTOMED: 26-Jan-1996

FORMATION RECORD

Interval	Thickness	Description
0.0-2.0	2.0	Tan topsoil material mostly sand and very loose.
2.0-18.0	16.0	Gray spoil material, mostly fine grained sand with shale.
18.0-24.0	6.0	Dark brown spoil, shale and sandstone.
24.0-76.0	52.0	Dark brown clay material well compacted, fine grained.
76.0		Bottom of hole.

REMARKS:

DATE PREPARED: Feb. 03-96

PREPARED BY: K. valdez

NAVAJO MINE

PROJECT: SGS Phase Two, BHP Minerals Navajo Mine
AREA: Bitsui A
SECTION: 15
TOWNSHIP: T29N
RANGE: R15W
CONTRACTOR: Philip Environment
DRILLER: Freddie Rivera

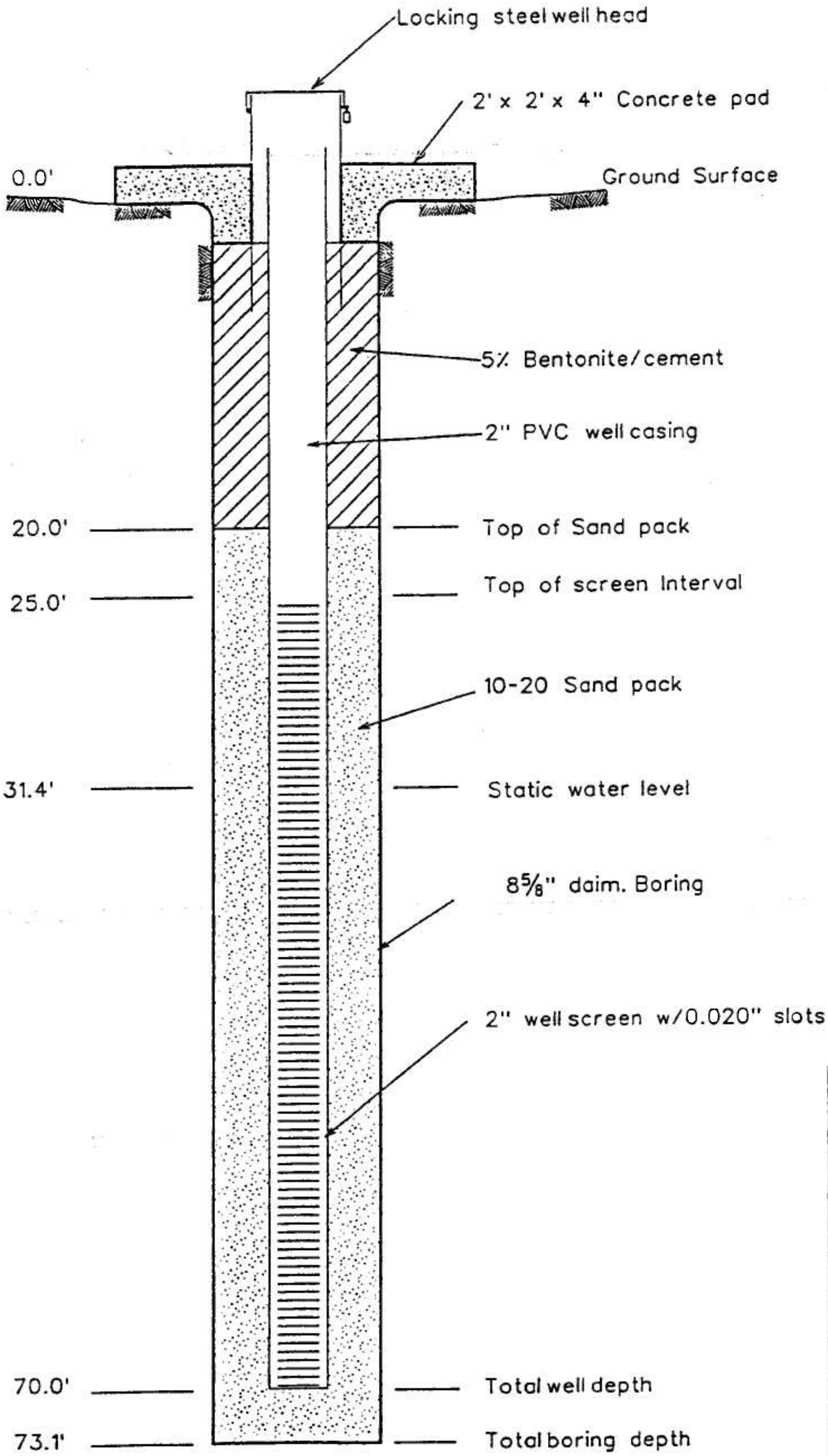
BORING NUMBER: Bitsui-6
TOTAL DEPTH: 76.0'
LOGGER: KEROY VALDEZ
NORTHING: 2,081,971.3
EASTING: 330,239.4
COLLAR ELEVATION: 5,195.6
DATE COLLARED: 31-Jan-1996
DATE BOTTOMED: 30-Jan-1996

FORMATION RECORD

Interval	Thickness	Description
0.0-2.0	2.0	Tan, sandy topsoil material, fine to coarse grained, soft.
2.0-7.0	5.0	Tan/gray, sandy spoil material, with shale and rounded sandstone, fine to coarse grained.
7.0-8.0	1.0	Tan/gray sandy spoil material with shale and rounded sandstone, fine to coarse grained.
8.0-23.0	15.0	Gray sandy spoil materiel with shale and rounded sandstone, fine to coarse grained.
23.0-38.0	15.0	Gray sandy spoil with shale and rounded sandstone, fine grained.
38.0-60.0	22.0	No material came up.
60.0-63.0	3.0	Hard rock and slow drilling.
63.0-76.0	13.0	No material came up, stopped activity at this point to have the water stabilize overnight.
76.0' T.D.		

DATE PREPARED: Feb. 03-96

PREPARED BY: K. valdez



BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

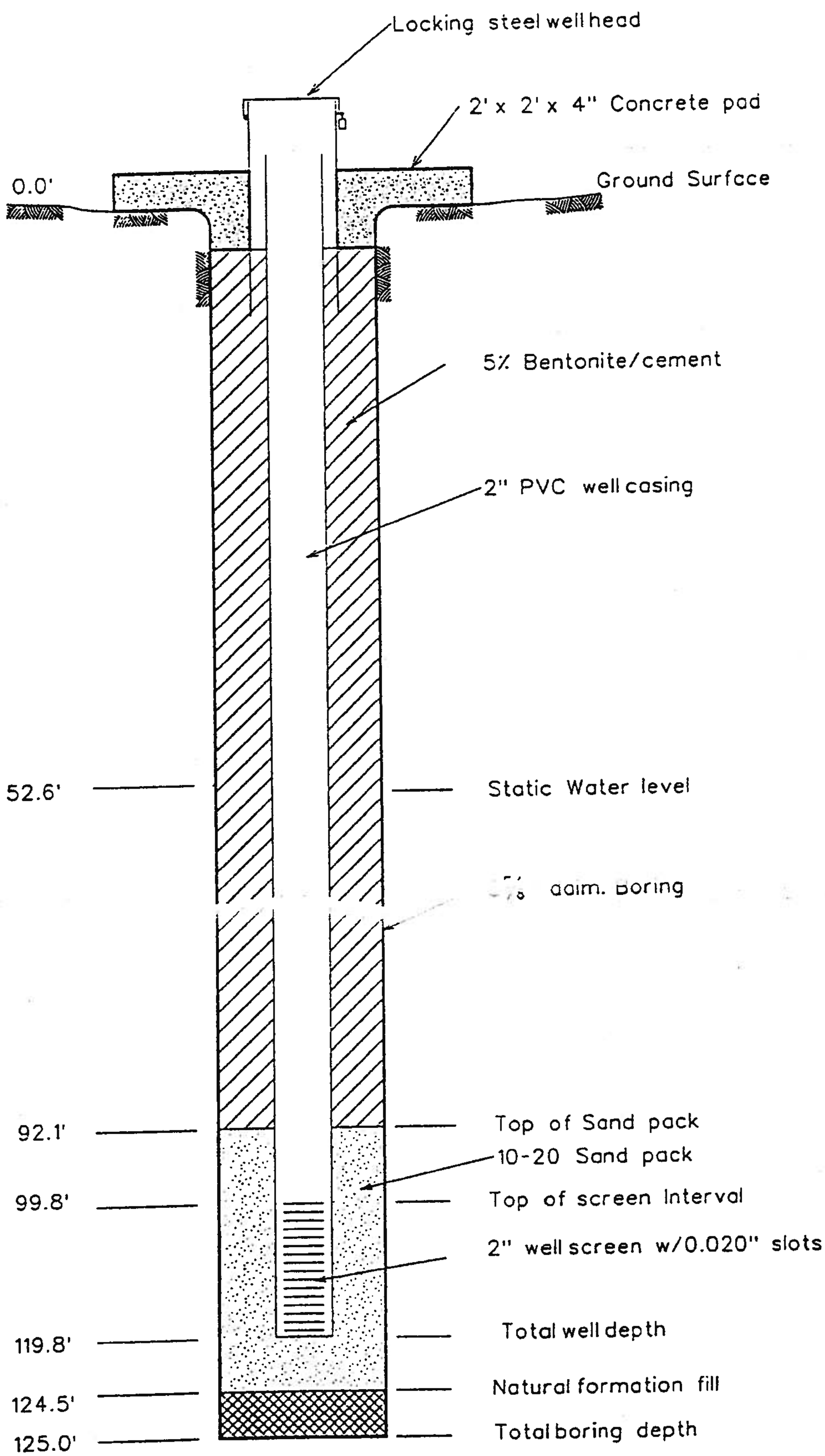
BITSUI-1

WELL CONSTRUCTION DIAGRAM

SUPPLEMENTAL

GROUNDWATER STUDY

PREPARED BY P.S	DRAWN BY PJS	SCALE N.T.S.
APPROVED BY	DATE OCT 13, 1996	DWG. LOC.
DWG. No.	REF. DWG.	



BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

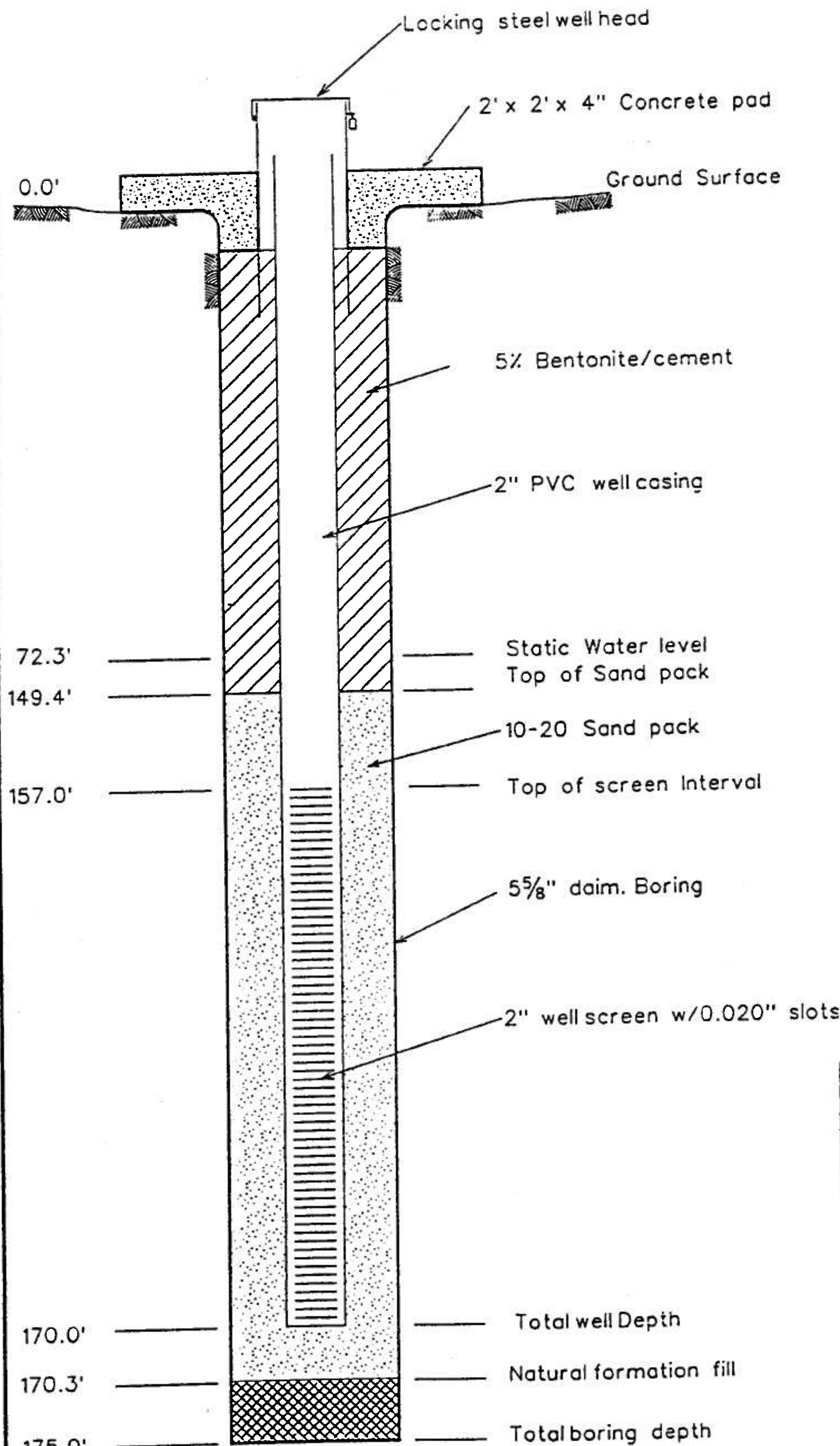
BITSUI-2

WELL CONSTRUCTION DIAGRAM

SUPPLEMENTAL

GROUNDWATER STUDY

PREPARED BY PJ	DRAWN BY PJB	SCALE N.T.S.
APPROVED BY	DATE OCT 12, 1996	DWG. LOC.
DWG. No.	REF. DWG.	



BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O BOX 155 FRUITLAND, NEW MEXICO 87416

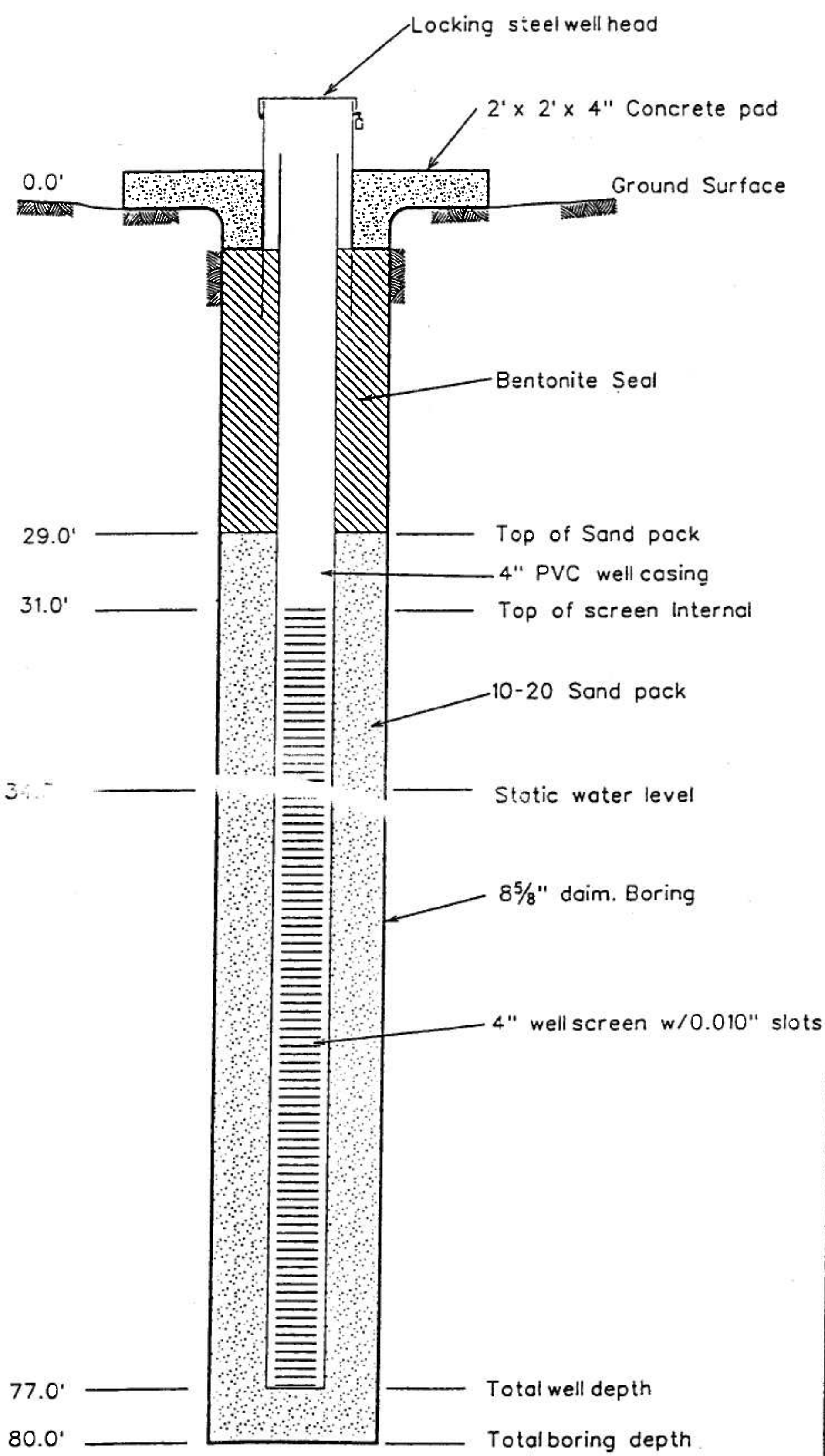
BITSUI-3

WELL CONSTRUCTION DIAGRAM

SUPPLEMENTAL

GROUNDWATER STUDY

PREPARED BY P.S.	DRAWN BY P.S.	SCALE N.T.S.
APPROVED BY	DATE OCT 13, 1996	DWG. LOC.
DWG. No.	REF. DWG.	



REV. No.	DATE	DRAFT'G BY	REVISION DESCRIPTION

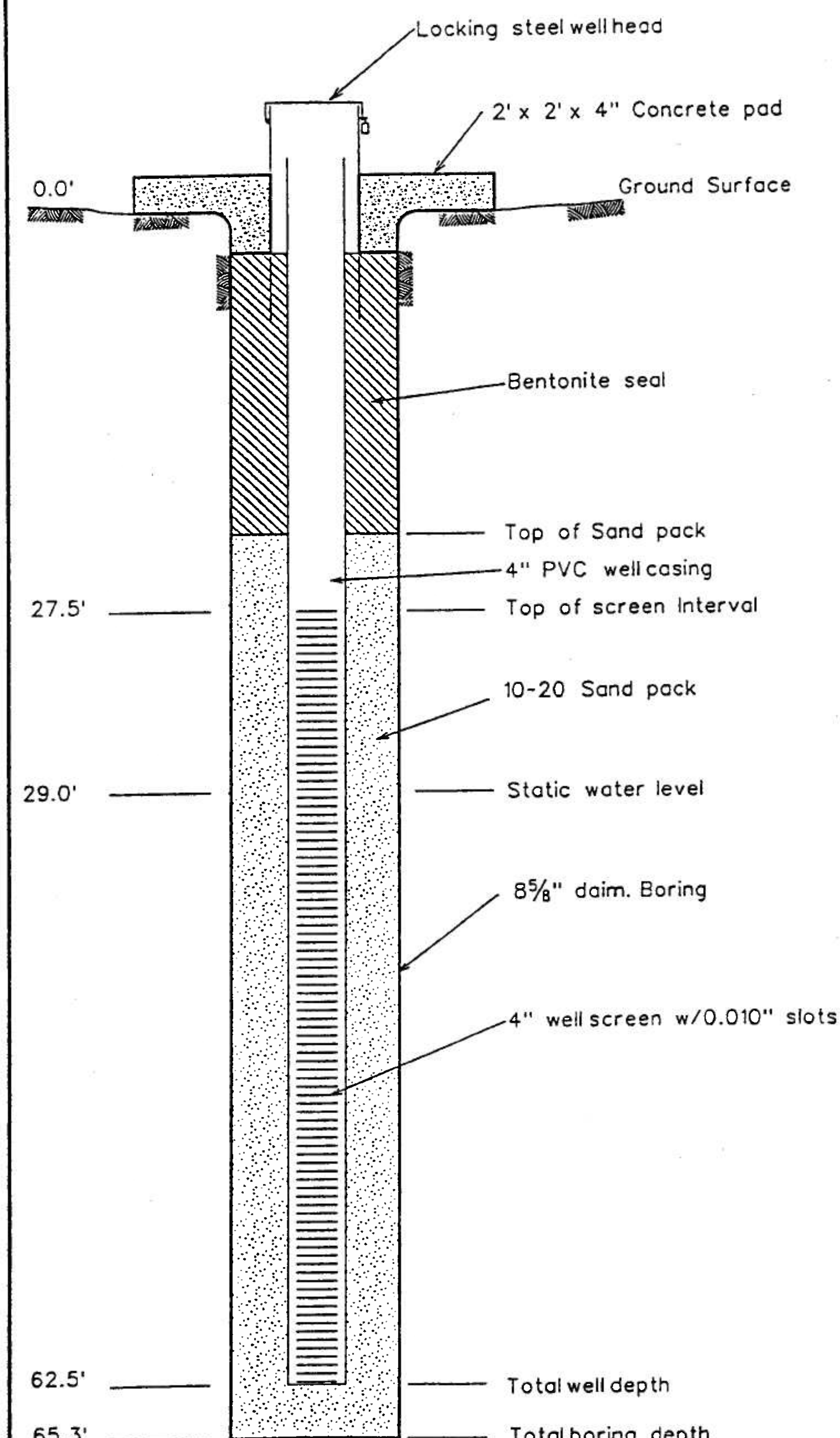
BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

BITSUI-4
WELL CONSTRUCTION DIAGRAM
SUPPLEMENTAL
GROUNDWATER STUDY

PREPARED BY PJF	DRAWN BY PJF	SCALE N.T.S.
APPROVED BY	DATE OCT 13, 1996	DWG. LOC.
DWG. No.	REF. DWG.	



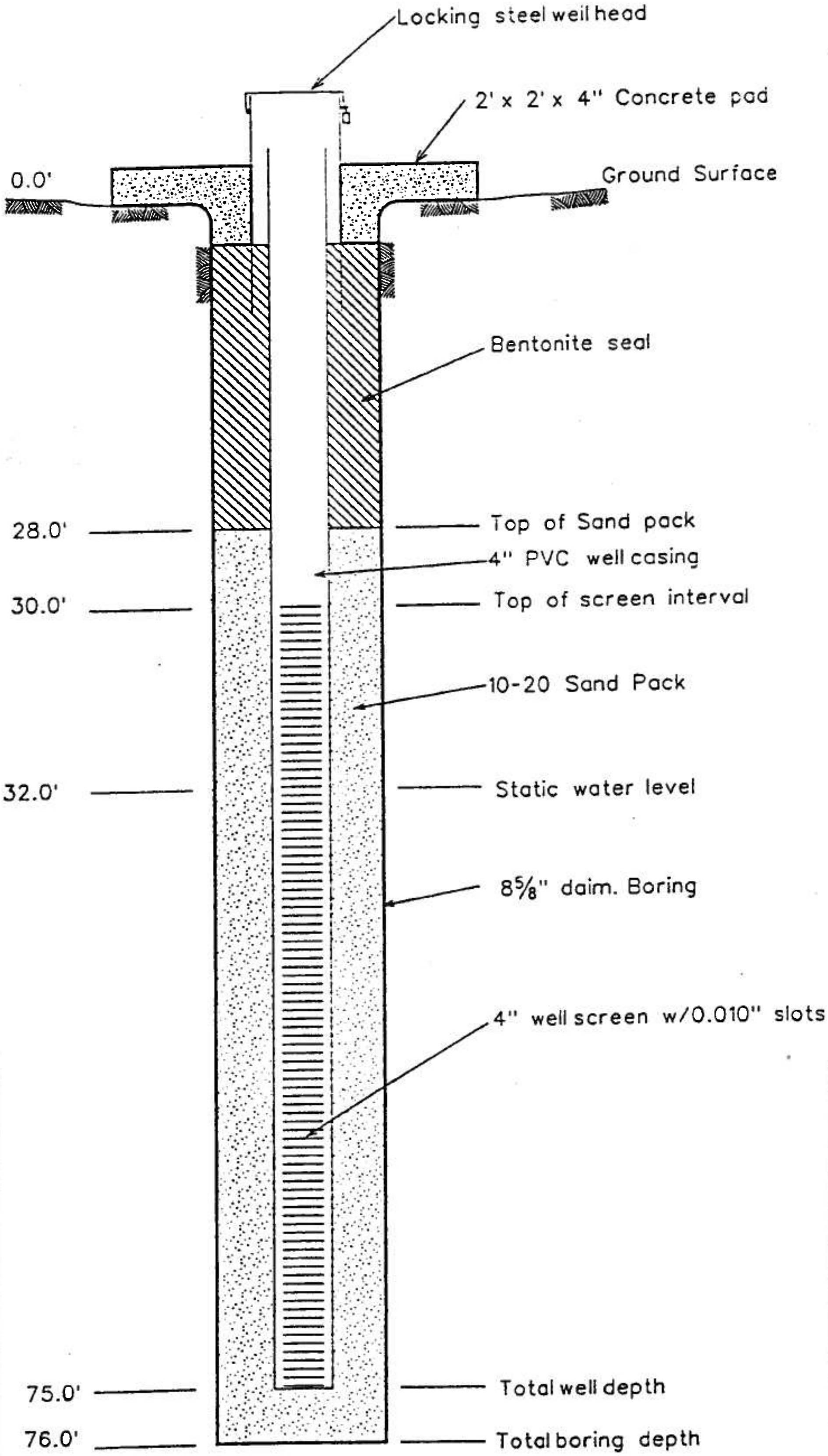
BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

BITSUI-5
WELL CONSTRUCTION DIAGRAM
SUPPLEMENTAL
GROUNDWATER STUDY

PREPARED BY PJ	DRAWN BY PJ	SCALE N.T.S.
APPROVED BY	DATE OCT 13, 1996	DWG. LOC.
DWG. No.		REF. DWG.



BHP NAVAJO COAL COMPANY

NAVAJO MINE

P.O. BOX 155 FRUITLAND, NEW MEXICO 87416

BITSUI-6
WELL CONSTRUCTION DIAGRAM
SUPPLEMENTAL
GROUNDWATER STUDY

PREPARED BY PJF	DRAWN BY PJF	SCALE N.T.S.
APPROVED BY	DATE OCT 13, 1996	DWG. LOC.
DWG. No.	REF. DWG.	

APPENDIX B

LEACH STUDY

TABLE 27.B2 AND TABLE 27.B20

November 1996

BHP Minerals

Navajo Mine

Fruitland

TABLE 27.B2

WATER ANALYSIS SUMMARY

PARAMETER	UNITS	SAMPLE IDENTIFICATION: SURFACE WATER	COMPOSITE 1	COMPOSITE 2	COMPOSITE 3
General Chemistry:					
Acidity	mg/ℓ[1] $CaCO_3$	<1	<1	NA[3]	<1
Alkalinity	mg/ℓ $CaCO_3$	88	3,100	NA	940
Chloride	mg/ℓ	15	380	7.5	310
Cyanide	mg/ℓ	<0.02	<0.02	<0.01	<0.02
Fluoride	mg/ℓ	1.0	2.2	0.62	2.6
Nitrate	mg/ℓ NO_3-N	9.7	4.5	0.03	1.3
pH	--	7.80	8.80	11.93	8.70
Phenolics	mg/ℓ	<0.01	<0.01	0.07	0.01
Residue:					
Filterable @ 180°C	mg/ℓ	1,900	4,400	7,250	4,100
Specific Conductance	umhos/cm @ 25°C	2,310	5,900	NA	6,000
Sulfate	mg/ℓ SO_4^{-2}	1,200	22	<1.0	1,500
Metals:					
Aluminum	mg/ℓ	0.69/0.75[2]	0.68	5.0	1.3
Arsenic	mg/ℓ	<0.001	0.004	<0.001	0.008
Barium	mg/ℓ	0.03/0.02	1.5	3.9	0.06
Boron	mg/ℓ	0.31	0.97	<0.01	0.20
Cadmium	mg/ℓ	<0.001/<0.002	<0.001/0.002	<0.004/0.004	0.002/0.002
Calcium	mg/ℓ	230	11	620	36
Chromium	mg/ℓ	0.002	0.001	0.14	0.006
Cobalt	mg/ℓ	<0.001/0.001	0.008/0.002	<0.01/<0.004	0.014/0.012
Copper	mg/ℓ	0.04/0.031	0.02/0.051	<0.02/0.029	<0.01/0.017
Iron	mg/ℓ	0.45	2.8	0.07	3.7/3.8
Lead	mg/ℓ	<0.01/<0.01	0.03/0.03	0.1	0.02/<0.01
Magnesium	mg/ℓ	28	3.6	0.8	4.5
Manganese	mg/ℓ	0.08	0.47	0.06	0.38
Mercury (Total)	mg/ℓ	<0.0002	<0.0002	<0.001	<0.0002
Molybdenum	mg/ℓ	<0.001	0.005	<0.05	0.003
Nickel	mg/ℓ	0.04	0.11	<0.01	0.07
Potassium	mg/ℓ	11	7.2	66	8.4
Selenium	mg/ℓ	<0.001	0.006	<0.018	0.014
Silver	mg/ℓ	<0.001/<0.002	<0.001/<0.002	<0.002	0.001/<0.002
Sodium	mg/ℓ	280	1,600	2,300	1,400
Zinc	mg/ℓ	0.06	0.07	0.04	0.08
Total Alpha	pCi/ℓ[4]	0.5±0.5	1.7±0.6	1.0±0.5	0.8±0.7
Total Beta	pCi/ℓ	4.7±4.7	4.2±4.1	5.2±4.5	4.0±4.3
Total Radium (226 and 228)	pCi/ℓ	0.3±0.6	0.3±0.6	0.5±0.7	0.2±0.5

TABLE 27.B2
(Continued)

PARAMETER	UNITS	SAMPLE IDENTIFICATION COMPOSITE 4	COMPOSITE 5
General Chemistry:			
Acidity	mg/ℓ[1] $CaCO_3$	<1	<1
Alkalinity	mg/ℓ $CaCO_3$	510	940
Chloride	mg/ℓ	5,200	2,000
Cyanide	mg/ℓ	<0.02	<0.02
Fluoride	mg/ℓ	0.3	1.3
Nitrate	mg/ℓ NO_3-N	18	11
pH	—	8.20	9.50
Phenolics	mg/ℓ	0.04	0.02
Residue:			
Filterable @ 180°C	mg/ℓ	9,800	4,600
Specific Conductance	umhos/cm @ 25°C	15,600	8,100
Sulfate	mg/ℓ SO_4^{-2}	120	55
Metals:			
Aluminum	mg/ℓ	<0.01	1.7
Arsenic	mg/ℓ	0.015	0.017
Barium	mg/ℓ	0.92	2.5
Boron	mg/ℓ	0.53	0.42
Cadmium	mg/ℓ	0.001	0.002/<0.001
Calcium	mg/ℓ	140	140
Chromium	mg/ℓ	0.008	0.034
Cobalt	mg/ℓ	0.035/0.034	0.017
Copper	mg/ℓ	<0.01	0.04
Iron	mg/ℓ	0.15	5.6
Lead	mg/ℓ	0.12	0.08
Magnesium	mg/ℓ	32	11
Manganese	mg/ℓ	0.03	0.70/0.70
Mercury (Total)	mg/ℓ	<0.0002	<0.0002
Molybdenum	mg/ℓ	0.025	0.008/0.006
Nickel	mg/ℓ	0.11	0.04/0.04
Potassium	mg/ℓ	19	12
Selenium	mg/ℓ	0.011	0.020
Silver	mg/ℓ	<0.001/<0.002	0.015/<0.002
Sodium	mg/ℓ	3,500	1,600
Zinc	mg/ℓ	0.21/0.22	0.09
Total Alpha	pCi/ℓ[4]	1.9±0.5	<0.1
Total Beta	pCi/ℓ	4.0±3.7	3.9±3.9
Total Radium (226 and 228)	pCi/ℓ	0.4±0.6	0.4±0.6

(1) mg/ℓ = milligrams per liter or parts per million.
(2) The indicated sample was analyzed in duplicate.
(3) Not analyzed.
(4) pCi/ℓ = pico curies per liter.

1:4 ASTM LEACHATE ANALYSIS SUMMARY
FOR FLY ASH

Amended 02/88, 01/89
27-B-52

PARAMETER	UNITS	FLY ASH LEACHED WITH: SURFACE WATER	COMPOSITE 1	COMPOSITE 3
General Chemistry:				
Acidity	mg/ℓ(1) $CaCO_3$	<1	<1	<1
Alkalinity	mg/ℓ $CaCO_3$	820	2,600	840
Chloride	mg/ℓ	16	360	290
Cyanide	mg/ℓ	<0.02	<0.02	<0.02
Fluoride	mg/ℓ	1.9	1.6	0.4
Nitrate	mg/ℓ NO_3-N	3.3	2.0	2.0
pH	—	12.20	10.30	11.80
Phenolics	mg/ℓ	0.03	0.03	0.03
Residue:				
Filterable @ 180°C	mg/ℓ	2,000	4,300	4,500
Specific Conductance	umhos/cm @ 25°C	5,490	7,470	7,350
Sulfate	mg/ℓ SO_4^{-2}	590	510	1,200
Metals:				
Aluminum	mg/ℓ	0.8	15	16
Arsenic	mg/ℓ	0.009	1.00	0.140
Barium	mg/ℓ	0.49	0.30	0.33
Boron	mg/ℓ	1.0	20	12
Cadmium	mg/ℓ	<0.001	<0.001	<0.001
Calcium	mg/ℓ	290	7	80
Chromium	mg/ℓ	0.14	0.24	0.22
Cobalt	mg/ℓ	<0.001	0.005	0.004
Copper	mg/ℓ	<0.01	<0.01	<0.01
Iron	mg/ℓ	0.02	0.07	0.04
Lead	mg/ℓ	<0.01	0.01	0.01
Magnesium	mg/ℓ	0.2	0.8	0.2
Manganese	mg/ℓ	0.02	0.02	<0.01
Mercury	mg/ℓ	<0.0002	<0.0002	<0.0002
Molybdenum	mg/ℓ	1.4	0.75	0.64
Nickel	mg/ℓ	<0.01	<0.01	<0.01
Potassium	mg/ℓ	17	7.0	9.2
Selenium	mg/ℓ	0.09	0.83	0.32
Silver	mg/ℓ	<0.001/<0.001	<0.001/0.002	0.001
Sodium	mg/ℓ	380	1,300	1,100
Zinc	mg/ℓ	0.01	0.01	0.01

PARAMETER	UNITS	COMPOSITE 4	COMPOSITE 5	DEIONIZED WATER
General Chemistry:				
Acidity	mg/ℓ(1) $CaCO_3$	<1	<1	<1
Alkalinity	mg/ℓ $CaCO_3$	960	1,000	1,400
Chloride	mg/ℓ	5,600	2,100	3.9
Cyanide	mg/ℓ	<0.02	0.04	<0.02
Fluoride	mg/ℓ	3.1	1.9	3.3
Nitrate	mg/ℓ NO_3-N	19	3.3	2.5
pH	—	12.00	12.15	12.10
Phenolics	mg/ℓ	0.03	0.05	0.05
Residue:				
Filterable @ 180°C	mg/ℓ	10,000	4,800	1,600
Specific Conductance	μmhos/cm @ 25°C	[illegible]	12,500	5,710
Sulfate	mg/ℓ SO_4^{-2}	320	370	130
Metals:				
Aluminum	mg/ℓ	0.3	2.0	<0.1
Arsenic	mg/ℓ	0.017	0.030	0.010
Barium	mg/ℓ	1.3	1.7	4.9
Boron	mg/ℓ	6.2	6.2	5.1
Cadmium	mg/ℓ	<0.001	<0.001	<0.001/<0.001
Calcium	mg/ℓ	520	160	590
Chromium	mg/ℓ	0.070	0.118	0.036
Cobalt	mg/ℓ	0.070	0.006	<0.001
Copper	mg/ℓ	<0.01	<0.01	<0.01/0.05
Iron	mg/ℓ	0.04	0.03	0.02
Lead	mg/ℓ	0.19	0.04	<0.01/<0.01
Magnesium	mg/ℓ	0.2	<0.1	0.2
Manganese	mg/ℓ	0.02	<0.01	0.02/0.02
Mercury	mg/ℓ	0.0006	<0.0002	<0.0002
Molybdenum	mg/ℓ	1.5	1.2	1.5
Nickel	mg/ℓ	0.05	<0.01	0.07
Potassium	mg/ℓ	22	14	2.0/2.0
Selenium	mg/ℓ	0.22	0.38	0.24
Silver	mg/ℓ	0.001/0.002	<0.001/0.001	0.016/0.014
Sodium	mg/ℓ	3,000	1,900	41
Zinc	mg/ℓ	0.01	0.01	0.04/0.04

APPENDIX C
GROUNDWATER POTENTIOMETRIC MAPS

November 1996

BHP Minerals

Navajo Mine

Fruitland

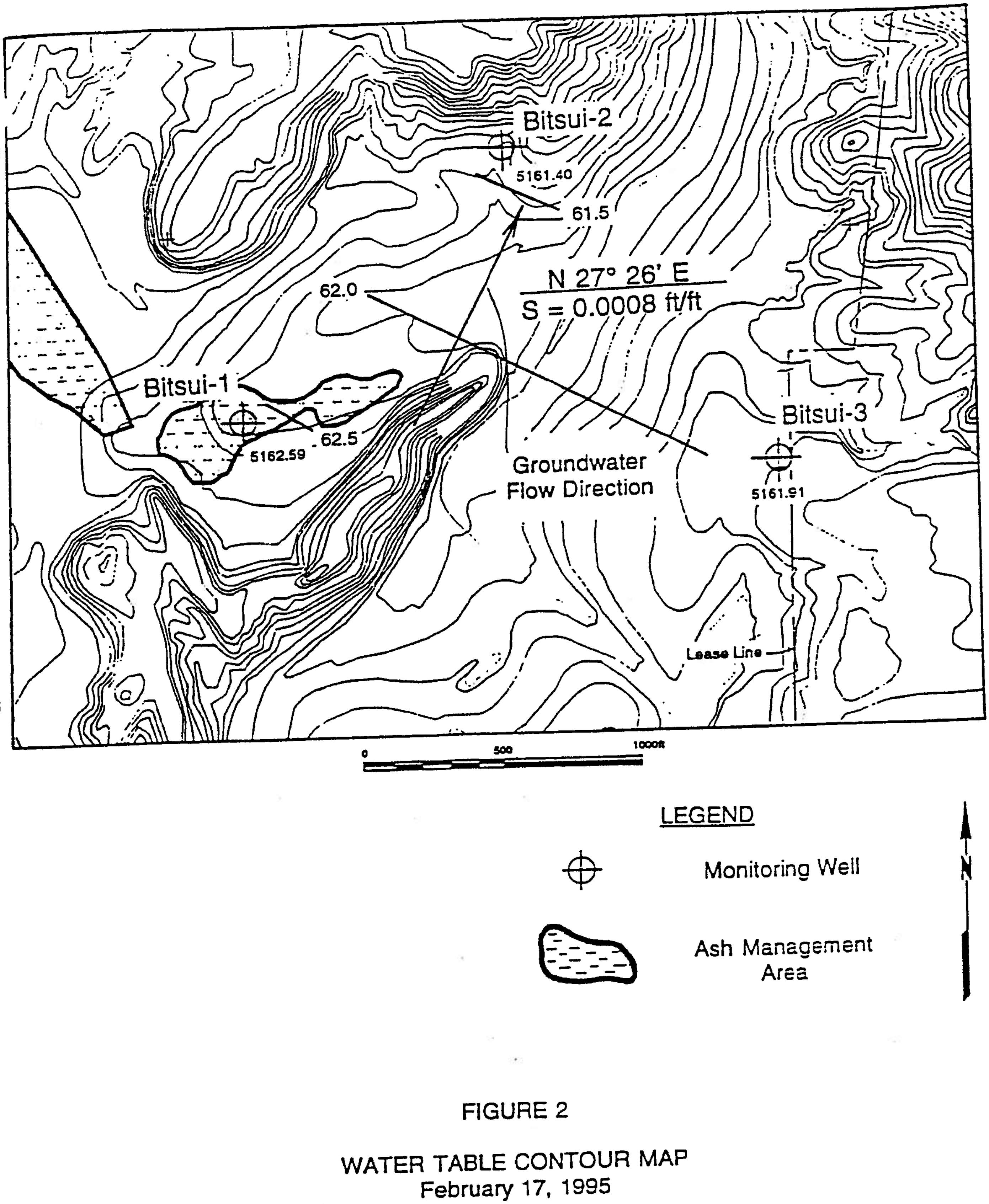


FIGURE 2

WATER TABLE CONTOUR MAP
February 17, 1995

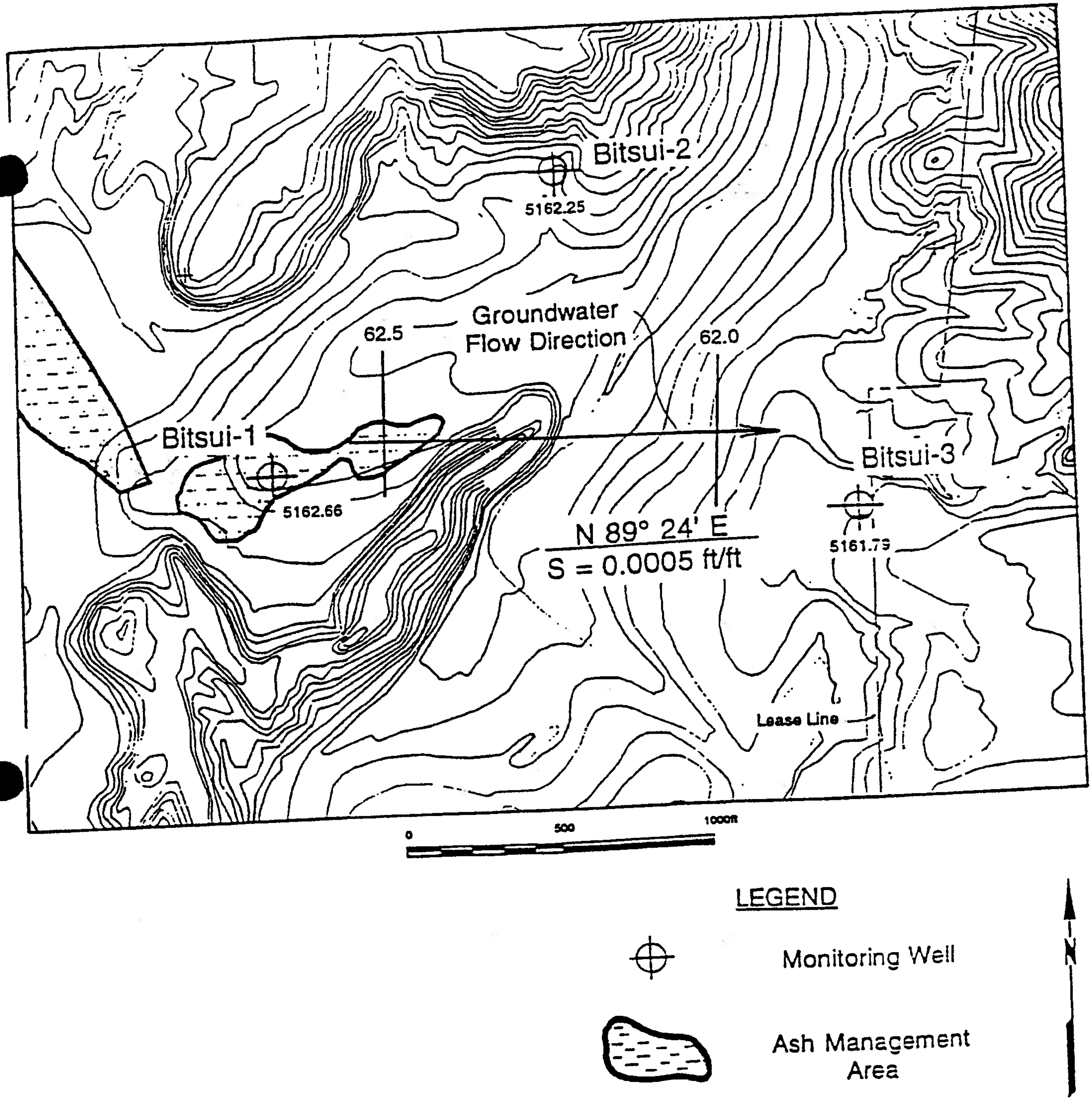


FIGURE 3

WATER TABLE CONTOUR MAP
March 1, 1995

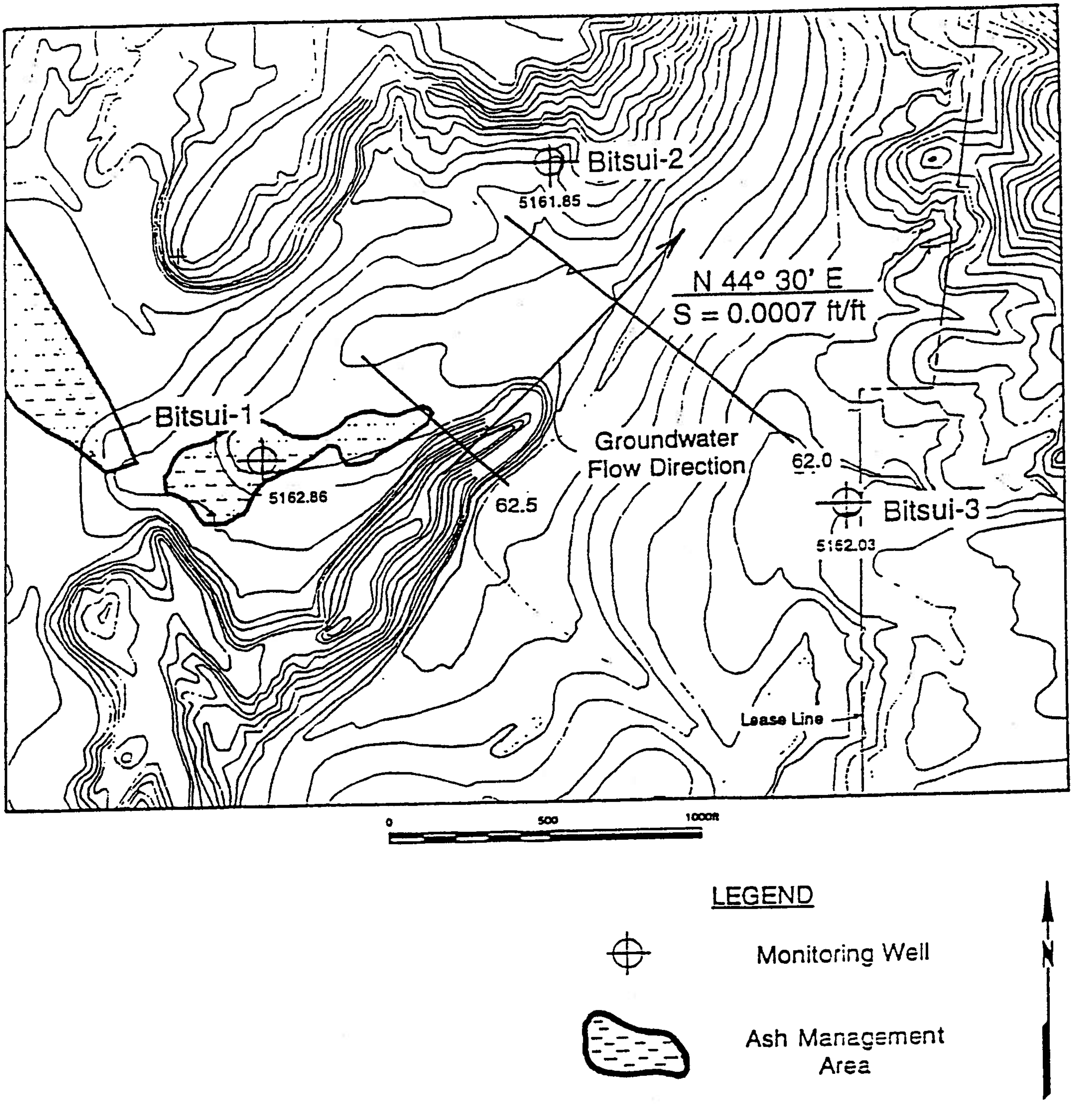


FIGURE 4

WATER TABLE CONTOUR MAP
April 27, 1995

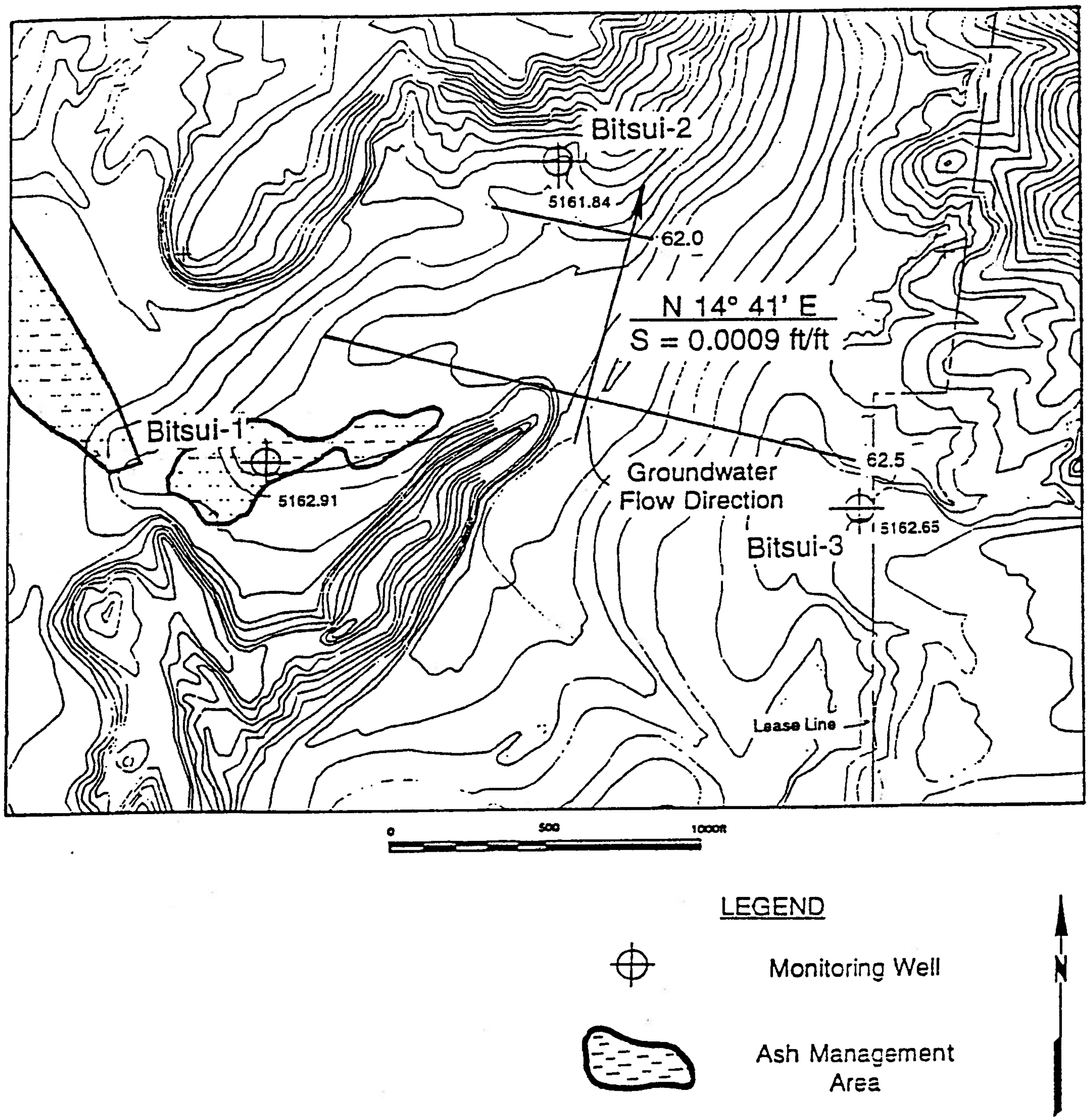


FIGURE 5

WATER TABLE CONTOUR MAP
May 18, 1995

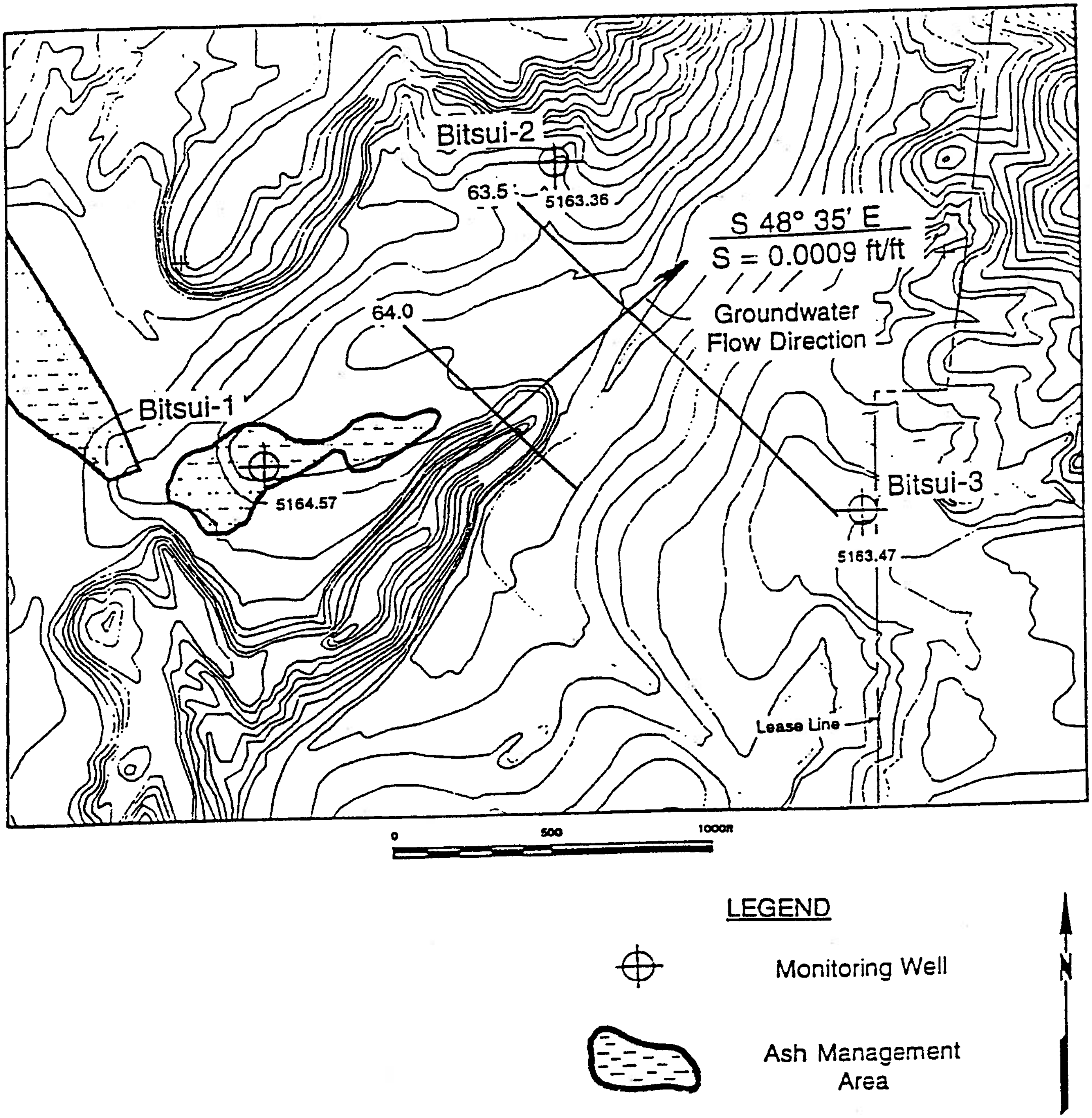


FIGURE 6

WATER TABLE CONTOUR MAP
October 18, 1995

APPENDIX D

ANALYTICAL DATA AND RESULTS

D-1	Groundwater Data Summary Tables
D-2	Piper Trilinear Plots
D-3	Statistical Summary Reports
D-4	Original Laboratory Data
D-5	Electronic Data (Originally submitted in June 1996 submission).
D-6	Water Quality Graphs

APPENDIX D
ANALYTICAL DATA AND RESULTS

D-1 Groundwater Data Summary Tables

November 1996

BHP Minerals

Navajo Mine

Fruitland

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-1	BITSUI-1	BITSUI-1	BITSUI-1	BITSUI-1
Sample Date:		03/01/95	04/27/95	05/19/95	10/19/95	01/02/96
LABORATORY MEASUREMENTS						
pH	(S.U.)	8.70	8.80	8.80	8.90	8.80
Conductivity	(umho/cm)	17800	18100	25900	17800	17300
TDS (180 deg C)	(mg/l)	14200	14200	14200	14200	14700
Boron	(mg/l)	9.20	7.60	8.44	6.98	8.30
Fluoride	(mg/l)	2.60	2.64	2.71	2.51	4.39
Nutrients						
Nitrate as N	(mg/l)	1.40	2.40	1.50	-0.01	0.73
Nitrite as N	(mg/l)	-0.01	-0.01	-0.01	-0.01	-0.05
Major Ions						
Bicarbonate as HCO3	(mg/l)	1020.00	1160.00	1180.00	1010.00	837.00
Carbonate as CO3	(mg/l)	82.00	60.00	84.00	108.00	96.00
Sulfate	(mg/l)	6780.00	6680.00	7100.00	6850.00	6990.00
Sulfide	(mg/l)	0.570	N	-0.010	N	-0.010
Calcium	(mg/l)	46.00	56.00	45.00	56.00	63.00
Magnesium	(mg/l)	28.00	34.00	29.00	27.00	32.00
Sodium	(mg/l)	4980.00	4970.00	4830.00	4860.00	5040.00
Potassium	(mg/l)	27.00	54.00	23.00	20.00	20.00
Chloride	(mg/l)	1880.00	2050.00	2070.00	1950.00	1930.00
Total Phosphorus	(mg/l)	1.89	1.88	N	N	N
Major Cations	(meq/l)	221.91	223.15	215.32	216.92	225.51
Major Anions	(meq/l)	213.75	218.08	228.47	217.77	218.36
Charge Balance	(percent)	1.87	1.15	2.96	0.20	1.61
Lab Determined Cations	(meq/l)	221.80	223.26	215.22	216.89	225.36
Lab Determined Anions	(meq/l)	213.93	218.10	228.70	218.06	218.69
Lab Determined Ion Balance	(percent)	1.81	1.17	3.04	0.27	1.50
Trace Metals (Dissolved)						
Aluminum	(mg/l)	-0.100	N	-0.100	N	0.150
Arsenic	(mg/l)	0.040	0.030	0.040	N	0.036
Barium	(mg/l)	-0.050	-0.500	-0.500	-0.500	0.030
Beryllium	(mg/l)	-0.0010	N	-0.0010	N	-0.0050
Cadmium	(mg/l)	0.0030	-0.0020	-0.0050	-0.0020	-0.0020
Copper	(mg/l)	-0.010	N	-0.010	N	-0.010
Iron	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.050
Lead	(mg/l)	0.006	0.011	-0.050	-0.005	-0.005
Manganese	(mg/l)	0.110	0.094	0.100	0.080	0.100
Mercury	(mg/l)	-0.00100	N	-0.00100	N	-0.00100
Selenium	(mg/l)	0.009	0.007	0.007	0.016	0.010
Silica as Si	(mg/l)	6.950	N	6.660	N	6.970
Silver	(mg/l)	-0.010	-0.010	-0.010	N	-0.010
Zinc	(mg/l)	0.050	-0.010	-0.010	N	-0.010
Trace Metals (Total)						
Total Iron	(mg/l)	1.50	0.90	1.06	0.62	0.65
Total Manganese	(mg/l)	0.14	0.11	0.11	0.07	0.10

Note: N => No measurement

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2
Sample Date:		03/02/95	04/27/95	05/19/95	10/18/95	01/02/96
LABORATORY MEASUREMENTS						
pH	(S.U.)	8.00	8.00	8.00	8.00	7.90
Conductivity	(umho/cm)	8080	8110	12100	7730	7590
TDS (180 deg C)	(mg/l)	5050	5020	5010	4910	5020
Boron	(mg/l)	0.93	0.91	1.03	0.83	1.01
Fluoride	(mg/l)	0.79	1.78	1.75	1.69	2.66
Nutrients						
Nitrate as N	(mg/l)	-0.01	0.15	-0.01	0.50	0.53
Nitrite as N	(mg/l)	-0.01	-0.01	0.05	-0.01	-0.05
Major Ions						
Bicarbonate as HCO3	(mg/l)	3480.00	3460.00	3520.00	3420.00	3510.00
Carbonate as CO3	(mg/l)	0.00	0.00	0.00	0.00	0.00
Sulfate	(mg/l)	7.00	48.00	28.00	17.00	4.50
Sulfide	(mg/l)	28.200	N	65.500	N	34.000
Calcium	(mg/l)	3.60	6.60	8.60	8.60	6.40
Magnesium	(mg/l)	1.50	2.70	3.00	1.90	2.60
Sodium	(mg/l)	1940.00	2110.00	2090.00	1990.00	2050.00
Potassium	(mg/l)	7.00	13.00	1.60	7.00	5.10
Chloride	(mg/l)	1160.00	1220.00	1220.00	1170.00	1150.00
Total Phosphorus	(mg/l)	-0.20	-0.50	N	N	N
Major Cations	(meq/l)	84.87	92.66	91.63	87.33	89.93
Major Anions	(meq/l)	89.90	92.13	92.68	89.44	91.73
Charge Balance	(percent)	2.88	0.29	0.57	1.19	1.05
Lab Determined Cations	(meq/l)	85.07	92.51	91.60	87.52	90.01
Lab Determined Anions	(meq/l)	89.97	92.07	92.85	89.45	91.82
Lab Determined Ion Balance	(percent)	2.80	0.24	0.68	1.09	0.99
Trace Metals (Dissolved)						
Aluminum	(mg/l)	-0.010	N	-0.100	N	-0.100
Arsenic	(mg/l)	-0.005	-0.005	-0.005	N	-0.005
Barium	(mg/l)	2.690	2.700	2.890	2.420	2.960
Beryllium	(mg/l)	-0.0010	N	-0.0010	N	-0.0050
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0020	-0.0020	-0.0020
Copper	(mg/l)	-0.010	N	-0.010	N	-0.010
Iron	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.050
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.020	-0.020	-0.020
Mercury	(mg/l)	-0.00100	N	-0.00100	N	-0.00100
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Silica as Si	(mg/l)	4.360	N	4.340	N	4.330
Silver	(mg/l)	-0.010	-0.010	-0.010	N	-0.010
Zinc	(mg/l)	-0.010	0.010	0.030	N	-0.010
Trace Metals (Total)						
Total Iron	(mg/l)	0.07	0.11	0.07	-0.05	-0.05
Total Manganese	(mg/l)	-0.02	-0.02	-0.02	-0.02	-0.02

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3
Sample Date:		03/02/95	04/27/95	05/18/95	10/18/95	12/29/95
LABORATORY MEASUREMENTS						
pH	(S.U.)	7.60	7.50	7.30	7.60	7.60
Conductivity	(umho/cm)	13000	13100	14600	12400	12600
TDS (180 deg C)	(mg/l)	7980	7740	7730	7790	8140
Boron	(mg/l)	1.07	1.00	1.05	0.92	1.08
Fluoride	(mg/l)	-0.01	0.99	0.99	1.02	1.27
Nutrients						
Nitrate as N	(mg/l)	1.00	4.10	-0.01	1.20	-0.05
Nitrite as N	(mg/l)	-0.01	-0.01	-0.01	-0.01	-0.05
Major Ions						
Bicarbonate as HCO3	(mg/l)	3.12	3050.00	3070.00	3220.00	2920.00
Carbonate as CO3	(mg/l)	0.00	0.00	0.00	0.00	0.00
Sulfate	(mg/l)	442.00	255.00	192.00	471.00	509.00
Sulfide	(mg/l)	6.100	N	2.800	N	-0.010
Calcium	(mg/l)	11.00	27.00	19.00	23.00	25.00
Magnesium	(mg/l)	5.20	12.00	6.10	12.00	10.00
Sodium	(mg/l)	3200.00	3150.00	3130.00	3390.00	3230.00
Potassium	(mg/l)	14.00	44.00	10.00	23.00	9.80
Chloride	(mg/l)	2820.00	3160.00	3080.00	2760.00	2910.00
Total Phosphorus	(mg/l)	-0.02	-0.50	N	N	N
Major Cations	(meq/l)	140.53	140.49	137.86	150.19	142.82
Major Anions	(meq/l)	88.86	144.72	141.19	140.52	137.72
Charge Balance	(percent)	22.52	1.48	1.19	3.33	1.82
Lab Determined Cations	(meq/l)	140.53	140.52	137.71	150.16	142.94
Lab Determined Anions	(meq/l)	139.99	144.57	141.36	140.75	137.78
Lab Determined Ion Balance	(percent)	0.19	1.42	1.31	3.23	1.84
Trace Metals (Dissolved)						
Aluminum	(mg/l)	-0.100	N	-0.100	N	-0.100
Arsenic	(mg/l)	-0.005	-0.005	-0.005	N	-0.005
Barium	(mg/l)	-0.500	1.300	0.510	-0.500	0.360
Beryllium	(mg/l)	-0.0010	N	-0.0010	N	-0.0050
Cadmium	(mg/l)	0.0040	-0.0020	-0.0050	-0.0020	-0.0020
Copper	(mg/l)	-0.010	N	-0.010	N	-0.010
Iron	(mg/l)	-0.050	-0.050	0.050	-0.050	-0.050
Lead	(mg/l)	0.012	0.033	-0.050	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.020	-0.020	-0.020
Mercury	(mg/l)	-0.00100	N	-0.00100	N	-0.00100
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Silica as Si	(mg/l)	N	N	4.690	N	4.960
Silver	(mg/l)	-0.010	-0.010	-0.010	N	-0.010
Zinc	(mg/l)	-0.010	0.010	0.100	N	-0.010
Trace Metals (Total)						
Total Iron	(mg/l)	0.24	0.75	0.28	0.12	0.18
Total Manganese	(mg/l)	-0.02	-0.02	-0.02	-0.02	-0.02

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-4	BITSUI-4	BITSUI-4
Sample Date:		01/26/96	02/12/96	04/10/96
LABORATORY MEASUREMENTS				
pH	(S.U.)	6.90	7.10	7.10
Conductivity	(umho/cm)	16700	14400	16500
TDS (180 deg C)	(mg/l)	15000	13100	13800
Boron	(mg/l)	1.71	1.49	1.54
Fluoride	(mg/l)	0.29	0.33	0.33
Nutrients				
Nitrate as N	(mg/l)	0.09	1.20	1.17
Nitrite as N	(mg/l)	-0.01	-0.01	0.05
Major Ions				
Bicarbonate as HCO3	(mg/l)	1760.00	1510.00	1650.00
Carbonate as CO3	(mg/l)	0.00	0.00	-1.00
Sulfate	(mg/l)	8640.00	6680.00	7860.00
Sulfide	(mg/l)	-0.010	-0.010	-0.010
Calcium	(mg/l)	15.00	287.00	231.00
Magnesium	(mg/l)	131.00	125.00	123.00
Sodium	(mg/l)	4650.00	3850.00	4280.00
Potassium	(mg/l)	538.00	22.00	19.20
Chloride	(mg/l)	634.00	451.00	651.00
Total Phosphorus	(mg/l)	N	N	-0.01
Major Cations	(meq/l)	227.55	192.64	208.31
Major Anions	(meq/l)	226.62	176.64	209.14
Charge Balance	(percent)	0.20	4.33	0.20
Lab Determined Cations	(meq/l)	228.00	192.63	208.00
Lab Determined Anions	(meq/l)	227.00	176.83	209.00
Lab Determined Ion Balance	(percent)	0.19	4.28	0.23
Trace Metals (Dissolved)				
Aluminum	(mg/l)	-0.100	-0.100	0.590
Arsenic	(mg/l)	-0.005	-0.005	-0.005
Barium	(mg/l)	0.030	-0.500	0.020
Beryllium	(mg/l)	-0.0050	-0.0010	-0.0010
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0020
Copper	(mg/l)	-0.010	-0.010	-0.010
Iron	(mg/l)	-0.050	0.060	0.260
Lead	(mg/l)	-0.005	-0.005	-0.005
Manganese	(mg/l)	2.400	3.180	2.660
Mercury	(mg/l)	-0.00100	-0.00100	-0.00100
Selenium	(mg/l)	-0.005	-0.005	-0.005
Silica as Si	(mg/l)	-0.010	4.270	6.470
Silver	(mg/l)	-0.010	-0.010	-0.010
Zinc	(mg/l)	0.030	0.140	0.020
Trace Metals (Total)				
Total Iron	(mg/l)	4.67	16.60	4.21
Total Manganese	(mg/l)	2.41	3.35	2.52

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-5	BITSUI-5
Sample Date:		02/13/96	04/11/96
LABORATORY MEASUREMENTS			
pH	(S.U.)	7.40	7.50
Conductivity	(umho/cm)	13000	14200
TDS (180 deg C)	(mg/l)	10300	10600
Boron	(mg/l)	1.10	1.13
Fluoride	(mg/l)	1.00	1.04
Nutrients			
Nitrate as N	(mg/l)	0.01	-0.05
Nitrite as N	(mg/l)	-0.05	-0.05
Major Ions			
Bicarbonate as HCO3	(mg/l)	3170.00	3090.00
Carbonate as CO3	(mg/l)	0.00	-1.00
Sulfate	(mg/l)	3550.00	4060.00
Sulfide	(mg/l)	-0.010	2.800
Calcium	(mg/l)	72.00	59.50
Magnesium	(mg/l)	30.00	27.50
Sodium	(mg/l)	3630.00	3830.00
Potassium	(mg/l)	16.00	14.10
Chloride	(mg/l)	1330.00	1210.00
Total Phosphorus	(mg/l)	N	-0.01
Major Cations	(meq/l)	164.37	172.19
Major Anions	(meq/l)	163.37	169.30
Charge Balance	(percent)	0.31	0.85
Lab Determined Cations	(meq/l)	164.49	172.00
Lab Determined Anions	(meq/l)	163.92	169.00
Lab Determined Ion Balance	(percent)	0.17	0.84
Trace Metals (Dissolved)			
Aluminum	(mg/l)	-0.100	0.110
Arsenic	(mg/l)	-0.005	-0.005
Barium	(mg/l)	-0.500	-0.500
Beryllium	(mg/l)	-0.0010	-0.0050
Cadmium	(mg/l)	-0.0020	-0.0020
Copper	(mg/l)	-0.010	-0.010
Iron	(mg/l)	0.480	0.310
Lead	(mg/l)	-0.005	-0.005
Manganese	(mg/l)	0.410	0.170
Mercury	(mg/l)	-0.00100	-0.00100
Selenium	(mg/l)	-0.005	-0.005
Silica as Si	(mg/l)	4.450	5.170
Silver	(mg/l)	-0.010	-0.010
Zinc	(mg/l)	0.010	0.030
Trace Metals (Total)			
Total Iron	(mg/l)	2.05	1.83
Total Manganese	(mg/l)	0.41	0.17

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		BITSUI-6	BITSUI-6
Sample Date:		02/12/96	04/11/96
LABORATORY MEASUREMENTS			
pH	(S.U.)	7.10	7.20
Conductivity	(umho/cm)	14300	15100
TDS (180 deg C)	(mg/l)	13200	13300
Boron	(mg/l)	1.57	1.47
Fluoride	(mg/l)	0.30	0.31
Nutrients			
Nitrate as N	(mg/l)	6.20	0.08
Nitrite as N	(mg/l)	-0.05	-0.05
Major Ions			
Bicarbonate as HCO3	(mg/l)	1440.00	1500.00
Carbonate as CO3	(mg/l)	0.00	-1.00
Sulfate	(mg/l)	7690.00	7920.00
Sulfide	(mg/l)	-0.010	-0.010
Calcium	(mg/l)	327.00	296.00
Magnesium	(mg/l)	158.00	161.00
Sodium	(mg/l)	3780.00	3940.00
Potassium	(mg/l)	24.00	21.90
Chloride	(mg/l)	392.00	356.00
Total Phosphorus	(mg/l)	N	-0.01
Major Cations	(meq/l)	194.35	199.96
Major Anions	(meq/l)	195.21	199.53
Charge Balance	(percent)	0.22	0.11
Lab Determined Cations	(meq/l)	194.24	200.00
Lab Determined Anions	(meq/l)	195.32	200.00
Lab Determined Ion Balance	(percent)	0.28	0.09
Trace Metals (Dissolved)			
Aluminum	(mg/l)	-0.100	0.460
Arsenic	(mg/l)	-0.005	-0.005
Barium	(mg/l)	-0.500	-0.500
Beryllium	(mg/l)	-0.0010	-0.0050
Cadmium	(mg/l)	-0.0020	0.0110
Copper	(mg/l)	-0.010	-0.010
Iron	(mg/l)	-0.050	0.190
Lead	(mg/l)	-0.005	-0.005
Manganese	(mg/l)	3.260	2.730
Mercury	(mg/l)	-0.00100	-0.00100
Selenium	(mg/l)	-0.005	-0.005
Silica as Si	(mg/l)	4.280	5.790
Silver	(mg/l)	-0.010	-0.010
Zinc	(mg/l)	0.050	0.020
Trace Metals (Total)			
Total Iron	(mg/l)	20.00	1.25
Total Manganese	(mg/l)	3.55	2.54

Note: N => No measurement

BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER QUALITY DATA

Sample Range: From 03/01/95 Through 04/30/96

Station Name:		KF83-1	KF83-1	KF83-1	KF83-1	KF83-1
Sample Date:		05/03/95	06/14/95	06/21/95	07/14/95	09/26/95
LABORATORY MEASUREMENTS						
pH	(S.U.)	7.60	7.90	7.90	7.80	7.90
Conductivity	(umho/cm)	11500	9690	10300	9850	9300
TDS (180 deg C)	(mg/l)	6820	5750	5670	5650	5330
Boron	(mg/l)	0.87	1.00	0.97	0.92	1.00
Fluoride	(mg/l)	0.83	1.44	1.54	1.57	1.29
Nutrients						
Nitrate as N	(mg/l)	6.24	-0.01	18.20	-0.01	-0.01
Nitrite as N	(mg/l)	-0.01	-0.01	-0.01	-0.01	-0.01
Major Ions						
Bicarbonate as HCO3	(mg/l)	2970.00	3690.00	3740.00	3630.00	3530.00
Carbonate as CO3	(mg/l)	0.00	0.00	0.00	0.00	0.00
Sulfate	(mg/l)	7.00	353.00	411.00	375.00	351.00
Sulfide	(mg/l)	N	N	N	N	N
Calcium	(mg/l)	28.00	11.00	11.00	11.00	14.60
Magnesium	(mg/l)	13.00	4.60	4.90	4.40	7.05
Sodium	(mg/l)	2760.00	2380.00	2370.00	2260.00	2430.00
[illegible]	[illegible]	[illegible]	7.00	[illegible]	8.20	[illegible]
Chloride	(mg/l)	2700.00	1210.00	1170.00	[illegible]	[illegible]
Total Phosphorus	(mg/l)	N	N	N	N	N
Major Cations	(meq/l)	123.31	104.63	104.37	99.42	109.43
Major Anions	(meq/l)	125.43	101.95	104.15	101.99	107.47
Charge Balance	(percent)	0.85	1.30	0.11	1.28	0.90
Lab Determined Cations	(meq/l)	123.27	104.52	104.48	99.53	109.36
Lab Determined Anions	(meq/l)	125.25	102.03	104.03	102.16	107.53
Lab Determined Ion Balance	(percent)	0.80	1.20	0.22	1.30	0.84
Trace Metals (Dissolved)						
Aluminum	(mg/l)	N	N	N	N	N
Arsenic	(mg/l)	N	N	N	N	N
Barium	(mg/l)	5.000	-0.500	1.700	0.580	-0.500
Beryllium	(mg/l)	N	N	N	N	N
Cadmium	(mg/l)	-0.0040	-0.0020	-0.0020	-0.0020	-0.0020
Copper	(mg/l)	N	N	N	N	N
Iron	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.050
Lead	(mg/l)	-0.010	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.020	-0.020	-0.020
Mercury	(mg/l)	N	N	N	N	N
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Silica as Si	(mg/l)	N	N	N	N	N
Silver	(mg/l)	N	N	N	N	N
Zinc	(mg/l)	N	N	N	N	N
Trace Metals (Total)						
Total Iron	(mg/l)	1.06	0.07	-0.05	-0.05	-0.05
Total Manganese	(mg/l)	0.03	-0.02	-0.02	-0.02	-0.02

Note: N => No measurement

APPENDIX D

ANALYTICAL DATA AND RESULTS

D-2 Piper Trilinear Plots

November 1996

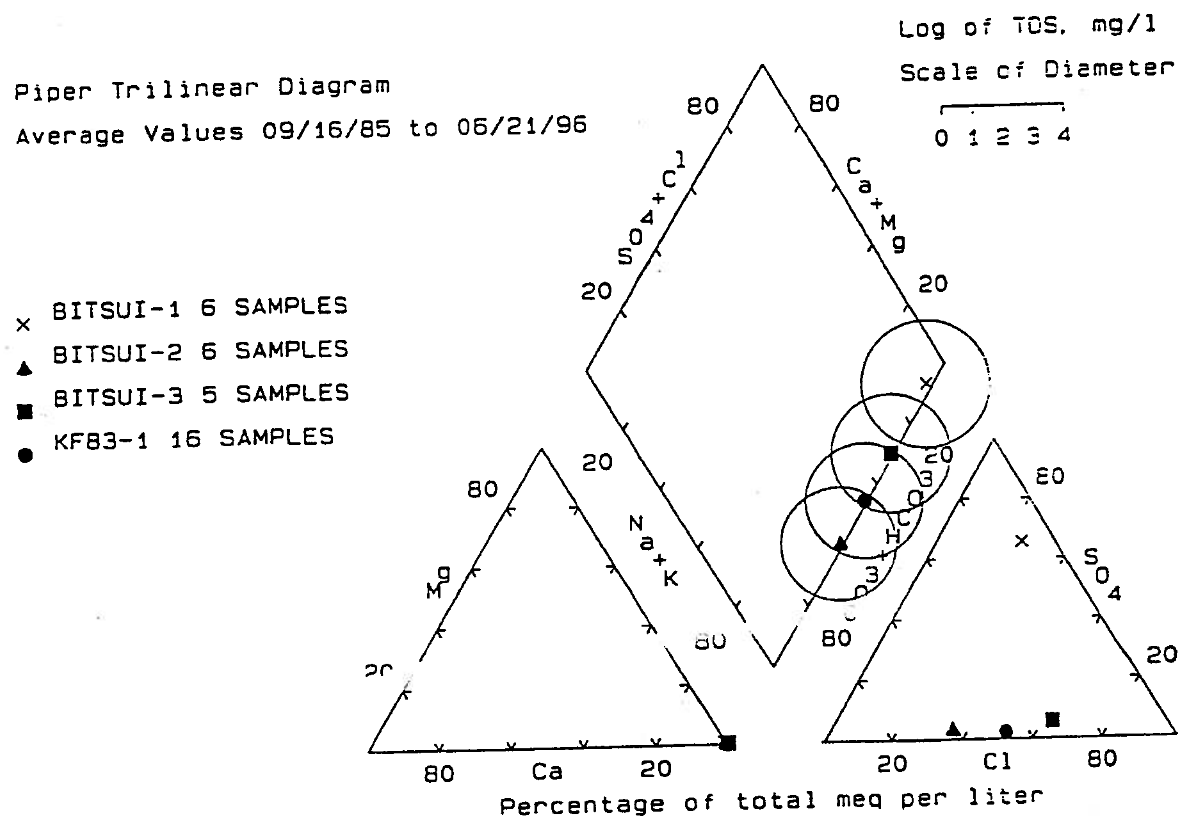
BHP Minerals

Navajo Mine

Fruitland

Piper Trilinear Diagram

Average Values 09/16/85 to 06/21/96



APPENDIX D

ANALYTICAL DATA AND RESULTS

D-3 Statistical Summary Reports

November 1996

BHP Minerals
Navajo Mine
Fruitland

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERAL, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-1
Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	8.80	0.07	1	0.20	8.90	8.70	10/18/95	03/01/95	5
Conductivity	(umho/cm)	19480	3591	18	8100	25900	17800	05/19/95	03/01/95	5
TDS (180 deg C)	(mg/l)	14300	224	2	500	14700	14200	01/02/96	03/01/95	5
Boron	(mg/l)	8.10	0.85	10	2.22	9.20	6.98	03/01/95	10/18/95	5
Fluoride	(mg/l)	2.97	0.80	27	1.88	4.39	2.51	01/02/96	10/18/95	5
Nutrients										
Nitrate as N	(mg/l)	1.21	0.90	74	2.40	2.40	0.02	04/27/95	10/18/95	5
Nitrite as N	(mg/l)	0.01	0.01	99	0.02	0.03	0.01	01/02/96	03/01/95	5
Total Phosphorus	(mg/l)	1.89	0.01	0	0.01	1.89	1.88	03/01/95	04/27/95	2
Major Ions										
Bicarbonate as HCO3	(mg/l)	1041.40	138.29	13	343.00	1180.00	837.00	05/19/95	01/02/96	5
Carbonate as CO3	(mg/l)	86.00	17.89	21	48.00	108.00	60.00	10/18/95	04/27/95	5
Chloride	(mg/l)	1986.00	77.01	4	190.00	2070.00	1880.00	05/19/95	03/01/95	5
Sulfate	(mg/l)	6880.00	156.88	2	420.00	7100.00	6680.00	05/19/95	04/27/95	5
Sulfide	(mg/l)	0.193	0.326	169	0.565	0.570	0.005	03/01/95	05/19/95	3
Calcium	(mg/l)	53.20	7.60	14	18.00	63.00	45.00	01/02/96	05/19/95	5
Potassium	(mg/l)	28.80	14.38	50	34.00	54.00	20.00	04/27/95	10/18/95	5
Magnesium	(mg/l)	30.00	2.92	10	7.00	34.00	27.00	04/27/95	10/18/95	5
Sodium	(mg/l)	4936.00	87.92	2	210.00	5040.00	4830.00	01/02/96	05/19/95	5
Major Cations	(meq/l)	220.56	4.29	2	10.19	225.51	215.32	01/02/96	05/19/95	5
Major Anions	(meq/l)	219.29	5.47	2	14.72	228.47	213.75	05/19/95	03/01/95	5
Charge Balance	(percent)	1.56	1.01	65	2.76	2.96	0.20	05/19/95	10/18/95	5
Lab Determined Cations	(meq/l)	220.51	4.30	2	10.14	225.36	215.22	01/02/96	05/19/95	5
Lab Determined Anions	(meq/l)	219.50	5.49	2	14.77	228.70	213.93	05/19/95	03/01/95	5
Lab Determined Ion Balance	(percent)	1.56	1.01	65	2.77	3.04	0.27	05/19/95	10/18/95	5
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.083	0.058	69	0.100	0.150	0.050	01/02/96	03/01/95	3
Arsenic	(mg/l)	0.037	0.005	13	0.010	0.040	0.030	03/01/95	04/27/95	4
Barium	(mg/l)	0.161	0.122	76	0.225	0.250	0.025	04/27/95	03/01/95	5
Beryllium	(mg/l)	0.0012	0.0012	99	0.0020	0.0025	0.0005	01/02/96	03/01/95	3
Cadmium	(mg/l)	0.0017	0.0010	57	0.0020	0.0030	0.0010	03/01/95	04/27/95	5
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/01/95	03/01/95	3
Iron	(mg/l)	0.025	0.000	0	0.000	0.025	0.025	03/01/95	03/01/95	5
Lead	(mg/l)	0.009	0.009	100	0.023	0.025	0.003	05/19/95	10/18/95	5
Manganese	(mg/l)	0.097	0.011	11	0.030	0.110	0.080	03/01/95	10/18/95	5
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/01/95	03/01/95	3
Silica as Si	(mg/l)	6.860	0.173	3	0.310	6.970	6.660	01/02/96	05/19/95	3
Selenium	(mg/l)	0.010	0.004	38	0.009	0.016	0.007	10/18/95	04/27/95	5
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/01/95	03/01/95	4
Zinc	(mg/l)	0.016	0.023	138	0.045	0.050	0.005	03/01/95	04/27/95	4
Trace Metals (Total)										
Total Iron	(mg/l)	0.95	0.36	38	0.88	1.50	0.62	03/01/95	10/18/95	5
Total Manganese	(mg/l)	0.11	0.03	24	0.07	0.14	0.07	03/01/95	10/18/95	5

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERAL, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-2
Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.98	0.04	1	0.10	8.00	7.90	03/02/95	01/02/96	5
Conductivity	(umho/cm)	8722	1902	22	4510	12100	7590	05/19/95	01/02/96	5
TDS (180 deg C)	(mg/l)	[illegible]	[illegible]	1	140	5050	4910	03/02/95	10/18/95	5
Boron	(mg/l)	0.94	0.08	[illegible]	0.20	1.03	0.83	05/19/95	10/18/[illegible]	5
Fluoride	(mg/l)	1.73	0.66	38	[illegible]	2.66	0.79	[illegible]	[illegible]	5
Nutrients										
Nitrate as N	(mg/l)	0.24	0.26	109	0.53	0.53	0.01	01/02/96	03/02/95	5
Nitrite as N	(mg/l)	0.02	0.02	110	0.05	0.05	0.01	05/19/95	03/02/95	5
Total Phosphorus	(mg/l)	0.18	0.11	61	0.15	0.25	0.10	04/27/95	03/02/95	2
Major Ions										
Bicarbonate as HCO3	(mg/l)	3498.00	72.25	2	190.00	3610.00	3420.00	01/02/96	10/18/95	5
Carbonate as CO3	(mg/l)	0.00	0.00		0.00	0.00	0.00	03/02/95	03/02/95	5
Chloride	(mg/l)	1184.00	33.62	3	70.00	1220.00	1150.00	04/27/95	01/02/96	5
Sulfate	(mg/l)	20.90	17.76	85	43.50	48.00	4.50	04/27/95	01/02/96	5
Sulfide	(mg/l)	42.567	20.071	47	37.300	65.500	28.200	05/19/95	03/02/95	3
Calcium	(mg/l)	6.76	2.06	30	5.00	8.60	3.60	05/19/95	03/02/95	5
Potassium	(mg/l)	6.74	4.14	61	11.40	13.00	1.60	04/27/95	05/19/95	5
Magnesium	(mg/l)	2.34	0.62	26	1.50	3.00	1.50	05/19/95	03/02/95	5
Sodium	(mg/l)	2036.00	70.57	3	170.00	2110.00	1940.00	04/27/95	03/02/95	5
Major Cations	(meq/l)	89.26	3.18	4	7.79	92.66	84.87	04/27/95	03/02/95	5
Major Anions	(meq/l)	91.18	1.42	2	3.24	92.68	89.44	05/19/95	10/18/95	5
Charge Balance	(percent)	1.20	1.01	84	2.59	2.88	0.29	03/02/95	04/27/95	5
Lab Determined Cations	(meq/l)	89.34	3.05	3	7.44	92.51	85.07	04/27/95	03/02/95	5
Lab Determined Anions	(meq/l)	91.23	1.45	2	3.40	92.85	89.45	05/19/95	10/18/95	5
Lab Determined Ion Balance	(percent)	1.16	0.97	84	2.56	2.80	0.24	03/02/95	04/27/95	5
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.035	0.026	74	0.045	0.050	0.005	05/19/95	03/02/95	3
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	4
Barium	(mg/l)	2.732	0.210	8	0.540	2.960	2.420	01/02/96	10/18/95	5
Beryllium	(mg/l)	0.0012	0.0012	99	0.0020	0.0025	0.0005	01/02/95	03/02/95	3
Cadmium	(mg/l)	0.0010	0.0000	0	0.0000	0.0010	0.0010	03/02/95	03/02/95	5
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/02/95	03/02/95	3
Iron	(mg/l)	0.025	0.000	0	0.000	0.025	0.025	03/02/95	03/02/95	5
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	5
Manganese	(mg/l)	0.010	0.000	0	0.000	0.010	0.010	03/02/95	03/02/95	5
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/02/95	03/02/95	3
Silica as Si	(mg/l)	4.360	0.020	0	0.040	4.380	4.340	01/02/96	05/19/95	3
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	5
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/02/95	03/02/95	4
Zinc	(mg/l)	0.013	0.012	95	0.025	0.030	0.005	05/19/95	03/02/95	4
Trace Metals (Total)										
Total Iron	(mg/l)	0.06	0.04	60	0.08	0.11	0.03	04/27/95	10/18/95	5
Total Manganese	(mg/l)	0.01	0.00	0	0.00	0.01	0.01	03/02/95	03/02/95	5

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERAL, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-3
Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.52	0.13	2	0.30	7.60	7.30	03/02/95	05/18/95	5
Conductivity	(umho/cm)	13140	865	7	2200	14600	12400	05/18/95	10/18/95	5
TDS (180 deg C)	(mg/l)	7876	179	2	410	8140	7730	12/29/95	05/18/95	5
Boron	(mg/l)	1.02	0.07	6	0.16	1.08	0.92	12/29/95	10/18/95	5
Fluoride	(mg/l)	0.86	0.49	57	1.27	1.27	0.01	12/29/95	03/02/95	5
Nutrients										
Nitrate as N	(mg/l)	1.27	1.68	132	4.10	4.10	0.01	04/27/95	05/18/95	5
Nitrite as N	(mg/l)	0.01	0.01	99	0.02	0.03	0.01	12/29/95	03/02/95	5
Total Phosphorus	(mg/l)	0.13	0.17	131	0.24	0.25	0.01	04/27/95	03/02/95	2
Major Ions										
Bicarbonate as HCO3	(mg/l)	2452.62	1373.44	56	3216.88	3220.00	3.12	10/18/95	03/02/95	5
Carbonate as CO3	(mg/l)	0.00	0.00		0.00	0.00	0.00	03/02/95	03/02/95	5
Chloride	(mg/l)	2926.00	180.78	6	400.00	3160.00	2760.00	04/27/95	10/18/95	5
Sulfate	(mg/l)	373.80	141.02	38	317.00	509.00	192.00	12/29/95	05/18/95	5
Sulfide	(mg/l)	2.968	3.051	103	6.095	6.100	0.005	03/02/95	12/29/95	3
Calcium	(mg/l)	21.00	6.32	30	16.00	27.00	11.00	04/27/95	03/02/95	5
Potassium	(mg/l)	20.16	14.36	71	34.20	44.00	9.80	04/27/95	12/29/95	5
Magnesium	(mg/l)	9.06	3.23	36	6.80	12.00	5.20	04/27/95	03/02/95	5
Sodium	(mg/l)	3220.00	102.96	3	260.00	3390.00	3130.00	10/18/95	05/18/95	5
Major Cations	(meq/l)	142.38	4.71	3	12.33	150.19	137.86	10/18/95	05/18/95	5
Major Anions	(meq/l)	130.60	23.47	18	55.86	144.72	88.86	04/27/95	03/02/95	5
Charge Balance	(percent)	6.07	9.23	152	21.33	22.52	1.19	03/02/95	05/18/95	5
Lab Determined Cations	(meq/l)	142.37	4.73	3	12.45	150.16	137.71	10/18/95	05/18/95	5
Lab Determined Anions	(meq/l)	140.89	2.46	2	6.79	144.57	137.78	04/27/95	12/29/95	5
Lab Determined Ion Balance	(percent)	1.60	1.10	69	3.04	3.23	0.19	10/18/95	03/02/95	5
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.050	0.000	0	0.000	0.050	0.050	03/02/95	03/02/95	3
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	4
Barium	(mg/l)	0.534	0.441	83	1.050	1.300	0.250	04/27/95	03/02/95	5
Beryllium	(mg/l)	0.0012	0.0012	99	0.0020	0.0025	0.0005	12/29/95	03/02/95	3
Cadmium	(mg/l)	0.0019	0.0013	71	0.0030	0.0040	0.0010	03/02/95	04/27/95	5
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/02/95	03/02/95	3
Iron	(mg/l)	0.030	0.011	37	0.025	0.050	0.025	05/18/95	03/02/95	5
Lead	(mg/l)	0.015	0.014	91	0.031	0.033	0.003	04/27/95	10/18/95	5
Manganese	(mg/l)	0.010	0.000	0	0.000	0.010	0.010	03/02/95	03/02/95	5
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/02/95	03/02/95	3
Silica as Si	(mg/l)	4.825	0.191	4	0.270	4.960	4.690	12/29/95	05/18/95	2
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	5
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/02/95	03/02/95	4
Zinc	(mg/l)	0.030	0.047	156	0.095	0.100	0.005	05/18/95	03/02/95	4
Trace Metals (Total)										
Total Iron	(mg/l)	0.31	0.25	80	0.63	0.75	0.12	04/27/95	10/18/95	5
Total Manganese	(mg/l)	0.01	0.00	0	0.00	0.01	0.01	03/02/95	03/02/95	5

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine

NAVAJO MINE

BHP MINERAL, NAVAJO MINE

SUPPLEMENTAL GROUNDWATER STUDY

QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-4

Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.03	0.12	2	0.20	7.10	6.90	02/12/96	01/26/96	3
Conductivity	(umho/cm)	15867	1274	8	2300	16700	14400	01/26/96	02/12/96	3
TDS (180 deg C)	(mg/l)	13967	961	7	1900	15000	13100	01/26/96	02/12/96	3
Boron	(mg/l)	1.58	0.12	7	0.22	1.71	1.49	01/26/96	02/12/96	3
Fluoride	(mg/l)	0.32	0.02	7	0.04	0.33	0.29	02/12/96	01/26/96	3
Nutrients										
Nitrate as N	(mg/l)	0.82	0.63	77	1.11	1.20	0.09	02/12/96	01/26/96	3
Nitrite as N	(mg/l)	0.02	0.03	130	0.05	0.05	0.01	04/10/96	01/26/96	3
Total Phosphorus	(mg/l)	0.01			0.00	0.01	0.01	04/10/96	04/10/96	1
Major Ions										
Bicarbonate as HCO3	(mg/l)	1640.00	125.30	8	250.00	1760.00	1510.00	01/26/96	02/12/96	3
Carbonate as CO3	(mg/l)	0.17	0.29	173	0.50	0.50	0.00	04/10/96	01/26/96	3
Chloride	(mg/l)	578.67	110.89	19	200.00	651.00	451.00	04/10/96	02/12/96	3
Sulfate	(mg/l)	7726.67	986.78	13	1960.00	8640.00	6680.00	01/26/96	02/12/96	3
Sulfide	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	01/26/96	01/26/96	3
Calcium	(mg/l)	177.67	143.63	81	272.00	287.00	15.00	02/12/96	01/26/96	3
Potassium	(mg/l)	193.07	298.72	155	518.80	538.00	19.20	01/26/96	04/10/96	3
Magnesium	(mg/l)	126.33	4.16	3	8.00	131.00	123.00	01/26/96	04/10/96	3
Sodium	(mg/l)	4260.00	400.37	9	800.00	4650.00	3850.00	01/26/96	02/12/96	3
Major Cations	(meq/l)	209.50	17.49	8	34.91	227.55	192.64	01/26/96	02/12/96	3
Major Anions	(meq/l)	204.13	25.36	12	49.98	226.62	176.64	01/26/96	02/12/96	3
Charge Balance	(percent)	1.58	2.38	151	4.13	4.33	0.20	02/12/96	01/26/96	3
Lab Determined Cations	(meq/l)	209.54	17.74	8	35.37	228.00	192.63	01/26/96	02/12/96	3
Lab Determined Anions	(meq/l)	204.28	25.42	12	50.17	227.00	176.83	01/26/96	02/12/96	3
Lab Determined Ion Balance	(percent)	1.57	2.35	150	4.09	4.28	0.19	02/12/96	01/26/96	3
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.230	0.312	136	0.540	0.590	0.050	04/10/96	01/26/96	3
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	3
Barium	(mg/l)	0.100	0.130	130	0.230	0.250	0.020	02/12/96	04/10/96	3
Beryllium	(mg/l)	0.0012	0.0012	99	0.0020	0.0025	0.0005	01/26/96	02/12/96	3
Cadmium	(mg/l)	0.0010	0.0000	0	0.0000	0.0010	0.0010	01/26/96	01/26/96	3
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	01/26/96	01/26/96	3
Iron	(mg/l)	0.115	0.127	110	0.235	0.260	0.025	04/10/96	01/26/96	3
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	3
Manganese	(mg/l)	2.747	0.397	14	0.780	3.180	2.400	02/12/96	01/26/96	3
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	01/26/96	01/26/96	3
Silica as Si	(mg/l)	3.582	3.287	92	6.465	6.470	0.005	04/10/96	01/26/96	3
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	3
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	01/26/96	01/26/96	3
Zinc	(mg/l)	0.063	0.067	105	0.120	0.140	0.020	02/12/96	04/10/96	3
Trace Metals (Total)										
Total Iron	(mg/l)	8.49	7.02	83	12.39	16.60	4.21	02/12/96	04/10/96	3
Total Manganese	(mg/l)	2.76	0.51	19	0.94	3.35	2.41	02/12/96	01/26/96	3

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERAL, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-5
Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.45	0.07	1	0.10	7.50	7.40	04/11/96	02/13/96	2
Conductivity	(umho/cm)	13600	849	6	1200	14200	13000	04/11/96	02/13/96	2
TDS (180 deg C)	(mg/l)	10450	212	2	300	10600	10300	04/11/96	02/13/96	2
Boron	(mg/l)	1.12	0.02	2	0.03	1.13	1.10	04/11/96	02/13/96	2
Fluoride	(mg/l)	1.02	0.03	3	0.04	1.04	1.00	04/11/96	02/13/96	2
Nutrients										
Nitrate as N	(mg/l)	0.02	0.01	61	0.02	0.03	0.01	04/11/96	02/13/96	2
Nitrite as N	(mg/l)	0.03	0.00	0	0.00	0.03	0.03	02/13/96	02/13/96	2
Total Phosphorus	(mg/l)	0.01			0.00	0.01	0.01	04/11/96	04/11/96	1
Major Ions										
Bicarbonate as HCO3	(mg/l)	3130.00	56.57	2	80.00	3170.00	3090.00	02/13/96	04/11/96	2
Carbonate as CO3	(mg/l)	0.25	0.35	141	0.50	0.50	0.00	04/11/96	02/13/96	2
Chloride	(mg/l)	1270.00	84.85	7	120.00	1330.00	1210.00	02/13/96	04/11/96	2
Sulfate	(mg/l)	3805.00	360.62	9	510.00	4060.00	3550.00	04/11/96	02/13/96	2
Sulfide	(mg/l)	1.403	1.976	141	2.795	2.800	0.005	04/11/96	02/13/96	2
Calcium	(mg/l)	65.75	8.84	13	12.50	72.00	59.50	02/13/96	04/11/96	2
Potassium	(mg/l)	15.05	1.34	9	1.90	16.00	14.10	02/13/96	04/11/96	2
Magnesium	(mg/l)	28.75	1.77	6	2.50	30.00	27.50	02/13/96	04/11/96	2
Sodium	(mg/l)	3730.00	141.42	4	200.00	3830.00	3630.00	04/11/96	02/13/96	2
Major Cations	(meq/l)	168.28	5.53	3	7.82	172.19	164.37	04/11/96	02/13/96	2
Major Anions	(meq/l)	166.34	4.19	3	5.93	169.30	163.37	04/11/96	02/13/96	2
Charge Balance	(percent)	0.58	0.38	66	0.54	0.85	0.31	04/11/96	02/13/96	2
Lab Determined Cations	(meq/l)	168.25	5.31	3	7.51	172.00	164.49	04/11/96	02/13/96	2
Lab Determined Anions	(meq/l)	166.46	3.59	2	5.08	169.00	163.92	04/11/96	02/13/96	2
Lab Determined Ion Balance	(percent)	0.51	0.47	94	0.67	0.84	0.17	04/11/96	02/13/96	2
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.080	0.042	53	0.060	0.110	0.050	04/11/96	02/13/96	2
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	2
Barium	(mg/l)	0.250	0.000	0	0.000	0.250	0.250	02/13/96	02/13/96	2
Beryllium	(mg/l)	0.0015	0.0014	94	0.0020	0.0025	0.0005	04/11/96	02/13/96	2
Cadmium	(mg/l)	0.0010	0.0000	0	0.0000	0.0010	0.0010	02/13/96	02/13/96	2
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/13/96	02/13/96	2
Iron	(mg/l)	0.395	0.120	30	0.170	0.480	0.310	02/13/96	04/11/96	2
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	2
Manganese	(mg/l)	0.290	0.170	59	0.240	0.410	0.170	02/13/96	04/11/96	2
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	02/13/96	02/13/96	2
Silica as Si	(mg/l)	4.810	0.509	11	0.720	5.170	4.450	04/11/96	02/13/96	2
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	2
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/13/96	02/13/96	2
Zinc	(mg/l)	0.020	0.014	71	0.020	0.030	0.010	04/11/96	02/13/96	2
Trace Metals (Total)										
Total Iron	(mg/l)	1.94	0.16	8	0.22	2.05	1.83	02/13/96	04/11/96	2
Total Manganese	(mg/l)	0.29	0.17	59	0.24	0.41	0.17	02/13/96	04/11/96	2

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine
NAVAJO MINE

BHP MINERAL, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
QUALITY STATISTICS FOR MONITORING WELLS

Station: BITSUI-6
Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.15	0.07	1	0.10	7.20	7.10	04/11/96	02/12/96	2
Conductivity	(umho/cm)	14700	566	4	800	15100	14300	04/11/96	02/12/96	2
TDS (180 deg C)	(mg/l)	13250	71	1	100	13300	13200	04/11/96	02/12/96	2
Boron	(mg/l)	1.52	0.07	5	0.10	1.57	1.47	02/12/96	04/11/96	2
Fluoride	(mg/l)	0.31	0.01	2	0.01	0.31	0.30	04/11/96	02/12/96	2
Nutrients										
Nitrate as N	(mg/l)	3.14	4.33	138	6.12	6.20	0.08	02/12/96	04/11/96	2
Nitrite as N	(mg/l)	0.03	0.00	0	0.00	0.03	0.03	02/12/96	02/12/96	2
Total Phosphorus	(mg/l)	0.01			0.00	0.01	0.01	04/11/96	04/11/96	1
Major Ions										
Bicarbonate as HCO3	(mg/l)	1470.00	42.43	3	60.00	1500.00	1440.00	04/11/96	02/12/96	2
Carbonate as CO3	(mg/l)	0.25	0.35	141	0.50	0.50	0.00	04/11/96	02/12/96	2
Chloride	(mg/l)	374.00	25.46	7	36.00	392.00	356.00	02/12/96	04/11/96	2
Sulfate	(mg/l)	7805.00	162.63	2	230.00	7920.00	7690.00	04/11/96	02/12/96	2
Sulfide	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/12/96	02/12/96	2
Calcium	(mg/l)	311.50	21.92	7	31.00	327.00	296.00	02/12/96	04/11/96	2
Potassium	(mg/l)	22.95	1.48	6	2.10	24.00	21.90	02/12/96	04/11/96	2
Magnesium	(mg/l)	159.50	2.12	1	3.00	161.00	158.00	04/11/96	02/12/96	2
Sodium	(mg/l)	3860.00	113.14	3	160.00	3940.00	3780.00	04/11/96	02/12/96	2
Major Cations	(meq/l)	197.16	3.97	2	5.61	199.96	194.35	04/11/96	02/12/96	2
Major Anions	(meq/l)	197.37	3.05	2	4.32	199.53	195.21	04/11/96	02/12/96	2
Charge Balance	(percent)	0.17	0.08	47	0.11	0.22	0.11	02/12/96	04/11/96	2
Lab Determined Cations	(meq/l)	197.12	4.07	2	5.76	200.00	194.24	04/11/96	02/12/96	2
Lab Determined Anions	(meq/l)	197.66	3.31	2	4.68	200.00	195.32	04/11/96	02/12/96	2
Lab Determined Ion Balance	(percent)	0.19	0.13	73	0.19	0.28	0.09	02/12/96	04/11/96	2
Trace Metals (Dissolved)										
Aluminum	(mg/l)	0.255	0.290	114	0.410	0.460	0.050	04/11/96	02/12/96	2
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	2
Barium	(mg/l)	0.250	0.000	0	0.000	0.250	0.250	02/12/96	02/12/96	2
Beryllium	(mg/l)	0.0015	0.0014	94	0.0020	0.0025	0.0005	04/11/96	02/12/96	2
Cadmium	(mg/l)	0.0060	0.0071	118	0.0100	0.0110	0.0010	04/11/96	02/12/96	2
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/12/96	02/12/96	2
Iron	(mg/l)	0.108	0.117	109	0.165	0.190	0.025	04/11/96	02/12/96	2
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	2
Manganese	(mg/l)	2.995	0.375	13	0.530	3.260	2.730	02/12/96	04/11/96	2
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	02/12/96	02/12/96	2
Silica as Si	(mg/l)	5.035	1.068	21	1.510	5.790	4.280	04/11/96	02/12/96	2
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	2
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/12/96	02/12/96	2
Zinc	(mg/l)	0.035	0.021	61	0.030	0.050	0.020	02/12/96	04/11/96	2
Trace Metals (Total)										
Total Iron	(mg/l)	10.63	13.26	125	18.75	20.00	1.25	02/12/96	04/11/96	2
Total Manganese	(mg/l)	3.05	0.71	23	1.01	3.55	2.54	02/12/96	04/11/96	2

Below detection limit values included at 0.5 times detection limit.

BHP Minerals Navajo Mine

NAVAJO MINE

BHP MINERAL, NAVAJO MINE

SUPPLEMENTAL GROUNDWATER STUDY

QUALITY STATISTICS FOR MONITORING WELLS

Station: KF83-1

Sample Range: From 03/01/95 Through 04/30/96

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH	(S.U.)	7.80	0.12	2	0.30	7.90	7.60	05/14/95	05/03/95	5
Conductivity	(umho/cm)	10128	847	8	2200	11500	9300	05/03/95	09/26/95	5
TDS (180 deg C)	(mg/l)	5984	473	8	1150	6820	5670	05/03/95	06/21/95	5
Boron	(mg/l)	0.95	0.06	6	0.13	1.00	0.87	05/14/95	05/03/95	5
Fluoride	(mg/l)	1.33	0.30	23	0.74	1.57	0.83	07/14/95	05/03/95	5
Nutrients										
Nitrate as N	(mg/l)	4.89	7.91	162	18.20	18.20	0.01	05/21/95	06/14/95	5
Nitrite as N	(mg/l)	0.01	0.00	0	0.00	0.01	0.01	05/03/95	05/03/95	5
Total Phosphorus	(mg/l)									0
Major Ions										
Bicarbonate as HCO3	(mg/l)	3512.00	312.92	9	770.00	3740.00	2970.00	06/21/95	05/03/95	5
Carbonate as CO3	(mg/l)	0.00	0.00		0.00	0.00	0.00	05/03/95	05/03/95	5
Chloride	(mg/l)	1562.00	649.36	42	1530.00	2700.00	1170.00	05/03/95	06/21/95	5
Sulfate	(mg/l)	299.40	165.23	55	404.00	411.00	7.00	05/21/95	05/03/95	5
Sulfide	(mg/l)									0
Calcium	(mg/l)	15.12	7.37	49	17.00	28.00	11.00	05/03/95	06/14/95	5
Potassium	(mg/l)	13.80	9.88	72	24.00	31.00	7.00	05/03/95	06/14/95	5
Magnesium	(mg/l)	6.79	3.63	53	8.60	13.00	4.40	05/03/95	07/14/95	5
Sodium	(mg/l)	2450.00	190.00	8	500.00	2760.00	2260.00	05/03/95	07/14/95	5
Major Cations	(meq/l)	108.23	9.14	8	23.89	123.31	99.42	05/03/95	07/14/95	5
Major Anions	(meq/l)	108.20	9.89	9	23.48	125.43	101.95	05/03/95	06/14/95	5
Charge Balance	(percent)	0.89	0.48	54	1.19	1.30	0.11	05/14/95	06/21/95	5
Lab Determined Cations	(meq/l)	108.23	9.10	8	23.74	123.27	99.53	05/03/95	07/14/95	5
Lab Determined Anions	(meq/l)	108.20	9.79	9	23.22	125.25	102.03	05/03/95	06/14/95	5
Lab Determined Ion Balance	(percent)	0.87	0.42	49	1.08	1.30	0.22	07/14/95	06/21/95	5
Trace Metals (Dissolved)										
Aluminum	(mg/l)									0
Arsenic	(mg/l)									0
Barium	(mg/l)	1.556	2.015	130	4.750	5.000	0.250	05/03/95	06/14/95	5
Beryllium	(mg/l)									0
Cadmium	(mg/l)	0.0012	0.0004	37	0.0010	0.0020	0.0010	05/03/95	06/14/95	5
Copper	(mg/l)									0
Iron	(mg/l)	0.025	0.000	0	0.000	0.025	0.025	05/03/95	05/03/95	5
Lead	(mg/l)	0.003	0.001	37	0.003	0.005	0.003	05/03/95	06/14/95	5
Manganese	(mg/l)	0.010	0.000	0	0.000	0.010	0.010	05/03/95	05/03/95	5
Mercury	(mg/l)									0
Silica as Si	(mg/l)									0
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	05/03/95	05/03/95	5
Silver	(mg/l)									0
Zinc	(mg/l)									0
Trace Metals (Total)										
Total Iron	(mg/l)	0.24	0.46	190	1.04	1.06	0.03	05/03/95	06/21/95	5
Total Manganese	(mg/l)	0.01	0.01	64	0.02	0.03	0.01	05/03/95	06/14/95	5

Below detection limit values included at 0.5 times detection limit.

APPENDIX D

ANALYTICAL DATA AND RESULTS

D-4 Original Laboratory Data

November 1996

BHP Minerals
Navajo Mine
Fruitland

er-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Cli	BHP Minerals		
Pr c:	Navajo Mine	Date Reported:	03/17/95
Sample ID:	Bitsui-1	Date Sampled:	03/01/95
Laboratory ID:	W02720	Time Sampled:	1000
Sample Matrix:	Water	Date Received:	03/01/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	8.7	s.u.		
Lab Conductivity @ 25° C	17,800	umhos/cm		
Total Dissolved Solids @ 180°C	14,200	mg/L		
Total Dissolved Solids (Calc)	14,300	mg/L		
Total Alkalinity as CaCO3	972	mg/L		
Total Hardness as CaCO3	230	mg/L		
Ortho Phosphate	12.3	mg/L		
Sulfide	0.57	mg/L		
Hydrogen Sulfide	0.01	mg/L		
Bicarbonate as HCO3	1,020	mg/L	16.72	meq/L
Carbonate as CO3	82	mg/L	2.72	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	2.60	mg/L	0.14	meq/L
Chloride	1,880	mg/L	53.10	meq/L
Sulfate	6,780	mg/L	141.29	meq/L
Nitrate as Nitrogen	1.4	mg/L	0.10	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	46	mg/L	2.28	meq/L
Magnesium	28	mg/L	2.32	meq/L
Potassium	27	mg/L	0.70	meq/L
Sodium	4,980	mg/L	216.50	meq/L
Cations			221.80	meq/L
Anions			213.93	meq/L
Cation/Anion Difference			1.81	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983. "Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Comments:

Reviewed by dr

Reported by M. Klute

nter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

...ent:	BHP Minerals	Date Reported:	03/17/95
...ject:	Navajo Mine	Date Sampled:	03/01/95
...ample ID:	Bitsui-1	Time Sampled:	1000
Laboratory ID:	W02720	Date Received:	03/01/95
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	0.04	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	9.20	mg/L		
Cadmium	0.003	mg/L		
...omium	NA	mg/L	<0.02	mg/L
...balt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	1.15	mg/L
Lead	0.006	mg/L		
Manganese	0.11	mg/L	0.14	mg/L
Mercury	<0.001	mg/L		
Phosphorus	NA	mg/L	1.89	mg/L
Selenium	0.009	mg/L		
Silica	6.95	mg/L		
Silver	<0.01	mg/L		
Zinc	0.05	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed.. 1989.

Comments:

Reported by M. Klute

Reviewed by dt

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine		
Sample ID:	Bitsui - 2	Date Reported:	03/22/95
Laboratory ID:	W02730	Date Sampled:	03/02/95
Sample Matrix:	Water	Time Sampled:	1040
Condition:	Cool/Intact	Date Received:	03/02/95

Parameter	Analytical Result	Units		Units
Lab pH	8.0	s.u.		
Lab Conductivity @ 25° C	8,080	umhos/cm		
Total Dissolved Solids @ 180°C	5,050	mg/L		
Total Dissolved Solids (Calc)	4,840	mg/L		
Total Alkalinity as CaCO3	2,860	mg/L		
Total Hardness as CaCO3	15	mg/L		
Ortho Phosphate	<0.01	mg/L		
Sulfide	28.2	mg/L		
Hydrogen Sulfide	2.26	mg/L		
Bicarbonate as HCO3	3,480	mg/L	57.12	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	0.79	mg/L	0.04	meq/L
Chloride	1,160	mg/L	32.71	meq/L
Sulfate	7	mg/L	0.14	meq/L
Nitrate as Nitrogen	<0.01	mg/L	<0.01	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	3.6	mg/L	0.18	meq/L
Magnesium	1.5	mg/L	0.12	meq/L
Potassium	7.0	mg/L	0.18	meq/L
Sodium	1,940	mg/L	84.59	meq/L
Cations			85.07	meq/L
Anions			89.97	meq/L
Cation/Anion Difference			2.80	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Comments:

Reported by M. Klute

Reviewed by dt

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	03/22/95
Project:	Navajo Mine	Date Sampled:	03/02/95
Sample ID:	Bitsui - 2	Time Sampled:	1040
Laboratory ID:	W02730	Date Received:	03/02/95
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Result	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	2.69	mg/L		
Beryllium	<0.001	mg/L		
Boron	0.93	mg/L		
Cadmium	<0.002	mg/L		
Chromium	<0.02	mg/L	<0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	0.07	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Phosphorus	NA	mg/L	<0.2	mg/L
Selenium	<0.005	mg/L		
Silica	4.36	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Comments:

Reported by M. Clute

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	03/22/95
Sample ID:	Bitsui - 3	Date Sampled:	03/02/95
Laboratory ID:	W02729	Time Sampled:	1000
Sample Matrix:	Water	Date Received:	03/02/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.6	s.u.		
Lab Conductivity @ 25° C	13,000	umhos/cm		
Total Dissolved Solids @ 180°C	7,980	mg/L		
Total Dissolved Solids (Calc)	8,030	mg/L		
Total Alkalinity as CaCO3	2,560	mg/L		
Total Hardness as CaCO3	49	mg/L		
Ortho Phosphate	3.5	mg/L		
Sulfide	6.1	mg/L		
Hydrogen Sulfide	1.04	mg/L		
Bicarbonate as HCO3	3,120	mg/L	51.20	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	<0.01	mg/L	<0.01	meq/L
Chloride	2,820	mg/L	79.57	meq/L
Sulfate	442	mg/L	9.22	meq/L
Nitrate as Nitrogen	1	mg/L	0.10	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	11	mg/L	0.55	meq/L
Magnesium	5.2	mg/L	0.43	meq/L
Potassium	14	mg/L	0.35	meq/L
Sodium	3,200	mg/L	139.20	meq/L
Cations			140.53	meq/L
Anions			139.99	meq/L
Cation/Anion Difference			0.19	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Comments:

Reported by M. Klento

Reviewed by dk

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	03/24/95
Sample ID:	Bitsui - 3	Date Sampled:	03/02/95
Laboratory ID:	W02729	Time Sampled:	1000
Sample Matrix:	Water	Date Received:	03/02/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.07	mg/L		
Cadmium	0.004	mg/L		
Chromium	<0.02	mg/L	<0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	0.24	mg/L
Lead	0.012	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Phosphorus	NA	mg/L	<0.2	mg/L
Selenium	<0.005	mg/L		
Silica	4.82	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Comments:

Reported by M. Klute

Reviewed by

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	05/17/95
Sample ID:	Bitsui-1	Date Sampled:	04/27/95
Laboratory ID:	W00337	Time Sampled:	1345
Sample Matrix:	Water	Date Received:	04/27/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Arsenic	0.03	mg/L		
Barium	<0.5	mg/L		
Boron	7.6	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	
Iron	<0.05	mg/L	0.90	mg/L
Lead	0.011	mg/L		
Manganese	0.094	mg/L	0.11	mg/L
Phosphorus	NA	mg/L	1.88	mg/L
Selenium	0.007	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by:

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	05/18/95
Sample ID:	Bitsui-1	Date Sampled:	04/27/95
Laboratory ID:	W00337	Time Sampled:	1345
Sample Matrix:	Water	Date Received:	04/27/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	8.8	s.u.		
Lab Conductivity @ 25° C	18,100	umhos/cm		
Total Dissolved Solids @ 180°C	14,200	mg/L		
Total Dissolved Solids (Calc)	14,500	mg/L		
Total Suspended Solids	74	mg/L		
Total Alkalinity as CaCO3	1,050	mg/L		
Total Hardness as CaCO3	280	mg/L		
Total Organic Carbon	33	mg/L		
SAR	129.380	ratio		
Grain Size Finer Than 0.062 mm	*NA	%		
Bicarbonate as HCO3	1,160	mg/L	19.00	meq/L
Carbonate as CO3	60	mg/L	2.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	2.64	mg/L	0.14	meq/L
Nitrate	2.4	mg/L	0.17	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Chloride	2,050	mg/L	57.8	meq/L
Sulfate	6,680	mg/L	139.10	meq/L
Calcium	56	mg/L	2.80	meq/L
Magnesium	34	mg/L	2.79	meq/L
Potassium	54	mg/L	1.37	meq/L
Sodium	4,970	mg/L	216.30	meq/L
Cations			223.26	meq/L
Anions			218.10	meq/L
Cation/Anion Difference			1.17	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments: *NA - Insufficient amount of suspended particulates to perform analysis.

Reported by M. Klute

Reviewed by

Inter·Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	05/18/95
Sample ID:	Bitsui-2	Date Sampled:	04/27/95
Laboratory ID:	W00336	Time Sampled:	1311
Sample Matrix:	Water	Date Received:	04/27/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	8.0	s.u.		
Lab Conductivity @ 25° C	8,110	umhos/cm		
Total Dissolved Solids @ 180°C	5,020	mg/L		
Total Dissolved Solids (Calc)	5,100	mg/L		
Total Suspended Solids	<10	mg/L		
Total Alkalinity as CaCO3	2,840	mg/L		
Total Hardness as CaCO3	28	mg/L		
Total Organic Carbon	11	mg/L		
SAR	174.732	ratio		
Grain Size Finer Than 0.062 mm	*NA	%		
Bicarbonate as HCO3	3,460	mg/L	56.72	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	1.78	mg/L	0.09	meq/L
Nitrate	0.15	mg/L	0.01	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Chloride	1,220	mg/L	34.3	meq/L
Sulfate	48	mg/L	1.00	meq/L
Calcium	6.6	mg/L	0.33	meq/L
Magnesium	2.7	mg/L	0.22	meq/L
Potassium	13	mg/L	0.33	meq/L
Sodium	2,110	mg/L	91.63	meq/L
Cations			92.51	meq/L
Anions			92.07	meq/L
Cation/Anion Difference			0.24	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments: *NA - Insufficient amount of suspended particulates to perform analysis.

Reported by M. Klute

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Str
Farmington, New Mexico 874

Client: BHP Minerals
Project: Navajo Mine
Sample ID: Bitsui-2
Laboratory ID: W00336
Sample Matrix: Water
Condition: Cool/Intact

Date Reported: 05/17/95
Date Sampled: 04/27/95
Time Sampled: 1311
Date Received: 04/27/95

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Arsenic............................	<0.005	mg/L		
Barium............................	2.7	mg/L		
Boron............................	0.91	mg/L		
Cadmium..........................	<0.002	mg/L		
Chromium....................	NA	mg/L	<0.02	
Iron..................................	<0.05	mg/L	0.11	mg/L
Lead................................	<0.005	mg/L		
Manganese......................	<0.02	mg/L	<0.02	mg/L
Phosphorus....................	NA	mg/L	<0.5	mg/L
Selenium..........................	<0.005	mg/L		
Silver..........................	<0.01	mg/L		
Zinc................................	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by M Klaxto

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	05/18/95
Sample ID:	Bitsui-3	Date Sampled:	04/27/95
Laboratory ID:	W00335	Time Sampled:	1220
Sample Matrix:	Water	Date Received:	04/27/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.5	s.u.		
Lab Conductivity @ 25° C	13,100	umhos/cm		
Total Dissolved Solids @ 180°C	7,740	mg/L		
Total Dissolved Solids (Calc)	8,150	mg/L		
Total Suspended Solids	20	mg/L		
Total Alkalinity as CaCO3	2,500	mg/L		
Total Hardness as CaCO3	115	mg/L		
Total Organic Carbon	7	mg/L		
SAR	128.125	ratio		
Grain Size Finer Than 0.062 mm	*NA	%		
Bicarbonate as HCO3	3,050	mg/L	49.92	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	0.99	mg/L	0.05	meq/L
Nitrate	4.1	mg/L	0.30	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Chloride	3,160	mg/L	89.0	meq/L
Sulfate	255	mg/L	5.32	meq/L
Calcium	27	mg/L	1.34	meq/L
Magnesium	12	mg/L	0.95	meq/L
Potassium	44	mg/L	1.13	meq/L
Sodium	3,150	mg/L	137.10	meq/L
Cations			140.52	meq/L
Anions			144.57	meq/L
Cation/Anion Difference			1.42	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments: *NA - Insufficient amount of suspended particulates to perform analysis.

Reported by M Klute

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	05/17/95
Project:	Navajo Mine	Date Sampled:	04/27/95
Sample ID:	Bitsui-3	Time Sampled:	1220
Laboratory ID:	W00335	Date Received:	04/27/95
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Arsenic	<0.005	mg/L		
Barium	1.3	mg/L		
Boron	1.0	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	
Iron	0.05	mg/L	0.75	mg/L
Lead	0.033	[illegible]		
Manganese	<0.02	mg/L	[illegible]	mg/L
Phosphorus	NA	mg/L	<0.5	[illegible]
Selenium	<0.005	mg/L		
Silver	<0.01	mg/L		
Zinc	0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by M. Klute

Reviewed by [signature]

Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

:	BHP Minerals		Date Reported:	06/03/95
ct:	Navajo Mine		Date Sampled:	05/19/95
le ID:	Bitsui - 1		Time Sampled:	0712
ratory ID:	W00532		Date Received:	05/19/95
le Matrix:	Water			
ition:	Cool/Intact			

meter	Analytical Result	Units		Units
pH	8.8	s.u.		
Conductivity @ 25° C	25,900	umhos/cm		
al Dissolved Solids @ 180°C	14,200	mg/L		
al Dissolved Solids (Calc)	14,800	mg/L		
al Alkalinity as CaCO3	1,110	mg/L		
al Ha[illegible]ss as CaCO3	232	mg/L		
no Ph[illegible]	<0.01	mg/L		
fide	<0.01	mg/L		
B[illegible]onate as HCO3	1,180	mg/L	[illegible].32	meq/L
C[illegible]onate as CO3	84	mg/L	2.80	meq/L
H[illegible]oxide as OH	0	mg/L	0.00	[illegible]
Fluoride	2.71	mg/L	0.14	meq/L
Chloride	2,070	mg/L	58.40	meq/L
Sulfate	7,100	mg/L	147.93	meq/L
Nitrate as Nitrogen	1.5	mg/L	0.11	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	45	mg/L	2.25	meq/L
Magnesium	29	mg/L	2.38	meq/L
Potassium	23	mg/L	0.59	meq/L
Sodium	4,830	mg/L	210.00	meq/L
ations			215.22	meq/L
nions			228.70	meq/L
ation/Anion Difference			3.04	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reviewed by [signature]

Reported by M. Klute

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	06/05/95
›ject:	Navajo Mine	Date Sampled:	05/19/95
Sample ID:	Bitsui - 1	Time Sampled:	0712
Laboratory ID:	W00532	Date Received:	05/19/95
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	0.04	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	8.44	mg/L		
Cadmium	<0.005	mg/L		
Chromium	NA		<0.02	mg/L
obalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	1.06	mg/L
Lead	<0.050	mg/L		
Manganese	0.10	mg/L	0.11	mg/L
Mercury	<0.001	mg/L		
Selenium	0.007	mg/L		
Silica	6.66	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by M. Klutz

Reviewed by [signature]

Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

n'	BHP Minerals			
e	Navajo Mine		Date Reported:	06/05/95
nple ID:	Bitsui - 2		Date Sampled:	05/19/95
oratory ID:	W00533		Time Sampled:	0745
nple Matrix:	Water		Date Received:	05/19/95
ndition:	Cool/Intact			

rameter	Analytical Result	Units		Units
b pH	8.0	s.u.		
b Conductivity @ 25° C.	12,100	umhos/cm		
tal Dissolved Solids @ 180°C.	5,010	mg/L		
tal Dissolved Solids (Calc)	5,080	mg/L		
tal Alkalinity as CaCO3	2,890	mg/L		
tal Hardness as CaCO3	34	mg/L		
tho Phosphate	<0.01	mg/L		
ulfide	65.5	mg/L		
rbonate as HCO3	3,520	mg/L	57.76	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
roxide as OH	0	mg/L	0.00	meq/L
Fluoride	1.75	mg/L	0.09	meq/L
Chloride	1,220	mg/L	34.41	meq/L
Sulfate	28	mg/L	0.58	meq/L
Nitrate as Nitrogen	<0.01	mg/L	<0.01	meq/L
Nitrite as Nitrogen	0.05	mg/L	<0.01	meq/L
Calcium	8.6	mg/L	0.43	meq/L
Magnesium	3.0	mg/L	0.25	meq/L
Potassium	1.6	mg/L	0.04	meq/L
Sodium	2,090	mg/L	90.88	meq/L
Cations			91.60	meq/L
Anions			92.85	meq/L
Cation/Anion Difference			0.68	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reviewed by *[signature]*

Reported by *M. Klute*

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
ject:	Navajo Mine	Date Reported:	06/05/95
ample ID:	Bitsui - 2	Date Sampled:	05/19/95
Laboratory ID:	W00533	Time Sampled:	0745
Sample Matrix:	Water	Date Received:	05/19/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	2.89	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.03	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA		<0.02	mg/L
balt	<0.05	mg/L		
opper	<0.01	mg/L		
Iron	<0.05	mg/L	0.07	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.34	mg/L		
Silver	<0.01	mg/L		
Zinc	0.03	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by M. Klute

Reviewed by

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	06/01/95
Sample ID:	Bitsui - 3	Date Sampled:	05/18/95
Laboratory ID:	W00530	Time Sampled:	1140
Sample Matrix:	Water	Date Received:	05/18/95
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.3	s.u.		
Lab Conductivity @ 25° C	14,600	umhos/cm		
Total Dissolved Solids @ 180°C	7,730	mg/L		
Total Dissolved Solids (Calc)	7,950	mg/L		
Total Alkalinity as CaCO3	2,520	mg/L		
Total Hardness as CaCO3	73	mg/L		
Ortho Phosphate	<0.01	mg/L		
Sulfide	2.8	mg/L		
Bicarbonate as HCO3	3,070	mg/L	50.40	meq/L
Carbonate as CO3	0	mg/L	0.00	meq/L
Hydroxide as OH	0	mg/L	0.00	meq/L
Fluoride	0.99	mg/L	0.05	meq/L
Chloride	3,080	mg/L	86.91	meq/L
Sulfate	192	mg/L	4.00	meq/L
Nitrate as Nitrogen	<0.01	mg/L	<0.01	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	19	mg/L	0.95	meq/L
Magnesium	6.1	mg/L	0.50	meq/L
Potassium	10	mg/L	0.26	meq/L
Sodium	3,130	mg/L	136.00	meq/L
Cations			137.71	meq/L
Anions			141.36	meq/L
Cation/Anion Difference			1.31	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by M. Klute

Reviewed by dt

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine	Date Reported:	06/01/95
Sample ID:	Bitsui - 3	Date Sampled:	05/18/95
Laboratory ID:	W00530	Time Sampled:	1140
Sample Matrix:	Water	Date Received:	05/18/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	0.51	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.05	mg/L		
Cadmium	<0.005	mg/L		
Chromium	NA		<0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.05	mg/L	0.28	mg/L
Lead	<0.05	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.69	mg/L		
Silver	<0.01	mg/L		
Zinc	0.10	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by [signature]

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2		
Sample ID:	Bitsui-1	Date Reported:	11/19/95
Laboratory ID:	0395W01941	Date Sampled:	10/18/95
Sample Matrix:	Water	Time Sampled:	1337
Condition:	Cool/Intact	Date Received:	10/19/95

Parameter	Analytical Result	Units		Units
Lab pH	8.9	s.u.		
Lab Conductivity @ 25° C	17,800	umhos/cm		
Total Dissolved Solids @ 180°C	*14200	mg/L		
Total Dissolved Solids (Calc)	*14400	mg/L		
Total Alkalinity as CaCO3	1,010	mg/L		
Total Hardness as CaCO3	249	mg/L		
Bicarbonate as HCO3	1,010	mg/L	16.6	meq/L
Carbonate as CO3	108	mg/L	3.60	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	2.51	mg/L	0.13	meq/L
Chloride	1,950	mg/L	54.98	meq/L
Sulfate	6,850	mg/L	142.75	meq/L
Nitrate	<0.01	mg/L	<0.01	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Calcium	56	mg/L	2.77	meq/L
Magnesium	27	mg/L	2.21	meq/L
Potassium	20	mg/L	0.51	meq/L
Sodium	4,860	mg/L	211.40	meq/L
Cations			216.89	meq/L
Anions			218.06	meq/L
Cation/Anion Difference			0.27	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983. "Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments: *Due to insuffient sample size and matrix effects, the ratio between the calculated TDS and the measured TDS does not meet criteria for balancing.

Reported by ~~AB~~ Reviewed by ~~CH~~

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2	Date Reported:	11/19/95
Sample ID:	Bitsui-1	Date Sampled:	10/18/95
Laboratory ID:	0395W01941	Time Sampled:	1337
Sample Matrix:	Water	Date Received:	10/19/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Barium............................	<0.5	mg/L		
Boron............................	6.98	mg/L		
Cadmium.........................	<0.002	mg/L		
Iron..................................	<0.05	mg/L	0.62	mg/L
Lead..............................	<0.005	mg/L		
Manganese....................	0.080	mg/L	0.07	mg/L
Selenium........................	0.016	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by ____________ Reviewed by ____________

Inter·Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2		
Sample ID:	Bitsui 2	Date Reported:	11/19/95
Laboratory ID:	0395W01943	Date Sampled:	10/18/95
Sample Matrix:	Water	Time Sampled:	1230
Condition:	Cool/Intact	Date Received:	10/19/95

Parameter	Analytical Result	Units		Units
Lab pH	8.0	s.u.		
Lab Conductivity @ 25° C	7,730	umhos/cm		
Total Dissolved Solids @ 180°C	4,910	mg/L		
Total Dissolved Solids (Calc)	4,880	mg/L		
Total Alkalinity as CaCO3	2,800	mg/L		
Total Hardness as CaCO3	30	mg/L		
Bicarbonate as HCO3	3,420	mg/L	56.0	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	1.69	mg/L	0.09	meq/L
Chloride	1,170	mg/L	32.95	meq/L
Sulfate	17	mg/L	0.36	meq/L
Nitrate	0.5	mg/L	0.04	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Calcium	8.6	mg/L	0.43	meq/L
Magnesium	1.9	mg/L	0.16	meq/L
Potassium	7.0	mg/L	0.18	meq/L
Sodium	1,990	mg/L	86.75	meq/L
Cations			87.52	meq/L
Anions			89.45	meq/L
Cation/Anion Difference			1.09	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983. "Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by ________ Reviewed by ________

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2	Date Reported:	11/19/95
Sample ID:	Bitsui 2	Date Sampled:	10/18/95
Laboratory ID:	0395W01943	Time Sampled:	1230
Sample Matrix:	Water	Date Received:	10/19/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Barium	2.42	mg/L		
Boron	0.83	mg/L		
Cadmium	<0.002	mg/L		
Iron	<0.05	mg/L	<0.05	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Selenium	<0.005	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by: SB

Reviewed by: AR

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2		
Sample ID:	Bitsui 3A	Date Reported:	11/19/95
Laboratory ID:	0395W01945	Date Sampled:	10/18/95
Sample Matrix:	Water	Time Sampled:	1005
Condition:	Cool/Intact	Date Received:	10/19/95

Parameter	Analytical Result	Units		Units
Lab pH	7.6	s.u.		
Lab Conductivity @ 25° C	12,400	umhos/cm		
Total Dissolved Solids @ 180°C	*7790	mg/L		
Total Dissolved Solids (Calc)	*8270	mg/L		
Total Alkalinity as $CaCO_3$	2,640	mg/L		
Total Hardness as $CaCO_3$	109	mg/L		
Bicarbonate as HCO_3	3,220	mg/L	52.9	meq/L
Carbonate as CO_3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	1.02	mg/L	0.05	meq/L
Chloride	2,760	mg/L	77.94	meq/L
Sulfate	471	mg/L	9.81	meq/L
Nitrate	1.20	mg/L	0.09	meq/L
Nitrite	<0.01	mg/L	<0.01	meq/L
Calcium	23	mg/L	1.16	meq/L
Magnesium	12	mg/L	1.02	meq/L
Potassium	23	mg/L	0.58	meq/L
Sodium	3,390	mg/L	147.40	meq/L
Cations			150.16	meq/L
Anions			140.75	meq/L
Cation/Anion Difference			3.23	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments: *Due to insuffient sample size and matrix effects, the ratio between the calculated TDS and the measured TDS does not meet criteria for balancing.

Reported by *GB*

Reviewed by *[signature]*

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine - Table 2	Date Reported:	11/19/95
Sample ID:	Bitsui 3A	Date Sampled:	10/18/95
Laboratory ID:	0395W01945	Time Sampled:	1005
Sample Matrix:	Water	Date Received:	10/19/95
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Result	Units	Total Analytical Result	Units
Trace Metals				
Barium	<0.5	mg/L		
Boron	0.92	mg/L		
Cadmium	<0.002	mg/L		
Iron	<0.05	mg/L	0.12	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Selenium	<0.005	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 18th ed., 1992.

Comments:

Reported by JB

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	01/11/96
Project:	Navajo Mine-Table 4	Date Sampled:	01/02/96
Sample ID:	Bitsui 1-4	Time Sampled:	13:30
Laboratory ID:	0396W00003	Date Received:	01/02/96
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	8.8	s.u.		
Lab Conductivity @ 25° C	17,800	umhos/cm		
Total Dissolved Solids @ 180°C	14,700	mg/L		
Total Dissolved Solids (Calc)	14,600	mg/L		
Total Alkalinity as $CaCO_3$	846	mg/L		
Total Hardness as $CaCO_3$	289	mg/L		
Ortho Phosphate	3.6	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO_3	837	mg/L	<0.01	meq/L
Carbonate as CO_3	96	mg/L	3.20	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	4.39	mg/L	0.23	meq/L
Chloride	1,980	mg/L	56.0	meq/L
Sulfate	6,990	mg/L	145.5	meq/L
Nitrate as Nitrogen	0.73	mg/L	0.05	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.01	meq/L
Calcium	63	mg/L	3.13	meq/L
Magnesium	32	mg/L	2.65	meq/L
Potassium	20	mg/L	0.51	meq/L
Sodium	5,040	mg/L	219.1	meq/L
Cations			225.36	meq/L
Anions			218.69	meq/L
Cation/Anion Difference			1.50	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983. "Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by JB

Reviewed by [signature]

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	01/11/96
Project:	Navajo Mine-Table 4	Date Sampled:	01/02/96
Sample ID:	Bitsui 1-4	Time Sampled:	13:30
Laboratory ID:	0396W00003	Date Received:	01/02/96
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	0.15	mg/L		
Arsenic	0.036	mg/L		
Barium	0.03	mg/L		
Beryllium	<0.005	mg/L		
Boron	8.30	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.02	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	0.65	mg/L
Lead	<0.005	mg/L		
Manganese	0.10	mg/L	0.10	mg/L
Mercury	<0.001	mg/L		
Selenium	0.010	mg/L		
Silica	6.97	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ________

Reviewed by ________

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4	Date Reported:	01/11/96
Sample ID:	Bitsui 2-4	Date Sampled:	01/02/96
Laboratory ID:	0396W00004	Time Sampled:	14:45
Sample Matrix:	Water	Date Received:	01/02/96
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.9	s.u.		
Lab Conductivity @ 25° C	7,590	umhos/cm		
Total Dissolved Solids @ 180°C	5,020	mg/L		
Total Dissolved Solids (Calc)	5,000	mg/L		
Total Alkalinity as CaCO3	2,960	mg/L		
Total Hardness as CaCO3	27	mg/L		
Ortho Phosphate	0.13	mg/L		
Sulfide	34	mg/L		
Bicarbonate as HCO3	3,610	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	2.66	mg/L	0.14	meq/L
Chloride	1,150	mg/L	32.5	meq/L
Sulfate	4.5	mg/L	0.09	meq/L
Nitrate as Nitrogen	0.53	mg/L	0.04	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.01	meq/L
Calcium	6.4	mg/L	0.32	meq/L
Magnesium	2.6	mg/L	0.21	meq/L
Potassium	5.1	mg/L	0.13	meq/L
Sodium	2,050	mg/L	89.4	meq/L
Cations			90.01	meq/L
Anions			91.82	meq/L
Cation/Anion Difference			0.99	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ________

Reviewed by ________

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
oject:	Navajo Mine-Table 4	Date Reported:	01/11/96
Sample ID:	Bitsui 2-4	Date Sampled:	01/02/96
Laboratory ID:	0396W00004	Time Sampled:	14:45
Sample Matrix:	Water	Date Received:	01/02/96
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	2.96	mg/L		
Beryllium	<0.005	mg/L		
Boron	1.01	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.02	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	<0.05	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.38	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ~~SB~~

Reviewed by dt

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	01/11/96
Project:	Navajo Mine-Table 4	Date Sampled:	12/29/95
Sample ID:	Bitsui 3-4	Time Sampled:	10:25
Laboratory ID:	0396W00001	Date Received:	12/29/95
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.6	s.u.		
Lab Conductivity @ 25° C	12,600	umhos/cm		
Total Dissolved Solids @ 180°C	8,140	mg/L		
Total Dissolved Solids (Calc)	8,030	mg/L		
Total Alkalinity as CaCO3	2,400	mg/L		
Total Hardness as CaCO3	104	mg/L		
Ortho Phosphate	0.11	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	2,920	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	1.27	mg/L	0.07	meq/L
Chloride	2,810	mg/L	79.2	meq/L
Sulfate	509	mg/L	10.6	meq/L
Nitrate as Nitrogen	<0.05	mg/L	<0.01	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.01	meq/L
Calcium	25	mg/L	1.23	meq/L
Magnesium	10	mg/L	0.85	meq/L
Potassium	9.8	mg/L	0.25	meq/L
Sodium	3,230	mg/L	140.6	meq/L
Cations			142.94	meq/L
Anions			137.78	meq/L
Cation/Anion Difference			1.84	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by: JB

Reviewed by: dt

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client: BHP Minerals
Project: Navajo Mine-Table 4
Sample ID: Bitsui 3-4
Laboratory ID: 0396W00001
Sample Matrix: Water
Condition: Cool/Intact

Date Reported: 01/11/96
Date Sampled: 12/29/95
Time Sampled: 10:25
Date Received: 12/29/95

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	0.36	mg/L		
Beryllium	<0.005	mg/L		
Boron	1.08	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.02	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	0.18	mg/L
Lead	<0.005	mg/L		
Manganese	<0.02	mg/L	<0.02	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.96	mg/L		
Silver	<0.01	mg/L		
Zinc	<0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by: SB

Reviewed by: [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui #4	Date Reported:	02/15/96
Laboratory ID:	0396W00117	Date Sampled:	01/26/96
Sample Matrix:	Water	Time Sampled:	15:30
Condition:	Cool/Intact	Date Received:	01/26/96

Parameter	Analytical Result	Units		Units
Lab pH	6.9	s.u.		
Lab Conductivity @ 25° C	16,700	umhos/cm		
Total Dissolved Solids @ 180°C	*15,000	mg/L		
Total Dissolved Solids (Calc)	*15,500	mg/L		
Total Hardness as CaCO3	576	mg/L		
Total Alkalinity as CaCO3	1,440	mg/L		
Ortho-Phosphate	0.02	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	1,760	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	0.29	mg/L	0.02	meq/L
Chloride	634	mg/L	17.9	meq/L
Sulfate	8,640	mg/L	180	meq/L
Nitrate as Nitrogen	0.09	mg/L	0.01	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	15	mg/L	0.73	meq/L
Magnesium	131	mg/L	10.8	meq/L
Potassium	538	mg/L	13.8	meq/L
Sodium	4,650	mg/L	202	meq/L
Cations			228	meq/L
Anions			227	meq/L
Cation/Anion Difference			0.19	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments: *TDS ratio does not meet normal criteria for balancing. Sample was reran several times with no significant change in result. Matrix interferences are suspect.

Reported by ________

Reviewed by ________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client: BHP Minerals
Project: Navajo Mine-Table 4
Sample ID: Bitsui #4
Laboratory ID: 0396W00117
Sample Matrix: Water
Condition: Cool/Intact

Date Reported: 02/15/96
Date Sampled: 01/26/96
Time Sampled: 15:30
Date Received: 01/26/96

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L	NA	mg/L
Arsenic	<0.005	mg/L	NA	mg/L
Barium	0.03	mg/L	NA	mg/L
Beryllium	<0.005	mg/L	NA	mg/L
Boron	1.71	mg/L	NA	mg/L
Cadmium	<0.002	mg/L	NA	mg/L
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.02	mg/L	NA	mg/L
Copper	<0.01	mg/L	NA	mg/L
Iron	<0.05	mg/L	4.67	mg/L
Lead	<0.005	mg/L	NA	mg/L
Manganese	2.40	mg/L	2.41	mg/L
Mercury	<0.001	mg/L	NA	mg/L
Selenium	<0.005	mg/L	NA	mg/L
Silica	<0.01	mg/L	NA	mg/L
Silver	<0.01	mg/L	NA	mg/L
Zinc	0.03	mg/L	NA	mg/L

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by JB

Reviewed by

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	02/28/96
Project:	Navajo Mine-Table 4	Date Sampled:	02/12/96
Sample ID:	Bitsui 4	Time Sampled:	1125
Laboratory ID:	0396W00177	Date Received:	02/12/96
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	14,400	umhos/cm		
Total Dissolved Solids @ 180°C	13,100	mg/L		
Total Dissolved Solids (Calc)	12,200	mg/L		
Total Alkalinity as CaCO3	1,240	mg/L		
Total Hardness as CaCO3	1,230	mg/L		
Ortho Phosphate	0.39	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	1,510	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	0.33	mg/L	0.02	meq/L
Chloride	451	mg/L	12.72	meq/L
Sulfate	6,680	mg/L	139.19	meq/L
Nitrate as Nitrogen	1.2	mg/L	0.09	meq/L
Nitrite as Nitrogen	<0.01	mg/L	<0.01	meq/L
Calcium	287	mg/L	14.30	meq/L
Magnesium	125	mg/L	10.28	meq/L
Potassium	22	mg/L	0.55	meq/L
Sodium	3,850	mg/L	167.50	meq/L
Cations			192.63	meq/L
Anions			176.83	meq/L
Cation/Anion Difference			4.28	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ________ Reviewed by SB ________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client: BHP Minerals
Project: Navajo Mine-Table 4
Sample ID: Bitsui 4
Laboratory ID: 0396W00177
Sample Matrix: Water
Condition: Cool/Intact

Date Reported: 02/28/96
Date Sampled: 02/12/96
Time Sampled: 1125
Date Received: 02/12/96

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.49	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	0.04	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.06	mg/L	16.6	mg/L
Lead	<0.005	mg/L		
Manganese	3.18	mg/L	3.35	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.27	mg/L		
Silver	<0.01	mg/L		
Zinc	0.14	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ________

Reviewed by ________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui 5	Date Reported:	02/28/96
Laboratory ID:	0396W00185	Date Sampled:	02/13/96
Sample Matrix:	Water	Time Sampled:	1420
Condition:	Cool/Intact	Date Received:	02/13/96

Parameter	Analytical Result	Units		Units
Lab pH	7.4	s.u.		
Lab Conductivity @ 25° C	13,000	umhos/cm		
Total Dissolved Solids @ 180°C	10,300	mg/L		
Total Dissolved Solids (Calc)	10,200	mg/L		
Total Alkalinity as CaCO3	2,600	mg/L		
Total Hardness as CaCO3	304	mg/L		
Ortho Phosphate	0.01	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	3,170	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	1.0	mg/L	0.45	meq/L
Chloride	1,330	mg/L	37.54	meq/L
Sulfate	3,550	mg/L	73.96	meq/L
Nitrate as Nitrogen	0.01	mg/L	<0.05	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.05	meq/L
Calcium	72	mg/L	3.58	meq/L
Magnesium	30	mg/L	2.49	meq/L
Potassium	16	mg/L	0.42	meq/L
Sodium	3,630	mg/L	158.00	meq/L
Cations			164.49	meq/L
Anions			163.92	meq/L
Cation/Anion Difference			0.17	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by [signature]

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals	Date Reported:	02/28/96
Project:	Navajo Mine-Table 4	Date Sampled:	02/13/96
Sample ID:	Bitsui 5	Time Sampled:	1420
Laboratory ID:	0396W00185	Date Received:	02/13/96
Sample Matrix:	Water		
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.10	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.48	mg/L	2.05	mg/L
Lead	<0.005	mg/L		
Manganese	0.41	mg/L	0.41	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.45	mg/L		
Silver	<0.01	mg/L		
Zinc	0.01	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ____________

Reviewed by ____________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui 6	Date Reported:	02/28/96
Laboratory ID:	0396W00178	Date Sampled:	02/12/96
Sample Matrix:	Water	Time Sampled:	1418
Condition:	Cool/Intact	Date Received:	02/12/96

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	14,300	umhos/cm		
Total Dissolved Solids @ 180°C	13,200	mg/L		
Total Dissolved Solids (Calc)	13,100	mg/L		
Total Alkalinity as CaCO3	1,180	mg/L		
Total Hardness as CaCO3	1,470	mg/L		
Ortho Phosphate	0.33	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	1,440	mg/L	<0.01	meq/L
Carbonate as CO3	0	mg/L	<0.01	meq/L
Hydroxide as OH	0	mg/L	<0.01	meq/L
Fluoride	0.30	mg/L	0.02	meq/L
Chloride	392	mg/L	11.05	meq/L
Sulfate	7,690	mg/L	160.22	meq/L
Nitrate as Nitrogen	6.2	mg/L	0.44	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.05	meq/L
Calcium	327	mg/L	16.34	meq/L
Magnesium	158	mg/L	12.98	meq/L
Potassium	24	mg/L	0.62	meq/L
Sodium	3,780	mg/L	164.30	meq/L
Cations			194.24	meq/L
Anions			195.32	meq/L
Cation/Anion Difference			0.28	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ______

Reviewed by ______

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

.ient:	BHP Minerals		
roject:	Navajo Mine-Table 4	Date Reported:	02/28/96
Sample ID:	Bitsui 6	Date Sampled:	02/12/96
Laboratory ID:	0396W00178	Time Sampled:	1418
Sample Matrix:	Water	Date Received:	02/12/96
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	<0.1	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.57	mg/L		
Cadmium	<0.002	mg/L		
'hromium	NA	mg/L	0.04	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	<0.05	mg/L	20.0	mg/L
Lead	<0.005	mg/L		
Manganese	3.26	mg/L	3.55	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	4.28	mg/L		
Silver	<0.01	mg/L		
Zinc	0.05	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by ____________

Reviewed by ____________

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui 4-1	Date Reported:	05/03/96
Laboratory ID:	0396W00600	Date Sampled:	04/10/96
Sample Matrix:	Water	Time Sampled:	13:45
Condition:	Cool/Intact	Date Received:	04/10/96

Parameter	Analytical Result	Units		Units
Lab pH	7.1	s.u.		
Lab Conductivity @ 25° C	16,500	umhos/cm		
Total Dissolved Solids @ 180°C	13,800	mg/L		
Total Dissolved Solids (Calc)	14,000	mg/L		
Total Alkalinity as CaCO3	1,350	mg/L		
Total Hardness as CaCO3	1,080	mg/L		
Total Phosphate	<0.01	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	1,650	mg/L	27.0	meq/L
Carbonate as CO3	<1.0	mg/L	<1.0	meq/L
Hydroxide as OH	<1.0	mg/L	<1.0	meq/L
Fluoride	0.33	mg/L	0.02	meq/L
Chloride	651	mg/L	18.4	meq/L
Sulfate	7,860	mg/L	164	meq/L
Nitrate as Nitrogen	1.17	mg/L	0.08	meq/L
Nitrite as Nitrogen	0.05	mg/L	<0.05	meq/L
Calcium	231	mg/L	11.6	meq/L
Magnesium	123	mg/L	10.1	meq/L
Potassium	19.2	mg/L	0.49	meq/L
Sodium	4,280	mg/L	186	meq/L
Cations			208	meq/L
Anions			209	meq/L
Cation/Anion Difference			0.23	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments: Electrical conductivity and TDS reanalyzed with no significant difference.

Reported by WM

Reviewed by CHolland

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4	Date Reported:	05/03/96
Sample ID:	Bitsui 4-1	Date Sampled:	04/10/96
Laboratory ID:	0396W00600	Time Sampled:	13:45
Sample Matrix:	Water	Date Received:	04/10/96
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	0.59	mg/L		
Arsenic	<0.005	mg/L		
Barium	0.02	mg/L		
Beryllium	<0.001	mg/L		
Boron	1.54	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	0.03	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.26	mg/L	4.21	mg/L
Lead	<0.005	mg/L		
Manganese	2.66	mg/L	2.52	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	6.47	mg/L		
Silver	<0.01	mg/L		
Zinc	0.02	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Reported by WM

Reviewed by CSHolland

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui 5-1	Date Reported:	05/10/96
Laboratory ID:	0396W00609	Date Sampled:	04/11/96
Sample Matrix:	Water	Time Sampled:	15:15
Condition:	Cool/Intact	Date Received:	04/12/96

Parameter	Analytical Result	Units		Units
Lab pH	7.5	s.u.		
Lab Conductivity @ 25° C	14,200	umhos/cm		
Total Dissolved Solids @ 180°C	10,600	mg/L		
Total Alkalinity as CaCO3	2,530	mg/L		
Total Hardness as CaCO3	262	mg/L		
Total Phosphorous	<0.01	mg/L		
Sulfide	2.8	mg/L		
Bicarbonate as HCO3	3,090	mg/L	50.6	meq/L
Carbonate as CO3	<1.00	mg/L	<1.00	meq/L
Hydroxide as OH	<1.00	mg/L	<1.00	meq/L
Fluoride	1.04	mg/L	0.05	meq/L
Chloride	1,210	mg/L	34.1	meq/L
Sulfate	4,060	mg/L	84.6	meq/L
Nitrate as Nitrogen	<0.05	mg/L	<0.05	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.05	meq/L
Calcium	59.5	mg/L	2.97	meq/L
Magnesium	27.5	mg/L	2.26	meq/L
Potassium	14.1	mg/L	0.36	meq/L
Sodium	3,830	mg/L	167	meq/L
Cations			172	meq/L
Anions			169	meq/L
Cation/Anion Difference			0.84	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by: WM

Reviewed by: [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4	Date Reported:	05/10/96
Sample ID:	Bitsui 5-1	Date Sampled:	04/11/96
Laboratory ID:	0396W00609	Time Sampled:	15:15
Sample Matrix:	Water	Date Received:	04/12/96
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	0.11	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.005	mg/L		
Boron	1.13	mg/L		
Cadmium	<0.002	mg/L		
Chromium	NA	mg/L	<0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.31	mg/L	1.83	mg/L
Lead	<0.005	mg/L		
Manganese	0.17	mg/L	0.17	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	5.17	mg/L		
Silver	<0.01	mg/L		
Zinc	0.03	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments: NA = Not Applicable

Reported by WM

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	BHP Minerals		
Project:	Navajo Mine-Table 4		
Sample ID:	Bitsui 6-1	Date Reported:	05/10/96
Laboratory ID:	0396W00610	Date Sampled:	04/11/96
Sample Matrix:	Water	Time Sampled:	12:32
Condition:	Cool/Intact	Date Received:	04/12/96

Parameter	Analytical Result	Units		Units
Lab pH	7.2	s.u.		
Lab Conductivity @ 25° C	15,100	umhos/cm		
Total Dissolved Solids @ 180°C	13,300	mg/L		
Total Dissolved Solids (Calc)	13,400	mg/L		
Total Alkalinity as CaCO3	1,230	mg/L		
Total Hardness as CaCO3	1,400	mg/L		
Total Phosphorous	<0.01	mg/L		
Sulfide	<0.01	mg/L		
Bicarbonate as HCO3	1,500	mg/L	24.6	meq/L
Carbonate as CO3	<1.00	mg/L	<1.00	meq/L
Hydroxide as OH	<1.00	mg/L	<1.00	meq/L
Fluoride	0.31	mg/L	0.02	meq/L
Chloride	356	mg/L	10.0	meq/L
Sulfate	7,920	mg/L	165	meq/L
Nitrate as Nitrogen	0.08	mg/L	<0.05	meq/L
Nitrite as Nitrogen	<0.05	mg/L	<0.05	meq/L
Calcium	296	mg/L	14.8	meq/L
Magnesium	161	mg/L	13.2	meq/L
Potassium	21.900	mg/L	0.56	meq/L
Sodium	3,940	mg/L	171	meq/L
Cations			200	meq/L
Anions			200	meq/L
Cation/Anion Difference			0.09	%

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments:

Reported by WM

Reviewed by [signature]

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

lient:	BHP Minerals		
Project:	Navajo Mine-Table 4	Date Reported:	05/10/96
Sample ID:	Bitsui 6-1	Date Sampled:	04/11/96
Laboratory ID:	0396W00610	Time Sampled:	12:32
Sample Matrix:	Water	Date Received:	04/12/96
Condition:	Cool/Intact		

Parameter	Dissolved Analytical Results	Units	Total Analytical Results	Units
Trace Metals				
Aluminum	0.46	mg/L		
Arsenic	<0.005	mg/L		
Barium	<0.5	mg/L		
Beryllium	<0.005	mg/L		
Boron	1.47	mg/L		
Cadmium	0.011	mg/L		
Chromium	NA	mg/L	0.02	mg/L
Cobalt	<0.05	mg/L		
Copper	<0.01	mg/L		
Iron	0.19	mg/L	1.25	mg/L
Lead	<0.005	mg/L		
*Manganese	2.73	mg/L	2.54	mg/L
Mercury	<0.001	mg/L		
Selenium	<0.005	mg/L		
Silica	5.79	mg/L		
Silver	<0.01	mg/L		
Zinc	0.02	mg/L		

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 19th ed., 1995.

Comments: Dissolved Mn > Total Mn, within range of laboratory error.

Reported by ______

Reviewed by ______

APPENDIX D

D-5 ELECTRONIC DATA

BLANK APPENDIX

(Data originally submitted in June 1996 submission)

November 1996

BHP Minerals

Navajo Mine

Fruitland

APPENDIX D

ANALYTICAL DATA AND RESULTS

D-6 Water Quality Graphs

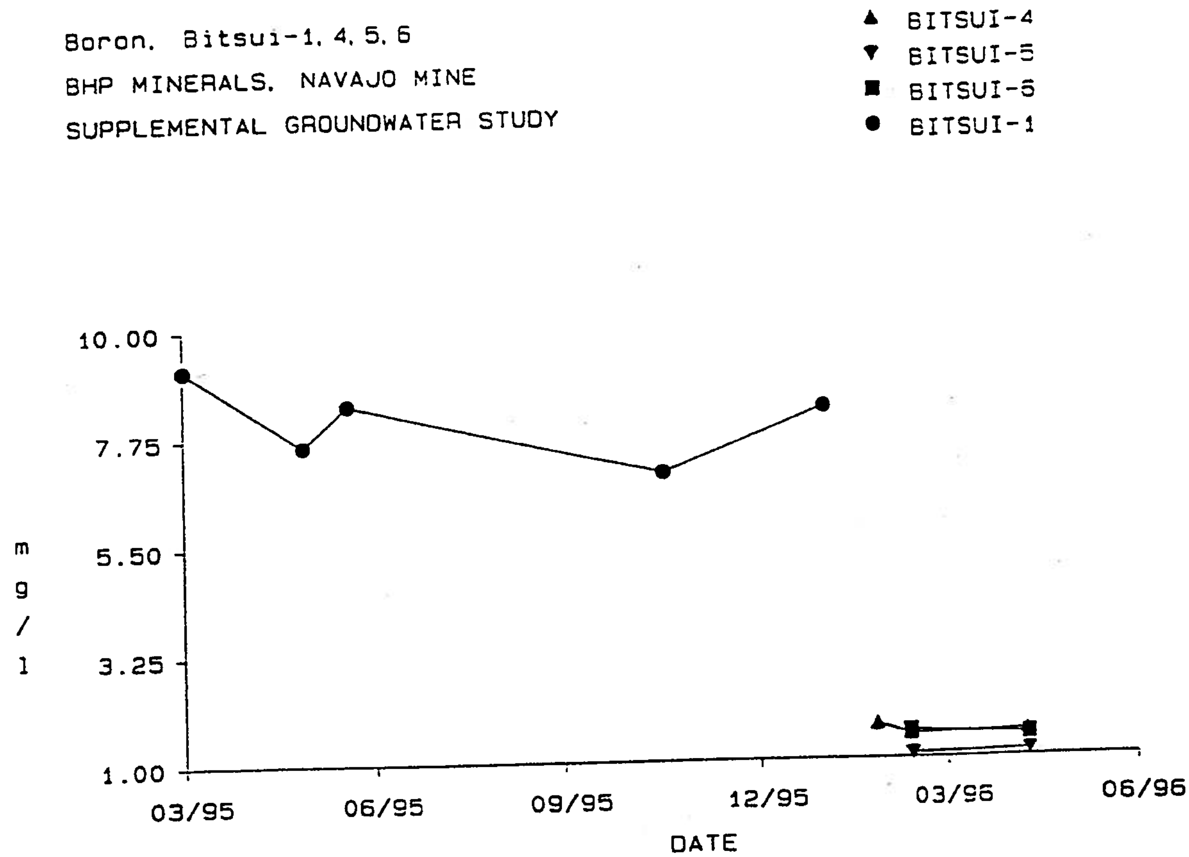
November 1996

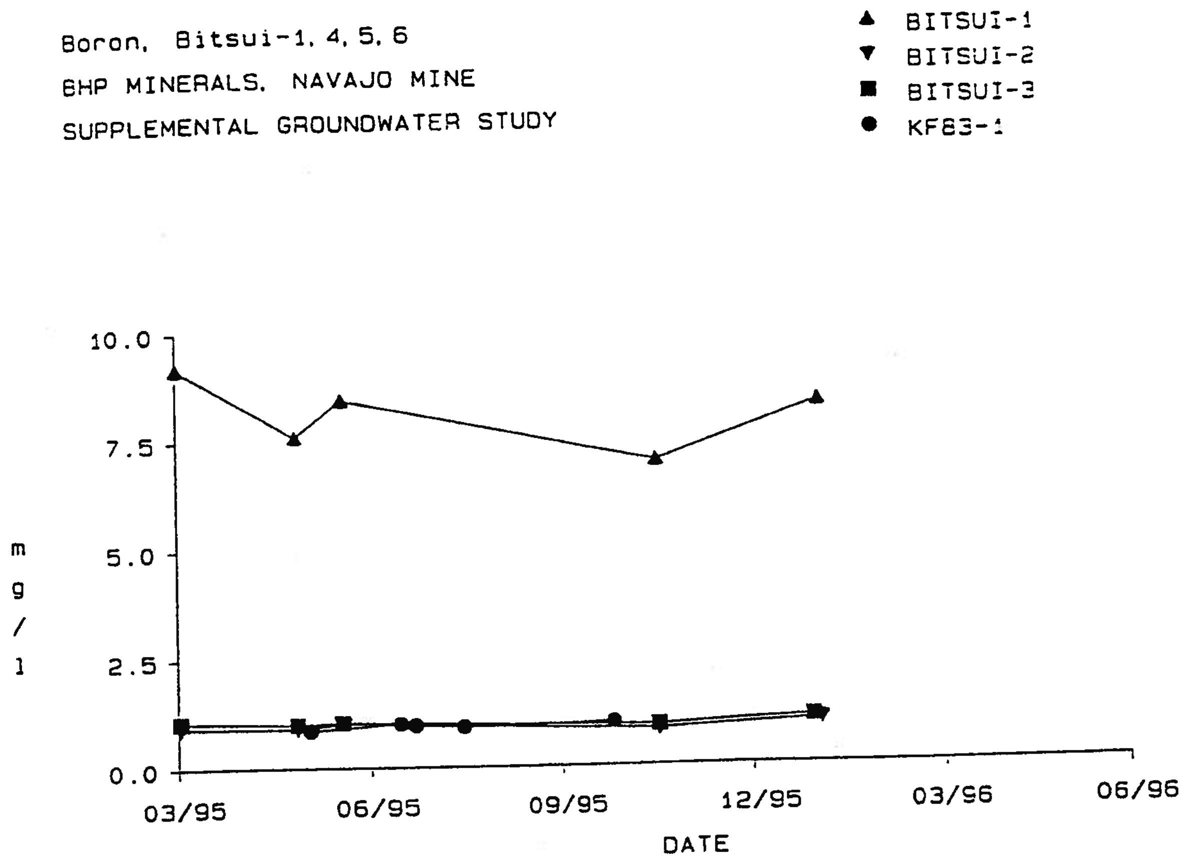
BHP Minerals
Navajo Mine
Fruitland

Boron. Bitsui-1, 4, 5, 6

BHP MINERALS, NAVAJO MINE

SUPPLEMENTAL GROUNDWATER STUDY




Boron, Bitsui-1, 4, 5, 6
BHP MINERALS, NAVAJO MINE
SUPPLEMENTAL GROUNDWATER STUDY
BITSUI-1
BITSUI-2
BITSUI-3
KF83-1
10.0
7.5
5.0
2.5
0.0
mg/l
03/95
06/95
09/95
12/95
03/96
06/96
DATE

SUPPLEMENTAL GROUNDWATER STUDY
GROUNDWATER DATA

- **THROUGH MARCH 1998**

(6/99)

SUPPLEMENTAL GROUNDWATER STUDY

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QUALITY REPORT

BHP Minerals Navajo Mine
NAVAJO MINE

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: ASH

Station Name:		BITSUI-1	BITSUI-1	BITSUI-1	BITSUI-1	BITSUI-1	BITSUI-1
Sample Date:		03/01/95	04/27/95	05/19/95	10/18/95	01/02/96	04/09/96
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.70	8.80	8.80	8.90	8.80	8.90
Conductivity (Lab)	(umho/cm)	17800	18100	25900	17800	17800	16600
TDS (180 deg C)	(mg/l)	14200	14200	14200	14200	14700	13200
Boron	(mg/l)	9.20	7.60	8.44	6.98	8.30	10.20
Fluoride	(mg/l)	2.60	2.64	2.71	2.51	4.39	2.18
NUTRIENTS							
Nitrate as N	(mg/l)	1.40	2.40	1.50	-0.01	0.73	-0.05
Nitrite as N	(mg/l)	-0.01	-0.01	-0.01	-0.01	-0.05	0.20
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	1020.00	1160.00	1180.00	1010.00	837.00	866.00
Carbonate as CO3	(mg/l)	82.00	60.00	84.00	108.00	96.00	84.00
Chloride	(mg/l)	1880.00	2050.00	2070.00	1950.00	1980.00	1800.00
Sulfate	(mg/l)	6780.00	6680.00	7100.00	6850.00	6990.00	6570.00
MAJOR CATIONS							
Calcium	(mg/l)	46.00	56.00	45.00	56.00	63.00	270.00
Magnesium	(mg/l)	28.00	34.00	29.00	27.00	32.00	119.00
Potassium	(mg/l)	27.00	54.00	23.00	20.00	20.00	21.10
Sodium	(mg/l)	4980.00	4970.00	4830.00	4860.00	5040.00	3980.00
Major Anions	(meq/l)	213.75	218.08	228.47	217.77	218.36	204.56
Major Cations	(meq/l)	221.91	223.15	215.32	216.92	225.51	196.92
Charge Balance	(percent)	1.87	1.15	2.96	0.20	1.61	1.90
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	0.040	0.030	0.040	N	0.036	0.030
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	-0.010	N	-0.010	N	-0.010	-0.010
Mercury	(mg/l)	-0.00100	N	-0.00100	N	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	N	-0.010	-0.010
Zinc	(mg/l)	0.050	-0.010	-0.010	N	-0.010	-0.010
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	-0.050	-0.500	-0.500	-0.500	0.030	-0.500
Cadmium	(mg/l)	0.0030	-0.0020	-0.0050	-0.0020	-0.0020	-0.0020
Iron	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.050	0.450
Total Iron	(mg/l)	1.50	0.90	1.06	0.62	0.65	21.40
Lead	(mg/l)	0.006	0.011	-0.050	-0.005	-0.005	-0.005
Manganese	(mg/l)	0.110	0.094	0.100	0.080	0.100	0.280
Total Manganese	(mg/l)	0.14	0.11	0.11	0.07	0.10	0.57
Selenium	(mg/l)	0.009	0.007	0.007	0.016	0.010	0.006

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: ASH

Station Name: / Sample Date:		BITSUI-1 06/21/96	BITSUI-1 09/27/96	BITSUI-1 12/12/96	BITSUI-1 03/12/97	BITSUI-1 06/17/97	BITSUI-1 10/01/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.50	8.90	N	8.90	N	8.80
Conductivity (Lab)	(umho/cm)	568	19300	N	19200	N	18500
TDS (180 deg C)	(mg/l)	N	15300	N	15400	N	15000
Boron	(mg/l)	N	8.75	N	8.01	N	8.97
Fluoride	(mg/l)	0.58	2.62	N	2.81	N	2.00
NUTRIENTS							
Nitrate as N	(mg/l)	N	0.24	N	-0.05	N	N
Nitrite as N	(mg/l)	N	-0.05	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	0.27
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	[illegible]	N	N	N
Bicarbonate as HCO3	[illegible]	[illegible]	[illegible]	[illegible]	1190.00	N	938.00
Carbonate as [illegible]	(mg/l)	2.88	120.00		91.90	N	92.00
[illegible]	(mg/l)	58.80	2310.00	N	[illegible]023.00	N	1980.00
[illegible]	(mg/l)	261.00	7460.00	N	758[illegible]	N	7040.00
MAJOR CATIONS							
Calcium	(mg/l)	56.50	51.10	N	51.60	N	[illegible]40
Magnesium	(mg/l)	11.70	31.50	N	33.60	N	30.70
Potassium	(mg/l)	2.35	18.40	N	22.30	N	3.00
Sodium	(mg/l)	120.00	5180.00	N	5077.00	N	5050.00
Major Anions	(meq/l)	9.21	242.53	N	237.61	N	220.89
Major Cations	(meq/l)	9.06	230.93	N	226.74	N	225.48
Charge Balance	(percent)	0.82	2.45	N	2.34	N	1.03
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	N	0.310	N	0.032
Chromium	(mg/l)	-0.0100	N	N	N	N	N
Copper	(mg/l)	N	-0.010	N	-0.010	N	-0.010
Mercury	(mg/l)	N	-0.00100	N	-0.00100	N	-0.00100
Silver	(mg/l)	-0.010	-0.010	N	-0.010	N	-0.010
Zinc	(mg/l)	-0.050	-0.050	N	-0.050	N	-0.020
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	0.050	0.030	N	0.040	N	0.030
Cadmium	(mg/l)	-0.0010	-0.0010	N	-0.0010	N	-0.0010
Iron	(mg/l)	0.030	0.250	N	0.400	N	0.210
Total Iron	(mg/l)	0.12	0.67	N	1.21	N	1.64
Lead	(mg/l)	-0.005	-0.005	N	-0.005	N	-0.005
Manganese	(mg/l)	0.020	0.120	N	0.140	N	0.190
Total Manganese	(mg/l)	0.02	0.11	N	0.14	N	0.03
Selenium	(mg/l)	0.006	0.006	N	-0.005	N	0.005

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: ASH

Station Name:		BITSUI-1	BITSUI-1
Sample Date:		01/20/98	03/26/98
LABORATORY MEASUREMENTS			
pH (Lab)	(S.U.)	8.90	8.80
Conductivity (Lab)	(umho/cm)	24900	19600
TDS (180 deg C)	(mg/l)	15200	14600
Boron	(mg/l)	9.52	12.10
Fluoride	(mg/l)	2.49	2.74
NUTRIENTS			
Nitrate as N	(mg/l)	N	N
Nitrite as N	(mg/l)	N	N
Nitrate + Nitrite as N	(mg/l)	-0.05	-0.05
MAJOR ANIONS			
Bicarbonate as CaCO3	(mg/l)	N	N
Carbonate as CaCO3	(mg/l)	N	N
Bicarbonate as HCO3	(mg/l)	765.00	950.00
Carbonate as CO3	(mg/l)	170.00	86.00
Chloride	(mg/l)	1830.00	1750.00
Sulfate	(mg/l)	6450.00	6200.00
MAJOR CATIONS			
Calcium	(mg/l)	65.60	52.00
Magnesium	(mg/l)	32.50	28.00
Potassium	(mg/l)	16.30	21.00
Sodium	(mg/l)	3750.00	4360.00
Major Anions	(meq/l)	204.12	196.89
Major Cations	(meq/l)	169.48	195.09
Charge Balance	(percent)	9.27	0.46
TRACE METALS (Dissolved)			
Arsenic	(mg/l)	0.029	-0.005
Chromium	(mg/l)	N	N
Copper	(mg/l)	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010
Zinc	(mg/l)	-0.020	-0.025
Radium 226	(pCi/l)	N	N
Radium 228	(pCi/l)	N	N
Barium	(mg/l)	0.030	0.040
Cadmium	(mg/l)	-0.0010	-0.0010
Iron	(mg/l)	0.200	0.350
Total Iron	(mg/l)	0.22	0.56
Lead	(mg/l)	-0.005	-0.005
Manganese	(mg/l)	0.249	0.391
Total Manganese	(mg/l)	0.26	0.41
Selenium	(mg/l)	-0.005	-0.005

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2
Sample Date:		03/02/95	04/27/95	05/19/95	10/18/95	01/02/96	04/09/96
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.00	8.00	8.00	8.00	7.90	8.20
Conductivity (Lab)	(umho/cm)	8080	8110	12100	7730	7590	7950
TDS (180 deg C)	(mg/l)	5050	5020	5010	4910	5020	5010
Boron	(mg/l)	0.93	0.91	1.03	0.83	1.01	0.97
Fluoride	(mg/l)	0.79	1.78	1.75	1.69	2.66	1.61
NUTRIENTS							
Nitrate as N	(mg/l)	-0.01	0.15	-0.01	0.50	0.53	-0.05
Nitrite as N	(mg/l)	-0.01	-0.01	0.05	-0.01	-0.05	-0.05
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	3480.00	3460.00	3520.00	3420.00	3610.00	3460.00
Carbonate as CO3	(mg/l)	0.00	0.00	0.00	0.00	0.00	-1.00
Chloride	(mg/l)	1160.00	1220.00	1220.00	1170.00	1150.00	1250.00
Sulfate	(mg/l)	7.00	48.00	28.00	17.00	4.50	24.70
MAJOR CATIONS							
Calcium	(mg/l)	3.60	6.60	8.60	8.60	6.40	6.01
Magnesium	(mg/l)	1.50	2.70	3.00	1.90	2.60	2.07
Potassium	(mg/l)	7.00	13.00	1.60	7.00	5.10	5.87
Sodium	(mg/l)	1940.00	2110.00	2090.00	1990.00	2050.00	1930.00
Major Anions	(meq/l)	89.90	92.13	92.68	89.44	91.73	92.48
Major Cations	(meq/l)	84.87	92.66	91.63	87.33	89.83	84.57
Charge Balance	(percent)	2.88	0.29	0.57	1.19	1.05	4.47
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	-0.005	N	-0.005	-0.005
Chromium	(mg/l)	-0.0200	N	N	N	N	N
Copper	(mg/l)	-0.010	N	-0.010	N	-0.010	-0.010
Mercury	(mg/l)	-0.00100	N	-0.00100	N	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	N	-0.010	-0.010
Zinc	(mg/l)	-0.010	0.010	0.030	N	-0.010	0.020
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	2.690	2.700	2.890	2.420	2.960	2.800
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0020	-0.0020	-0.0020	-0.0020
Iron	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.050	-0.050
Total Iron	(mg/l)	0.07	0.11	0.07	-0.05	-0.05	0.12
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.020	-0.020	-0.020	-0.020
Total Manganese	(mg/l)	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-2
Sample Date:		06/21/96	09/27/96	01/10/97	03/11/97	06/18/97	10/01/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.50	8.00	7.90	8.00	8.00	7.90
Conductivity (Lab)	(umho/cm)	2030	7990	8010	8000	7900	8000
TDS (180 deg C)	(mg/l)	1450	5160	5130	5080	5100	5090
Boron	(mg/l)	0.27	1.05	0.95	0.97	1.02	0.93
Fluoride	(mg/l)	1.36	1.74	1.68	1.75	1.71	2.00
NUTRIENTS							
Nitrate as N	(mg/l)	N	1.01	0.11	-0.05	N	N
Nitrite as N	(mg/l)	N	-0.05	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	-0.05	-0.05
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	182.00	3510.00	3370.00	3340.00	3320.00	3160.00
Carbonate as CO3	(mg/l)	30.00	-1.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	130.00	1260.00	1270.00	1154.00	1150.00	1200.00
Sulfate	(mg/l)	744.00	82.30	70.00	37.00	95.00	264.00
MAJOR CATIONS							
Calcium	(mg/l)	70.30	4.61	5.21	4.87	5.50	5.10
Magnesium	(mg/l)	23.20	1.94	2.07	2.10	2.00	1.50
Potassium	(mg/l)	4.30	5.47	7.43	6.13	8.00	3.30
Sodium	(mg/l)	390.00	1980.00	2220.00	2002.00	2150.00	2060.00
Major Anions	(meq/l)	23.14	94.84	92.52	88.06	88.83	91.13
Major Cations	(meq/l)	22.49	86.66	97.18	87.65	94.16	90.07
Charge Balance	(percent)	1.42	4.51	2.46	0.23	2.92	0.59
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	-0.0100	N	N	N	N	N
Copper	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	N	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	-0.010	0.050	-0.010
Zinc	(mg/l)	-0.050	-0.050	-0.050	-0.050	-0.020	-0.020
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	0.030	2.990	2.930	3.120	2.830	2.720
Cadmium	(mg/l)	-0.0010	-0.0010	-0.0010	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	0.140	0.030	-0.030	-0.030	-0.020	-0.020
Total Iron	(mg/l)	0.24	0.19	0.07	0.10	0.06	0.48
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	0.020	-0.010	-0.010	-0.010	-0.005	-0.010
Total Manganese	(mg/l)	0.06	-0.01	-0.01	-0.01	-0.01	0.18
Selenium	(mg/l)	0.006	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		BITSUI-2	BITSUI-2	BITSUI-2	BITSUI-3	BITSUI-3	BITSUI-3
Sample Date:		10/05/97	01/22/98	03/26/98	03/02/95	04/27/95	05/18/95
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	N	7.90	8.00	7.60	7.50	7.30
Conductivity (Lab)	(umho/cm)	N	7510	8700	13000	13100	14600
TDS (180 deg C)	(mg/l)	N	5190	5050	7980	7740	7730
Boron	(mg/l)	N	0.87	1.06	1.07	1.00	1.05
Fluoride	(mg/l)	N	1.87	1.86	-0.01	0.99	0.99
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	N	1.00	4.10	-0.01
Nitrite as N	(mg/l)	N	N	N	-0.01	-0.01	-0.01
Nitrate + Nitrite as N	(mg/l)	N	0.12	-0.05	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	N	2590.00	3390.00	3.12	3050.00	3070.00
Carbonate as CO3	(mg/l)	N	-1.00	-1.00	0.00	0.00	0.00
Chloride	(mg/l)	N	1150.00	1040.00	2820.00	3160.00	3080.00
Sulfate	(mg/l)	N	51.00	34.00	442.00	255.00	192.00
MAJOR CATIONS							
Calcium	(mg/l)	N	4.70	4.00	11.00	27.00	19.00
Magnesium	(mg/l)	N	1.10	2.00	5.20	12.00	6.10
Potassium	(mg/l)	N	3.80	8.00	14.00	44.00	10.00
Sodium	(mg/l)	N	1740.00	1750.00	3200.00	3150.00	3130.00
Major Anions	(meq/l)	N	75.95	85.60	88.86	144.72	141.19
Major Cations	(meq/l)	N	76.11	76.69	140.53	140.49	137.86
Charge Balance	(percent)	N	0.10	5.49	22.52	1.48	1.19
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	-0.0200	N	N
Copper	(mg/l)	N	0.040	-0.010	-0.010	N	-0.010
Mercury	(mg/l)	N	-0.00100	-0.00100	-0.00100	N	-0.00100
Silver	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	N	-0.025	-0.025	-0.010	0.010	0.100
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	N	2.860	3.130	-0.500	1.300	0.510
Cadmium	(mg/l)	N	-0.0010	-0.0010	0.0040	-0.0020	-0.0050
Iron	(mg/l)	N	0.040	-0.020	-0.050	-0.050	0.050
Total Iron	(mg/l)	N	0.08	0.09	0.24	0.75	0.28
Lead	(mg/l)	N	-0.005	-0.005	0.012	0.033	-0.050
Manganese	(mg/l)	N	-0.005	-0.005	-0.020	-0.020	-0.020
Total Manganese	(mg/l)	N	-0.01	0.03	-0.02	-0.02	-0.02
Selenium	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3
Sample Date:		10/18/95	12/29/95	03/25/96	09/26/96	01/10/97	03/12/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	7.60	7.60	7.70	7.60	7.40	7.60
Conductivity (Lab)	(umho/cm)	12400	12600	12900	12900	12800	12700
TDS (180 deg C)	(mg/l)	7790	8140	8010	8120	8220	8100
Boron	(mg/l)	0.92	1.08	1.15	1.07	1.09	1.02
Fluoride	(mg/l)	1.02	1.27	1.04	1.01	0.94	1.11
NUTRIENTS							
Nitrate as N	(mg/l)	1.20	-0.05	-0.05	0.25	-0.05	-0.05
Nitrite as N	(mg/l)	-0.01	-0.05	-0.05	-0.05	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	3220.00	2920.00	3290.00	3200.00	3000.00	3090.00
Carbonate as CO3	(mg/l)	0.00	0.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	2760.00	2810.00	2610.00	3070.00	2970.00	2890.00
Sulfate	(mg/l)	471.00	509.00	604.00	530.00	400.00	321.00
MAJOR CATIONS							
Calcium	(mg/l)	23.00	25.00	23.00	18.20	22.40	21.50
Magnesium	(mg/l)	12.00	10.00	9.70	7.53	10.20	9.30
Potassium	(mg/l)	23.00	9.80	11.00	8.60	11.70	12.30
Sodium	(mg/l)	3390.00	3230.00	3210.00	3420.00	3380.00	3093.00
Major Anions	(meq/l)	140.52	137.72	140.12	150.09	141.27	138.84
Major Cations	(meq/l)	150.19	142.82	141.86	150.51	149.28	136.69
Charge Balance	(percent)	3.33	1.82	0.62	0.14	2.76	0.78
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	N	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	N	-0.010	-0.010	-0.050	-0.050	-0.050
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	-0.500	0.360	-0.500	0.240	0.090	5.850
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0020	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	-0.050	-0.050	0.400	0.060	0.220	0.140
Total Iron	(mg/l)	0.12	0.18	0.85	0.16	0.35	0.21
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.020	-0.010	-0.010	-0.010
Total Manganese	(mg/l)	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

BHP Minerals Navajo Mine
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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		BITSUI-3	BITSUI-3	BITSUI-3	BITSUI-3	KF83-1	KF83-1
Sample Date:		06/17/97	10/01/97	01/22/98	03/26/98	09/16/85	09/16/86
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	N	7.50	7.50	7.50	8.28	8.25
Conductivity (Lab)	(umho/cm)	N	12500	11900	14100	9400	9600
TDS (180 deg C)	(mg/l)	N	N	N	N	7080	7050
Boron	(mg/l)	N	1.02	1.03	1.10	1.16	1.10
Fluoride	(mg/l)	N	1.00	1.14	1.05	1.32	1.13
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	N	N	N	N
Nitrite as N	(mg/l)	N	N	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	0.29	0.12	-0.05	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	2630.00	2790.00
Carbonate as CaCO3	(mg/l)	N	N	N	N	300.00	320.00
Bicarbonate as HCO3	(mg/l)	N	3140.00	3240.00	3200.00	N	N
Carbonate as CO3	(mg/l)	N	-1.00	-1.00	-1.00	N	N
Chloride	(mg/l)	N	2780.00	2650.00	2430.00	2255.00	2460.00
Sulfate	(mg/l)	N	560.00	529.00	317.00	83.00	72.00
MAJOR CATIONS							
Calcium	(mg/l)	N	100.00	17.50	17.00	20.00	16.20
Magnesium	(mg/l)	N	12.00	7.10	8.00	6.40	6.00
Potassium	(mg/l)	N	1.90	5.70	11.00	18.00	26.90
Sodium	(mg/l)	N	3320.00	3100.00	2590.00	2630.00	2750.00
Major Anions	(meq/l)	N	141.55	138.87	127.58	123.88	133.03
Major Cations	(meq/l)	N	150.44	136.44	114.45	116.39	121.61
Charge Balance	(percent)	N	3.04	0.88	5.42	3.12	4.48
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	-0.005	-0.005	-0.005	0.002	0.002
Chromium	(mg/l)	N	N	N	N	0.0050	-0.0020
Copper	(mg/l)	N	-0.010	0.030	-0.010	N	N
Mercury	(mg/l)	N	-0.00100	-0.00100	-0.00100	N	N
Silver	(mg/l)	N	-0.010	-0.010	-0.010	N	N
Zinc	(mg/l)	N	-0.020	-0.025	-0.025	0.050	-0.050
Radium 226	(pCi/l)	N	N	N	N	3.4	1.0
Radium 228	(pCi/l)	N	N	N	N	1.1	1.9
Barium	(mg/l)	N	0.070	0.050	0.120	6.000	6.100
Cadmium	(mg/l)	N	-0.0010	-0.0010	-0.0010	0.0010	-0.0010
Iron	(mg/l)	N	-0.020	0.200	0.140	3.000	0.230
Total Iron	(mg/l)	N	0.57	0.22	0.29	N	N
Lead	(mg/l)	N	-0.005	-0.005	-0.005	0.007	0.010
Manganese	(mg/l)	N	-0.010	-0.005	-0.005	0.210	0.038
Total Manganese	(mg/l)	N	0.03	-0.01	0.03	N	N
Selenium	(mg/l)	N	-0.005	-0.005	-0.005	-0.001	-0.001

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		KF83-1	KF83-1	KF83-1	KF83-1	KF83-1	KF83-1
Sample Date:		09/16/87	09/23/88	09/21/89	09/21/90	09/23/91	09/22/92
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.06	7.99	8.05	8.53	8.02	8.68
Conductivity (Lab)	(umho/cm)	10000	9900	10000	9400	9800	11000
TDS (180 deg C)	(mg/l)	7300	7040	7440	7100	7250	7270
Boron	(mg/l)	1.70	1.04	1.09	1.08	0.99	1.00
Fluoride	(mg/l)	0.93	0.93	0.98	1.06	0.90	1.08
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	N	-0.05	-0.05	-0.05
Nitrite as N	(mg/l)	N	N	N	-0.05	-0.05	-0.05
Nitrate + Nitrite as N	(mg/l)	N	N	N	-0.05	-0.04	-0.04
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	1880.00	2530.00	2340.00	2660.00	2600.00	2260.00
Carbonate as CaCO3	(mg/l)	600.00	0.00	220.00	160.00	0.00	240.00
Bicarbonate as HCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CO3	(mg/l)	N	N	N	N	N	N
Chloride	(mg/l)	2485.00	2760.00	2530.00	2260.00	2400.00	2680.00
Sulfate	(mg/l)	50.00	-10.00	34.00	80.00	50.00	-10.00
MAJOR CATIONS							
Calcium	(mg/l)	22.10	20.00	18.80	23.90	19.60	19.60
Magnesium	(mg/l)	7.20	8.20	6.60	7.00	6.90	7.00
Potassium	(mg/l)	11.50	12.10	13.00	11.80	9.40	9.80
Sodium	(mg/l)	2650.00	2650.00	2350.00	2690.00	2670.00	2890.00
Major Anions	(meq/l)	120.69	128.40	123.23	121.77	120.69	125.55
Major Cations	(meq/l)	117.25	117.25	104.03	119.08	117.93	127.52
Charge Balance	(percent)	1.45	4.54	8.45	1.12	1.16	0.78
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	0.002	0.002	0.004	0.003	0.001	0.002
Chromium	(mg/l)	0.0150	-0.0200	-0.0100	-0.0100	-0.0200	-0.0200
Copper	(mg/l)	N	N	N	N	N	N
Mercury	(mg/l)	N	N	N	N	N	N
Silver	(mg/l)	N	N	N	N	N	N
Zinc	(mg/l)	-0.050	-0.050	-0.100	-0.050	-0.250	-0.250
Radium 226	(pCi/l)	3.1	2.5	2.3	2.2	1.6	2.6
Radium 228	(pCi/l)	1.6	0.8	0.1	4.1	9.5	-4.2
Barium	(mg/l)	-1.000	6.600	4.400	2.100	3.800	5.100
Cadmium	(mg/l)	0.0900	-0.0100	-0.0050	-0.0050	-0.0050	-0.0050
Iron	(mg/l)	-0.500	0.500	-0.500	1.300	-0.500	-0.200
Total Iron	(mg/l)	N	N	N	N	N	N
Lead	(mg/l)	0.095	0.040	0.030	0.050	0.020	-0.020
Manganese	(mg/l)	-0.200	-0.200	-0.200	-0.200	-0.200	-0.200
Total Manganese	(mg/l)	N	N	N	N	N	N
Selenium	(mg/l)	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001

Note: N => No measurement

BHP Minerals Navajo Mine
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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		KF83-1	KF83-1	KF83-1	KF83-1	KF83-1	KF83-1
Sample Date:		09/08/93	09/07/94	05/03/95	06/14/95	06/21/95	07/14/95
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	8.57	7.65	7.60	7.90	7.90	7.80
Conductivity (Lab)	(umho/cm)	9300	9600	11500	9690	10300	9850
TDS (180 deg C)	(mg/l)	6710	7330	6820	5750	5670	5850
Boron	(mg/l)	0.93	0.90	0.87	1.00	0.97	0.92
Fluoride	(mg/l)	1.13	1.07	0.83	1.44	1.54	1.57
NUTRIENTS							
Nitrate as N	(mg/l)	-0.05	-0.05	6.24	-0.01	18.20	-0.01
Nitrite as N	(mg/l)	-0.05	-0.05	-0.01	-0.01	-0.01	-0.01
Nitrate + Nitrite as N	(mg/l)	-0.04	-0.04	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	2260.00	2740.00	N	N	N	N
Carbonate as CaCO3	(mg/l)	480.00	0.00	N	N	N	N
Bicarbonate as HCO3	(mg/l)	N	N	2970.00	3690.00	3740.00	3630.00
Carbonate as CO3	(mg/l)	N	N	0.00	0.00	0.00	0.00
Chloride	(mg/l)	2180.00	2080.00	2700.00	1210.00	1170.00	1230.00
Sulfate	(mg/l)	74.00	142.00	7.00	353.00	411.00	375.00
MAJOR CATIONS							
Calcium	(mg/l)	19.00	14.00	28.00	11.00	11.00	11.00
Magnesium	(mg/l)	5.60	4.90	13.00	4.60	4.90	4.40
Potassium	(mg/l)	9.30	8.20	31.00	7.00	13.00	8.20
Sodium	(mg/l)	2590.00	2670.00	2760.00	2380.00	2370.00	2260.00
Major Anions	(meq/l)	117.78	116.38	125.43	101.95	104.15	101.99
Major Cations	(meq/l)	118.66	117.45	123.31	104.63	104.37	99.42
Charge Balance	(percent)	0.37	0.46	0.85	1.30	0.11	1.28
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	N	N	N	N	N
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	N	N	N	N	N	N
Mercury	(mg/l)	N	N	N	N	N	N
Silver	(mg/l)	N	N	N	N	N	N
Zinc	(mg/l)	N	N	N	N	N	N
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	1.400	-1.000	5.000	-0.500	1.700	0.580
Cadmium	(mg/l)	-0.0050	-0.0050	-0.0040	-0.0020	-0.0020	-0.0020
Iron	(mg/l)	-0.300	-0.200	-0.050	-0.050	-0.050	-0.050
Total Iron	(mg/l)	-0.30	-0.20	1.06	0.07	-0.05	-0.05
Lead	(mg/l)	-0.020	-0.020	-0.010	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.200	-0.200	-0.020	-0.020	-0.020	-0.020
Total Manganese	(mg/l)	-0.20	-0.20	0.03	-0.02	-0.02	-0.02
Selenium	(mg/l)	-0.001	-0.001	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		KF83-1	KF83-1	KF83-1	KF83-1	KF83-1	KF83-1
Sample Date:		09/26/95	03/25/96	10/03/96	12/03/96	03/26/97	07/01/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	7.80	7.70	7.80	7.60	7.70	7.70
Conductivity (Lab)	(umho/cm)	9300	11100	9650	10500	11650	11300
TDS (180 deg C)	(mg/l)	5830	6860	6270	6860	7168	7100
Boron	(mg/l)	1.00	0.90	0.94	1.04	0.95	1.03
Fluoride	(mg/l)	1.29	0.90	1.38	1.07	1.05	0.95
NUTRIENTS							
Nitrate as N	(mg/l)	-0.01	0.14	-0.05	-0.05	-0.05	N
Nitrite as N	(mg/l)	-0.01	-0.05	-0.05	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	-0.05
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	3530.00	3130.00	3360.00	3180.00	2764.00	3010.00
Carbonate as CO3	(mg/l)	0.00	-1.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	1500.00	2610.00	123.00	2089.00	2610.00	2620.00
Sulfate	(mg/l)	351.00	123.50	980.00	360.00	239.00	379.00
MAJOR CATIONS							
Calcium	(mg/l)	14.60	19.40	11.60	16.20	21.20	20.50
Magnesium	(mg/l)	7.05	7.41	4.50	5.83	8.10	7.00
Potassium	(mg/l)	9.80	8.60	7.82	8.21	15.00	8.50
Sodium	(mg/l)	2480.00	2720.00	2400.00	2601.00	2620.00	2290.00
Major Anions	(meq/l)	107.47	127.50	78.94	118.54	123.90	131.12
Major Cations	(meq/l)	109.43	120.11	105.54	114.64	116.07	101.43
Charge Balance	(percent)	0.90	2.98	14.42	1.67	3.26	12.77
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	N	N	N	N	N
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	N	N	N	N	N	N
Mercury	(mg/l)	N	N	N	N	N	N
Silver	(mg/l)	N	N	N	N	N	N
Zinc	(mg/l)	N	N	N	N	N	N
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	-0.500	3.770	0.050	0.170	0.250	-0.010
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0010	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	-0.050	0.140	0.040	0.170	0.150	0.100
Total Iron	(mg/l)	-0.05	0.22	0.10	0.83	0.19	0.11
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	-0.020	-0.020	-0.010	0.030	0.030	0.023
Total Manganese	(mg/l)	-0.02	-0.02	-0.01	0.02	0.03	0.02
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: FRUITLAND FM; CS#8

Station Name:		KF83-1	KF83-1	KF83-1	KF83-1	KF83-1	KF83-1
Sample Date:		09/26/97	12/22/97	12/22/97	03/19/98	06/18/98	09/21/98
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	7.60	7.70	7.70	7.60	7.60	7.60
Conductivity (Lab)	(umho/cm)	11400	11700	11600	11700	12900	11800
TDS (180 deg C)	(mg/l)	7140	7140	7290	7350	7280	7500
Boron	(mg/l)	0.92	1.04	1.04	1.15	1.02	1.04
Fluoride	(mg/l)	1.11	1.19	1.20	1.05	0.91	0.93
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	N	N	N	N
Nitrite as N	(mg/l)	N	N	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	0.29	0.14	0.14	0.07	0.32	-0.05
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	2500.00	2910.00	2970.00	2700.00	2740.00	2580.00
Carbonate as CO3	(mg/l)	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	2270.00	2660.00	2670.00	2260.00	2380.00	2000.00
Sulfate	(mg/l)	435.00	619.00	825.00	276.00	371.00	503.00
MAJOR CATIONS							
Calcium	(mg/l)	-0.20	23.40	23.70	15.80	25.00	24.90
Magnesium	(mg/l)	3.20	7.30	7.90	5.80	10.00	7.40
Potassium	(mg/l)	5.80	11.00	10.90	7.70	15.00	7.60
Sodium	(mg/l)	2370.00	2960.00	3100.00	2530.00	2400.00	2440.00
Major Anions	(meq/l)	114.08	135.62	141.17	113.75	119.78	109.17
Major Cations	(meq/l)	103.50	130.80	136.95	111.51	106.85	108.18
Charge Balance	(percent)	4.86	1.81	1.52	0.99	5.71	0.45
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	-0.0100
Copper	(mg/l)	-0.010	0.130	0.170	-0.010	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	-0.025	-0.020	-0.020	-0.025	-0.025	-0.025
Radium 226	(pCi/l)	N	N	N	N	N	1.9
Radium 228	(pCi/l)	N	N	N	N	N	-1.5
Barium	(mg/l)	0.220	0.160	0.110	0.280	-0.010	0.400
Cadmium	(mg/l)	0.0040	-0.0010	-0.0010	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	0.050	0.140	0.140	0.230	0.240	0.100
Total Iron	(mg/l)	0.95	0.12	0.14	0.27	0.29	0.27
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	0.023	0.018	0.019	0.027	-0.005	0.018
Total Manganese	(mg/l)	0.87	0.02	0.02	0.02	-0.01	0.02
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

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Aquifer: FRUITLAND FM; CS#3

Station Name:		KF83-1
Sample Date:		12/30/98
LABORATORY MEASUREMENTS		
pH (Lab)	(S.U.)	7.70
Conductivity (Lab)	(umho/cm)	11900
TDS (180 deg C)	(mg/l)	7370
Boron	(mg/l)	1.12
Fluoride	(mg/l)	0.92
NUTRIENTS		
Nitrate as N	(mg/l)	N
Nitrite as N	(mg/l)	N
Nitrate + Nitrite as N	(mg/l)	-0.05
MAJOR ANIONS		
Bicarbonate as CaCO3	(mg/l)	N
Carbonate as CaCO3	(mg/l)	N
Bicarbonate as HCO3	(mg/l)	2690.00
Carbonate as CO3	(mg/l)	-1.00
Chloride	(mg/l)	2450.00
Sulfate	(mg/l)	549.00
MAJOR CATIONS		
Calcium	(mg/l)	28.00
Magnesium	(mg/l)	9.00
Potassium	(mg/l)	8.00
Sodium	(mg/l)	2840.00
Major Anions	(meq/l)	124.62
Major Cations	(meq/l)	125.88
Charge Balance	(percent)	0.50
TRACE METALS (Dissolved)		
Arsenic	(mg/l)	-0.005
Chromium	(mg/l)	-0.0100
Copper	(mg/l)	-0.010
Mercury	(mg/l)	-0.00100
Silver	(mg/l)	-0.010
Zinc	(mg/l)	-0.025
Radium 226	(pCi/l)	1.8
Radium 228	(pCi/l)	-1.5
Barium	(mg/l)	0.500
Cadmium	(mg/l)	-0.0010
Iron	(mg/l)	N
Total Iron	(mg/l)	0.36
Lead	(mg/l)	-0.005
Manganese	(mg/l)	0.020
Total Manganese	(mg/l)	0.08
Selenium	(mg/l)	-0.005

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: SPOIL

Station Name:		BITSUI-4	BITSUI-4	BITSUI-4	BITSUI-4	BITSUI-4	BITSUI-4
Sample Date:		01/26/96	02/12/96	04/10/96	10/02/96	01/13/97	03/12/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	6.90	7.10	7.10	6.80	6.80	6.90
Conductivity (Lab)	(umho/cm)	16700	14400	16500	17500	17500	18200
TDS (180 deg C)	(mg/l)	15000	13100	13800	15100	15500	16100
Boron	(mg/l)	1.71	1.49	1.54	1.49	1.67	1.61
Fluoride	(mg/l)	0.29	0.33	0.33	0.32	0.30	0.32
NUTRIENTS							
Nitrate as N	(mg/l)	0.09	1.20	1.17	0.33	0.09	-0.05
Nitrite as N	(mg/l)	-0.01	-0.01	0.05	-0.05	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	1760.00	1510.00	1650.00	1650.00	1800.00	1840.00
Carbonate as CO3	(mg/l)	0.00	0.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	634.00	451.00	651.00	45.70	630.00	659.00
Sulfate	(mg/l)	6640.00	6680.00	7860.00	8710.00	9460.00	9205.00
MAJOR CATIONS							
Calcium	(mg/l)	15.00	287.00	231.00	270.00	270.00	251.00
Magnesium	(mg/l)	131.00	125.00	123.00	130.00	130.00	129.00
Potassium	(mg/l)	538.00	22.00	19.20	20.70	22.30	24.80
Sodium	(mg/l)	4650.00	3850.00	4280.00	4610.00	4710.00	4824.00
Major Anions	(meq/l)	226.62	176.64	209.14	209.70	244.25	240.41
Major Cations	(meq/l)	227.55	192.64	208.31	225.22	229.61	233.60
Charge Balance	(percent)	0.20	4.33	0.20	3.57	3.09	1.44
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	0.030	0.140	0.020	0.060	-0.050	-0.050
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	0.030	-0.500	0.020	0.010	0.010	0.010
Cadmium	(mg/l)	-0.0020	-0.0020	-0.0020	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	-0.050	0.060	0.260	0.370	0.400	0.550
Total Iron	(mg/l)	4.67	16.60	4.21	0.74	0.67	1.02
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	2.400	3.180	2.660	2.420	2.790	2.080
Total Manganese	(mg/l)	2.41	3.35	2.52	2.73	2.63	1.95
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: SPOIL

Station Name:		BITSUI-4	BITSUI-4	BITSUI-4	BITSUI-4	BITSUI-5	BITSUI-5
Sample Date:		06/17/97	10/02/97	01/20/98	03/26/98	02/13/96	04/11/96
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	N	6.80	6.80	6.80	7.40	7.50
Conductivity (Lab)	(umho/cm)	N	16900	24600	18600	13000	14200
TDS (180 deg C)	(mg/l)	N	15000	15200	15100	10300	10600
Boron	(mg/l)	N	1.52	2.24	1.71	1.10	1.13
Fluoride	(mg/l)	N	0.26	0.29	0.34	1.00	1.04
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	N	N	0.01	-0.05
Nitrite as N	(mg/l)	N	N	N	N	-0.05	-0.05
Nitrate + Nitrite as N	(mg/l)	N	0.27	0.21	-0.05	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	N	1810.00	1080.00	1760.00	3170.00	3090.00
Carbonate as CO3	(mg/l)	N	-1.00	-1.00	-1.00	0.00	-1.00
Chloride	(mg/l)	N	696.00	540.00	508.00	1330.00	1210.00
Sulfate	(mg/l)	N	8670.00	7880.00	8130.00	3550.00	4060.00
MAJOR CATIONS							
Calcium	(mg/l)	N	284.00	256.00	194.00	72.00	59.50
Magnesium	(mg/l)	N	135.00	131.00	112.00	30.00	27.50
Potassium	(mg/l)	N	10.20	18.90	23.00	16.00	14.10
Sodium	(mg/l)	N	4920.00	3660.00	4090.00	3630.00	3830.00
Major Anions	(meq/l)	N	229.83	197.01	212.45	163.37	169.30
Major Cations	(meq/l)	N	239.55	183.24	197.39	164.37	172.19
Charge Balance	(percent)	N	2.07	3.62	3.67	0.31	0.85
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	N	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	N	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	N	-0.025	-0.020	-0.025	0.010	0.030
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	N	0.010	-0.010	0.010	-0.500	-0.500
Cadmium	(mg/l)	N	-0.0010	-0.0010	-0.0010	-0.0020	-0.0020
Iron	(mg/l)	N	0.520	0.690	0.890	0.480	0.310
Total Iron	(mg/l)	N	0.83	0.72	1.33	2.05	1.83
Lead	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	N	2.240	2.990	4.270	0.410	0.170
Total Manganese	(mg/l)	N	2.49	3.02	5.09	0.41	0.17
Selenium	(mg/l)	N	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

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Aquifer: SPOIL

Station Name:		BITSUI-5	BITSUI-5	BITSUI-5	BITSUI-5	BITSUI-5	BITSUI-5
Sample Date:		10/03/96	01/10/97	01/22/97	03/12/97	06/18/97	10/03/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	7.40	7.40	N	7.40	7.40	7.40
Conductivity (Lab)	(umho/cm)	15000	14900	N	15100	14900	15100
TDS (180 deg C)	(mg/l)	11400	11500	N	11600	11700	11600
Boron	(mg/l)	1.11	1.06	N	0.96	1.33	0.11
Fluoride	(mg/l)	1.02	1.00	N	1.04	1.00	0.85
NUTRIENTS							
Nitrate as N	(mg/l)	-0.05	0.09	N	-0.05	N	N
Nitrite as N	(mg/l)	-0.05	N	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	N	N	N	-0.05	0.28
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	3050.00	2960.00	N	2940.00	-1.00	3010.00
Carbonate as CO3	(mg/l)	-1.00	-1.00	N	-1.00	-1.00	-1.00
Chloride	(mg/l)	1320.00	1260.00	N	1222.00	1200.00	1210.00
Sulfate	(mg/l)	4770.00	4770.00	N	4876.00	5030.00	5030.00
MAJOR CATIONS							
Calcium	(mg/l)	56.70	59.70	N	61.70	68.60	77.20
Magnesium	(mg/l)	27.60	29.60	N	30.70	33.30	34.90
Potassium	(mg/l)	13.30	10.40	N	15.60	16.60	11.60
Sodium	(mg/l)	4030.00	4000.00	N	4019.00	4300.00	3850.00
Major Anions	(meq/l)	186.54	183.38	N	184.17	186.26	188.21
Major Cations	(meq/l)	180.74	179.68	N	180.83	193.63	174.49
Charge Balance	(percent)	1.58	1.02	N	0.92	1.94	3.78
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	N	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	-0.010	-0.010	N	-0.010	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100	N	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	N	-0.010	0.050	-0.010
Zinc	(mg/l)	13.500	-0.050	N	-0.050	-0.020	-0.025
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	0.010	0.010	N	0.010	-0.010	-0.010
Cadmium	(mg/l)	-0.0010	-0.0010	N	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	0.280	0.230	N	0.190	0.210	-0.020
Total Iron	(mg/l)	0.46	0.34	N	0.31	0.49	0.43
Lead	(mg/l)	-0.005	-0.005	N	-0.005	-0.005	-0.005
Manganese	(mg/l)	0.090	0.100	N	0.080	0.104	-0.005
Total Manganese	(mg/l)	0.08	0.09	N	0.09	0.09	0.11
Selenium	(mg/l)	-0.005	-0.005	N	-0.005	-0.005	-0.005

Note: N => No measurement

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GROUNDWATER QUALITY REPORT

Aquifer: SPOIL

Station Name:		BITSUI-5	BITSUI-5	BITSUI-6	BITSUI-6	BITSUI-6	BITSUI-6
Sample Date:		01/22/98	03/26/98	02/12/96	04/11/96	10/02/96	01/13/97
LABORATORY MEASUREMENTS							
pH (Lab)	(S.U.)	7.40	7.40	7.10	7.20	6.60	6.80
Conductivity (Lab)	(umho/cm)	19300	16900	14300	15100	18200	17600
TDS (180 deg C)	(mg/l)	12300	11800	13200	13300	16200	16500
Boron	(mg/l)	1.05	1.10	1.57	1.47	2.34	2.59
Fluoride	(mg/l)	1.12	1.12	0.30	0.31	1.34	0.28
NUTRIENTS							
Nitrate as N	(mg/l)	N	N	6.20	0.08	-0.05	0.10
Nitrite as N	(mg/l)	N	N	-0.05	-0.05	-0.05	N
Nitrate + Nitrite as N	(mg/l)	0.13	0.15	N	N	N	N
MAJOR ANIONS							
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	3010.00	3010.00	1440.00	1500.00	1620.00	1530.00
Carbonate as CO3	(mg/l)	-1.00	-1.00	0.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	1080.00	1030.00	392.00	356.00	56.90	490.00
Sulfate	(mg/l)	4770.00	4780.00	7690.00	7920.00	9890.00	10280.00
MAJOR CATIONS							
Calcium	(mg/l)	57.20	42.00	327.00	296.00	390.00	380.00
Magnesium	(mg/l)	27.00	27.00	158.00	161.00	170.00	170.00
Potassium	(mg/l)	11.60	15.00	24.00	21.90	23.50	23.90
Sodium	(mg/l)	3490.00	3690.00	3780.00	3940.00	4730.00	4860.00
Major Anions	(meq/l)	179.12	177.92	195.21	199.53	234.07	252.94
Major Cations	(meq/l)	157.18	165.21	194.35	199.96	239.79	244.96
Charge Balance	(percent)	6.52	3.70	0.22	0.11	1.21	1.60
TRACE METALS (Dissolved)							
Arsenic	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N	N
Copper	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010	-0.010
Zinc	(mg/l)	-0.025	-0.025	0.050	0.020	0.280	-0.050
Radium 226	(pCi/l)	N	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N	N
Barium	(mg/l)	0.010	0.010	-0.500	-0.500	0.010	0.010
Cadmium	(mg/l)	-0.0010	-0.0010	-0.0020	0.0110	-0.0010	-0.0010
Iron	(mg/l)	0.180	0.100	-0.050	0.190	1.350	1.880
Total Iron	(mg/l)	0.17	0.21	20.00	1.25	2.08	1.79
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	0.108	0.144	3.260	2.730	3.730	0.130
Total Manganese	(mg/l)	0.13	0.16	3.55	2.54	4.05	3.60
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

BHP Minerals Navajo Mine
NAVAJO MINE

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GROUNDWATER QUALITY REPORT

Aquifer: SPOIL

Station Name:		BITSUI-6	BITSUI-6	BITSUI-6	BITSUI-6	BITSUI-6
Sample Date:		03/12/97	06/18/97	10/02/97	01/20/98	03/26/98
LABORATORY MEASUREMENTS						
pH (Lab)	(S.U.)	6.80	6.60	6.70	6.80	6.70
Conductivity (Lab)	(umho/cm)	17700	1780	15900	23200	17400
TDS (180 deg C)	(mg/l)	16100	16200	14500	14700	14300
Boron	(mg/l)	2.41	2.61	2.04	2.26	2.34
Fluoride	(mg/l)	0.29	0.28	0.26	0.27	0.33
NUTRIENTS						
Nitrate as N	(mg/l)	0.07	N	N	N	N
Nitrite as N	(mg/l)	N	N	N	N	N
Nitrate + Nitrite as N	(mg/l)	N	-0.05	0.30	0.21	0.21
MAJOR ANIONS						
Bicarbonate as CaCO3	(mg/l)	N	N	N	N	N
Carbonate as CaCO3	(mg/l)	N	N	N	N	N
Bicarbonate as HCO3	(mg/l)	1530.00	1540.00	1420.00	744.00	1490.00
Carbonate as CO3	(mg/l)	-1.00	-1.00	-1.00	-1.00	-1.00
Chloride	(mg/l)	460.00	450.00	470.00	364.00	354.00
Sulfate	(mg/l)	9818.00	9920.00	8710.00	7810.00	7610.00
MAJOR CATIONS						
Calcium	(mg/l)	377.00	360.00	389.00	332.00	238.00
Magnesium	(mg/l)	164.00	145.00	183.00	165.00	139.00
Potassium	(mg/l)	25.00	26.90	11.40	18.50	21.00
Sodium	(mg/l)	4629.00	3880.00	4560.00	3180.00	3570.00
Major Anions	(meq/l)	242.46	244.47	217.90	185.08	192.87
Major Cations	(meq/l)	234.30	199.35	233.11	168.94	179.15
Charge Balance	(percent)	1.71	10.17	3.37	4.56	3.69
TRACE METALS (Dissolved)						
Arsenic	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Chromium	(mg/l)	N	N	N	N	N
Copper	(mg/l)	-0.010	-0.010	-0.010	-0.010	-0.010
Mercury	(mg/l)	-0.00100	-0.00100	-0.00100	-0.00100	-0.00100
Silver	(mg/l)	-0.010	0.040	-0.010	-0.010	-0.010
Zinc	(mg/l)	-0.050	0.030	-0.025	-0.020	-0.025
Radium 226	(pCi/l)	N	N	N	N	N
Radium 228	(pCi/l)	N	N	N	N	N
Barium	(mg/l)	0.010	-0.010	0.010	0.010	0.020
Cadmium	(mg/l)	0.0010	-0.0010	-0.0010	-0.0010	-0.0010
Iron	(mg/l)	0.800	1.320	0.490	0.740	0.780
Total Iron	(mg/l)	1.28	1.36	0.41	0.96	1.18
Lead	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005
Manganese	(mg/l)	3.620	3.600	3.510	4.350	6.600
Total Manganese	(mg/l)	3.58	3.39	1.24	4.48	6.48
Selenium	(mg/l)	-0.005	-0.005	-0.005	-0.005	-0.005

Note: N => No measurement

SUMMARY STATISTICS

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER STATISTICAL REPORT

Station: BITSUI-1

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	8.79				8.90	8.50	10/18/95	06/21/96	12
Conductivity (Lab)	(umho/cm)	18031	6117	34	25032	25900	868	05/19/95	06/21/96	12
TDS (180 deg C)	(mg/l)	14564	652	4	2200	15400	13200	03/12/97	04/09/96	11
Boron	(mg/l)	8.92	1.38	16	5.12	12.10	6.98	03/26/98	10/18/95	11
Fluoride	(mg/l)	2.52	0.84	33	3.81	4.39	0.58	01/02/96	06/21/96	12
NUTRIENTS										
Nitrate as N	(mg/l)	0.79	0.89	113	2.40	2.40	0.01	04/27/95	10/18/95	8
Nitrite as N	(mg/l)	0.04	0.07	186	0.20	0.20	0.01	04/09/96	03/01/95	7
Nitrate + Nitrite as N	(mg/l)	0.11	0.14	133	0.25	0.27	0.03	10/01/97	01/20/98	3
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	928.25	288.89	31	1067.00	1190.00	123.00	03/12/97	06/21/96	12
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	89.73	38.50	43	167.12	170.00	2.88	01/20/98	06/21/96	12
Chloride	(mg/l)	1806.82	569.97	32	2251.20	2310.00	58.80	09/27/96	06/21/96	12
Sulfate	(mg/l)	6330.75	1951.90	31	7327.00	7588.00	261.00	03/12/97	06/21/96	12
MAJOR CATIONS										
Calcium	(mg/l)	73.10	62.36	85	225.00	270.00	45.00	04/09/96	05/19/95	12
Magnesium	(mg/l)	36.42	26.67	73	107.30	119.00	11.70	04/09/96	06/21/96	12
Potassium	(mg/l)	20.70	12.91	62	51.65	54.00	2.35	04/27/95	06/21/96	12
Sodium	(mg/l)	4349.75	1409.23	32	5060.00	5180.00	120.00	09/27/96	06/21/96	12
Major Anions	(meq/l)	201.02	61.85	31	233.32	242.53	9.21	09/27/96	06/21/96	12
Major Cations	(meq/l)	196.38	61.63	31	221.87	230.93	9.06	09/27/96	06/21/96	12
Charge Balance	(percent)	2.17	2.39	110	9.07	9.27	0.20	01/20/98	10/18/95	12
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.050	0.087	173	0.308	0.310	0.003	03/12/97	06/21/96	11
Chromium	(mg/l)	0.0050			0.0000	0.0050	0.0050	06/21/96	06/21/96	1
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/01/95	03/01/95	9
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/01/95	03/01/95	9
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/01/95	03/01/95	11
Zinc	(mg/l)	0.016	0.014	87	0.045	0.050	0.005	03/01/95	04/27/95	11
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	0.106	0.106	100	0.225	0.250	0.025	04/27/95	03/01/95	12
Cadmium	(mg/l)	0.0010	0.0008	80	0.0025	0.0030	0.0005	03/01/95	06/21/96	12
Iron	(mg/l)	0.168	0.164	98	0.425	0.450	0.025	04/09/96	03/01/95	12
Total Iron	(mg/l)	2.55	5.96	234	21.28	21.40	0.12	04/09/96	06/21/96	12
Lead	(mg/l)	0.005	0.007	124	0.023	0.025	0.003	05/19/95	10/18/95	12
Manganese	(mg/l)	0.156	0.104	66	0.371	0.391	0.020	03/26/98	06/21/96	12
Total Manganese	(mg/l)	0.17	0.16	95	0.55	0.57	0.02	04/09/96	06/21/96	12
Selenium	(mg/l)	0.007	0.004	58	0.014	0.016	0.003	10/18/95	03/12/97	12

Below detection limit values included at 0.5 times detection limit.

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GROUNDWATER STATISTICAL REPORT

Station: BITSUI-2

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	8.00				8.50	7.90	06/21/96	01/02/96	14
Conductivity (Lab)	(umho/cm)	7836	2021	26	10070	12100	2030	05/19/95	06/21/96	14
TDS (180 deg C)	(mg/l)	4805	968	20	3740	5190	1450	01/22/98	06/21/96	14
Boron	(mg/l)	0.91	0.20	22	0.79	1.06	0.27	03/26/98	06/21/96	14
Fluoride	(mg/l)	1.73	0.39	23	1.87	2.66	0.79	01/02/96	03/02/95	14
NUTRIENTS										
Nitrate as N	(mg/l)	0.26	0.35	133	1.01	1.01	0.01	09/27/96	03/02/95	9
Nitrite as N	(mg/l)	0.02	0.02	83	0.05	0.05	0.01	05/19/95	03/02/95	7
Nitrate + Nitrite as N	(mg/l)	0.05	0.05	97	0.10	0.12	0.03	01/22/98	06/18/97	4
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	3129.43	883.17	28	3428.00	3610.00	182.00	01/02/96	06/21/96	14
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	2.43	7.94	327	30.00	30.00	0.00	06/21/96	03/02/95	14
Chloride	(mg/l)	1108.86	287.98	26	1140.00	1270.00	130.00	01/10/97	06/21/96	14
Sulfate	(mg/l)	107.61	194.34	181	739.50	744.00	4.50	06/21/96	01/02/96	14
MAJOR CATIONS										
Calcium	(mg/l)	10.29	17.34	168	66.70	70.30	3.60	06/21/96	03/02/95	14
Magnesium	(mg/l)	3.55	5.68	160	22.10	23.20	1.10	06/21/96	01/22/98	14
Potassium	(mg/l)	6.14	2.72	44	11.40	13.00	1.60	04/27/95	05/19/95	14
Sodium	(mg/l)	1985.86	451.15	24	1830.00	2220.00	390.00	01/10/97	06/21/96	14
Major Anions	(meq/l)	84.89	18.35	22	71.70	94.84	23.14	09/27/96	06/21/96	14
Major Cations	(meq/l)	82.99	18.39	22	74.69	97.18	22.49	01/10/97	06/21/96	14
Charge Balance	(percent)	2.01	1.80	89	5.39	5.49	0.10	03/26/98	01/22/98	14
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	13
Chromium	(mg/l)	0.0075	0.0035	47	0.0050	0.0100	0.0050	03/02/95	06/21/96	2
Copper	(mg/l)	0.008	0.011	129	0.035	0.040	0.005	01/22/98	03/02/95	11
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/02/95	03/02/95	11
Silver	(mg/l)	0.008	0.012	147	0.045	0.050	0.005	06/18/97	03/02/95	13
Zinc	(mg/l)	0.017	0.009	53	0.025	0.030	0.005	05/19/95	03/02/95	13
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	2.648	0.776	29	3.100	3.130	0.030	03/26/98	06/21/96	14
Cadmium	(mg/l)	0.0007	0.0003	36	0.0005	0.0010	0.0005	03/02/95	06/21/96	14
Iron	(mg/l)	0.030	0.033	109	0.130	0.140	0.010	06/21/96	06/18/97	14
Total Iron	(mg/l)	0.12	0.12	95	0.46	0.48	0.03	10/01/97	10/18/95	14
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	14
Manganese	(mg/l)	0.008	0.005	62	0.018	0.020	0.003	06/21/96	06/18/97	14
Total Manganese	(mg/l)	0.03	0.05	185	0.18	0.18	0.01	10/01/97	09/27/96	14
Selenium	(mg/l)	0.003	0.001	34	0.004	0.006	0.003	06/21/96	03/02/95	14

Below detection limit values included at 0.5 times detection limit.

BHP NAVAJO MINE
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GROUNDWATER STATISTICAL REPORT

Station: BITSUI-3

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	7.52				7.70	7.30	03/25/96	05/18/95	12
Conductivity (Lab)	(umho/cm)	12958	732	6	2700	14600	11900	05/18/95	01/22/98	12
TDS (180 deg C)	(mg/l)	7981	185	2	490	8220	7730	01/10/97	05/18/95	9
Boron	(mg/l)	1.05	0.06	6	0.23	1.15	0.92	03/25/96	10/18/95	12
Fluoride	(mg/l)	0.96	0.31	33	1.27	1.27	0.01	12/29/95	03/02/95	12
NUTRIENTS										
Nitrate as N	(mg/l)	0.74	1.34	181	4.10	4.10	0.01	04/27/95	05/18/95	9
Nitrite as N	(mg/l)	0.01	0.01	79	0.02	0.03	0.01	12/29/95	03/02/95	7
Nitrate + Nitrite as N	(mg/l)	0.15	0.13	93	0.27	0.29	0.03	10/01/97	03/26/98	3
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	2868.59	908.83	32	3286.88	3290.00	3.12	03/25/96	03/02/95	12
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	0.29	0.26	88	0.50	0.50	0.00	03/25/96	03/02/95	12
Chloride	(mg/l)	2835.83	213.31	8	730.00	3160.00	2430.00	04/27/95	03/26/98	12
Sulfate	(mg/l)	427.50	130.66	31	412.00	604.00	192.00	03/25/96	05/18/95	12
MAJOR CATIONS										
Calcium	(mg/l)	27.05	23.36	86	89.00	100.00	11.00	10/01/97	03/02/95	12
Magnesium	(mg/l)	9.09	2.33	26	6.80	12.00	5.20	04/27/95	03/02/95	12
Potassium	(mg/l)	13.58	10.80	80	42.10	44.00	1.90	04/27/95	10/01/97	12
Sodium	(mg/l)	3184.42	219.57	7	830.00	3420.00	2590.00	09/26/96	03/26/98	12
Major Anions	(meq/l)	135.94	15.70	12	61.23	150.09	88.86	09/26/96	03/02/95	12
Major Cations	(meq/l)	140.96	9.96	7	36.06	150.51	114.45	09/26/96	03/26/98	12
Charge Balance	(percent)	3.67	6.12	167	22.38	22.52	0.14	03/02/95	09/26/96	12
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	11
Chromium	(mg/l)	0.0100			0.0000	0.0100	0.0100	03/02/95	03/02/95	1
Copper	(mg/l)	0.008	0.008	105	0.025	0.030	0.005	01/22/98	03/02/95	10
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	03/02/95	03/02/95	10
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	03/02/95	03/02/95	11
Zinc	(mg/l)	0.021	0.027	128	0.095	0.100	0.005	05/18/95	03/02/95	11
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	0.778	1.632	210	5.800	5.850	0.050	03/12/97	01/22/98	12
Cadmium	(mg/l)	0.0011	0.0011	95	0.0035	0.0040	0.0005	03/02/95	09/26/96	12
Iron	(mg/l)	0.110	0.117	107	0.390	0.400	0.010	03/25/96	10/01/97	12
Total Iron	(mg/l)	0.35	0.24	68	0.73	0.85	0.12	03/25/96	10/18/95	12
Lead	(mg/l)	0.008	0.010	136	0.031	0.033	0.003	04/27/95	10/18/95	12
Manganese	(mg/l)	0.007	0.003	45	0.008	0.010	0.003	03/02/95	01/22/98	12
Total Manganese	(mg/l)	0.01	0.01	76	0.03	0.03	0.01	10/01/97	09/26/96	12
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	03/02/95	03/02/95	12

Below detection limit values included at 0.5 times detection limit.

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER STATISTICAL REPORT

Station: BITSUI-4

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	6.87				7.10	6.80	02/12/96	10/02/96	9
Conductivity (Lab)	(umho/cm)	17878	2794	16	10200	24600	14400	01/20/98	02/12/96	9
TDS (180 deg C)	(mg/l)	14878	897	6	3000	16100	13100	03/12/97	02/12/96	9
Boron	(mg/l)	1.66	0.23	14	0.75	2.24	1.49	01/20/98	02/12/96	9
Fluoride	(mg/l)	0.31	0.03	8	0.08	0.34	0.26	03/26/98	10/02/97	9
NUTRIENTS										
Nitrate as N	(mg/l)	0.48	0.55	114	1.18	1.20	0.03	02/12/96	03/12/97	6
Nitrite as N	(mg/l)	0.02	0.02	101	0.05	0.05	0.01	04/10/96	01/26/96	4
Nitrate + Nitrite as N	(mg/l)	0.17	0.13	76	0.25	0.27	0.03	10/02/97	03/26/98	3
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	1651.11	237.93	14	760.00	1840.00	1080.00	03/12/97	01/20/98	9
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	0.39	0.22	57	0.50	0.50	0.00	04/10/96	01/26/96	9
Chloride	(mg/l)	534.97	200.25	37	650.30	696.00	45.70	10/02/97	10/02/96	9
Sulfate	(mg/l)	8359.44	834.92	10	2780.00	9460.00	6680.00	01/13/97	02/12/96	9
MAJOR CATIONS										
Calcium	(mg/l)	228.67	85.14	37	272.00	287.00	15.00	02/12/96	01/26/96	9
Magnesium	(mg/l)	127.33	6.73	5	23.00	135.00	112.00	10/02/97	03/26/98	9
Potassium	(mg/l)	77.68	172.67	222	527.80	538.00	10.20	01/26/96	10/02/97	9
Sodium	(mg/l)	4399.33	449.09	10	1260.00	4920.00	3660.00	10/02/97	01/20/98	9
Major Anions	(meq/l)	216.23	21.53	10	67.61	244.25	176.64	01/13/97	02/12/96	9
Major Cations	(meq/l)	215.23	20.27	9	56.31	239.55	183.24	10/02/97	01/20/98	9
Charge Balance	(percent)	2.47	1.55	63	4.13	4.33	0.20	02/12/96	01/26/96	9
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	9
Chromium	(mg/l)									0
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	01/26/96	01/26/96	9
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	01/26/96	01/26/96	9
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	01/26/96	01/26/96	9
Zinc	(mg/l)	0.037	0.041	111	0.130	0.140	0.010	02/12/96	01/20/98	9
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	0.039	0.079	201	0.245	0.250	0.005	02/12/96	01/20/98	9
Cadmium	(mg/l)	0.0007	0.0002	37	0.0005	0.0010	0.0005	01/26/96	10/02/96	9
Iron	(mg/l)	0.418	0.282	67	0.865	0.890	0.025	03/26/98	01/26/96	9
Total Iron	(mg/l)	3.42	5.18	151	15.93	16.60	0.67	02/12/96	01/13/97	9
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	9
Manganese	(mg/l)	2.781	0.661	24	2.190	4.270	2.080	03/26/98	03/12/97	9
Total Manganese	(mg/l)	2.91	0.91	31	3.14	5.09	1.95	03/26/98	03/12/97	9
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	01/26/96	01/26/96	9

Below detection limit values included at 0.5 times detection limit.

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER STATISTICAL REPORT

Station: BITSUI-5

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	7.41				7.50	7.40	04/11/96	02/13/96	9
Conductivity (Lab)	(umho/cm)	15378	1785	12	6300	19300	13000	01/22/98	02/13/96	9
TDS (180 deg C)	(mg/l)	11422	612	5	2000	12300	10300	01/22/98	02/13/96	9
Boron	(mg/l)	0.99	0.35	35	1.22	1.33	0.11	06/18/97	10/03/97	9
Fluoride	(mg/l)	1.02	0.08	8	0.27	1.12	0.85	01/22/98	10/03/97	9
NUTRIENTS										
Nitrate as N	(mg/l)	0.04	0.03	90	0.08	0.09	0.01	01/10/97	02/13/96	5
Nitrite as N	(mg/l)	0.03	0.00	0	0.00	0.03	0.03	02/13/96	02/13/96	3
Nitrate + Nitrite as N	(mg/l)	0.15	0.10	72	0.26	0.28	0.03	10/03/97	06/18/97	4
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	2693.39	1012.17	38	3169.50	3170.00	0.50	02/13/96	06/18/97	9
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	0.44	0.17	38	0.50	0.50	0.00	04/11/96	02/13/96	9
Chloride	(mg/l)	1206.89	99.03	8	300.00	1330.00	1030.00	02/13/96	03/26/98	9
Sulfate	(mg/l)	4626.22	494.09	11	1480.00	5030.00	3550.00	06/18/97	02/13/96	9
MAJOR CATIONS										
Calcium	(mg/l)	61.62	10.22	17	35.20	77.20	42.00	10/03/97	03/26/98	9
Magnesium	(mg/l)	29.73	2.85	10	7.90	34.90	27.00	10/03/97	01/22/98	9
Potassium	(mg/l)	13.80	2.21	16	6.20	16.60	10.40	06/18/97	01/10/97	9
Sodium	(mg/l)	3871.00	246.47	6	810.00	4300.00	3490.00	06/18/97	01/22/98	9
Major Anions	(meq/l)	179.81	8.47	5	24.84	188.21	163.37	10/03/97	02/13/96	9
Major Cations	(meq/l)	174.26	10.99	6	36.45	193.63	157.18	06/18/97	01/22/98	9
Charge Balance	(percent)	2.29	2.01	88	6.21	6.52	0.31	01/22/98	02/13/96	9
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	9
Chromium	(mg/l)									0
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/13/96	02/13/96	9
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	02/13/96	02/13/96	9
Silver	(mg/l)	0.010	0.015	150	0.045	0.050	0.005	06/18/97	02/13/96	9
Zinc	(mg/l)	1.515	4.494	297	13.490	13.500	0.010	10/03/96	02/13/96	9
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	0.062	0.106	171	0.245	0.250	0.005	02/13/96	06/18/97	9
Cadmium	(mg/l)	0.0006	0.0002	36	0.0005	0.0010	0.0005	02/13/96	10/03/96	9
Iron	(mg/l)	0.221	0.133	60	0.470	0.480	0.010	02/13/96	10/03/97	9
Total Iron	(mg/l)	0.70	0.71	102	1.88	2.05	0.17	02/13/96	01/22/98	9
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	9
Manganese	(mg/l)	0.134	0.113	84	0.408	0.410	0.003	02/13/96	10/03/97	9
Total Manganese	(mg/l)	0.15	0.10	70	0.33	0.41	0.08	02/13/96	10/03/96	9
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/13/96	02/13/96	9

Below detection limit values included at 0.5 times detection limit.

BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER STATISTICAL REPORT

Station: BITSUI-6

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	6.77				7.20	6.60	04/11/96	10/02/96	9
Conductivity (Lab)	(umho/cm)	15687	5800	37	21420	23200	1780	01/20/98	06/18/97	9
TDS (180 deg C)	(mg/l)	15000	1289	9	3300	16500	13200	01/13/97	02/12/96	9
Boron	(mg/l)	2.18	0.41	19	1.14	2.61	1.47	06/18/97	04/11/96	9
Fluoride	(mg/l)	0.41	0.35	86	1.08	1.34	0.26	10/02/96	10/02/97	9
NUTRIENTS										
Nitrate as N	(mg/l)	1.30	2.74	212	6.18	6.20	0.03	02/12/96	10/02/96	5
Nitrite as N	(mg/l)	0.03	0.00	0	0.00	0.03	0.03	02/12/96	02/12/96	3
Nitrate + Nitrite as N	(mg/l)	0.19	0.12	62	0.28	0.30	0.03	10/02/97	06/18/97	4
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	1423.78	261.52	18	876.00	1620.00	744.00	10/02/96	01/20/98	9
Bicarbonate as CaCO3	(mg/l)									0
Carbonate as CaCO3	(mg/l)									0
Carbonate as CO3	(mg/l)	0.44	0.17	38	0.50	0.50	0.00	04/11/96	02/12/96	9
Chloride	(mg/l)	376.99	131.08	35	433.10	490.00	56.90	01/13/97	10/02/96	9
Sulfate	(mg/l)	8849.78	1121.26	13	2670.00	10280.00	7610.00	01/13/97	03/26/98	9
MAJOR CATIONS										
Calcium	(mg/l)	343.22	50.93	15	152.00	390.00	238.00	10/02/96	03/26/98	9
Magnesium	(mg/l)	161.67	13.30	8	44.00	183.00	139.00	10/02/97	03/26/98	9
Potassium	(mg/l)	21.79	4.58	21	15.50	26.90	11.40	06/18/97	10/02/97	9
Sodium	(mg/l)	4125.44	587.77	14	1680.00	4860.00	3180.00	01/13/97	01/20/98	9
Major Anions	(meq/l)	218.28	25.87	12	67.86	252.94	185.08	01/13/97	01/20/98	9
Major Cations	(meq/l)	210.43	28.13	13	76.02	244.96	168.94	01/13/97	01/20/98	9
Charge Balance	(percent)	2.96	3.11	105	10.06	10.17	0.11	06/18/97	04/11/96	9
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	9
Chromium	(mg/l)									0
Copper	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	02/12/96	02/12/96	9
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	02/12/96	02/12/96	9
Silver	(mg/l)	0.009	0.012	131	0.035	0.040	0.005	06/18/97	02/12/96	9
Zinc	(mg/l)	0.052	0.086	167	0.270	0.280	0.010	10/02/96	01/20/98	9
Radium 226	(pCi/l)									0
Radium 228	(pCi/l)									0
Barium	(mg/l)	0.064	0.106	165	0.245	0.250	0.005	02/12/96	06/18/97	9
Cadmium	(mg/l)	0.0018	0.0035	195	0.0105	0.0110	0.0005	04/11/96	10/02/96	9
Iron	(mg/l)	0.842	0.591	70	1.855	1.880	0.025	01/13/97	02/12/96	9
Total Iron	(mg/l)	3.37	6.25	186	19.59	20.00	0.41	02/12/96	10/02/97	9
Lead	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	9
Manganese	(mg/l)	3.503	1.674	48	6.470	6.600	0.130	03/26/98	01/13/97	9
Total Manganese	(mg/l)	3.66	1.41	39	5.24	6.48	1.24	03/26/98	10/02/97	9
Selenium	(mg/l)	0.003	0.000	0	0.000	0.003	0.003	02/12/96	02/12/96	9

Below detection limit values included at 0.5 times detection limit.

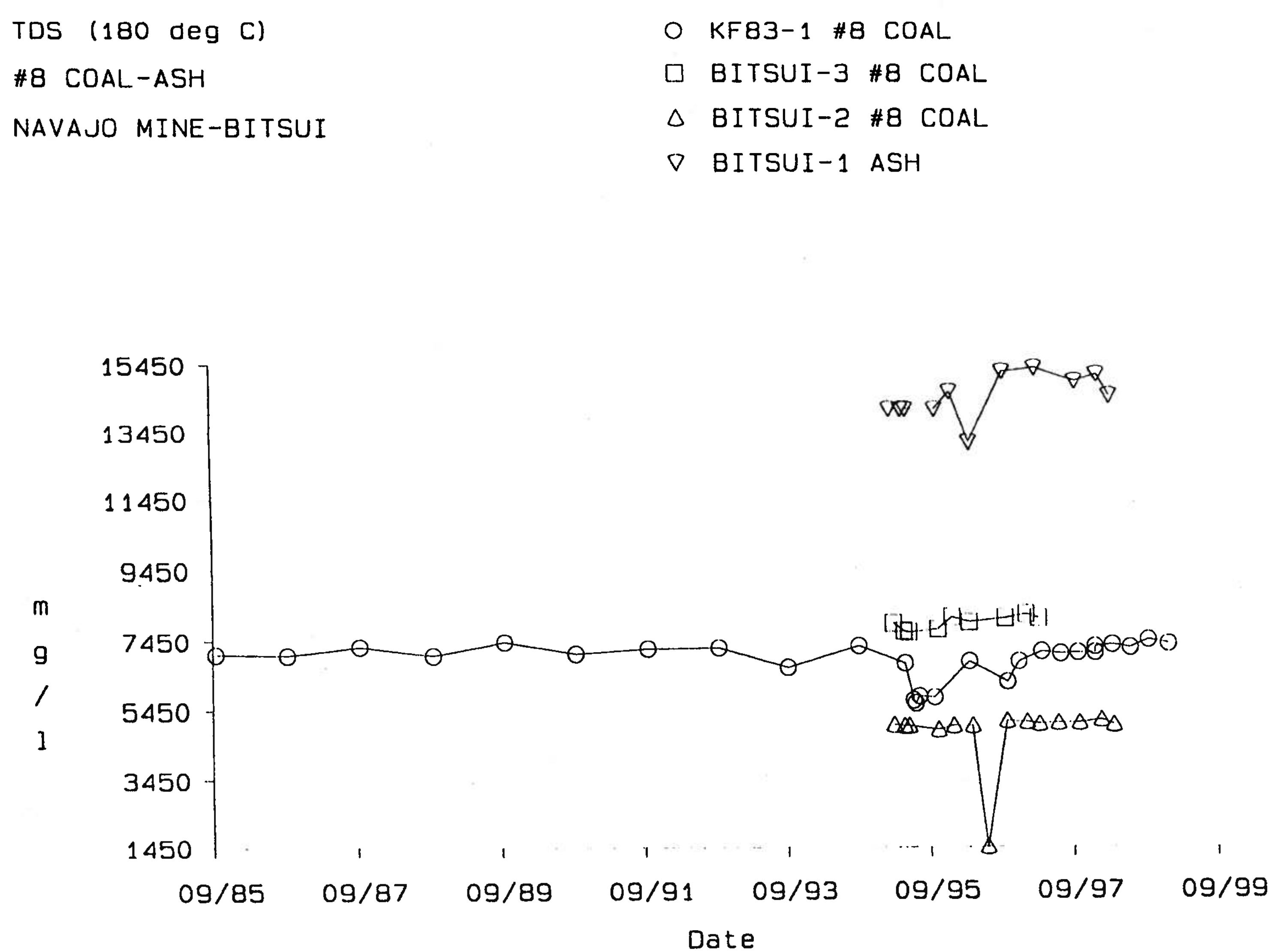
BHP NAVAJO MINE
1998 ANNUAL HYDROLOGY REPORT
GROUNDWATER STATISTICAL REPORT

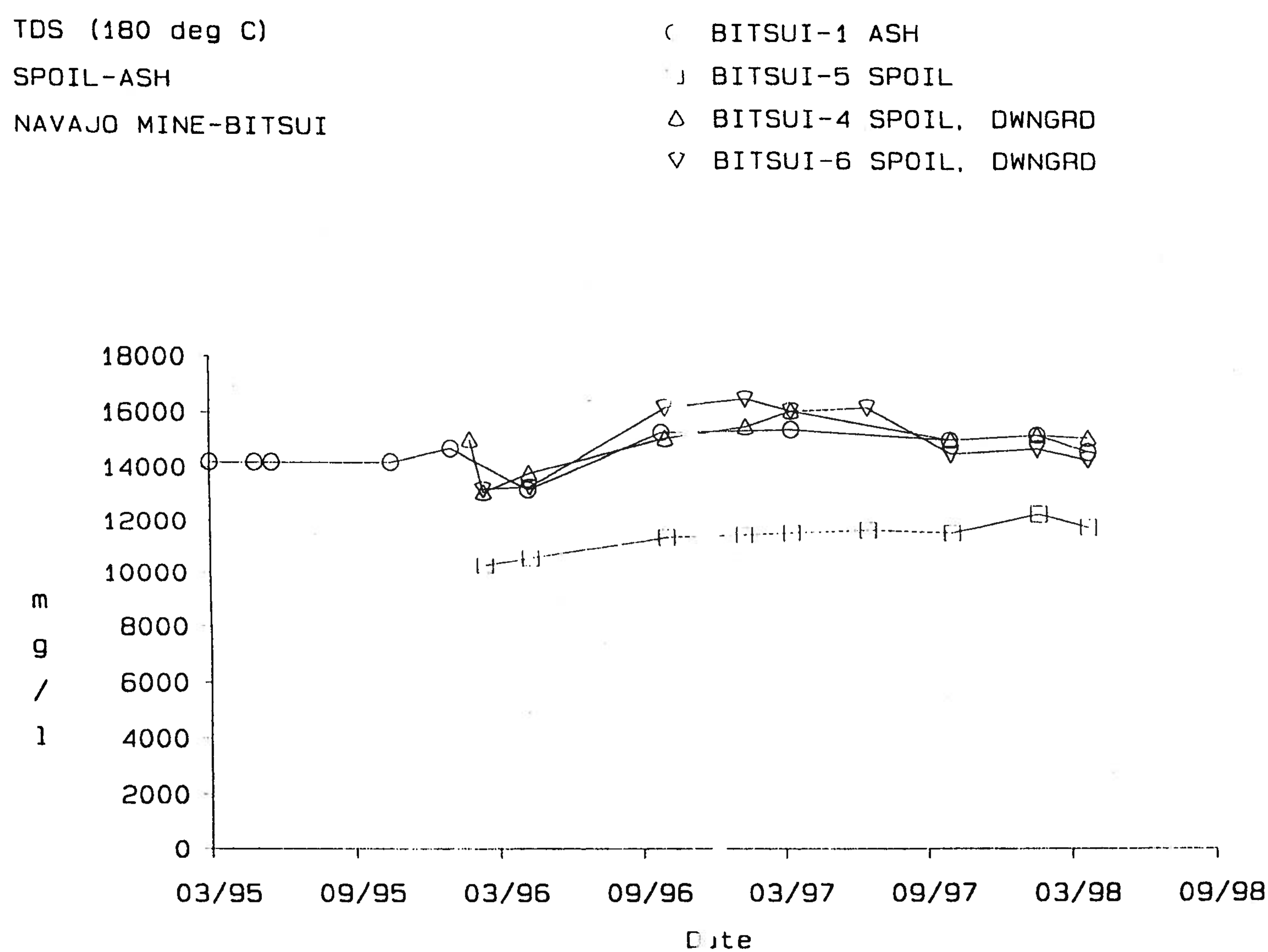
Station: KF83-1

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
LABORATORY MEASUREMENTS										
pH (Lab)	(S.U.)	7.81				8.68	7.60	09/22/92	05/03/95	27
Conductivity (Lab)	(umho/cm)	10576	1050	10	3900	12900	9000	06/18/98	09/08/93	27
TDS (180 deg C)	(mg/l)	6919	549	8	1830	7500	5670	09/21/98	06/21/95	27
Boron	(mg/l)	1.03	0.15	15	0.83	1.70	0.87	09/16/87	05/03/95	27
Fluoride	(mg/l)	1.11	0.20	18	0.74	1.57	0.83	07/14/95	05/03/95	27
NUTRIENTS										
Nitrate as N	(mg/l)	1.77	5.01	283	18.20	18.20	0.01	06/21/95	06/14/95	14
Nitrite as N	(mg/l)	0.02	0.01	62	0.02	0.03	0.01	09/21/90	05/03/95	12
Nitrate + Nitrite as N	(mg/l)	0.09	0.11	121	0.30	0.32	0.02	06/18/98	09/23/91	13
MAJOR ANIONS										
Bicarbonate as HCO3	(mg/l)	3064.35	399.67	13	1240.00	3740.00	2500.00	06/21/95	09/26/97	17
Bicarbonate as CaCO3	(mg/l)	2469.00	281.01	11	910.00	2790.00	1880.00	09/16/86	09/16/87	10
Carbonate as CaCO3	(mg/l)	232.00	204.44	88	600.00	600.00	0.00	09/16/87	09/23/88	10
Carbonate as CO3	(mg/l)	0.35	0.23	67	0.50	0.50	0.00	03/25/96	05/03/95	17
Chloride	(mg/l)	2171.93	619.51	29	2637.00	2760.00	123.00	09/23/88	10/03/96	27
Sulfate	(mg/l)	287.09	256.42	89	975.00	980.00	5.00	10/03/96	09/23/88	27
MAJOR CATIONS										
Calcium	(mg/l)	18.47	6.15	33	27.90	28.00	0.10	05/03/95	09/26/97	27
Magnesium	(mg/l)	6.78	1.96	29	9.80	13.00	3.20	05/03/95	09/26/97	27
Potassium	(mg/l)	11.60	5.76	50	25.20	31.00	5.80	05/03/95	09/26/97	27
Sodium	(mg/l)	2598.56	212.07	8	840.00	3100.00	2260.00	12/22/97	07/14/95	27
Major Anions	(meq/l)	118.91	12.65	11	62.23	141.17	78.94	12/22/97	10/03/96	27
Major Cations	(meq/l)	114.81	9.50	8	37.53	136.95	99.42	12/22/97	07/14/95	27
Charge Balance	(percent)	3.01	3.64	121	14.31	14.42	0.11	10/03/96	06/21/95	27
TRACE METALS (Dissolved)										
Arsenic	(mg/l)	0.002	0.001	27	0.003	0.004	0.001	09/21/89	09/23/91	15
Chromium	(mg/l)	0.0071	0.0040	57	0.0140	0.0150	0.0010	09/16/87	09/16/86	10
Copper	(mg/l)	0.046	0.072	154	0.165	0.170	0.005	12/22/97	09/26/97	7
Mercury	(mg/l)	0.00050	0.00000	0	0.00000	0.00050	0.00050	09/26/97	09/26/97	7
Silver	(mg/l)	0.005	0.000	0	0.000	0.005	0.005	09/26/97	09/26/97	7
Zinc	(mg/l)	0.035	0.039	109	0.115	0.125	0.010	09/23/91	12/22/97	15
Radium 226	(pCi/l)	2.2	0.7	32	2.4	3.4	1.0	09/16/85	09/16/86	10
Radium 228	(pCi/l)	2.3	2.8	122	9.4	9.5	0.1	09/23/91	09/21/89	10
Barium	(mg/l)	1.859	2.265	122	6.595	6.600	0.005	09/23/88	07/01/97	27
Cadmium	(mg/l)	0.0047	0.0171	362	0.0895	0.0900	0.0005	09/16/87	09/16/86	27
Iron	(mg/l)	0.298	0.605	203	2.975	3.000	0.025	09/16/85	05/03/95	26
Total Iron	(mg/l)	0.28	0.31	112	1.04	1.06	0.03	05/03/95	06/21/95	19
Lead	(mg/l)	0.012	0.021	170	0.093	0.095	0.003	09/16/87	06/14/95	27
Manganese	(mg/l)	0.049	0.050	103	0.208	0.210	0.003	09/16/85	06/18/98	27
Total Manganese	(mg/l)	0.07	0.20	267	0.87	0.87	0.01	09/26/97	10/03/96	19
Selenium	(mg/l)	0.002	0.001	56	0.002	0.003	0.001	05/03/95	09/16/85	27

Below detection limit values included at 0.5 times detection limit.

CONCENTRATION VERSUS TIME PLOTS


TDS (180 deg C)
#8 COAL-ASH
NAVAJO MINE-BITSUI
○ KF83-1 #8 COAL
□ BITSUI-3 #8 COAL
△ BITSUI-2 #8 COAL
▽ BITSUI-1 ASH
15450
13450
11450
9450
7450
5450
3450
1450
mg/l
09/85
09/87
09/89
09/91
09/93
09/95
09/97
09/99
Date

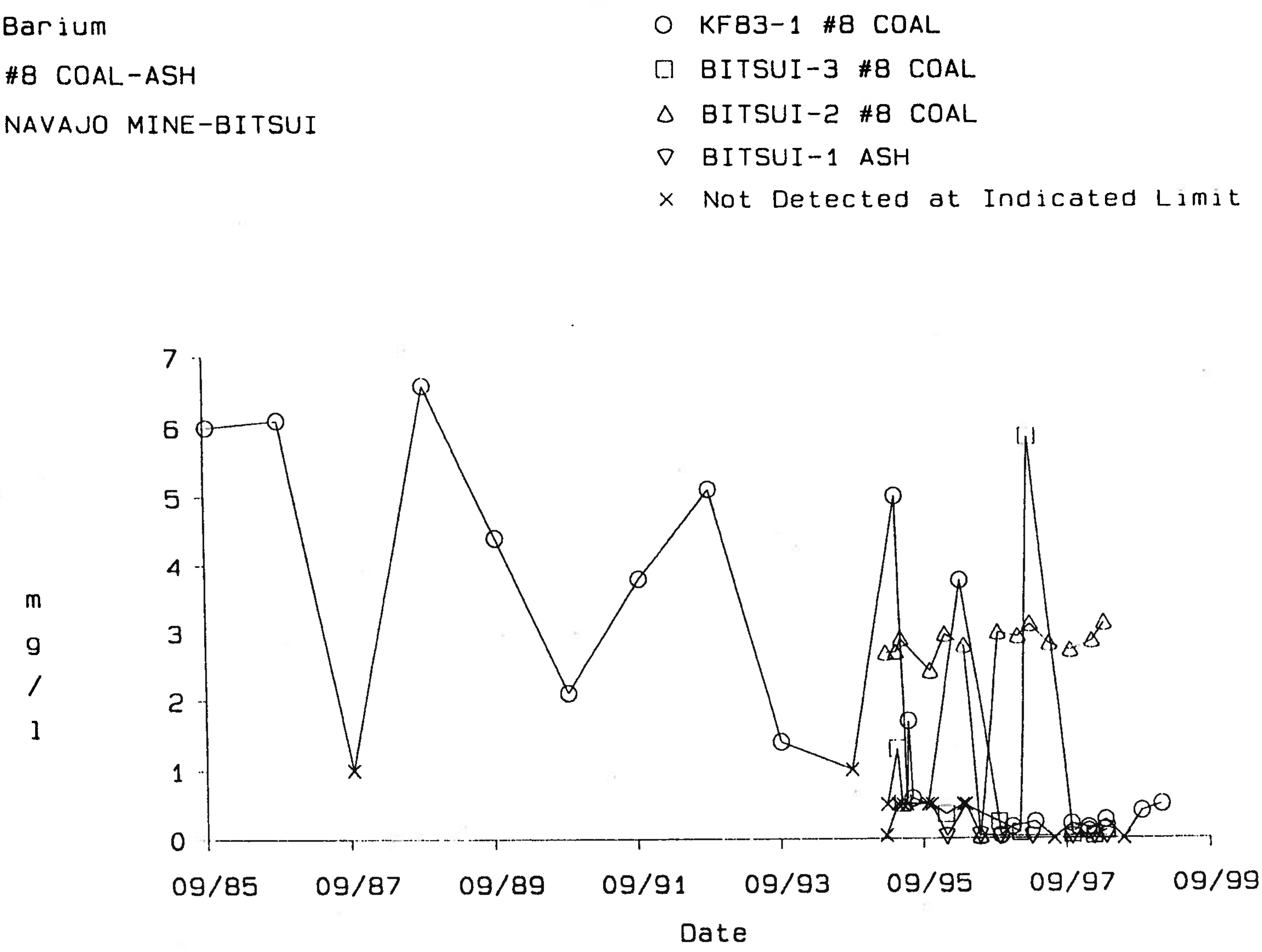


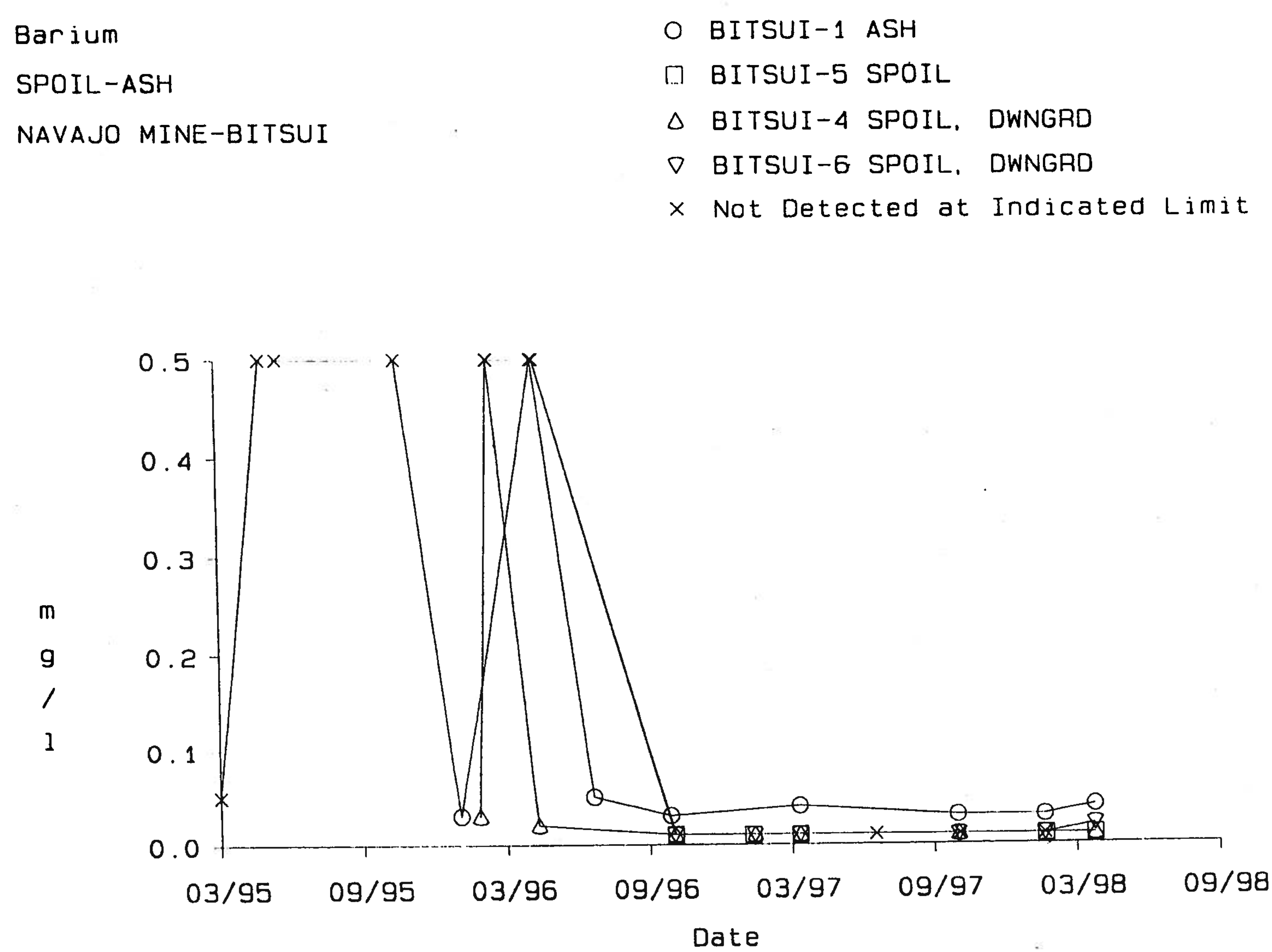
TDS (180 deg C)
SPOIL-ASH
NAVAJO MINE-BITSUI
BITSUI-1 ASH
BITSUI-5 SPOIL
BITSUI-4 SPOIL, DWNGRD
BITSUI-6 SPOIL, DWNGRD
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
m g / l
03/95
09/95
03/96
09/96
03/97
09/97
03/98
09/98
Date

Barium

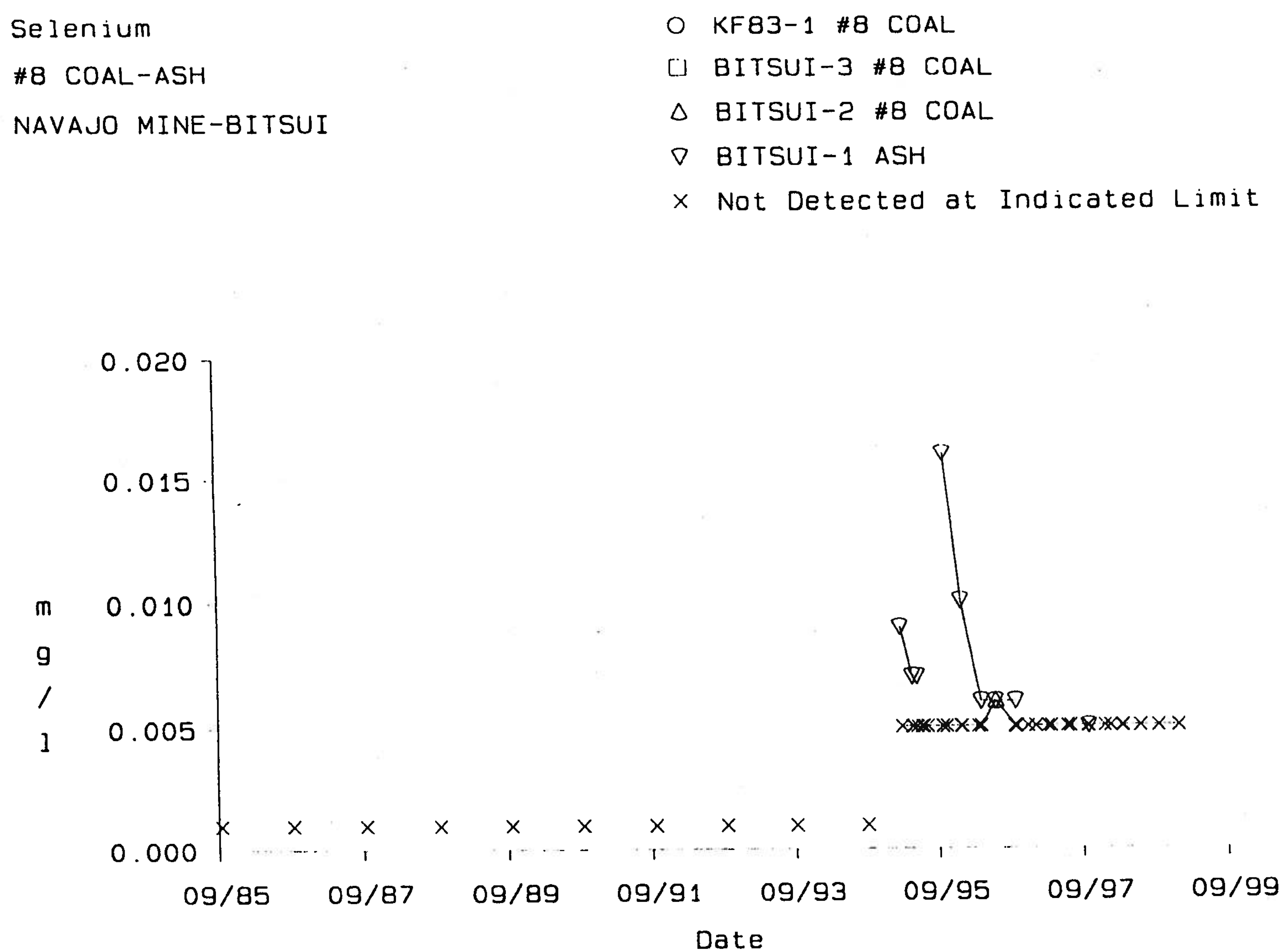
#8 COAL-ASH

NAVAJO MINE-BITSUI

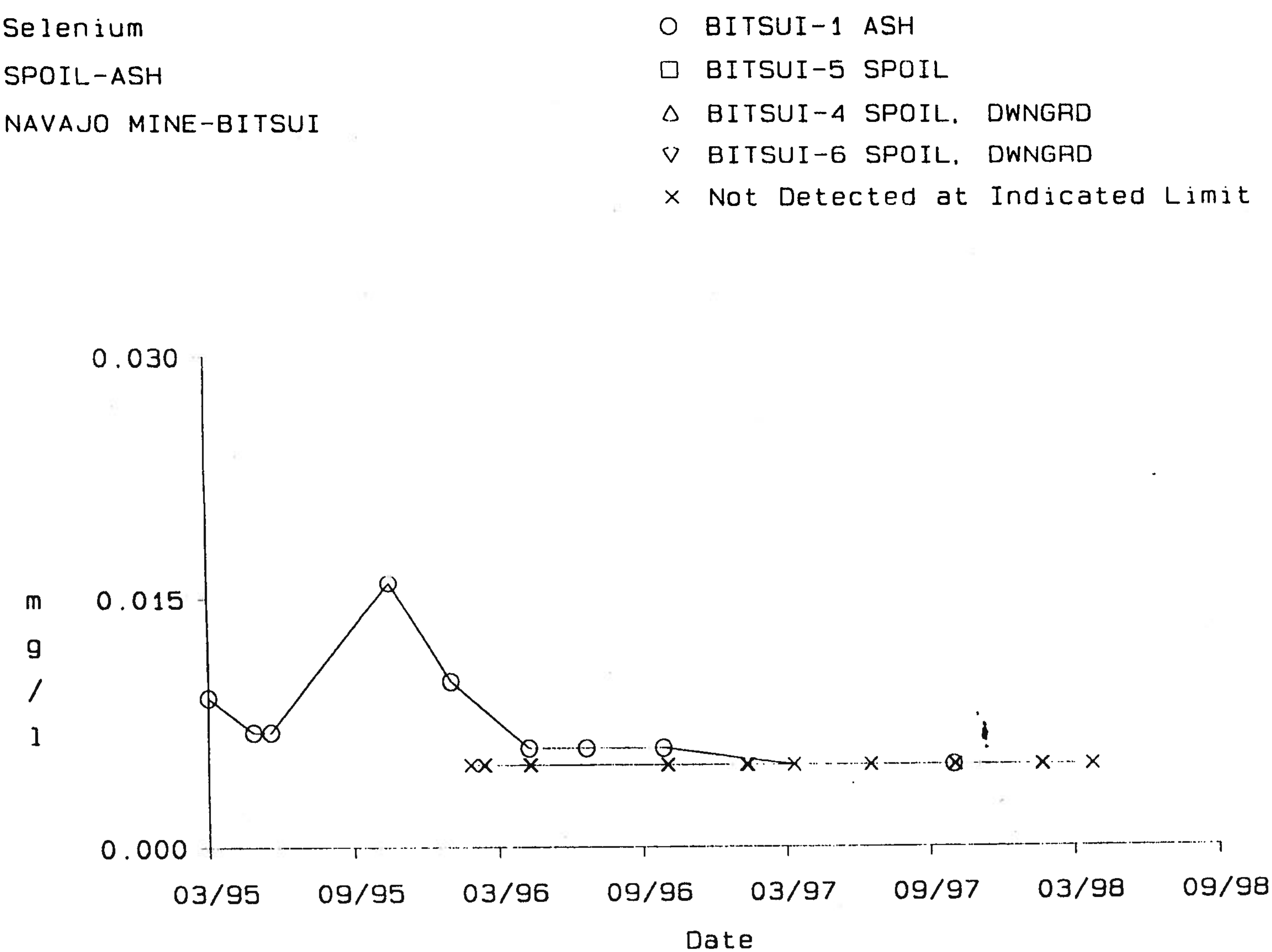


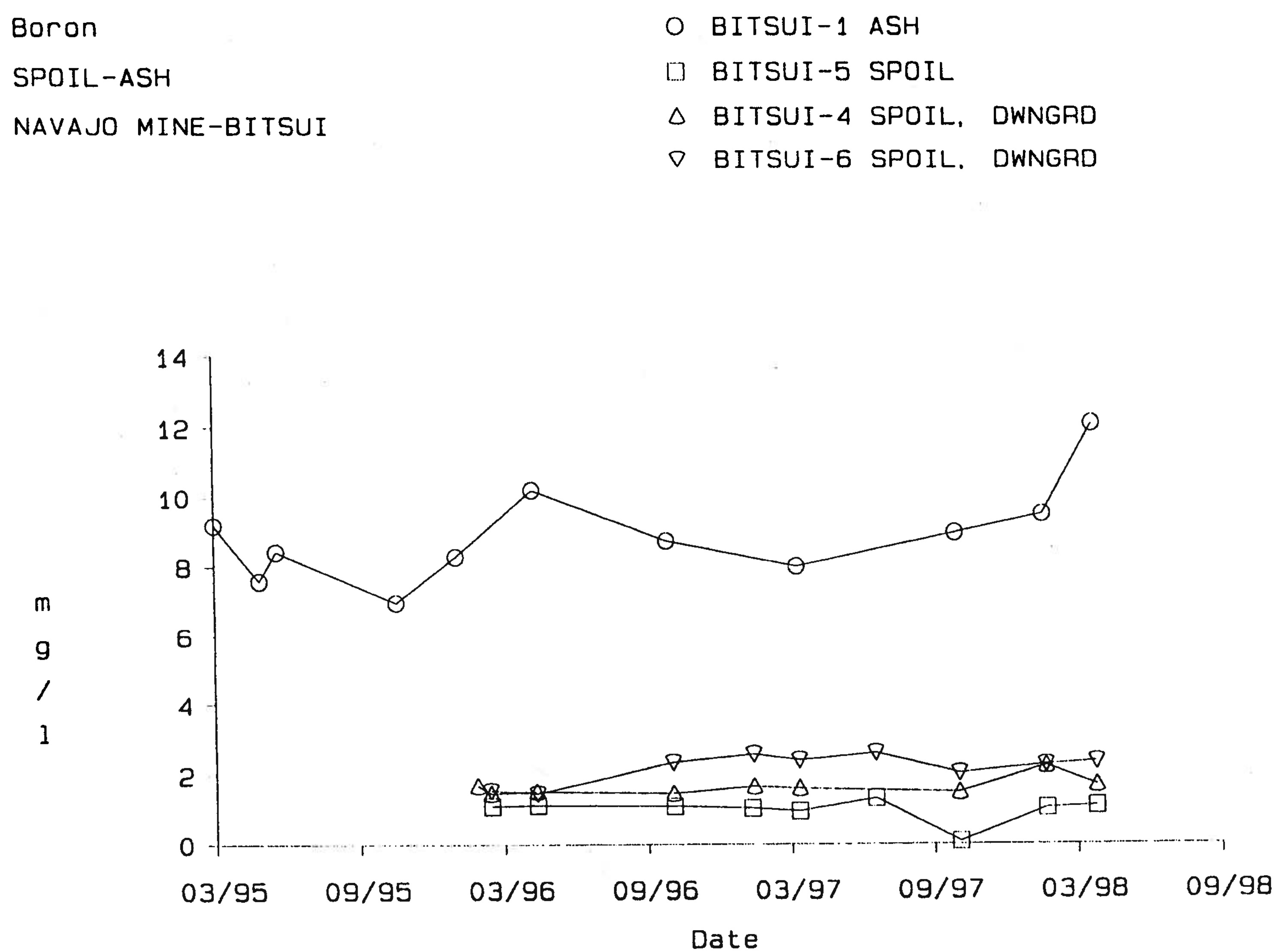


Barium
SPOIL-ASH
NAVAJO MINE-BITSUI
BITSUI-1 ASH
BITSUI-5 SPOIL
BITSUI-4 SPOIL, DWNGRD
BITSUI-6 SPOIL, DWNGRD
Not Detected at Indicated Limit
0.5
0.4
0.3
0.2
0.1
0.0
mg/l
03/95
09/95
03/96
09/96
03/97
09/97
03/98
09/98
Date


Selenium
#8 COAL-ASH
NAVAJO MINE-BITSUI
KF83-1 #8 COAL
BITSUI-3 #8 COAL
BITSUI-2 #8 COAL
BITSUI-1 ASH
Not Detected at Indicated Limit
m g / l
0.020
0.015
0.010
0.005
0.000
09/85
09/87
09/89
09/91
09/93
09/95
09/97
09/99
Date

Selenium
SPOIL-ASH
NAVAJO MINE-BITSUI

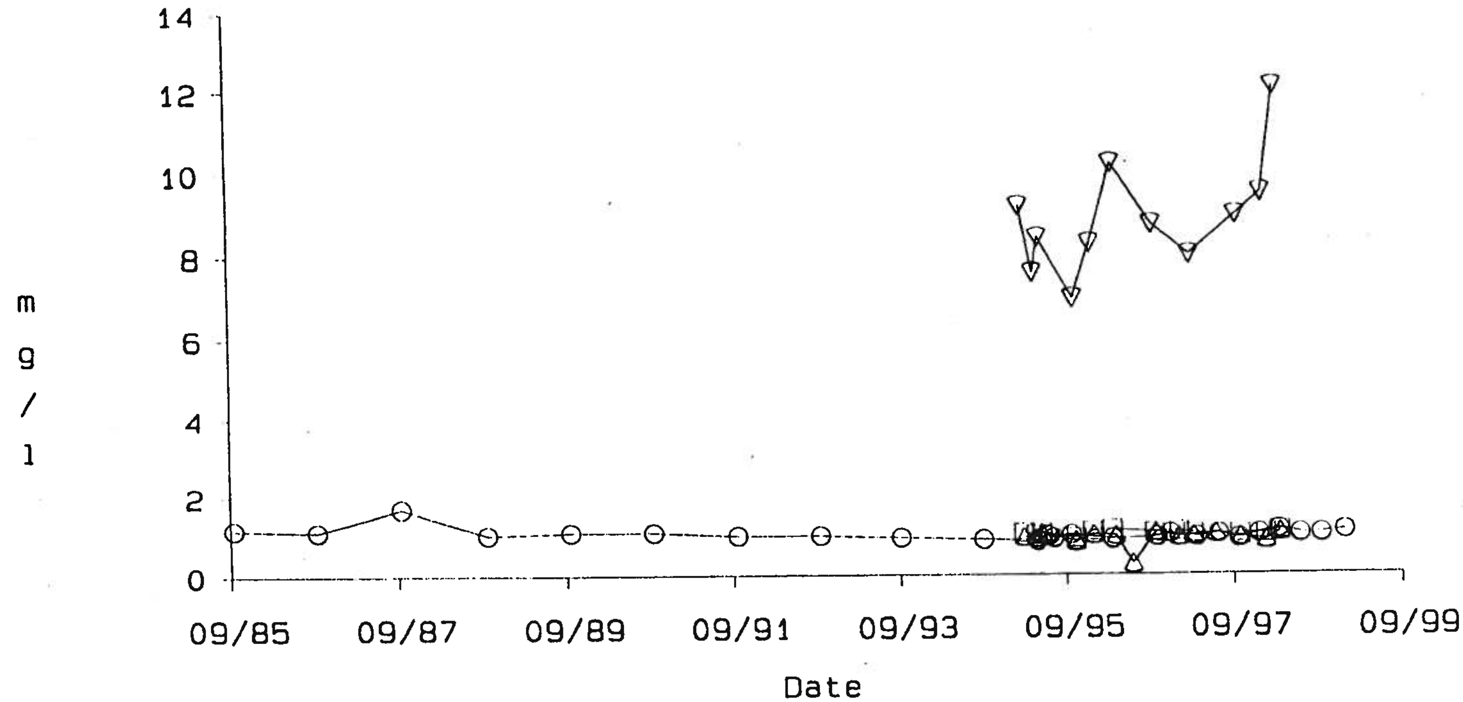



Boron
SPOIL-ASH
NAVAJO MINE-BITSUI
BITSUI-1 ASH
BITSUI-5 SPOIL
BITSUI-4 SPOIL, DWNGRD
BITSUI-6 SPOIL, DWNGRD
m g / l
0
2
4
6
8
10
12
14
03/95
09/95
03/96
09/96
03/97
09/97
03/98
09/98
Date

Boron

#8 COAL-ASH

NAVAJO MINE-BITSUI



TRILINEAR DIAGRAMS

Piper Trilinear Diagram

BITSUI-SPOIL, ASH, COAL

NAVAJO MINE

A KF83-1 8 COAL

B BITSUI-3 8 COAL

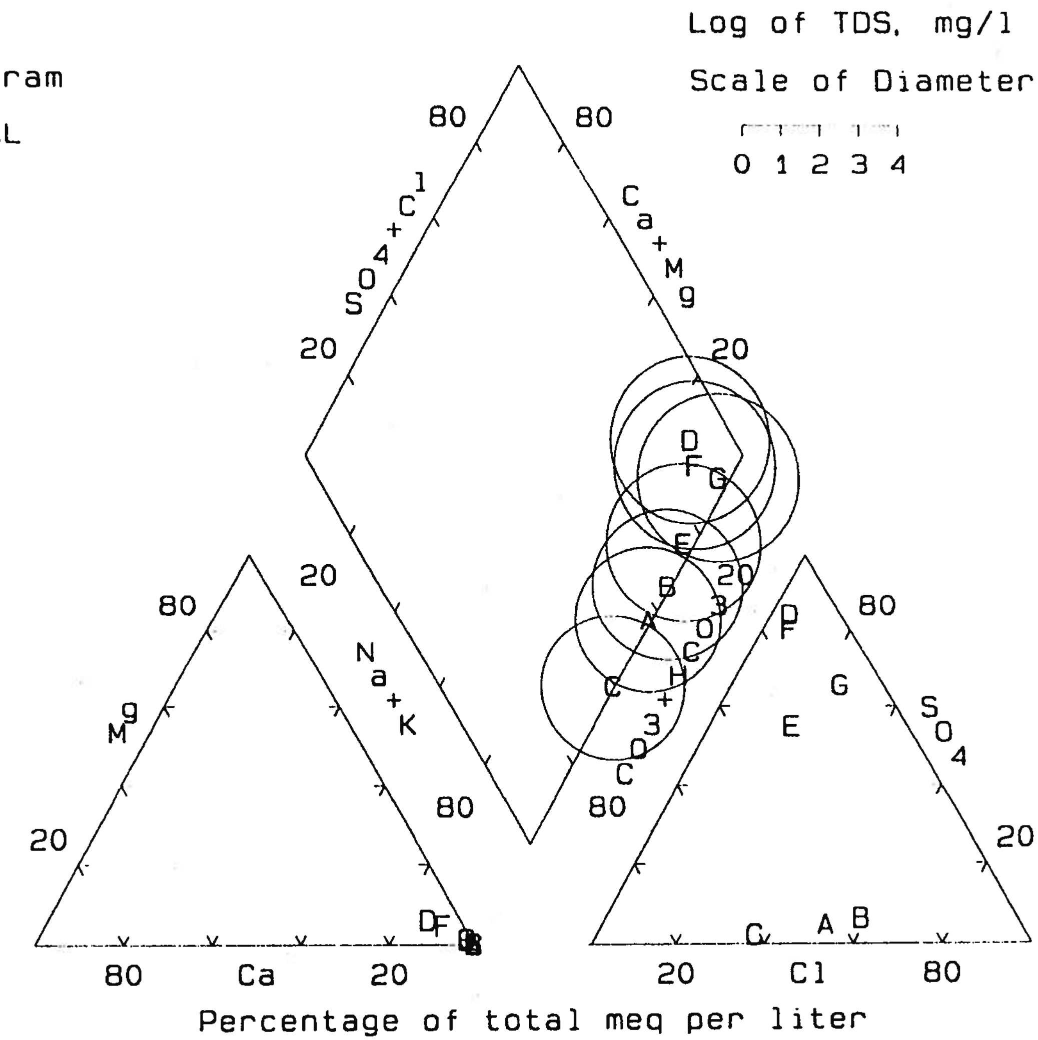
C BITSUI-2 8 COAL

D BITSUI-6 SPOIL

E BITSUI-5 SPOIL

F BITSUI-4 SPOIL

G BITSUI-1 ASH



ATTACHMENT 3

Probable Hydrologic Consequences Study

11.6 PROBABLE HYDROLOGIC CONSEQUENCES

11.6.1 Summary of Probable Hydrologic Consequences

This Section provides a detailed assessment of the probable hydrologic consequences of mining activities to surface and groundwater. The results and conclusions presented are based on baseline groundwater and surface water information contained in CHAPTERS 6 and 7, respectively.

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 provided from past geological investigations and from observations made by BHP staff during the day-to-day operations of the mine.

Water quality parameters will be monitored to confirm predictions made in the PHC and reported to the regulatory authority as outlined in CHAPTERS 6 and 7.

11.6.1.1 Groundwater

Probable hydrological consequences of mining activities upon the quality and quantity of groundwater are negligible. As discussed in Section 11.6.2.2, groundwater quality is expected to generally improve (metal concentration usually decreases while sulfate values increase) when natural groundwater is exposed to spoil. When groundwater travels through the coal seams, additional attenuation of some chemical species is also seen, further reducing the potential impact of mining on regional groundwater quality. Mining activities are not expected to have a degradation effect on any principal aquifer (Section 11.6.2.3). Impacts to the San Juan River water quality due to groundwater affected by mining are expected to be so small as to be unmeasurable (Section 11.6.2.4).

The quantity of groundwater available is also expected to be essentially unchanged. As discussed in Section 11.6.2.5, a slight drop in local water tables is expected while the pits are open. Following mining, recharge to the aquifer along the disturbed zone is expected to increase.

Mining activities will not disrupt a developed water source (Section 11.6.2.5). Groundwater quality in the Fruitland Formation is naturally poor and production is so low, that regional use is virtually nonexistent (CHAPTER 6).

The collected baseline and monitoring data was used to describe and evaluate the geologic setting of the mine and the occurrence of groundwater at the mine with respect to mining operations and potential groundwater quality impacts. Based on drilling and excavation activities, only the Quaternary Alluvium, the coal seams and inter-bedded lithologic units of the Fruitland Formation, and the Pictured Cliffs Sandstone bear appreciable amounts of water within the mine area. Water level determinations from mine area monitor and piezometer wells are discussed in CHAPTER 6.

Estimates of groundwater flow velocities, projected travel times, and volumes of groundwater flow were calculated for the evaluations of potential spoil leachate transport. These analyses were compared with the results of the Leach study (APPENDIX 11-K) to determine the effect of potential leachate transport to groundwater from CCB and spoil disposal.

No acid forming or toxic materials are present in the spoil or CCB as demonstrated by the toxicity tests in APPENDIX 11-K. Characterization investigations conducted on CCB disposal at Navajo Mine contained in APPENDIX 11-K demonstrate that no degradation effects will occur to post-mine groundwater. In addition, analysis of solid samples of spoil and CCB indicate that, except for boron, the two materials have similar parameter concentrations.

TABLE 11-14

COMPARISON OF NATURAL GROUNDWATER QUALITY BEFORE AND AFTER LEACHING THROUGH A SPOIL MIXTURE

Parameter		Groundwater (Composite 5) (see Table 27.B2 in APPENDIX 11-K)	Composite 3 Leached through Spoil S-3 (see Table 27.B17 in APPENDIX 11-K)	Percent Change
Acidity	mg/l CaC03	1	1	0
Alkalinity	mg/l CaC03	940	860	- 9
Chloride	mg/l	2000	320	- 84
Cyanide	mg/l	0.02	0.02	0
Fluoride	mg/l	1.3	2.2	69
Nitrate	mg/l N03	11	12	9
pH		9.5	8.3	- 13
Phenolics	mg/l	0.02	0.01	- 50
Residue	mg/l	4600	4800	4
Specific Conductance		8100	6840	- 16
Sulfate	mg/l	55	1800	3173
Aluminum	mg/l	1.7	0.1	- 94
Arsenic	mg/l	0.017	0.003	- 82
Barium	mg/l	2.5	0.037	- 99
Boron	mg/l	0.42	0.5	19
Cadmium	mg/l	0.0015	0.001	- 33
Calcium	mg/l	140	110	- 21
Chromium	mg/l	0.034	0.005	- 85
Cobalt	mg/l	0.017	0.012	- 29
Copper	mg/l	0.04	0.02	- 50
Iron	mg/l	5.6	0.08	- 99
Lead	mg/l	0.08	0.03	- 63
Magnesium	mg/l	11	19	73
Manganese	mg/l	0.7	0.26	- 63
Mercury	mg/l	0.0002	0.0002	0
Molybdenum	mg/l	0.007	0.007	0
Nickel	mg/l	0.04	0.01	- 75
Potassium	mg/l	12	16	33
Selenium	mg/l	0.02	0.02	0
Silver	mg/l	0.0085	0.002	- 76
Sodium	mg/l	1600	1300	- 19
Zinc	mg/l	0.09	0.05	- 44
Total Dissolved Metals	mg/l	1774.275	1446.137	- 18

CCB disposal does not adversely effect post-mine groundwater quality. The chemical effect is dominantly a small change in the major ion chemistry (i.e., changes in sulfate and sodium concentrations), as opposed to any degradation or harmful changes in groundwater quality. Furthermore, spoil will likely cause similar or greater changes in post-mine water chemistry than CCB disposal.

Navajo Mine well data collected from historic CCB disposal on pre-law and interim lands (Supplemental Groundwater Study (SGS), APPENDIX 11-MM) support the leach study conclusion of no degradation effects to groundwater. Conclusions reported in these two Navajo Mine studies (Leach and SGS) are further supported by independent research (U.S.G.S.) at other western surface coal mines.

CCB disposal locations and techniques are described in Section 11.2.5.1.

11.6.1.2 <u>Surface Water</u>

A slight decrease in surface water availability is expected due to the improved infiltration of topdressing materials placed on badlands areas (Section 11.6.3). Surface water quality is expected to be at least as good as it was before mining as a result of the revegetation practices outlined in Section 12.6.

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.

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. Sediment yield will thus not be adversely affected. Acidity, total suspended and dissolved solids and other important water quality parameters will not be adversely affected by mining activities. See APPENDIX 11-K, TABLE 11-14 and Section 11.6.3 for details.

11.6.2 Assessment of Potential Groundwater Quality Impacts

The assessment of potential impacts to groundwater quality on any potential receptors caused by Navajo Mine mining operations was evaluated using a groundwater and surface water leach transport study. The study (APPENDIX 11-K) contains information on natural groundwater and surface water quality and presents water quality changes when surface water and groundwater is leached through representative spoils, fly ash, bottom ash, and mixtures of ash and spoil.

Baseline data used to determine transport mechanisms for post-mine groundwater is contained in Chapter 5, - Geology and Chapter 6 - Groundwater. This information includes aquifer characteristics, regional hydrology information, and geology.

11.6.2.1 Groundwater Quality Impacts due to Spoil

Laboratory analyses of Fruitland Formation coal seam water and spoil leachate indicate that these waters are relatively poor in quality. Both water types exceed the New Mexico Quality Control Commission (NMQCC) standards and criteria for groundwater for fluoride, chloride, sulfate, and total dissolved solids. Table 14, from the leach study, shows natural groundwater quality and the change in water quality when it is passed through the spoil mixture.

In most cases, when groundwater is exposed to spoils, the overall quality improves. In general, most metal concentrations, such as iron, decrease after exposure to spoil. When groundwater containing low sulfate levels interacts with the spoil, sulfate levels increase. Laboratory data suggest that colloidal hydroxides are formed when the spoils and water interact. This intimate interaction and mixing facilitates the adsorption and precipitation of metals, thus reducing their concentrations.

The attenuation data from the leach study showed that the concentrations of many parameters would be reduced after contact with the coal seam. The results of these reductions or retardation factors indicate that a contaminant plume would not migrate through the coal seam at the same rate that water migrates.

The No. 2-3, No. 4-6, No. 7, and No. 8 Coal Seams at Navajo Mine were identified as the major units capable of transporting leachate out of the mining area. Groundwater movement within these seams, even under worst-case conditions, is no greater than 0.076 feet per day. Based on this flow rate, the shortest time of travel for leachate-affected groundwater from the northern most portion of the mine to a potential receptor point (San Juan River) was estimated to be about 200 years. Retardation factors for specific chemical species suggest that contaminants will lag behind this flow rate by at least an order of magnitude.

When the coal seams and inter-bedded lithologic units of the Fruitland Formation are treated as a single aquifer, groundwater movement, under worse case conditions, was 0.06 feet per day. Based on this flow rate, and worse case assumptions, the shortest time of travel for leachate affected groundwater from the northern most portion of the mine to reach the San Juan River was estimated to be 240 years.

The travel time for groundwater from the permit area will be considerably greater. Not only is travel time long, but the quantity of leachate-affected groundwater that could reach any potential receptors is relatively small even under worst-case conditions. The flow rates are four orders of magnitude (10^{-4}) smaller than those found in the San Juan River under extreme low-flow conditions. Thus, this potentially affected groundwater would have no measurable impacts on San Juan River water quality.

Potential future use of groundwater within the reclaimed mine is negligible, due to the low permeability of the spoil and poor water quality. In addition, the use of groundwater from bedrock units near the mine is limited, due to the low permeability and poor water quality historically encountered in these units.

While wells completed in the Quaternary Alluvium of the San Juan River Valley could potentially intercept leachate-affected groundwater received from the coal seam alluvium contact, the dilution of this groundwater by recharge from the San Juan River to the alluvium will greatly reduce the impact of this addition.

In comparison, the estimated worst-case flow contribution of coal seam leachate to mean annual flow in the San Juan River rates was determined to be 0.000002:1.0. For the historical low flow in the San Juan River, this ratio is raised only to 0.0005:1.0. Thus, even when historical low flows in the San Juan River are considered, the dilution rate for leachate-affected groundwater would still be very high.

When the coal seams and inter-bedded lithologic units of the Fruitland Formation are treated as a single aquifer, the estimated worse case flow contribution of leachate-affected groundwater to mean annual flow in the San Juan River was determined to be 0.000074: 1.0.

11.6.2.2 Groundwater Impacts due to CCB Disposal

The probable hydrologic consequences resulting from pit disposal of CCB at Navajo Mine is no degradation in the quality or quantity of post-mine groundwater. This probable consequence of CCB disposal is the result of review and analysis of data collected from Navajo Mine and outside sources. The data reviewed includes results of laboratory analysis on parameter concentrations of the ash, leachate tests, water quality and quantity data from Navajo Mine ash and coal wells, aquifer transmissivity tests. A literature review was also completed.

Groundwater transport mechanisms discussed above for spoil are similar for the transport of CCB leachate. Consequently, the analysis and discussion that follows focuses on potential changes to post-mine groundwater chemistry due to CCB disposal.

Parameter concentrations (mg/kg) of a solid matrix of CCB and of spoil disposed of at Navajo Mine are presented in Table 14a and 14b (Taken from the APPENDIX 11-K, Tables 27-B3 and 27-B4). The only notable parameter differences with the spoil are 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.

Fly ash and bottom ash are not classified as hazardous wastes. 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 14c is a comparison of surface and groundwater concentrations before and after they have been leached through different solid mixtures of spoil. The water chemistry of the leaching groundwater or surface water that was used is also presented for further comparison. The data presented in Table 14c was selectively obtained from data tables contained in Appendix 11-K. Several general relationships are evident from Table 14c for both ground and surface water follow.

1. Surface water leached through fly ash or bottom ash had lower TDS than when leached through either spoil S-4 or S-5 and is similar to the original concentration of the surface water (pre-leach).

TABLE 11-14a
ASH ANALYSIS SUMMARY
(TABLE 27-B3, APPENDIX K)

PARAMETER	UNIT	ASH	
		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
<u>Metals:</u>			
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 11-14b
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 °C	mg/kg	NA	NA	NA	NA	NA	NA	NA
Specific Conductance @ 25 °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.

Table 11-14c

Selective Results of Batch Leach Tests

Comparison of leaching water (surface water from Chinde Wash 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**	**Sulfate**	**Fe**	**Mn**	**B**	**Se**	**As**	**Cd**
Surface Water from Chinde Wash	7.8	1,900	230	280	15	1,200	0.45	0.08	0.31	<0.001	<0.001	<0.001
SW Leachate:												
Spoils S-4	7.8	4,600	640	850	43	2,700	0.06	0.7	<0.5	0.20	0.002	<0.001
Spoils S-5	8.2	3,500	320	750	27	2,300	0.02	0.26	<0.5	0.018	0.002	<0.001
Fly Ash	12.2	2,000	290	380	16	590	0.02	0.02	1.0	0.09	0.009	<0.001
Bottom Ash	8.5	2,000	260	330	22	940	0.03	0.07	<0.5	0.046	<0.001	<0.001
Ash w/ S-4	7.7	5,300	670	850	37	3,200	0.02	1.4	<0.5	0.018	<0.003	<0.001
Ash w/ S-5	8.1	4,500	550	800	29	3,000	0.08	0.39	<0.5	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	0.011	0.015	0.001
GW Leachate:												
Spoils S-4	7.8	12,000	730	3,200	5,500	2,700	0.06	0.7	<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	0.018	0.002	<0.001
Fly Ash	12	10,000	520	3,000	5,600	320	0.02	0.02	6.2	0.22	0.017	<0.001
Bottom Ash	8.5	8,700	170	3,500	5,500	170	0.03	0.07	0.6	0.020	<0.001	<0.001
Ash w/ S-4	7.9	12,000	790	3,100	5,700	2,000	0.04	1.3	<0.5	0.016	0.009	<0.001
Ash w/ S-5	7.9	12,000	740	3,700	5,600	2,000	0.09	0.64	0.9	0.009	0.008	<0.001

2. Concentrations in the surface water leachate for boron and selenium increased when leached through fly ash. However, the levels of boron declined when leached through a mixture of ash and spoil, and the increased selenium concentrations are similar to the selenium concentrations in leachate produced by spoil alone. The iron concentration in both surface and groundwater decreased following leaching through spoil, CCB, or a mixture of the two.

3. Leachate produced from mixtures of ash and spoil has a lower TDS and lower trace metal concentrations than natural groundwater from coal seam #4-6.

4. 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 original concentration of the coal groundwater.

5. Trace metal concentrations are similar for all the leachates produced, with the exception of fly ash alone, which increased boron concentrations. However, boron concentrations in groundwater leached through a mixture of ash and spoil are similar to the original concentration of the groundwater

The leach study predicts that in the event CCB should contact groundwater, regardless if the water originates from coal seam groundwater or infiltrating surface water, no degradation to post-mine groundwater should occur. The leach study concludes that the spoils are capable of retarding the movement of metals in water. Specifically, levels of metals such as barium, iron, selenium and lead decreased in some cases. Geochemical processes postulated as responsible are adsorption; the high cation-exchange-capacity (CEC) measured in the spoil, and precipitation.

Data collected during the Supplemental Groundwater Study (SGS) (APPENDIX 11-MM) provide a field confirmation of laboratory predictions made in the leach study. The purpose of the SGS was to investigate possible impacts to groundwater from previous CCB disposal at Navajo Mine. The investigation was accomplished by installing six groundwater-monitoring wells in and around ash and spoil disposal areas in Bitsui pit. The wells were monitored quarterly for static water levels and water quality.

Results from the SGS and more recent monitoring indicate that parameter concentrations are similar for water derived from an ash well when compared to water derived from a spoil well. Monitoring data has recorded elevated levels of boron in well Bitsui-1. Bitsui-1 is screened in ash and has approximately a fifty-foot column of water in the well. No other parameters in Bitsui-1 are elevated relative to the down gradient spoil wells (Bitsui-4, Bitsui-5, and Bitsui-6). TDS concentrations in Bitsui-4, Bitsui-1, Bitsui-6 are similar. A complete summary of data from the SGS, including summary statistics, time verse concentration plots, and trilinear diagrams is in APPENDIX 11-MM.

Elevated levels of boron from Bitsui-1 compare favorably with lab results and predictions made in the leach study for surface and groundwater leached through fly ash. The lack of elevated constituents in surrounding Bitsui spoil monitoring wells, particularly boron, confirms predictions that geochemical processes within the spoil are attenuating metals migration and thus limiting the extent of effects from saturated CCB.

A recent USGS report on the effects of coal mining in Montana on water quality documents that as spoil water migrates through an unmined coal aquifer, TDS concentrations may decrease. Clark (1995) reports that at the Decker Mine, TDS concentrations decreased from 4,100 milligrams per liter (mg/l) to 2,100 mg/l along a flow path from a spoils aquifer to a down gradient coal aquifer. Geochemical processes postulated as responsible for the decrease in TDS are sulfate reducing bacteria, reverse cation exchange of sodium for calcium, and precipitation of carbonate and iron-sulfate minerals.

The determination of no significant impact to post-mine groundwater from CCB disposal is based on laboratory and field studies conducted at Navajo Mine. The primary basis for this conclusion relies upon the basic chemical characteristics of the CCB. CCB are similar in chemical composition to spoil with the exception that fly ash has greater concentrations of boron, selenium and barium. EP Toxicity tests conducted on CCB determined that the material is not a hazardous substance. Leachate studies and well monitoring verified changes in water chemistry due to contact with spoil and CCB and that boron levels can increase within the ash alone. However, the studies also verified that attenuation processes active in the spoil could reduce metal concentrations, particularly boron.

If sufficient post-mine groundwater does contact the CCB in a large enough volume to migrate, significant geochemical processes occurring along the migration flow path will likely diminish the concentration of any elevated metals, such as boron. The same geochemical processes as discussed above for spoil leachate (Section 11.6.2.2.1) may also reduce the salt load carried by the post-mine groundwater. The small volume and slow rate at which post-mine groundwater migrates toward a receiving water (i.e., San Juan River) will prevent detection of any effects down gradient.

In the unlikely event that groundwater does saturate CCB, the probable result is that concentrations of boron may increase and that the overall chemistry of the major ions will likely change. However, as this water migrates into spoil following contact with the CCB, boron concentrations are predicted to decrease due to attenuation. Other trace metal concentrations in groundwater are not predicted to increase. In fact, changes to the water chemistry are as much effected by spoil as by ash, particularly for infiltrating surface water.

This assessment, therefore, determined that the significance of potential groundwater quality impacts of mining operations is minimal based on the following.

1. The estimated quality of leachate from mine spoil relative to the existing poor groundwater quality in units directly contacted by the mine.

2. The apparent chemical attenuation (retardation) potential of the spoils and coal seams.

3. The low velocity of flow in the coal seams.

4. Regardless of whether CCB disposal is wet or dry, no degradation to post-mine groundwater will occur.

5. The relatively benign nature of CCB.

6. Groundwater will not be significantly degraded should CCB actually contact groundwater.

7. The high potential for dilution of any leachate-affected groundwater received by the San Juan River and San Juan River Valley alluvial aquifer. Under a worst case condition of post-mine groundwater discharge to a potable receiving water, impacts will be so small as to be unmeasurable due to attenuation processes and slow flow rates.

11.6.2.3 Potential Migration of Spoil Leachate in Groundwater

During mining operations, all strata overlying the Fruitland coal seams are stripped to expose the coal for mining. As mining operations proceed, each cut is successively backfilled with spoil for reclamation.

The coal seams and inter-bedded lithologic units of the Fruitland Formation are the only laterally extensive water-bearing unit to be directly disturbed by mining operations. During mining operations, each successive open cut will serve as a source of drawdown for water in the overlying formations.

The ten to twenty-five foot thick layer of shale separating the bottom of the lowest mineable coal seam and the Pictured Cliffs Sandstone (see CHAPTER 6) acts to isolate groundwater in the Pictured Cliffs from mining activities. To date, no noticeable upward seepage through the shale or significant disruption of the mine floor (shale layer) has been observed in the pits, even though some of the pits are significantly below the projected potentiometric levels that are found in the Pictured Cliffs Formation. In the area of the Navajo Mine, the Pictured Cliff Sandstone was found to yield very small quantities of poor quality water. It is, therefore, unlikely that leachate will enter the Pictured Cliffs Sandstone and should it occur, the potential for the transport of leachate and significant degradation of water quality in this unit would be extremely small.

Because the coal seams will be disrupted by mining activities and spoil materials placed in the reclaimed mine areas will directly abut the coal seams at the limits of the mine cuts, the coal seams and inter-bedded lithologic units of the Fruitland Formation are considered to be the water bearing units of principal concern, with respect to potential groundwater quality impacts of mining.

11.6.2.3.1 Present Flow Conditions in Coal Seams of the Fruitland Formation

To evaluate the potential effects of the mine spoil on groundwater in the coal seams and inter-bedded lithologic units of the Fruitland Formation, the flow characteristics of this unit were determined. Groundwater flow conditions in the coal seams and inter-bedded lithologic units of the Fruitland Formation were determined from water level data obtained from a system of monitor/piezometer wells installed by BHP in the individual coal seams during the summer of 1983 and 1984 and from surrounding wells (see CHAPTER 6). From these data, potentiometric maps (shown in EXHIBITS 6-2 through 6-5) were constructed.

Based on an analysis of these potentiometric surface maps, coal seam groundwater occurs primarily under confined conditions within the mine area. Nearly all of the North Area and Area II Seams were found to be dry, with minor occurrences of water only near eastern and northern lease boundaries. In the southern part of Area III, all but the No. 8 Coal Seam was found to be saturated throughout most of the permit area.

Discharge locations for the No. 8 Coal Seam included the outcrop (subcrop) locations in the San Juan River Valley to the north and Cottonwood Arroyo Valley to the south, and down dip towards the center of the San Juan Basin where the groundwater flow joins the regional flow to the north. Discharge from the No. 7 Seam appears to be at Cottonwood Arroyo to the south and down dip; however, very flat flow gradients were found. Discharge from the No. 4-6 and No. 2-3 seams is principally at the Cottonwood Arroyo stream valley and down dip towards the middle of the San Juan Basin where it also joins the regional flow north to the San Juan River.

The subcrop of the No. 8 Seam beneath the San Juan River Valley Alluvium occurs at elevations below the water levels in the coal seam to the south. Based on the direction of flow indicated by the potentiometric map for Coal Seam No. 8, this subcrop could serve as a discharge point for this coal seam. However, no significant seeps or springs have been observed to date along the exposure of the No. 8 Coal Seam in the San Juan River Valley north of the mine.

Discharge from the coal seam may also occur as leakage into the units which are above or below the Fruitland Formation. Because of the significant thickness of shale, mudstone, and siltstone which overlies the coal seam as the upper portion of the Fruitland Formation and the lower shale member of the Kirtland Shale, upward leakage through these units is in all probability very small and occurs only down dip from the mine. The layer of shale below the main coal seam (No. 8) also serves to restrict inter-flow between the coal seam and the Pictured Cliffs Sandstone. This conclusion is supported by observations made during mining, as discussed earlier. Potential discharges of coal seam water to the Pictured Cliffs would be limited from further downward migration by the extensive thickness of shale and other low permeability materials in the Lewis Shale which is below the Pictured Cliffs.

11.6.2.3.2 Structural Effects on Groundwater Flow

Small scale faults and related structural features were discovered during mining and drilling operations within the mine lease area. The effect of these small scale warps and faults on vertical permeability of the coal seam and the hydraulic interconnection between strata at the mine is not known. Because strata in the area of the mine have not been intensively folded and faults in the strata tend to be limited in displacement and extent, vertical permeability between strata is probably limited by the lithologic composition of the strata. The presence of perched groundwater conditions within the coal seams and the absence of water in adjacent units supports this assertion. A more detailed analysis of the hydrogeologic effects of the various minor structural features found at the mine are presented in CHAPTER 6.

11.6.2.3.3 Postmining Flow Conditions

Following the completion of mining activities, the last cuts will be backfilled with mine spoil. These filled mine pits may then begin to receive contributions of groundwater from their contacts with the coal seams at the periphery of the reclaimed pits, and from the alluvial subcrops to the west. Due to high evapotranspiration rates, surface water percolation into the reclaimed spoil is expected to be negligible, though higher than pre-mine conditions. This conclusion is supported by infiltration studies by Stone (1984, 1986, 1987), which indicate that surface recharge rates for reclaimed areas are approximately 0.003 inches per year. Pit inflow modeling studies at mines adjacent to the Navajo Mine indicate that water levels in the backfilled mine blocks generally rise at a rate of less than one foot per year as a result of inflow received from the coal seams (San Juan Coal Company, 1982; San Juan Coal Company, 1983).

Based upon laboratory determinations, the hydraulic conductivity or permeability for compacted backfilled spoil is in the range of 3.5 to 5.4 x 10^{-6} centimeter per second (APPENDIX 11-K). Uncompacted spoils are expected to have permeabilities similar to that of the Fruitland Formation as a whole. This conclusion is consistent with dragline spoils permeability information reported by Van Vost et al. (1976). Thus, the permeability of backfilled materials is approximately the same as that of the coal seams and interbedded lithologic units of the Fruitland Formation; i.e., 1.2 feet per day. As a result, groundwater flow through the mined out areas should be roughly equivalent to that which occurred in these areas before mining.

As water levels in the reclaimed mine areas rise with time, the pits will receive successively less inflow from the coal seams. After the water levels in the coal seams have sufficiently recovered, the coal will begin to receive leachate from the spoil as groundwater flows through the mine blocks. Rising water levels in the mine area will cause water within the reclaimed mine blocks to abut the undisturbed coal seams and interbedded lithologic units of the Fruitland Formation at the periphery of the mine. The flow rate through the Fruitland Formation is described in detail in CHAPTER 6.

After significant recovery has occurred in the coal, the area discharge and recharge points to the north and south of the mine should serve as the principal controls to flow in the Fruitland coal seams. Due to the probable absence of a confining layer, water table conditions will ultimately be attained in the reclaimed pits.

11.6.2.3.4 Potential Rate of Spoil Leachate Transport

To evaluate the potential water quality impact of spoil on the coal seams and on the interbedded lithologic units of the Fruitland Formation, conceptual models for leachate transport were used. The first conceptual model considered flow and discharge rates in the coal seams and hydrologic relationships of the coal seams to receptor points as a means of assessing leachate transport. This model entails the simplification of the coal seam flow system for calculation purposes. These simplification measures can be expected to bias the calculated outcome to over predict leachate transport. Estimates of hydraulic variables and physical relationships used for the model are based on presently available data. Where known variability exists in a given input value, the value selected for computations represents the highest or lowest reasonable value providing an over prediction (or conservative estimate) of potential leachate migration.

Based on tests conducted by BHP, the permeability of the coal seams appears to be very low and somewhat variable in the area of the mine. The permeability is primarily attributable to cleating and small scale fracturing of the coal. To provide a conservative estimate of flow in the coal seam, favoring higher flow and leachate transport rates, the highest value of hydraulic conductivity determined was used for the purposes of calculating flow towards potential receptor points.

11.6.2.3.4.1 North Area

No. 8 Coal Seam

As stated in CHAPTER 6, flow in the No. 8 Coal Seam is generally towards the east (down dip) and towards major discharge points (e.g., San Juan River). Most of the permit area is dry with limited saturated areas on the eastern permit boundary and to the north. For the purpose of this evaluation, it is assumed that groundwater will extend throughout all areas where only partial saturation currently exists and that flow will take place in one direction, towards the formation contact in the San Juan River alluvial aquifer (see FIGURE 11-24). By assuming this hydrologic scenario, a worst-case conceptual model is obtained.

The most northern portion of the mine area, where spoils will be placed, is approximately 6,000 feet from the formation contact with the San Juan River alluvial aquifer. Based on the highest estimates of groundwater velocity (0.076 feet per day) and assuming that the leachate will take the shortest path of travel, it is estimated that about 216 years would be required for leachate emanating from the most northern area of the mine to reach the coal seam contact with the San Juan River. Travel time from the permit area will be considerably greater as the nearest portion of the permit area is an additional 20,000 feet from the most northern portion of the mine area. As seen from FIGURE 11-24, the distance of flow from the most southern spoil area is about 43,000 feet. This distance corresponds with a leachate travel time to the San Juan alluvial aquifer of about 1,568 years.

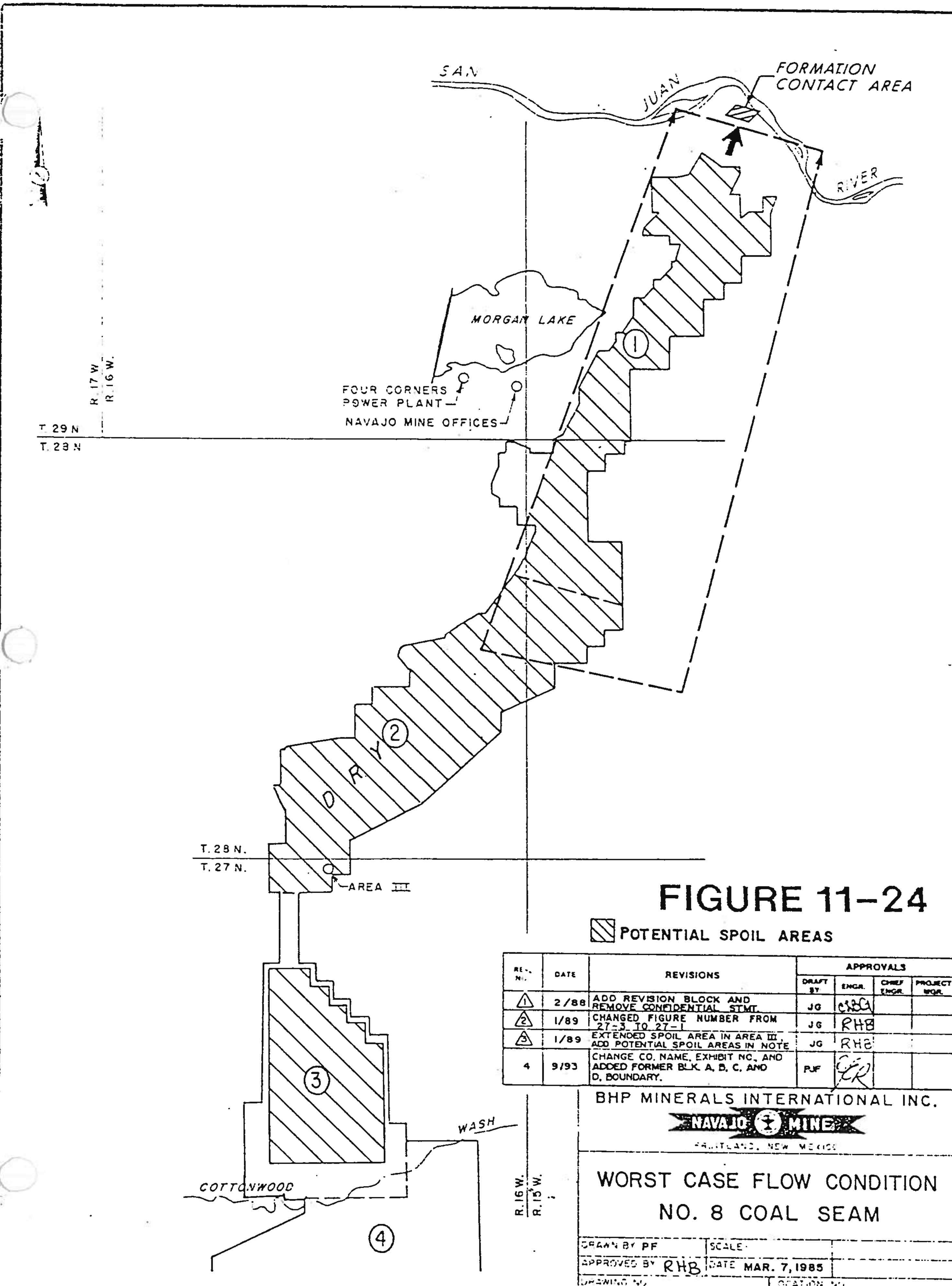


FIGURE 11-24

POTENTIAL SPOIL AREAS

REV. NO.	DATE	REVISIONS	APPROVALS: DRAFT BY	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	2/88	ADD REVISION BLOCK AND REMOVE CONFIDENTIAL STMT.	JG	CSBG		
2	1/89	CHANGED FIGURE NUMBER FROM 27-3 TO 27-1	JG	RHB		
3	1/89	EXTENDED SPOIL AREA IN AREA III, ADD POTENTIAL SPOIL AREAS IN NOTE	JG	RHB		
4	9/93	CHANGE CO. NAME, EXHIBIT NO., AND ADDED FORMER BLK. A, B, C, AND D, BOUNDARY.	PJF	[illegible]		

BHP MINERALS INTERNATIONAL INC.

NAVAJO MINE

FRUITLAND, NEW MEXICO

WORST CASE FLOW CONDITION
NO. 8 COAL SEAM

DRAWN BY PF	SCALE
APPROVED BY RHB	DATE MAR. 7, 1985
DRAWING NO.	LOCATION NO.

No. 4-6 Coal Seam

The No. 4-6 Coal Seam is only partially saturated within the permit area. These saturated areas are restricted to Area III and the extreme eastern permit boundary of mid-Area II. As discussed in CHAPTER 6, the No. 4-6 unit pinches out entirely in the southern portion of the North Area. Flow from this seam is then encompassed in that of the interbedded lithologic units of the Fruitland Formation. Flow from the entire formation is considered in Section 11.6.2.3.4.3.

11.6.2.3.4.2 Areas II-III

In Area II, the No. 8 Coal Seam was not found to contain water within the permit area. Because of this fact, no transport of water will occur and no hydrologic impact assessment is needed.

As discussed in CHAPTER 6, the No. 8, 7, 4-6, and 2-3 Coal Seams all exhibit extremely low permeabilities and flow velocities. Travel times for all these units from the extreme southern portion of Area III, assuming that leachate will take the shortest path of travel towards Cottonwood Arroyo located in Area IV North, are in excess of 1,000 years.

11.6.2.3.4.3 Coal Seams and Interbedded Lithologic Units Treated as a Single Aquifer

When the coal seams and interbedded lithologic units of the Fruitland Formation are treated as a single aquifer, the potential migration of spoil leachate in groundwater is found to be similar to that predicted using No. 8 Coal Seam (i.e., flow rates were found to be 0.06 feet per day). Travel time, using the formation as a whole, from the northern most point on the mine to the San Juan River was found to be at least 240 years. See CHAPTER 6 for a complete discussion.

11.6.2.4 Potential Direct Impact to the San Juan River

In order to evaluate the potential impact of leachate on the San Juan River and its associated alluvial aquifer, the volume of flow received from the mine area by the river valley alluvium, and ultimately, the river was evaluated. As discussed earlier, the contact area between the San Juan alluvial aquifer and the No. 8 Coal Seam can be considered as a primary discharge point. Little is known about how much coal seam water from the mine area currently discharges at the seam outcrop along the walls of the San Juan River Valley and at the seam contact with river alluvium. In actuality, most of the water flowing through the mine area may not discharge directly north to the river valley but rather continue down dip toward the center of the San Juan Basin and then join the regional flow to the north.

In the interest of arriving at a conservative estimate of leachate discharge to the alluvial aquifer and river, it is assumed that all coal seam groundwater which flows through the mine area will produce spoil leachate and that all of this leachate will enter the alluvial aquifer at the coal seam-alluvium contact. Given that the general direction of flow is to the north and that the lateral extent of the mine perpendicular to this flow direction is approximately 5,500 feet (as shown in FIGURE 11-24), the discharge of spoil leachate to the alluvium can be estimated using the following equation:

$$Q = v \cdot N_e \cdot L \cdot M$$

where:

Q = Estimated discharge of spoil leachate-affected groundwater from the mine to the alluvial aquifer (ft^3/year)

v	=	Velocity of groundwater in the main coal seam = 27.7 ft/yr
N_e	=	Effective porosity of the coal seam = 0.05
L	=	Lateral extent of the mine normal to the general direction of flow in the coal seam = 5,500 ft
M	=	Estimated average thickness of the coal seam in the southern area of the mine = 18 ft

Substitution values:

Q = [27.7 ft/year] . [0.05] . [5,500 ft] . [18 ft] or,

Q = 137,300 ft^3/yr or 3.1 acre/ft/yr

Based on the gross overestimation used in calculating the yearly production of leachate-affected groundwater to the alluvial aquifer, it is felt that the actual value of leachate inflow will be considerably less. The results of these calculations, nonetheless, demonstrate that the annual production of leachate-affected groundwater to the river valley is small, especially when compared to the average flow in the San Juan River.

Groundwater contributions to the San Juan River Valley alluvium from bedrock sources are reported to be small (Stone et al., 1983). Historical low flow discharge reported for the San Juan River at the Farmington and Shiprock, New Mexico gauging stations (14 and 8 cfs, respectively) (Stone et al., 1983) during the period of record (1935 to present) support this contention. In addition, relatively low values of specific conductivity for wells completed in the river valley alluvial aquifer in the area of the mine suggest that poor quality water from bedrock sources is not a major source of recharge to this aquifer.

Mean discharge for the San Juan River at the Farmington and Shiprock gauging stations is reported as 2,370 and 2,175 cubic feet per second, respectively (Stone et al., 1983). In relation to the conservative estimate of spoil leachate discharge to the alluvial aquifer and San Juan River from the coal seam, stream flows are very large. Using the mean flow of the San Juan River at the Shiprock station (as a conservative estimate for the San Juan River near Waterflow, New Mexico) the ratio of the estimated discharge of spoil leachate-affected groundwater from the coal seam to average discharge in the San Juan River is:

$$R = \frac{Q_c}{Q_r}$$

Where:

Q_c = Estimated discharge of spoil leachate-affected groundwater from the main coal seam to the San Juan River = 137,300 ft^3/yr

Q_r = Mean annual flow in the San Juan River at the Shiprock Station = 2,175 $ft^3/sec \times 3.1536 \times 10^7$ sec/yr = 6.86×10^{10} ft^3/yr

$$\text{or} \quad R = \frac{137{,}300 \ ft^3/yr}{6.86 \times 10^{10} \ ft^3/yr} = 2.00 \times 10^{-6}$$

If the historical low discharge of 8 ft^3/sec or 2.52×10^8 ft^3/yr at the Shiprock gauging station is used, the ratio becomes:

$$R = \frac{137{,}300 \ ft^3/yr}{2.52 \times 10^8 \ ft^3/yr} = 5.45 \times 10^{-4}$$

Given the calculations, the potential contribution of leachate-affected groundwater to the San Juan River flow, even under extreme low-flow conditions, will be extremely small. Based on the laboratory determinations of leachate quality and chemical interactions (attenuation potentials) and the flow calculations, affected groundwater will have no significant effect on the quality of water in the San Juan River.

Spoil leachate-affected groundwater could also possibly reach wells completed in the San Juan River Valley alluvium, especially in the vicinity of the coal seam alluvium contact. The impact, if any, of leachate-affected groundwater reaching these wells will be negligible because the majority of recharge received by this aquifer, in the area of the mine, comes from the San Juan River itself.

When the coal seams and interbedded lithologic units of the Fruitland Formation are treated as a single aquifer, the direct impact to the San Juan River is found to be negligible. The estimated worse case flow contribution of leachate-affected groundwater to mean annual flow in the San Juan River was determined to be 0.000074:1.0. The impact from this small contribution is expected to be unmeasurable. See CHAPTER 6.

11.6.2.5 Assessment of Potential Groundwater Quantity Impacts

The potential impact of mining activities on groundwater quantities are addressed in detail in CHAPTER 6. In that analysis, a three dimensional model was used to evaluate hydrologic consequences due to stress propagation from pit inflow. The analysis showed that the stress propagation resulted in minimal impacts to the hydraulic regime as drawdowns 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 Pictured Cliffs Sandstone unit is projected to see a drawdown of less than 0.005 feet. The effects of mining on the water bearing strata decrease by orders of magnitude within a few miles of the mine area.

Average inflow to the entire mine area is projected to be approximately 239 acre-feet per year over a total simulation time of 12 years. This volume is predominately from storage with only minor contributions (4 acre-feet) from captured surface flows. Actual field experience indicates that this figure is probably very generous as none of the pits collect sufficient groundwater to form puddles or ponds which must be pumped to facilitate mining. The pit floors remain dry except on rare occasions when surface flows are captured. It is assumed that bedrock groundwater inflows to the mine are minor and primarily consumed by evaporation from the highwall.

Postmine surface recharge to the aquifers through the regraded spoils is expected to be greater than pre-mine recharge, by approximately 80 to 100 percent (Stone, 1987).

11.6.2.6 Assessment of Impact on Adjacent Groundwater Users

Wells located on or near the permit area are shown on FIGURE 11-25. No use is made of BHP's wells located on or near the permit except for taking water measurements. Other wells which could be impacted by mining are located to the east and north of the permit area. Wells located to the west and south will not be impacted as the groundwater flows near the mine go east and then turn north, joining the regional pattern.

Evaluation of the wells whose water quality could potentially be affected will proceed on a case by case basis. Numbers 70, 93, and 91 (FIGURE 11-25) of Township 26N, Range 16W are non-BHP wells to the east of the permit boundary. All three are alluvial, hand dug wells. They will not be affected as their source of water is derived from a formation geologically above those potentially impacted by contamination (i.e., Kirtland/ Fruitland Formation and Pictured Cliffs Sandstone). Numbers 38, 44, and 46 are several miles east of the permit boundary located in Township 27N, Range 15W. Number 46 is an alluvial, hand dug well and cannot be impacted. Numbers 38 and 44 derive their source of water from the Pictured Cliffs Sandstone. Water quality has caused 38 to be abandoned and 44 to be classified unfit for human consumption. Numbers 51 and 41 (Township 28N, Range 15W), are several miles east of the permit boundary, and both have been abandoned . Based on the velocity calculations above, they can be ruled out for further evaluation. Number 149, in the southeast corner of Township 29N, Range 15W, appears to be a test well installed by Public Service Company of New Mexico. Between the mining area and the San Juan River of Township 29N, Range 15W, there exist only three non-BHP wells with associated beneficial uses (numbers 54, 56, and 146). Wells north of the San Juan River are not considered, as the San Juan acts as an aquifer discharge point in this vicinity (CHAPTER 6). Number 146 is an alluvial well, approximately 28 feet deep. Ownership and usage is unknown, but the well appears to be attached to a windmill. Numbers 54 and 56 are springs owned by the Navajo Nation. It is unknown whether the springs are currently flowing. Spring 56 appears to derive its source from the Pictured Cliffs Sandstone, which has a permeability lower than the Fruitland Formation. Consequently, migration rate through the Pictured Cliffs would be less than the 0.06 feet/day as computed above. Spring 54

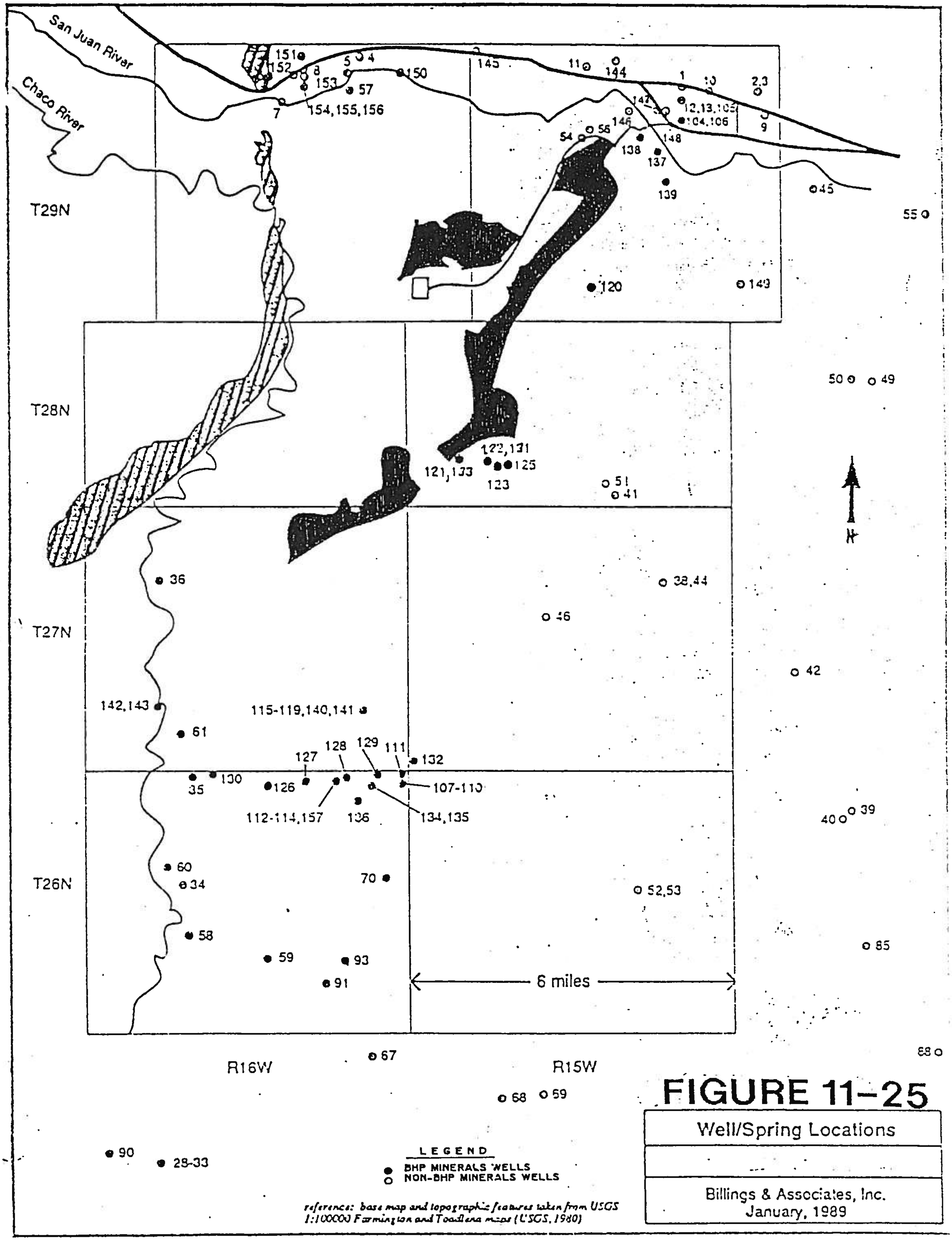


FIGURE 11-25

Well/Spring Locations

Billings & Associates, Inc.
January, 1989

surfaces from a terrace, and the ultimate water source is unknown. Uses for both springs include domestic, stock and/or irrigation, with a total dissolved solids ranging from 600 to 700 mg/L.

Thus, over the vast majority of the permit boundary area, the only wells that could be potentially affected by BHP activities are BHP wells. Given that the BHP wells are for monitoring purposes, any potential impact to these wells does not preclude their use. The database and analysis identify three locations (numbers 54, 56, and 146) within the range of potential contaminant migration, if the source of water was derived from the Fruitland Formation. Given the recharge mechanisms and dilution capabilities of the alluvial fill of the San Juan River, potential impact to 146 is considered negligible. The ultimate source of water from Spring 54 is unknown. The source of water to Spring 56 is from the Pictured Cliffs Sandstone. Groundwater velocity through the Pictured Cliffs is estimated to be approximately 0.0003 feet/day (0.11 feet/year), based on an average gradient of 0.0038 ft/ft (CHAPTER 6), hydraulic conductivity of 0.007 ft/day, an effective porosity of 0.1, and use of the pore velocity equation presented in CHAPTER 6.

11.6.3 Probable Hydrologic Consequences - Surface Water

11.6.3.1 Introduction

Baseline surface water information is provided in CHAPTER 7. Postmine surface water drainage information is provided in Section 11.6.5 and 11.6.5.1. This subsection provides an assessment of hydrologic impacts related to mining and reclamation activities planned for the permit.

As discussed in CHAPTER 7, there are eight drainages within the Permit Area. These drainages are Bitsui Wash, Chinde Wash, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo, and Pinabete Arroyo. Each of these drainages has been or will be disturbed by mining activities. However, only a very minor portion of the Neck and Pinabete drainage basins will be disturbed by mining activities.

Peak Flow, runoff volume, sediment yield, and peak sediment concentrations were predicted for both pre- and postmine drainages for Chinde Wash, Hosteen Wash, Barber Wash, South Barber Drainage, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo and the tributaries to the Chaco Wash and Pinabete Arroyo 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 (TABLES 11-15 and 11-16) to determine an appropriate curve number. 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. The curve number of reclaimed areas was based on this soil type.

The Probable Hydrologic Consequences (PHC) analysis also includes a geomorphic characterization and evaluation of reclaimed channels and surface topography. Dynamic equilibrium is the criterion under which reclaimed stream channels are evaluated. From a hydrologic perspective, postmining topography is evaluated on the basis of adequate drainage density.

TABLE 11-15
TOPDRESSING TYPES AND QUANTITIES (1)

Soil Mapping Unit Symbol	Soil Mapping Units	Percent of Map Unit (3)	Soil volume (Cubic yards) Area I	Area II	Area III	Area IV	Total	Title of SCS Soil Survey (4)	Hydrologic Group
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	Farb 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 Caltivated 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 form 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/	86.0	1.23
-	Monierco Soils	57,967	2.23	D	91.0	2.03
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	8,024	0.31	D/D	91.0	0.28
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	503,634	19.37	B/B	78.0	15.11
Jh	Jocity, very hard	0	0.00	B	78.0	0.00
Ma	Mack	0	0.00	C	86.0	0.00
Mn	Mayqueen	295,981	11.39	B	78.0	8.88
Ms	Mayqueen - Shiprock	421,971	16.23	B/B	78.0	12.66
Mv	Mayqueen - Shiprock, very hard	85,805	3.30	B/B	78.0	2.57
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	2,159	0.08	D	91.0	0.08
Ra	Razito	599,753	23.07	A	65.0	15.00
Rh	Razito, very hard	73,893	2.84	A	65.0	1.85
Rl	Redlands Variant	19,683	0.76	B	78.0	0.59
Rv	Redlands Variant, very hard	0	0.00	B	78.0	0.00
Sc	Shiprock	192,636	7.41	B	78.0	5.78
Sh	Shiprock, very hard	22,430	0.86	B	78.0	0.67
Sl	Shiprock - Blancot	278,724	10.72	B/B	78.0	8.36
Sv	Shiprock Variant	0	0.00	B	78.0	0.00
Sz	Stumble	0	0.00	A	65.0	0.00
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	0	0.00	A	65.0	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 hydrologicl 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	0.90
-	Monierco Soils	32,101	1.64	D	91.0	1.49
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	83,158	4.24	D/D	91.0	3.85
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	183,596	9.35	B/B	78.0	7.29
Jh	Jocity, very hard	0	0.00	B	78.0	0.00
Ma	Mack	0	0.00	C	86.0	0.00
Mn	Mayqueen	55,176	2.81	B	78.0	2.19
Ms	Mayqueen - Shiprock	341.951	17.42	B/B	78.0	13.59
Mv	Mayqueen - Shiprock, very hard	0	0.00	B/B	78.0	0.00
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	6,628	0.34	D	91.0	0.31
Nv	Natrargids. overblown	82,861	4.22	D	91.0	3.84
Ra	Razito	521,804	26.58	A	65.0	17.28
Rh	Razito, very hard	0	0.00	A	65.0	0.00
Rl	Redlands Variant	33,505	1.71	B	78.0	1.33
Rv	Redlands Variant, very hard	0	0.00	B	78.0	0.00
Sc	Shiprock	540,865	27.55	B	78.0	21.49
Sh	Shiprock, very hard	21,812	1.11	B	78.0	0.87
Sl	Shiprock - Blancot	0	0.00	B/B	78.0	0.00
Sv	Shiprock Variant	0	0.00	B	78.0	0.00
Sz	Stumble	0	0.00	A	65.0	0.00
Ta	Trail	23.210	1.18	A	65.0	0.77
Th	Trail. very hard	16.144	0.82	A	65.0	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 hydrologicl 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/	86.0	2.41
-	Monierco Soils	315,290	4.38	D	91.0	3.98
Bc	Blancot	664,484	9.23	B	78.0	7.20
Bh	Blancot, very hard	307,680	4.27	B	78.0	3.33
Fa	Farb and Persayo Soils	0	0.00	D/D	91.0	0.00
Gr	Grieta	0	0.00	B	78.0	0.00
Jc	Jocity - Gilco	481,270	6.68	B/B	78.0	5.21
Jh	Jocity, very hard	103,722	1.44	B	78.0	1.12
Ma	Mack	1,433,038	19.90	C	86.0	17.11
Mn	Mayqueen	0	0.00	B	78.0	0.00
Ms	Mayqueen - Shiprock	614,672	8.54	B/B	78.0	6.66
Mv	Mayqueen - Shiprock, very hard	61,024	0.85	B/B	78.0	0.66
Na	Nakia	0	0.00	B	78.0	0.00
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	97,028	1.35	D	91.0	1.23
Ra	Razito	458,595	6.37	A	65.0	4.14
Rh	Razito, very hard	21,089	0.29	A	65.0	0.19
Rl	Redlands Variant	945,193	13.12	B	78.0	10.24
Rv	Redlands Variant, very hard	105,452	1.46	B	78.0	1.14
Sc	Shiprock	868,130	12.05	B	78.0	9.40
Sh	Shiprock, very hard	67,523	0.94	B	78.0	0.73
Sl	Shiprock - Blancot	23,813	0.33	B/B	78.0	0.26
Sv	Shiprock Variant	416,510	5.78	B	78.0	4.51
Sz	Stumble	15,596	0.22	A	65.0	0.14
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	0	0.00	A	65.0	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 hydrologicl group classification was taken from Table 11-16 (reclaimed).

TABLE 11-16D

TOPDRESSING TYPE, QUANTITIES, AND CURVE NUMBERS FOR AREA IV

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/	86.0	6.04
-	Monierco Soils	535,401	10.99	D	91.0	10.00
Bc	Blancot	0	0.00	B	78.0	0.00
Bh	Blancot, very hard	0	0.00	B	78.0	0.00
Fa	Farb and Persayo Soils	161,922	3.32	D/D	91.0	3.02
Gr	Grieta	69,104	1.42	B	78.0	1.11
Jc	Jocity - Gilco	1,525,313	31.31	B/B	78.0	24.42
Jh	Jocity, very hard	46,339	0.95	B	78.0	0.74
Ma	Mack	176,992	3.63	C	86.0	3.12
Mn	Mayqueen	23,851	0.49	B	78.0	0.38
Ms	Mayqueen - Shiprock	333,565	6.85	B/B	78.0	5.34
Mv	Mayqueen - Shiprock, very hard	0	0.00	B/B	78.0	0.00
Na	Nakia	53,010	1.09	B	78.0	0.85
Nt	Natrargids	0	0.00	D	91.0	0.00
Nv	Natrargids, overblown	218,490	4.49	D	91.0	4.08
Ra	Razito	311,260	6.39	A	65.0	4.15
Rh	Razito, very hard	196,707	4.04	A	65.0	2.62
Rl	Redlands Variant	331,678	6.81	B	78.0	5.31
Rv	Redlands Variant, very hard	61,901	1.27	B	78.0	0.99
Sc	Shiprock	160,006	3.28	B	78.0	2.56
Sh	Shiprock, very hard	143,239	2.94	B	78.0	2.29
Sl	Shiprock - Blancot	0	0.00	B/B	78.0	0.00
Sv	Shiprock Variant	70,420	1.45	B	78.0	1.13
Sz	Stumble	105,082	2.16	A	65.0	1.40
Ta	Trail	0	0.00	A	65.0	0.00
Th	Trail, very hard	4,538	0.09	A	65.0	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 hydrologicl group classification was taken from Table 11-16 (reclaimed).

Dynamic equilibrium is the condition that exists when stream channels are neither aggrading or degrading over time. It does not mean there is no reworking of channel materials or change in channel geometry.

Drainage density is an integrative measure of drainage basin morphology. Drainage density is the length of stream channels per unit area within a drainage basin. The restoration of postmine drainage networks within the range of pre-mine drainage densities and configurations or regional norms will ensure that pre-mine geomorphic 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 postmining 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. Postmining drainage densities were determined from the 1:6000 scale final surface configuration topography maps provided in CHAPTER 12.

The Chinde Wash and Cottonwood Arroyo are impacted by the activities of the Navajo Agricultural Products Industry located hydraulically upgradient from the mine. These impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. However, the impacts are similar to both streams with the exception that the Chinde is a perennial stream.

NAPI direct discharges are a result of an over supply of water in the canal that is released directly to the wash. 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 wash caused by the infiltrating irrigation water. The irrigation return waters have changed the Chinde Wash into a perennial stream with a base flow containing greater dissolved –solids concentrations. The greater dissolved-solids concentrations are 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 is 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 is being collected as part of the surface water monitoring plan.

The Surface Water PHC discussion is provided below for each major permit area drainage.

11.6.3.3 Chinde Wash

The present watershed area of Chinde Wash is about 42.4 square miles (27,130 acres). An additional 11 square miles does not contribute to the present Chinde watershed as it is diverted by NAPI's Ojo Amarillo canal into Cottonwood Arroyo. About 4.06 square miles of the Chinde Wash drainage basin is disturbed by mining activities. Chinde Wash increases in size by 1,124 acres primarily because of changes in the drainage divide between Hosteen Wash and Chinde Wash, and the drainage divide between Dodge Diversion and Chinde Wash.

Pre-mining drainage density of Chinde Wash was estimated to be 1.4 mi./sq. mile for the entire drainage area and 2.8-mi./sq. mile for the area disturbed by mining. Higher drainage density within the mine area reflects the greater relief in this area. Postmining drainage density for Chinde Wash is 4.7 mi./sq. mile over the area disturbed by mining. Both pre- and postmining 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, contour crenulations associated with badlands topography did not enter into the drainage density measurement.

These results indicate a higher postmining 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 postmining surface. Final Surface Configuration designs weredeveloped 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 is in the Doby reclamation area 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 11-85 and 12-5A for the location and alignment of the post-mine channel.

Comparison of SEDCAD4 predictions for pre- (see CHAPTER 7, APPENDIX 7-G) and postmining (see CHAPTER 11, APPENDIX 11-BB) flows and sedimentology from a 10-year, 6-hour event are provided in TABLE 11-17. Sediment yields for the 10-year, 6-hour event at the downstream outlet (Structure 24) are predicted to decline, despite an increase of 1,124 acres in watershed size postmining, from a pre-mining yield of 8,657 tons to a postmining 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 form a 10-yr., 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 715 cfs to a postmining estimate 705 cfs for Chinde Wash below the lease boundary (Structure 24).

The runoff volume was predicted to decline from 502 acre-feet, pre-mining, to 488 acre-feet, postmining. The postmining SEDCAD 4 modeling for the 10-yr., 6-hr event indicates that although the total sediment is less than the pre-mine, the peak sediment concentration (milligrams per liter, mg/l) and peak settleable concentration (milliliters per liter, 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.

Baseline water quality in Chinde Wash indicates concentrations that usually exceed drinking water standards (see CHAPTER 7). Postmining concentrations of sulfate, iron, manganese, and TDS parameters may actually decrease slightly due to better distribution of topsoil 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.

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 Surface Water Gain/Loss in Chinde Wash

The results of a gain/loss study conducted from April 1999 through March 2000 are reported in Appendix OO, Chinde Wash Surface Water Gain/Loss Report. The synoptic, NAPI and continuous surface water monitoring data collected during the monitoring year for Chinde Wash records 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 spill. Similar instances of flow volume decreases between CD-1A and CD-2A occurred throughout the year, such as on July 1, 1999 in which CD-1A recorded 11.11 acre-feet of volume and CD-2A recorded only 0.82 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 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 (202 to 321), 11 (0 to 11) and 49 (458 to 507) gpm and decreased during one measurement by 30 (115 to 85) gpm along Reach 4. Pit run spoil permeability was determined in the Leach Study (Chapter 11, Appendix K) to be 10^{-6} cm/sec (four 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 Gain/Loss Report and permeability values, future surface water losses along the permanent Chinde Wash 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 lessor 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 772 (974 to 202), 283 (283 to 0) and 275 (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, is to reduce the amount of available surface water for downstream flows

Following backfilling of Yazzie pit, the 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, there is an increase in flow volume from CD-1A to CD-2A. This flow volume increase is typical of an ephemeral channel and is the result of increasing watershed size downstream. Specifically, the contributions of additional flow from tributaries progressively produce an increasing volume of flow downstream.

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

11.6.3.4 Hosteen Wash

The Hosteen Wash watershed area is about 9.1 square miles. Mining activities disturbs approximately 3.7 square miles of this drainage. The Hosteen Wash watershed will decrease in size by 1,271 acres postmining. This is largely a result of postmining changes in the drainage divide between Hosteen and Chinde Wash, in which Chinde Wash increases by 844 acres.

Pre-mining drainage density for Hosteen Wash was estimated to be 3.18-mi./sq. mile for the entire drainage area and 2.8-mi./sq. mile for the area disturbed by mining. Postmining drainage density for Hosteen Wash is 6.1 mi./sq. mile over the area disturbed by mining. These results indicate a higher postmining 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. 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 develop headcuts and begin to erode.

With the postmining 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 for information regarding the design of reclamation structures.

Comparison of SEDCAD 4 predictions for pre- (see CHAPTER 7, APPENDIX 7-A) and postmining (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 postmining 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 postmining 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, postmining.

The SEDCAD 4.0 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 2.31 ml/l. The increase in peak settleable solids is attributable to replacement of pre-mining badland areas (clay-rich) with a postmining 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.

TABLE 11-18
COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
HOSTEEN 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)
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

Comparison of pre-mining and postmining 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 subwatersheds that increased in size following mining.

Baseline water quality in Hosteen Wash should be similar to that of Chinde Wash because of the similar soils, geology and vegetation found within the basins (see CHAPTER 7). Postmining concentrations for sulfate, iron manganese and TDS should decrease slightly due to reduction of badlands area and better distribution of topsoil over the disturbed areas. Acid forming or toxic materials are not present in the drainage.

11.6.3.5 Barber Wash

The Barber Wash watershed area is about 5.3 square miles. Mining activities disturbs approximately 1.4 square miles of this drainage. Barber Wash will decrease in size by 849 acres postmining. 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 928 acres. The upper portion of the Barber drainage has the most significant change; approximately 928 acres will be diverted into the South Barber Channel (see Exhibits 7-4C and 11-75A).

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

These results indicate a higher postmining drainage density over the area disturbed by mining. The postmining drainage density may be greater than necessary to achieve a geomorphically 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 an equilibrium with the flow and sediment yield regime of the contributing watershed.

Final Surface Configuration designs were developed 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 headcuts and begin to erode.

Comparison of SEDCAD 4.0 predictions for pre- (see CHAPTER 7, APPENDIX 7-B) and postmining (see 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 postmining 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 postmining 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, postmining.

The SEDCAD 4.0 modeling for the 10-yr., 6-hr event indicates that the predicted peak sediment concentration (milligrams per liter) for post-mine decreased compared to pre-mine, 24,586 mg/l for post-mine and 27,241 for pre-mine. Total sediment yields (tons) decreased for postmining conditions while the predicted settleable solid concentrations increased. 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 premining badland areas (clay-rich) with a postmining 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 postmining in the peak concentrations of total suspended solids and total settleable solids. Sediment yields for the same event declined from a pre-mining yield of 1,672 tons to a postmining yield of 1,076 tons.

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). Postmining concentrations for sulfate, iron, and manganese should decrease slightly due to a reduction of badlands area and better distribution of topsoil over the disturbed areas. Acid forming or toxic materials are not present within the drainage.

11.6.3.6 Neck Arroyo

The Neck Arroyo watershed area is about 1.88 square miles. Approximately 14 percent of this drainage lies within the permit area, although mining disturbs about three percent of the drainage, while about one percent of the drainage will be directly disturbed by the location of roads.

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 to develop 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. Acid forming or toxic materials are not present where they could contaminate water supplies within Neck Arroyo.

TABLE 11-23

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

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

Comparison of SEDCAD+ predictions for pre- (see CHAPTER 7) and postmining flows and sedimentology are provided in TABLE 11-20. This comparison suggests slight decreases in flow and sediment yields under postmining 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 11-20

COMPARISON OF PRE- & POST MINING PEAK FLOWS AND SEDIMENT YIELDS
NECK ARROYO
10 - YEAR, 6 - HOUR PRECIPITATION EVENT

SEDCAD+ Subwatershed				Pre-mining		Postmining		Difference from Pre-mining	
J	B	S	SW	Flow (cfs)	Sediment (Tons)	Flow (cfs)	Sediment (Tons)	Flow (cfs)	Sediment (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	361.50	-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 247 cfs to a postmining estimate of 244 cfs for the entire Neck drainage. Likewise, the runoff volume was predicted to decline from 39.0 acre-feet, pre-mining, to 38.7 acre-feet, postmining.

The SEDCAD+ modeling for the 10-yr., 6-hr event indicates that predicted peak concentration of total suspended solids increased slightly for postmining conditions 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 postmining in the peak concentrations of total suspended solids and total settleable solids. Sediment yields for the same event declined from a pre-mining yield of 14,351 tons to a postmining yield of 14,284 tons.

Comparison of pre-mining and postmining 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 11-20). 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 sq./mi. for the entire drainage area and should not change as a result of mining.

11.6.3.7 Lowe Arroyo

The Lowe Arroyo watershed area is about 11.25 square miles. Approximately four square miles of this drainage lies within the permit area. Final surface configuration and drainage designs have been developed as discussed in CHAPTER 12 (see Section 12.3) and Section 11.6.5.1.

Drainage geometry and grade were selected to maximize stability without causing sediment deposition. Such sediment deposition may subsequently develop headcuts and erode as local convexities in the channel develop as a result of aggrading conditions. With the postmining channel, some reworking of channel materials will occur especially during the large flood events. However, major channel aggradation or channel degradation would not develop within the reclaimed channel because the graded profile and channel dimensions are designed to maintain dynamic equilibrium. Channel instabilities could develop as a result of headcuts working upstream from changes in base level on Chaco Wash or the San Juan River.

The largest hydrologic change is the routing of undisturbed drainages east of the lease boundary. Premine, the drainages east of the lease formed the main branch of the Lowe channel which flowed east to west toward SEDCAD structure 10. In the postmine, these drainages are routed to the south initially before flowing west and north toward SEDCAD structure 11 (See pre- and postmine watershed maps for Lowe, Exhibits 7-4 & 11-77). As shown on Table 11-21, the watershed to structure 7 decreases by 1808 acres in the postmine while the watershed to structure 11 increases by 1584 acres. The outlet for the Lowe drainage is the same location (lease boundary) as the premine at structure 12.

The southern post mining drainage that flows to structure 11 differs from the premine 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 premine channel.

TABLE 11-21

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
LOWE WASH
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

In the postmine, the Lowe watershed increases by 93 acres at the expense of Cottonwood Wash. This change in watershed acres occurs along the southern boundary between Lowe and Cottonwood drainages. The shifting of 93 acres from Cottonwood Wash to Lowe Wash 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 4.0 predictions for pre-mining (see APPENDIX 7-D and APPENDIX 11-X) and postmining flows and sedimentology provided in TABLE 11-21 for a 10-year, 6-hour event. Overall there is a slight decrease in peak flow and sediment yields postmining. Sediment yields for the 10-year, 6-hour event at the downstream outlet (Structure 12, lease line) are predicted to decline, despite an increase of 93 acres in watershed size postmining, from a pre-mining yield of 3682 tons to a postmining yield of 3227 tons. The decline in sediment yields and peak flows is due primarily to a lower curve number resulting from reclaiming with sandy topsoil, better vegetation cover on reclaimed areas and terraces that reduce the slope lengths for the post-mine drainage. .

The peak flow resulting form a 10-yr., 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 926 cfs to a postmining estimate 514 cfs for Lowe Wash 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, postmining.

11.6.3.8 Cottonwood Arroyo

The Cottonwood Arroyo watershed area is about 80 square miles and approximately 14 percent of this drainage is within the mine lease area. 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.

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

Table 11-22 shows the comparison of flow and sediment yield for the 10-yr, 6-hr. precipitation event for portions of Cottonwood tributaries that drain the mined area and the outlet of Cottonwood Wash into Chaco Wash. The differences in sediment yields (tons/acre) and peak flow are negligible between pre and postmining at the lease line (structure 36). Sediment yields for the 10-year, 6-hour event at the downstream lease line are predicted to slightly decrease from a pre-mining yield of 30,644 tons to a postmining yield of 30,409 tons. The small changes in the sediment and peak flow figures reflect the small amount 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 is predicted to slightly decrease from a pre-mining estimate of 2,890 cfs to a postmining estimate 2,880 cfs. The runoff volume at structure 36 is predicted to decline from 1,473 acre-feet, pre-mining, to 1,384 acre-feet, postmining

TABLE 11-22

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS
COTTONWOOD WASH
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	1,561	13,076	1.0	13,332	1,527	13,029	1.0	-160	-34	-48	0.0
S34	S34	18,191	674	7,939	0.4	18,279	665	8,049	0.4	88	-9	110	0.0
S36 (lease line)	S36	49,221	2,890	30,538	0.6	49,104	2,880	30,409	0.6	-117	-10	-129	0.0
S37(Outlet)	S37	51,430	2,854	30,543	0.6	51,173	2,831	30,586	0.6	-257	-22	43	0.0

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11.6.3.9 San Juan River and Chaco River

The San Juan River Basin covers an area of about 12,900 square miles. Approximately 0.2 percent of this drainage lies within the permit area. The Chaco River has a watershed area of 4,350 square miles. The mine permit area occupies about 0.6 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 11.6.2.4, 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 totally contained within the mine and is not discharged to surface water 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 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 Wash 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 which are likely to have minimal impact on channel conditions and sediment loads in the San Juan and Chaco Rivers.

11.6.3.10 Surface Water Reference Criteria

Surface water reference criteria were developed from eight (8) years of surface water monitoring data to aid in the evaluation of future surface water monitoring data.

Each reference criteria value at each station (TABLE 11-24a through 11-24g) was determined by selecting the larger of the mean plus two (2) standard deviations which was determined from the baseline data, the maximum value in the data set or the standard. The standard was determined as the smallest of the following three (3) categories:

- Irrigation Water criteria
- Livestock Water Criteria
- 40 CFR Part 434 Coal Mining Point Source Effluent Limitations

Reference criteria were not determined for calcium, magnesium, sodium, potassium, carbonate, bicarbonate and sulfate because these parameters will be used to calculate an ion balance.

The reference criteria will be adjusted based on changing technical information and regulations and new field data. The criteria will be re-evaluated at permit renewal time.

11.6.3.11 South Barber Drainage

The South Barber Drainage has a watershed of about 0.8 square miles. Mining activities will disturb approximately 0.03 square 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 drainages that increases the South Barber drainage by 928 acres. 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 mi./sq. mile for the entire drainage area. Post-mining drainage density for the South Barber drainage is 5.98 mi./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 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 headcuts and begin to erode.

Comparison of SEDCAD 4.0 predictions for pre-mining (APPENDIX 7-N) and post-mining (APPENDIX 11-EE) flows and sedimentology is provided in TABLE 11-23 for a 10-year, 6-hour event. The comparison indicates an increase 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/ac for pre-mine and 0.5 tons/ac 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.

11.6.3.12 Pinabete/Chaco Tributaries

Three tributaries to the Pinabete Arroyo will be disturbed by mining activities in Area 4 North. The tributaries are identified as Tributary A, B, and C on Exhibit 11-77. The Pinabete Arroyo drainage basin is about 59.1 square miles. A small portion, approximately 1.7 square miles or 2.9 percent of the drainage basin will be disturbed. The post-mining topography increases the Pinabete Arroyo drainage basin by 84 acres. This is primary due to the topography changes at the drainage divide between the Pinabete Arroyo and Cottonwood Arroyo.

A tributary to the Chaco Wash will also be disturbed by mining activities in Area 4 North. The tributary is identified as Tributary A to the Chaco on Exhibit 11-77. The Chaco Wash drainage basin is approximately 4,350 square miles. A very small portion, approximately 0.8 square miles will be disturbed. Due to the topography changes at the drainage divide between the Chaco Wash and Cottonwood Arroyo the drainage basin or affected tributary decreases by 53 acres.

Pre-mining drainage density within the Area 4 North disturbance area was estimated to be 2.64 mi./sq. mile. Post-mining drainage density for the area was estimated to be 2.67 mi./sq. mile. The pre and post-mine drainage density are approximately equal. This will achieve geomorphically stable conditions that are equivalent to pre-mine.

Final Surface Configuration designs were developed in CHAPTER 12 (see Section 12.3, EXHIBITS 12-7A). For design of the reclaimed channels, see Section 11.6.5.3.

Comparison of SEDCAD 4 predictions for pre- (see CHAPTER 7, APPENDIX 7-O) and postmining (see CHAPTER 11, APPENDIX 11-SS) flows and sedimentology are provided in

TABLE 11-30. The comparison of the peak flows and sediment yields from the 10 year-6 hour storm event indicates decreases in flow and sediment yield in the post-mine conditions from Tributary B and C to the Pinabete that are sufficient to offset the increases in sediment yield and flow from Tributary A to the Chaco and Tributary A to the Pinabete. The total sediment yield is predicted to decline from 468 tons pre-mine to 346 tons post-mine. The total flow leaving the permit area is predicted to decline from 238 cfs pre-mine to 180 cfs post-mine.

The runoff volume resulting from a 10 year-6 hour precipitation event in the post-mine condition is predicted to decline from a pre-mining estimate of 30 ac-ft to a post-mining estimate of 23 ac-ft for all the tributaries combined.

The SEDCAD 4.0 modeling for the 10 year-6 hour event indicates that the predicted peak sediment concentration for Tributary A to the Chaco and Tributary B to the Pinabete in the post-mining conditions are similar to pre-mine even though the predicted peak settleable solids concentration increased from 8 ml/l to 9 ml/l and 0 ml/l to 11 ml/l, respectively. The increase in peak settleable solids is attributable to replacement of premining badland areas (clay-rich) with a postmining 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 modeling also indicates a decrease in peak sediment concentration for Tributary C to the Pinabete in the post-mine condition that is sufficient to offset the increase peak sediment concentration for Tributary A to the Pinabete. The peak sediment concentration for Tributary C and A to the Pinabete are 41,628 mg/l pre-mine, 31,607 mg/l post-mine and 9,517 mg/l pre-mine, 15,224 mg/l post-mine, respectively. The overall sediment yield, all tributaries combined, is 0.4 tons/acre pre-mine and 0.2 tons/acre post-mine.

TABLE 11-30

COMPARISON OF PRE- & POSTMINING AREAS, PEAK FLOWS AND SEDIMENT YIELDS TRIBUTARIES TO THE CHACO AND PINABETE 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)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)	Area (acres)	Peak Flow (cfs)	Runoff (ac-ft)	Sediment (tons)	Yield (tons/acre)
Tributary A to Chaco	S1SW1	S1SW1	295	31	4	41	0.1	381	47	6	68	0.2	85	16	2	27	0.0
Tributary A to Pinabete	S1SW1	S1SW1	345	30	5	40	0.1	371	42	6	67	0.2	26	12	0	27	0.1
Tributary B to Pinabete	S1SW1	S1SW1	476	130	17	269	0.6	401	44	6	96	0.2	-75	-86	-10	-173	-0.3
Tributary C to Pinabete	S1SW1	S1SW1	142	47	4	118	0.8	314	46	5	114	0.4	172	-1	1	-4	-0.5
Total Sediment Yield and Flow off Permit area			1,258	238	30	468	0.4	1,467	180	23	346	0.2	209	-59	-7	-123	-0.1

TABLE 11-24a
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CD-1[1,2]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	3189	10
pH	Units	8.7	-
TDS	mg/l	2284	25
TSS	mg/l	1265	25
Calcium	mg/l	120	10
Magnesium	mg/l	32.4	10
Sodium	mg/l	586	25
Potassium	mg/l	5.23	0.5
Carbonate	mg/l	44.3	2
Bicarbonate	mg/l	572	10
Sulfate	mg/l	986	10
Chloride	mg/l	139	10
Fluoride	mg/l	4.3	0.1
Iron	mg/l	20.7	0.25
Boron	mg/l	0.90	0.1
Selenium	mg/l	0.015	0.001

(1) Data set includes NAPI irrigation, seasonal seepage, and precipitation runoff samples.

(2) Data set represents samples from 1996-2003.

TABLE 11-24b
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CD-2[1,2]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	4187	10
pH	Units	8.5	-
TDS	mg/l	3328	25
TSS	mg/l	365	25
Calcium	mg/l	624	10
Magnesium	mg/l	56.4	10
Sodium	mg/l	727	25
Potassium	mg/l	11.0	0.5
Carbonate	mg/l	36.8	2
Bicarbonate	mg/l	398	10
Sulfate	mg/l	1763	10
Chloride	mg/l	176	10
Fluoride	mg/l	2.14	0.1
Iron	mg/l	6.1	0.25
Boron	mg/l	0.55	0.1
Selenium	mg/l	0.013	0.001

(1) Data set includes NAPI irrigation, seasonal seepage, and precipitation runoff samples.

(2) Data set represents samples from 1996-2003

TABLE 11-24c
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CN-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	2019	1
pH	Units	8.6	-
TDS	mg/l	1611	25
TSS	mg/l	293,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.84	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.78	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24d
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CNS-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	2300	1
pH	Units	8.7	-
TDS	mg/l	1669	25
TSS	mg/l	1,120,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.84	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	1.02	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24e
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION CS-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	5620	1
pH	Units	8.62	-
TDS	mg/l	1240	25
TSS	mg/l	1,030,000	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.32	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	17.6	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	1.10	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24f
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION NB-1[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	8200	1
pH	Units	8.6	-
TDS	mg/l	8260	25
TSS	mg/l	67,300	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	2.96	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.98	0.1
Selenium	mg/l	0.02	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

TABLE 11-24g
SURFACE WATER MONITORING REFERENCE CRITERIA
STATION NB-2[3,4]

PARAMETER	UNIT	SELECTED CRITERIA	MAX DETECT LIMIT
Conductivity	µmhos/cm	4200	1
pH	Units	8.6	-
TDS	mg/l	3840	25
TSS	mg/l	64,500	1
Calcium	mg/l	-	0.5
Magnesium	mg/l	-	0.5
Sodium	mg/l	-	0.5
Potassium	mg/l	-	0.5
Carbonate	mg/l	-	2
Bicarbonate	mg/l	-	10
Sulfate	mg/l	-	10
Chloride	mg/l	1500	10
Fluoride	mg/l	1.86	0.1
Nitrate	mg/l	-[5]	0.05
Iron	mg/l	7.0	0.25
Manganese	mg/l	4.0	0.25
Boron	mg/l	0.75	0.1
Selenium	mg/l	0.022	0.001

(3) Data set includes irrigation and precipitation runoff samples.
(4) Data set represents eight (8) years of data collection, 1985-1992
(5) Baseline data collection is not complete, monitoring discontinued May 2000.

11.6.4 Stream Buffer Zone Evaluation

Seven major drainages have been identified within the Navajo Mine permit area and are discussed in Section 11.6.3.1, and shown on EXHIBIT'S 7-3, 7-4, and 7-4C (CHAPTER 7). The seven drainages are: Chinde Wash, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo and Pinabete Arroyo. Mining or support activities are projected to occur in all of the listed drainages except in the Pinabete Arroyo.

Mining will not occur in the Neck Arroyo, however, transportation roads and facilities are present. The drainage to the Lowe Arroyo has been diverted around the mining area see Section 11.5.5.3.

A Summary of the Probable Hydrologic Consequences, Section 11.6.1, the discussion of mining activities upon the quality and quantity of surface water was concluded to be negligible. See CHAPTER 7, for a review and understanding of the results and conclusions reached for surface water in Section 11.6.1. The conclusions reached in Section 11.6.1, meets the requirements found at 30 CFR 816.57.

Those areas identified as stream buffer zones (EXHIBIT'S 11-9 through 11-11) outside the approved mining disturbance (see CHAPTER 12, EXHIBIT'S 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.

The stream buffer zone for the Pinabete Arroyo will fall outside the permit boundary, thus it will not be identified and marked.

11.6.5 Area II Reclaimed Channels

Three 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. The three reclaimed channels are Chinde Arroyo Branch 1, Hosteen Wash Branch 1, and South Barber Channel. The design of the main branch of Chinde Arroyo will be submitted under a separate cover. The alignments of the reclaimed channels are shown on EXHIBIT 11-76 and the pre-mine surface configuration with channels is shown on EXHIBIT 11-76F.

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-year, 6-hour event.

Table 11-26 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 three drainages modeled. Table 11-27 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 premine channels see Table 11-26. Results of the HEC-RAS analysis also indicate that the reclaimed channels will convey the peak flows generated by the 100-year, 6-hour precipitation event. Complete HEC-RAS output files for all three modeled channels by design storm events (2, 10, 25, 100-year, 6-hour 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 EXHIBIT 11-76E). The geometry of the design sections for the reclaimed channels were 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-year, 6-hour 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 7N (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. Inputting 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-year, 6-hour peak flow for the modeled channels are in Appendix 11-PP, HEC-RAS Results for Area II Pre-Mine Channels.

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, 1300 to 1500 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 lease 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 USGS and aerial surveys at 10-foot contours.

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 EXHIBITS 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 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-year, 6-hour stability and 100-year, 6-hour 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 to the to the Chinde Permanent Diversion, 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-year, 6-hour average velocity (see Table 11-26).

The Chinde Branch 1 Reclaimed Channel converges with the Chinde Diversion at approximately Sta 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 Sta 0+00 to the western lease boundary will be a part of the Chinde Permanent Diversion. The design section for Chinde Branch 1 is shown on Exhibit 11-76 E, 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-DD 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 11-26).

<u>Reclaimed Channel Development</u>

The reclaimed channels are designed to have flow velocities equal to or less than the pre-mine channels. Some erosion is expected, particularly in the pilot channels. All natural channels erode because they are in constant state of change depending 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 where the channel bed widens and the flow spreads out, thus reducing the velocity. Erosion (down cutting with some lateral movement) will occur in reaches

TABLE 11-26

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 11-27

HEC-RAS RESULTS

Chinde Branch 1 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
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 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
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 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
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 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
15.42	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 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
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

where the channel bed narrows and confines the flow, which increases the velocity. This generally occurs in reaches with increases in channel bed slopes.

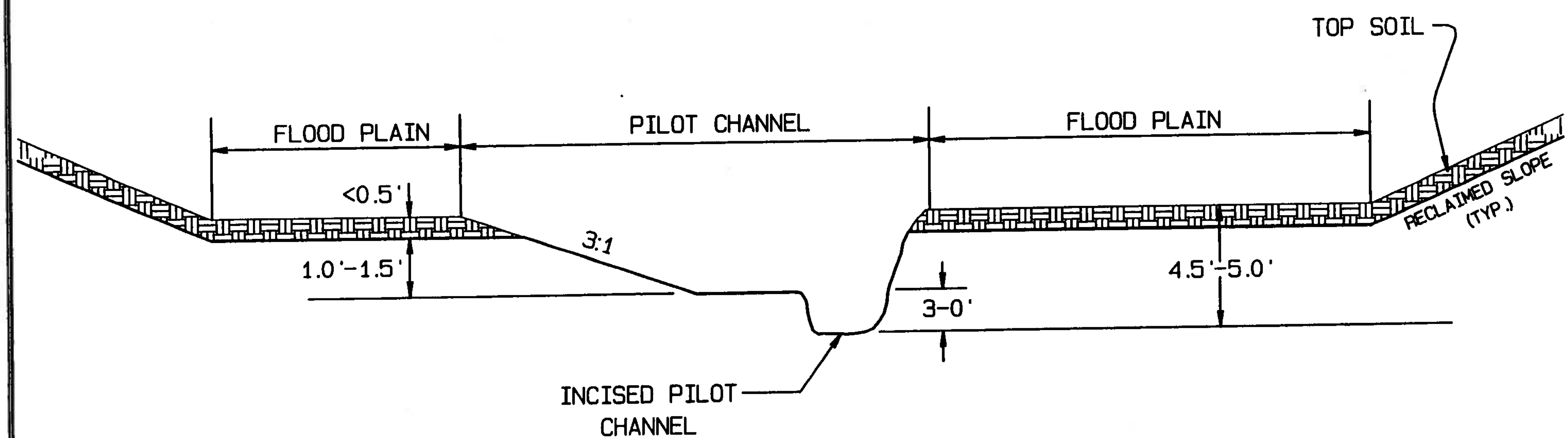
During high flows the sediment deposited during the low flows will be washed down stream and lateral movement of the channel banks will also occur with some down cutting of the channel bed. This process is also expected to occur in the reclaimed channels. Lateral movement of the pilot channel is expected but will be confined within the banks of the main channel. The pilot channel in time is expected to resemble the surrounding natural channels. It could be incised in some reaches of the channel with depths as deep as 5 feet at the floodplain. The 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 less since the flow velocities in the reclaimed channels are less than the pre-mine (See TABLES 11-26 and 11-27).

The erosion depth or incised pilot channel depth was selected based on observations of channel erosion in mine spoils. Typically at a scour depth of three feet or less into the spoil material, armoring of the channel bottom has occurred as the finer-grained sediments are winnowed away. Armoring of the channel consists of the preferential concentration of the remaining coarser material that range in size from pea – sized gravel up to large (3 foot length of the long axis) sandstone cobbles and boulders.

Low frequency (10-year, 6-hour or greater) large flows and corresponding higher velocities are required to transport these coarse materials. Consequently for the higher frequency (2-year, 6-hour) 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 feet deep incised pilot channel should migrate and abut against a 1.5 to 2.0 feet thick floodplain bank (See FIGURE 11-27). If the incised pilot channel exceeds three feet deep or should erode beyond the toe of the main channel into the reclaimed slope, the area/erosion will be repaired.

FIGURE 11-27



TYPICAL RECLAIMED INCISED PILOT CHANNEL SECTION
NTS

11.6.5.1 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. 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-year, 6-hour 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 year-6 hour 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 lease boundary were analyzed as pre-mine channels for comparisons with the post-mining channel.

Table 11-28 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 11-29 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 premine channels. For all the reclaimed channels not compared to a pre-mining channel the average flow velocities during the 2 year-6 hour 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-year, 6-hour 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 year-6 hour peak flow with a floodplain. The flows larger than the 2 year-6 hour 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-year, 6-hour 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.

Analysis of Pre-mine Channels

Mining has not disturbed the North Fork of the Cottonwood Arroyo, the 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 Table 11-28 and 11-29 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 11-28 and 11-29 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 preformed for these channels.

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 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 EXHIBITS 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 year-6 hour 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 11-28 and 11-29.

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 year-6 hour peak flow and pass the 100 year-6 hour 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 regarding process and will be presented on reclamation as-built drawings. The as-built drawings will be submitted to the regulatory agency.

Reclaimed Channel Development

The reclaimed channels are designed to have the average flow velocities less than the pre-mine channels or less than 5 fps. Some erosion is expected, particularly in the main channels. All natural channels erode because they are in constant state of change depending 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 where the channel bed widens and the flow spreads out, thus reducing the velocity. Erosion (down cutting with some lateral movement) will occur in reaches where the channel bed narrows and confines the flow, which increases the velocity. This generally occurs in reaches with increases in channel bed slopes.

During high flows the sediment deposited during the low flows will be washed down stream and lateral movement of the channel banks will also occur with some down cutting of the channel bed. This process is also expected to occur in the reclaimed channels. A pilot channel is expected to develop within the main channel. Lateral movement of the pilot channel is expected occur but will be confined within the banks of the main channel. The pilot channel in time is expected to resemble the surrounding natural channels. It could be incised in some reaches of the channel with depths as deep as 6 feet at the floodplain. The incised channel depths in the existing or natural channels directly downstream of the lease are much deeper. Erosion is expected to occur in the reclaimed channels but the erosion rate will be less since the flow velocities in the reclaimed channels are less than the pre-mine (See TABLES 11-28 and 11-29).

The erosion depth or incised pilot channel depth was selected based on observations of channel erosion in mine spoils. Typically at a scour depth of three feet or less into the spoil material, armoring of the channel bottom has occurred as the finer-grained sediments are winnowed away. Armoring of the channel consists of the preferential concentration of the remaining coarser material that range in size from pea-sized gravel up to large (3 foot length of the long axis) sandstone cobbles and boulders.

Low frequency (10-year, 6-hour or greater) large flows and corresponding higher velocities are required to transport these coarse materials. Consequently for the higher frequency (2-year, 6-hour) 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 6 feet deep could result if a 3 feet deep incised pilot channel should migrate and abut against a 2.0 to 2.5 feet thick floodplain bank (See FIGURE 11-29). If the incised pilot channel exceeds three feet deep or should erode beyond the toe of the main channel into the reclaimed slope, the area/erosion will be repaired.

TABLE 11-28
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 11-29
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

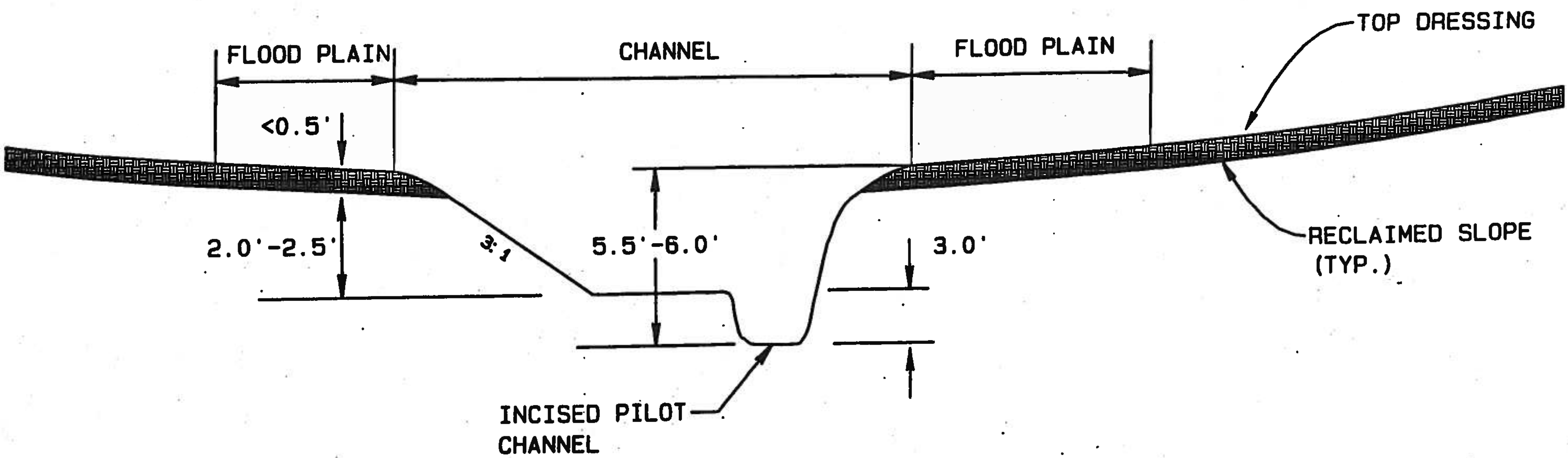
Flow Change Location (Sta)	2-Year Q (cfs)	2-Year Velocity (fps) Max	2-Year Velocity (fps) Avg	10-Year Q (cfs)	10-Year Velocity (fps) Max	10-Year Velocity (fps) Avg	25-Year Q (cfs)	25-Year Velocity (fps) Max	25-Year Velocity (fps) Avg	100-Year Q (cfs)	100-Year Velocity (fps) Max	100-Year Velocity (fps) 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

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11.6.5.2 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. Therefore, this section provides information concerning design of permanent diversions for ephemeral streams and addresses low order stream segments with drainage areas less than one square mile. Reclamation structures will be designed in accordance with the Reclamation Surface Stabilization Handbook.

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

11.6.5.3 Area IV North Reclaimed Channels

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

11.6.5.4 Area I South Reclaimed Channels

There is one reclaimed channel in the Area I South FSC with a watershed larger than 640 acres, which requires detailed designs according to the Reclamation Surface Stabilization Handbook. The reclaimed channel is designated as the Doby North Channel. The alignment of the reclaimed channel is shown on EXHIBIT 11-85 and 12-5A.

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 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-year, 6-hour event.

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 year- 6 hour storm events. The channel was designed to retain the 10 year-6 hour peak flow without overflowing the banks. The watershed subdivisions used in the model is presented in Exhibit 11-85. The results from the SEDCAD runs are presented in Appendix 11-FF. During storms greater than the 10 year-6 hour, 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-year, 6-hour stability and 100-year, 6-hour capacity. The design of drop structure is included in the SEDCAD hydrology model. Refer to Appendix 11-FF.

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

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 on disk.

In addition to the quarterly hydrologic monitoring report, an in-depth hydrology report will be submitted twice during the permit term. This detailed hydrologic monitoring report will provide a detailed reduction, analysis and interpretation of surface 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 Wash stations, CD-1A and CD-2A, weekly 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 Wash, 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 State of New Mexico for Interstate and Intrastate Streams standards and Navajo Nation Stream Standards for both the biannual report and the quarterly reports.

Discussion on requirements of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES) is found in Section 11.2.6.

11.7 REFERENCES

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