Limited Groundwater Investigation of The Atlas Corporation Moab Mill Moab, Utah

January 9, 1998

Prepared for the U.S. Fish and Wildlife Service
Lincoln Plaza, Suite 404
Salt Lake City, Utah 84115

Prepared by Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, Colorado 81503

Table of Contents

1 .0 Introduction

The project described in this report was conducted by personnel from Oak Ridge National Laboratory's Grand Junction Office (ORNL/GJ). The purpose was to refine information regarding groundwater contamination emanating from the Atlas Corporation's former uranium mill in Moab, Utah.

1.1 Project Planning

The first phase of project planning occurred September 9 in a meeting in the National Park Service (NPS) offices in Moab, Utah. Attendees included representatives from ORNL/GJ, National Park Service (NPS), U.S. Fish and Wildlife Service (FWS), the State of Utah (by phone) and the Grand Canyon Trust. The discussion focused on potential effects of groundwater discharge to the Colorado River. The concern was prompted by the results of recent "grab" samples of river water collected by personnel from the State of Utah. Those samples had shown ammonia, presumably related to the tailings pile. Accordingly, ORNL/GJ was tasked with developing a sampling scheme to more accurately delineate the content and width of the contaminant plume. A letter proposal was distributed September 19 and is attached in Appendix A.

On October 23, 1997, ORNL/GJ attended a meeting convened at the FWS offices in Denver, Colorado to address the status of the proposal. Present at the meeting were staff members from FWS, Nuclear Regulatory Commission (NRC), Atlas Corporation, Harding Lawson Associates, and ORNL/GJ. Personnel from FWS indicated that the Council on Environmental Quality (CEQ) had approved the original proposal and that the purpose of the meeting was to negotiate any remaining issues. Additionally, it was stated that any change in scope to the proposal would require approval by the CEQ. During the task review and discussion, ORNL/GJ agreed to perform the field work and to provide a report 60 days following the awarding of funds. At adjournment, the group consensus was for ORNL/GJ to submit a revised proposal to the CEQ to seek approval for changes in scope discussed at the meeting. The revised ORNL /GJ letter proposal was distributed on October 29, 1997 and is attached in Appendix A.

The ORNL/GJ proposal presented five tasks that were formulated at the Moab meeting in early September. The tasks were then refined after the Denver meeting. The tasks and the changes in scope are summarized below:

Task A: Installing a monitoring well through the pile to determine the connection between the tailings and the underlying water table. The purpose of this task was to confirm or deny the presence of tailings or slimes within the alluvial deposits under the tailings pile. Changes in the scope for this task included the installation of two boreholes in lieu of the monitoring well, the use of a more expensive drilling method to accommodate site conditions, and analytical costs for soil samples previously not included.

Task B: Plume delineation: The purpose of this task was to delineate the lateral extent of groundwater contamination emanating from the tailings pile. These data were subsequently used to locate the temporary piezometers proposed to evaluate groundwater quality where it discharges to the Colorado River (Task C). Changes in scope for this task included the addition of analytical costs which were originally to be covered by the State of Utah. Additionally, an equipment mobilization charge was added to cover the costs of mobilizing ORNL/GJ equipment that was required to satisfy the schedule.

Task C: Evaluate riverside water quality in the groundwater: The objective of this task was to provide groundwater quality data adjacent to the Colorado River so that the flux of contamination into the river could be calculated. Changes in scope for this task were the addition of analytical costs.

Task D: Install new reference well north of Atlas property. This task was origmally included to alleviate continuing questions regarding the background water quality. Although Atlas's current background well is located in close proximity to a former ore storage area, the proposed well was regarded as sufficiently upgradient, but felt to be in a different flow system by NRC and Atlas. Discussion regarding a new background well on Atlas property was entertained but specification of the NRC licensee's new background well was determined to be beyond the scope for FWS and ORNL/GJ. However, it was agreed that the originally proposed location would serve as a new "reference well" to establish ground water quality between the Atlas site and Arches National Park.

Task E: Modeling drainage from the pile: The original objective of this task as proposed by ORNL/GJ, was to provide a simple analytical solution to pile drainage using previously collected data. However, during the October 23 meeting, NRC indicated that a numerical solution using an unsaturated code would be of greater benefit and would be pursued with DOE's Grand Junction office. However, the following day NRC requested ORNL/GJ to prepare the model. ORNL/GJ proposed using a proprietary code (PORFLOW ™) capable of modeling saturated and unsaturated flow.

On November 10, 1997 ORNL/GJ received budget authorization to proceed with the work outlined in Tasks A through D. Funding was provided by the U.S. Department of Energy (DOE) at the request of the CEQ. NRC provided funding for Task E as described in the companion report.

1.2 Report Outline

This report presents the findings for Tasks A through D previously discussed. Section 1 provides background information and the report outline. Section 2 presents a discussion of the various methods used for data collection and analysis. Section 3 presents the results of Tasks A, B, C, and D. At NRC's request, the tailings pile seepage model (Task E) has been prepared under separate cover and is provided as a companion report.

2.0 Methods

The data collection and analytical methods are presented in this section. Where possible, reference is made to the ORNL/GJ technical procedure or the instrument manufacturer's operating procedure. The discussion is divided into two sections: Field Methods and Laboratory Methods.

2.1 Field Methods

The field methods used for the data collection and field analysis cover a range of equipment and procedures. Following is a list of the ORNL/GJ procedures used for the data collection and analysis:

Procedure Number	Procedure Title
TE-03 6	Analysis of Radionuclides in Soil
TE-06 1	Measurement of pH in Water Samples
TE-062	Measurement of Electrical Conductivity of Water Samples
TE-064	Measurement of Alkalinity of Water Samples
TE-073	Equipment Decontamination
TE-078	Subsoil Sampling Probe
TE-079	Collecting Soil Samples in Brass Sleeves
TE-08 1	Water Sampling for Analysis of Inorganic Compounds and Radio nuclides
TE-09 1	Field Determination of Gravirnetric Moisture
TE-100	Drilling Log Preparation and Well Construction, Documentation

Procedure Number	Procedure Title
TE-101	Subsurface Sampling Using a 5-ft Continuous Sampler and a Split Barrel Sampler
TE-105	U2CRT Operation
TE-106	Solid-Stem Augering Using the U2CRT
TE-111	Well Development
TE-113	Well Abandonment
TE-120	Physical Surveying
TE-130	Peristaltic Pump Operation
TE-170	AMS-16000 Drill Rig Operation
TE-173	Soil Sampling for Field Screening Using the Geoprobe ® Sampler and the AMS-16000 Drill Rig
TE-174	Small Diameter Piezometer Installation Using the Geo-Insight™ Assemblies and the AMS-16000 Drill Rig

In addition to the ORNL/GJ procedures, specific methods provided by equipment manufactures were used. Following is a list of these methods.

Manufacturer/Method Number	Method Name
HACH/380	Nitrogen Ammonia (0 to 2.5 mg./L NH_3-N) Nessler Method
HACH/70	Chloride (0 to 20 mg/L Cl^-) Mercuric Thiocyanate Method
HACH/700	Sulfur, Sulfate (0 to 0.45% SO_4^{2-}-S)

The procedures listed above have not been included in this report but are available upon request. In addition project log books were kept and will remain on file.

2.1.1 Field Methods for Plume Delineation

Temporary piezometers were drilled and installed using ORNL/GJ procedures TE-073, TE-078, TE-100, TE-105, TE-106 and TE-174. Use of the GeoInsight™ assemblies described in TE-174, permitted the installation of 3/4 in. PVC piezometers. The wells were then developed with a peristaltic pump until clear water flowed before sampling. Temperature, pH, and conductivity were measured at the wellhead using a Hydrolab Scout equipped with a flow-through cell. The conductivity cell in the Hydrolab unit had a range of 0 to 10,000 umhos/cm.

The plume delineation study was guided by performing selected analyses in the field: alkalinity, sulfate (SO_4^{2-}), chloride (Cl^-), and ammonium as nitrogen (NH_4-N) using the aforementioned procedures/methods. Additionally, unfiltered nitric-preserved (HNO_3^-) samples were submitted to the DOE's Grand Junction Office (GJO)Analytical Services Laboratory for total uranium analysis.

2.1.2 Field Methods for Pile Drilling and Reference Well Installation

The tailings pile borehole drilling and reference well installations were performed by Layne-Christensen under contract to ORNL/GJ. Drilling was performed using a dual-wall reverse-circulation (DWRC) percussion-hammer rig (Foremost Drills AP-1000) equipped with a wire-line split-spoon for undisturbed sample collection at designated intervals. The DWRC drilling method permits continuous drill-cuttings analysis. The cuttings are returned to the surface (with minimal lag time) by compressed air where they drop out of a cyclone without any screening. Thus, lithologic changes not captured in split-spoon sample intervals can be readily identified in the cuttings.

The reference monitoring well installation with the DWRC rig was accomplished by setting the 2-m well screen and casing through the inner 5.5-in diameter drill pipe to the bottom of the boring drilled to 80 ft. A prepacked well screen (10 ft) was used to facilitate the installation and well development process. Annular material (sand pack [2-16 grade], bentonite seal, and bentonite grout) were added as the drill pipe was removed from the bore hole. The reference well was then flush-mounted with the ground surface and completed in an 8-in. diameter traffic-rated vault. The wellhead is also secured with a locking cap equipped with a combination lock.

2.1.3 Physical Surveying

The surveying process to establish coordinate and elevation control for new sampling locations entailed a two-step process. First, the coordinate information was collected with the use of a Trimble PRO XR global positioning system (GPS) with a guaranteed accuracy of less than 1 ft. The GPS unit was "calibrated" to the site by collecting coordinate information for previously existing wells and comparing it with the available coordinate data. This practice enabled a rapid location survey of the piezometers, boreholes and reference well. The second step (elevation control) required the use of a stadia rod and Nikon automatic level to carry elevation control across the site. ORNL/GJ attempted to use vertical control available for existing wells at the site, but discrepancies in the existing elevation data were discovered. Additionally, the broken condition of the surface casings on several wells (ATP-3, ATP- 1) made the use of these points for reference questionable. Therefore , ORNL/GJ personnel were required to carry elevation control from the nearest benchmark, located on Hwy. 191 north of the Atlas site. This was performed by carrying the elevation to well ATP-3, where the existing unbroken casing was assigned a new elevation of 3995.13 ft amsl, and then carried to well AMM-1 which was assigned a new elevation of 3968.86 ft amsl.

2.1.4 Field Analysis

Water samples were analyzed in the field by ORNL personnel for the following parameters: specific conductance, pH, temperature, ammonia-nitrogen, sulfate, chloride and alkalinity. Specific conductance, pH, and temperature were measured during sample collection with a Hydrolab Scout equipped with a flow-through cell. Calibrations for pH and conductance were performed immediately prior to the measurements. Except for the samples from RW-1 and ATP3, ammonium-nitrogen, sulfate, chloride and alkalinity were determined on-site in a field laboratory set up in an existing building. The samples from RW-1 and ATP3 were analyzed in the GJO analytical laboratory.

Sulfate was determined turbidimetrically using the Hach (Loveland, CO) SulfaVer 4 method and a Hach model DR-2000 spectrophotometer. This is a turbidimetric method that relies on the formation of barium sulfate. The barium sulfate precipitate is suspended in the water sample. Light is passed through the barium sulfate suspension and the amount of light scattered is proportional to the amount of precipitate. Because the method is turbidimetric, the dynamic range is narrow. Thus, all samples were diluted to a range of 30-60 ppm for analysis. Although the spectrophotometer has a standard calibration curve, a 40 ppm sulfate standard, diluted from a 1000 ppm standard freshly purchased from Hach, was measured with each batch of field samples. Acceptance criteria were that the standard, which should read 40ppm, read between 30 and 50 ppm. Laboratory analyses were used to confirm the field analyses. Four samples were analyzed in the laboratory. The following comparisons, with the field result listed first, were obtained: (TP-1 = 3330/2660, TP-9 = 16250/15400, TP-12= 6666/4710, and TP-19 =5440/4340). These results indicate that the relative difference among the samples was adequately determined with either method, but that the field method has a high bias relative to ion chromatography, the method used in the laboratory. The high bias was observed in the field where all 32 standard readings exceeded the expected value. The average for the high bias was approximately 13%. Adjusting for the 13% bias, the comparisons as above, become: (TP-1 = 2920/2660, TP-9 = 14251/15400, TP-12= 5846/4710, and TP-19 =4770/4340). Because of the consistent bias, the readings used in the report have all been adjusted by 13% as noted.

Ammonia was determined in the field with the Nessler method using the Hach model DR-2000 spectrophotometer. Most samples had to be diluted significantly in order for their concentrations to be within the linear range (0 - 2.5 mg/L). Each batch of samples had a 0.8 ppm ammonia standard as part of the batch. The acceptance criterion was that the 0.8 ppm standard read between 0.7 and 0.9 ppm. Of 28 results used in the field determinations, the average was 0.83. This error is sufficiently small, that no adjustment for bias was indicated. Four samples were run in the laboratory by ion chromatography for comparison purposes. Those results were as follows: (TP-1 = 0.4/0.01, TP-9 = 1895/1850, TP-12 = 382/322, and TP-19 = 10.2/3.3). These data show good agreement for the very high results but that the field method is probably unreliable for values less than 10 ppm. Hence, in all of the reporting of the field data, values of 10 ppm or less are shown as <10 ppm. The ammonia sample from ATP-3 was not analyzed within the prescribed holding time because of shipping/delivery problems. The sample was, however, analyzed within 72 hours and the very low result (<0.5 ppm) reported indicates that the area is not contaminated with ammonia.

Chloride was determined with the Hach DR-2000 spectrophotometer and the mercuric thiocyanate method. Chloride in the sample reacts with mercuric thiocyanate to form mercuric chloride and liberate thiocyanate ion. Thiocyanate ions react with ferric ions to form an orange ferric-thiocyanate complex, the amount of which is proportional to the chloride in the sample. A standard was not run with the samples in the field. Instead, the factory-derived instrument calibration curve was used for the determination of the final result. Four samples were analyzed in the laboratory with ion chromatography to provide a comparison. Those results were as follows: (TP-1 = 3490/4850, TP-9 = 1737/1 130, TP-12 = 696/636, TP-19 =5760/6070). The results for TP-1 and TP-9 show percent differences of approximately 30%. The results for TP-12 and TP-19 are quite good considering the high levels of chloride at the site and the dilutions that have to be performed during the analysis. It should be noted, that chloride determinations typically show poor precision because of the high levels of chloride in the environment. A review of the overall data showed that the contrast in chloride concentration from one portion of the site to another was so great that the field data are adequate for representing groundwater conditions at the site. Consequently, additional comparison samples were not analyzed.

2.1.5 Laboratory Analyses

The following is the list of analytes for water samples collected during the project: uranium (U), arsenic (As), selenium (Se), molybdenum (MO), vanadium (V), copper (Cu), ammonia (NH_3-N), sulfate (SO_4), nitrate (NO,), nitrite (NO_2), chloride (Cl^-), specific conductance, pH and temperature. Soil/tailings samples were analyzed for As, barium (Ba), Cu, MO, Se, U, V, and radium (Ra^{-226}). This list was agreed to by the project participants (Atlas, FWS, NRC and ORNL) in the meeting that was held in Denver, CO, on October 23. U, As, Se, MO and V were included because these elements are commonly associated with uranium in ore deposits on the Colorado plateau. These elements have a similar geochemistry in that each can form soluble oxyanions under the appropriate conditions. In the case of uranium, a negatively charged uranyl carbonate complex is likely. The anionic state is important because most soil particles are negatively- charged. Hence, these oxyanions are not strongly retained by soils, and tend to migrate the farthest whenever uranium mill tailings are leached with oxygenated water.

Copper, ammonia and sulfate were included in the analyte list because they were used in the ore-processing. Nitrate was included because of some use on' site and also because the ammonia added from ore-processing might be oxidized to nitrate. Chloride, specific conductance, pH, alkalinity and temperature were included as general groundwater quality parameters that might be useful markers for different groundwater regimes that could be encountered.

Gross alpha and gross beta were not measured because uranium is the most mobile radioactive constituent in uranium mill tailings. Moreover, the analytical methods for uranium are more sensitive and less subject to error than those for gross alpha and beta. Uranium analyses, therefore, provide the best assessment for the extent of the contaminated groundwater.

All of the water sampling was conducted near the pile with most of it occurring between the pile and the river. Two borings, however, were performed on the pile as a means of evaluating the connection between the tailings and the underlying groundwater. A few samples of tailings and soil were collected from these borings.

Samples were preserved in the field and returned to the laboratory facility at the GJO. All of the laboratory analyses except radium were performed in this laboratory. The analytical methods used are listed in Table 2.1. Copies of the analytical results for all samples analyzed by the GJO laboratory are provided in Appendix B. A copy of the State of Utah certification relative to the GJO laboratory can be made available upon request. Radium analyses were performed by gamma spectrometry at the ORNL facilities in Grand Junction. The soil samples were sealed in cans to permit ingrowth of Rn- and Bi^{-214} which is measured with a sodium-iodide detector and related to the radium in the sample. Laboratory quality assurance data have not been appended to the report but are available upon request.

Table 2.1 Analytical Methods

Analyte	Sample Type	Method	EPA Reference
As and Se	soil	Axial View ICP-AES	SW-846 6010
As	Water	Hydride AA	SW-846 7062
Se	Water	Hydride AA	SW-846 7742
Ba, Cu, and V	Soil and Water	ICP-AES	SW-846 6010
U and Mo	Soil	ICP-MS	SW-846 6020
U and Mo (high concentrations	Water	ICP-AES	SW-846 6010
U and Mo (low concentrations	Water	ICP-MS	SW-846 6020
NH_3-N	Water	Colorimetric	MCAWW 350.1
NO_2, NO_3, and SO_4	Water	Ion Chromatography	SW-846 9056

3.0 Investigation Results

This section provides the results of the investigation for Tasks A, B, C, and D.

3.1 Tailings Pile Borehole Drilling (Task A)

The purpose of this task was to confirm or deny the presence of tailings or slimes within the alluvial deposits under the tailings pile. The controversy over the presence of tailings in the alluvium resulted from a summary report (Canonie Environmental 1994) that suggested that the base of the tailings extended into the native alluvial sediments in the vicinity of wells PW-1 and PW-2. The Canonie (1994) interpretation of the boring logs placed the bottom of the tailings in PW-1 and PW-2 at a depth of 105 ft (3949.7 ft amsl) and 110 ft (3940.9 ft amsl), respectively. Using a water table elevation of 3,953 ft (Canonie Environmental 1994) thus placed a portion of the tailings from 3 to 12 ft below the water table.

ORNL originally proposed the installation of a monitoring well through the tailings to address groundwater hydraulics and quality under the pile. The well installation was proposed to include soil sample collection to also delineate the tailings/alluvium interface. However, at the October 23 meeting in Denver, Atlas and NRC personnel insisted that the well would present a conduit for contaminant migration from the tailings to the groundwater. Therefore, the scope of the task was changed to include two soil borings through the tailings. Thus, in the revised proposal submitted October 29, two borings were proposed: one adjacent to PW-2 and the second in the center of the tailings pile.

The boring planned for the center of the tailings pile was added to obtain data in an area of the pile where no other borings had been drilled. However, the saturated conditions over the center of the tailings pile (from precipitation and de-watering efforts), combined with field reconnaissance data indicating that the tailings thickness was less than anticipated, precluded angle-drilling to intercept the bottom of the tailings below the center of the pile. Therefore, concurrence was obtained to drill the second borehole next to PW-1.

3.1.1 Task Planning

ORNL/GJ reviewed the boring log data from PW-1 and PW-2 and proposed that a better lithologic evaluation could be achieved with a more discrete sampling interval (every 5 ft) through the tailings pile followed by continuous sampling across the tailings/alluvium interface. Additionally, radium analyses were proposed to create a profile through the tailings and shallow alluvial sediments. Also proposed was the collection of representative samples of the tailings/alluvial interface for analyses of U, V, As, Ba, Cu, MO and Se. The final comprehensive data evaluation would include review-of new and existing lithologic data as well as the analytical **results**.

3.1.2 Data Collection

Two boreholes (PB-1 and PB-2) were drilled on the tailings pile adjacent to PW-1 and PW-2. Samples were collected at 5 **ft** intervals beginning at 10 **ft** below ground surface in each boring using a 24-m split spoon on a wire-line hammer. Continuous sampling was **performed** from 79 to 9 1 **ft** in PB-1 and from 7 1 to 8 1 **ft** in PB-2. Lithologic logs for PB-1, PB-2, PW-1 and PW-2 are presented in Appendix C.

3.1.2.1 Lithologic Analysis

Review of the lithology presented in the boring log for PB-1 (Appendix C) indicates that the tailings between 10 and 83 **ft** are comprised of fine to very-fine-grained gray to light-brown, sand occasionally streaked with thin, brown and gray, silt and clay layers or slimes. The tailings became wet at a depth of 39 ft. A significant lithology change occurs at 83 **ft** where the predominantly wet sandy tailings changes to a stiff, dry, gray clay which corresponds with the slime tailings descriptions provided in the "B" series boring logs (B-l through B-28 prepared by Dames **&** Moore 1981). The gray, clay unit (slime tailings) is continuous to a depth of 94.5 **ft** where a dry, red sand with scattered gravels (alluvium) predominates to a depth of 99.5 ft. The red sand is underlain by a wet, brown silty-sand that is interbedded with gray and red clayey silt to a depth of 108 ft. At 108 **ft** a saturated sandy gravel is encountered which persists to 111 **ft, the** total depth of the boring.

Review of the lithology presented in the boring log for PB-2 (Appendix C) indicates that the tailings between 10 and 72.5 **ft** are comprised predominantly of fine-grained, gray to light-brown, sand occasionally streaked with very thin, brown and **gray,** silt 'and clay layers (slime tailings). A thin, perched wet zone was noted at 23 **ft** but uniform saturation was not observed until a depth of 39 ft. At a depth of 45 **ft** a black sand was observed that could denote the change from an acid to alkaline leach process **in** the null operation (Personal communication between Frank Gardner and **Dale Edwards on 12/12/97)**. A significant **lithology** change occurs **at 72.5 ft** where the predominantly wet, sandy tailings changes to a stiff, dry, gray clay which corresponds with the slime tailings descriptions provided in the **"B"** series boring logs (B-l through B-28 prepared by Dames & Moore 1981). The gray clay (slime tailings) is continuous to a depth of 88 **ft** where a dry, red sand is encountered that grades to a gravelly sand at a depth of 99 ft. At this point, the lithology changes to a saturated, brown silty sand to a depth of 108 **ft**. At 108 **ft** a saturated, sandy, gravel is observed which persists to 111 **ft,** the total depth of the boring.

Because a **10-ft** sampling interval was used during the drilling of PW-1 and PW-2, there are, unfortunately, no samples that capture any of the sign&cant lithologic changes denoted by the PB borings. The Canonie report **(1994),** however, footnoted the source of the lithologic data for PW-1 and PW-2 as being from an unreferenced text table rather than the **boring** log. The combination of limited discrete samples and an unreferenced table used as the **source** of, the data, may explain why Canonie (1994) reported the bottom of the tailings at 105 and 110 **ft** in PW-1 and PW-2, respectively.

To evaluate the lithologic data collected in PB-1 and PB-2 (Fig. 3. **1),** a cross section was constructed (Fig 3.2) along the south end of the pile. **In** addition to the new PB borings, **ORNL/GJ** used selected boring logs presented by Dames **&** Moore (198 1). The cross section presented in Fig. 3.2 was constructed using the data presented below:

Borehole Number	Ground Elevation	Top of Gray Clay	Top of Alluvium	Top of Gravel
PB-1	4053.88	3970.88	3959.38	3945.88
PB-2	4048.41	3975.91	3960.41	3940.41
B-l	4039.00	3976.50	3957.00	3945 .oo
B-10	4045.10	3973.10	3959.00	Not found
B-18	4046.00	3963.00	3960.00	Not found
B-19	**4046.00**	**3983.00**	**3957.00**	**Not found**

The above data and the cross-section display the uniform distribution of the gray clay across the southern side of the pile. **ORNL/GJ** has interpreted this unit to be slime tailings from a lithologic perspective for two reasons. First, existing boring logs (Dames **&** Moore 198 1) repeatedly referred to the same or similar fine-grained sediments as slime tailings. And secondly, it is highly unlikely that the deposition of such uniform, fine-grained **,sediments** could take place in the high-energy depositional environment associated with the naturally-occurring **fluvial** and alluvial system. **In** addition, the data and cross-section depict a relatively uniform **contact of the** gray clay (slime tailings) with the alluvial sediments, The top of the alluvial sediments is represented by a reddish-brown sand underlying the slime tailings in the **"B"** series borings as well as the PB-1 and PB-2 borings drilled by **ORNL/GJ**. Therefore, the lithologic interpretation of the relevant data do not support the premise that tailings exist within the **alluvial** sediments under normal conditions. However, based on seasonal fluctuations of **the river level,** there is an opportunity for tailings to be in direct **contact with** groundwater for limited time intervals (e.g., The river elevation reached 3964 **ft** amsl during the 1993 runoff). According to Atlas personnel, during spring runoff, river water has been

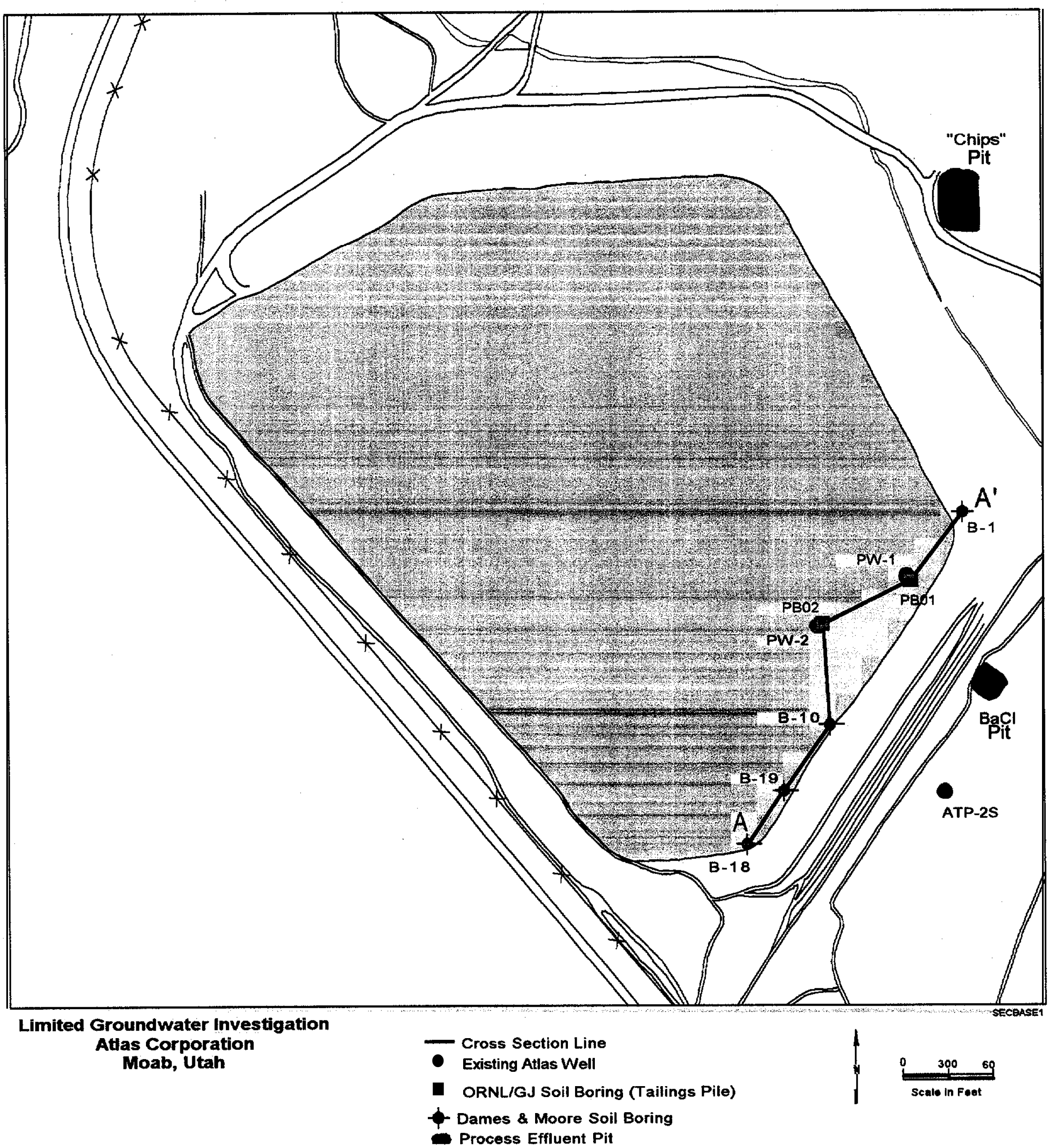


Fig. 3.1. Borehole location map.

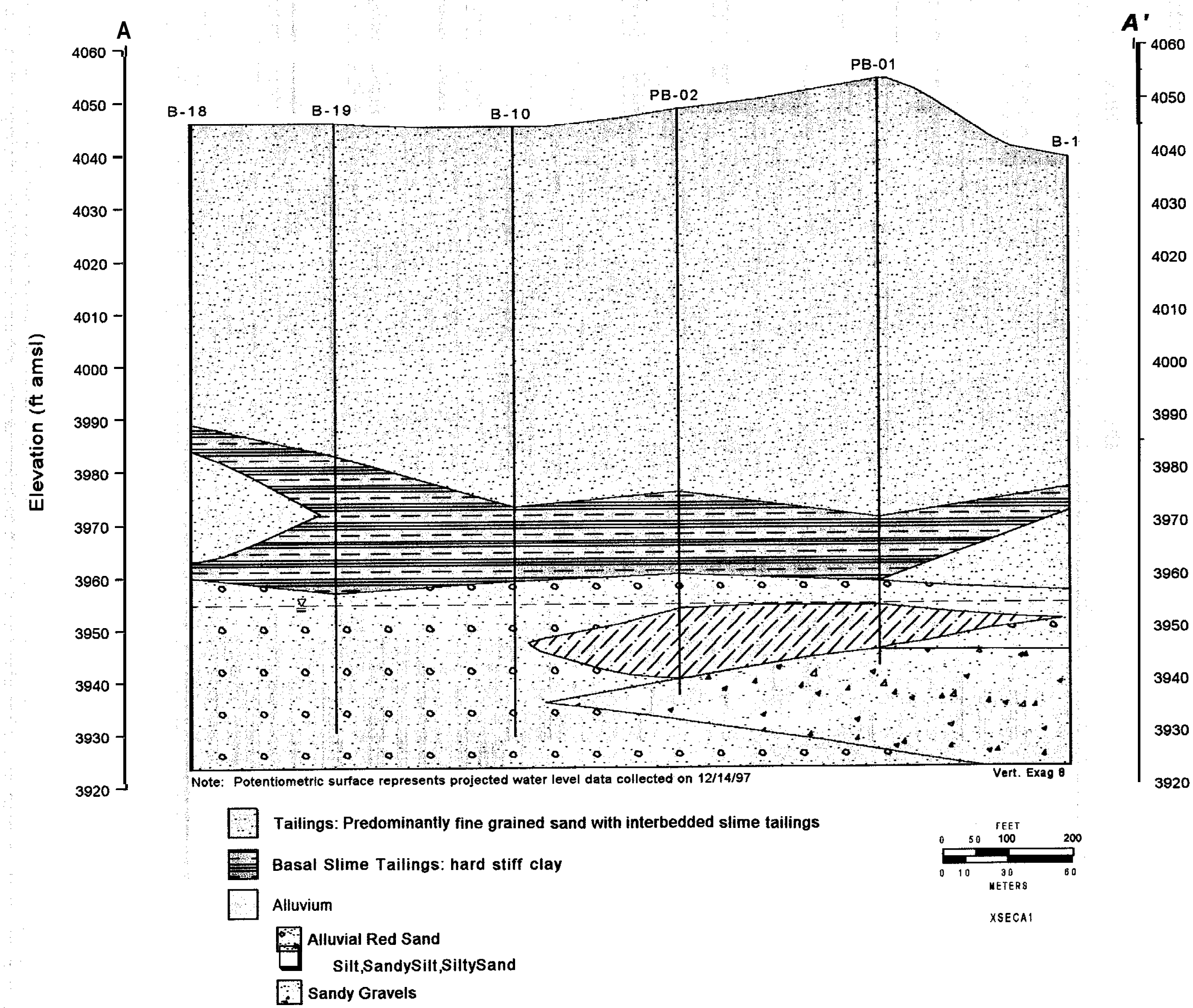


Fig. 3.2. Cross-section of tailings pile from B-18 to B-l

observed extending to the base of the tailings pile. Unfortunately, there are no wells completed withing the alluvial aquifer to confirm the potentiometric surface beneath the tailings pile. The potentiometric surface line on the cross section is representative of December 14, 1997 and was determined from the water level data collected during the plume delineation task (See Sect. 3.2).

3.1.2.2 Radium Analysis

Radium analyses were performed following sample preparation: drying, crushing, canning, and weighing followed by an **18-day ingrowth** period. The analysis is performed using sodium iodide detectors **configured** in a 4-n geometry inside a lead container or pig. The analytical algorithm provides values for radium **(Ra^{226})**, thorium **(Th^{232})**, and potassium **(K^{40})**.

Tables 3.1 and 3.2 present the results of the Ra^{226}, Th^{232} ,and K^{40} analyses on all sampling intervals in boreholes PB-1 and PB-2, respectively. These results are in good agreement with information provided by the NRC in the Final Technical Evaluation Report for the Atlas site (NRC 1997) which states:" A composite analysis of the tailings by Atlas, determined that the average radium activity of the slimes was 1275 picocuries per gram **(pCi/g)** and that of the sands was 241 **pCi/g**." Review of the radium data concurs
3 with the lithologic evaluation relative to the tailings/alluvium contact. In other **words,** the sharp decrease in radium concentration between. the red **sand (alluvium)** and **the** gray clay(slime tailings) would support the lithologic interpretation previously discussed.

3.1.2.3 Metals Analysis

Analytical results for soil samples from PB-1 and PB-2 are presented in Table 3.3. To facilitate the review, a descriptor of the sample material is provided. Most significant among the data is the marked decrease in the concentration of metals constituents **between** the **tailings** and the alluvial sediments. The **uranium** and vanadium data **from** sample PB-l-94, however, do suggest that some leaching has occurred through the slime tailings into the alluvial sediments.

Table 3.1 Radium Analysis Results for Boring PB-1

Sample Interval	Material Description	Radium (Ra^{226}) (pCi/g)	Thorium (Th^{232}) (pCi/g)	Potassium (K^{40}) (pCi/g)
9 - 11	sand tailings	215	1.67	0
14 -16	sand tailings	99.7	0	7.68
19 - 21	sand tailings	202	1.25	4.49
24 - 26	sand tailings	148	0	0
29 - 31	sand tailings	153	1.08	19.9
34 -36	sand tailings with <25% clay	447	8.82	0
39-41	sand tailings with <25% clay	335	7.8	0
44-46	sand tailings with <10% clay	464	13.1	0
49-51	sand tailings	566	23.3	0
54 - 56	slime tailings (gray sandy clay)	849	52.4	0
59-61	sand tailings	236	4.57	8.86
64 - 66	sand tailings with <10% clay	418	9.89	0
69-71	slime tailings (gray clay)	748	29.9	0
74-76	sand tailings with <10% clay	605	24.8	0
79-81	sand tailings with <10% clay	220	3.96	19.2
81-83	sand tailings with <10% clay	201	1.14	13.3
83 -85	slime tailings (reddish gray clay)	1600	114	0
85 - 87	slime tailings (reddish gray clay)	2040	185	0
87-89	slime tailings (reddish gray clay)	1640	109	0
89-91	slime tailings (sandy clay)	1690	94.5	0
94 - 96	**alluvium** (red sand)	2.80	0.714	26.9
99 - 101	alluvium (gray brown silt)	2.26	0.986	20.6
104 - 106	alluvium (gray brown silt	1.93	1.06	24.9
109 - 111	alluvium (sandy gravel)	1.62	0.608	23.3

Table 3.2 Radium Analysis Results for Boring PB-2

Sample Interval	Material Description	Radium (Ra^{226}) (pCi/g)	Thorium (Th^{232}) (pCi/g)	Potassium (K^{40}) (pCi/g)
9-11	sand tailings with <10% clay	803	20.7	0
14 -16	sand tailings	269	2.3	0
19-21	sand tailings	150	1.7	7.79
24 - 26	sand tailings	100	1.22	6.11
29-31	sand tailings with <10% clay	192	2.7	17.2
34 -36	slime tailings (clay)	782	49.1	0
39 - 41	**sand tailings with <10% clay**	**325**	**7.33**	**0**
44 - 46	**slime tailings (clay)**	**1740**	**96.3**	**0**
49 - 51	**sand tailings with <25% clay**	**816**	**43.7**	**0**
54 - 56	**slime tailings**	2070	200	**0**
59 - 61	**sand tailings with <25% clay**	**781**	**45**	**0**
64 - 66	**sand tailings with <25% clay**	**711**	**36.5**	**0**
69 - 71	**sand tailings with <25% clay**	**614**	**28.5**	**0**
71-73	slime tailings (gray clay)	1390	64.4	0
73 -75	slime tailings (gray clay)	1280	74.5	0
75 -77	slime tailings (gray clay)	1130	52.4	0
77-79	slime tailings (gray clay)	1240	65	0
79-81	slime tailings (gray clay)	1550	112	0
84-86	slime tailings (gray clay)	1620	96.4	0
89-91	**alluvium** (red sand)	1.83	0	27.1
94 - 96	**alluvium** (red sand/silt)	2.23	0.626	32.1
99 - 101	**alluvium** (brown silt)	1.58	0.912	21.2
104 - 106	**alluvium** (brown silt/sand)	1.33	0.921	19.9
109 - 111	**alluvium** (gravelly **sand)**	3.15	1.05	1.88

Table 3.3 Analytical Results for Metals Analyses in Soil from PB-1 and PB-2								
Sample Identity	Sample **Description**	Arsenic **(mg/kg)**	Barium* **(mg/kg)**	Copper **(mg/kg)**	Molybdenum **(mg/kg)**	Selenium **(mg/kg)**	Uranium **(mg/kg)**	Vanadium **(mg/kg)**
PB-1-83	slime tailings	12.9	343.0	29.4	71.9	0.4 B	103.0	525.0
PB-1-85	slime tailings	13.2	206.0	45.5	65.3	0.2 u	176.0	649.0
PB-l-89	slime tailings	14.8	267.0	95.6	105.0	0.2 u	163.0	15 10.0
PB-1-94	alluvium	3.1	75.8	15.4	20.5	0.62	52.3	1720.0
PB-l-101	alluvium	5.5	187.0	10.7	0.98 B	0.2 u	5.4	31.2
PB-2-45	sand tailings	113.0	1290.0	‘832.0	78.8	3.7	338.0	597.0
PB-2-74	slime tailings	9.2	340.0	21.5	27.6	0.34	65.8	496.0
PB-2-76	slime tailings	7.7	276.0	36.1	68.3	0.3 B	231.0	489.0
PB-2-78.5	slime tailings	78.9	365.0	306.0	133.0	1.2	158.0	2460.0
PB-2-90	alluvium	2.5	92.4	8.6	1.3 B	0.3 B	3.60	33.20
PB-2-100	**alluvium**	5.5	195.0	10.3	1.3 B	0.3 B	8.3	22.30

U = detection limit, B = estimated value,* All barium results are flagged E = reported value is estimated because of the possible presence of interference, and N = spike sample recovery is not within control limits.

3.1.3 Task A Conclusion

Results of the tailings pile drilling indicate that, except for the possibility of very high river levels, the tailings are not within the alluvial aquifer. In addition, based on the reported concentrations (Table 3.3), the tailings show little enrichment with arsenic, copper, and selenium (except two samples) relative to what would be expected for native soils.

3.2 Plume Delineation and Riverside Ground Water Quality (Tasks B and C)

The objectives of these tasks were to delineate the lateral extent of groundwater contamination emanating from the tailings pile (Task B) and to evaluate groundwater quality where it discharges to the Colorado River (Task C). Locating the riverside piezometers without the lateral extent of the plume defined would be of limited benefit. Therefore, these tasks were intertwined to satisfy the comprehensive objective of the testing plan, which was to provide an evaluation of groundwater quality between the tailings pile and the riverbank. Using the available data, a calculation of the flux of selected contaminants (ammonia, uranium, sulfate and molybdenum) from the groundwater to the river water has also been prepared.

3.2.1 Task Planning

ORNL/GJ reviewed the available lithologic data from the borings on Atlas property and determined that the target depth for the piezometers would be the uppermost permeable unit identified as a gravel or sandy gravel in wells ATP-1, ATP-2, and AMM-1, The gravel's occurrence in these wells suggested that the unit has a uniform distribution and was extensive in its lateral and vertical extent. To perform the proposed hydraulic testing, ORNL/GJ selected well ATP-2-S for a pump test.

3.2.2 Data Collection

A total of 21 piezometers (TP-1 through TP-21 in Fig. 3.3) were installed to complete the task. In addition, 4 observation wells (OW-1 through OW-4 in Fig. 3.3) were installed for hydraulic testing purposes. Discussion of the various kinds of data collected during this task are presented in the following sections.

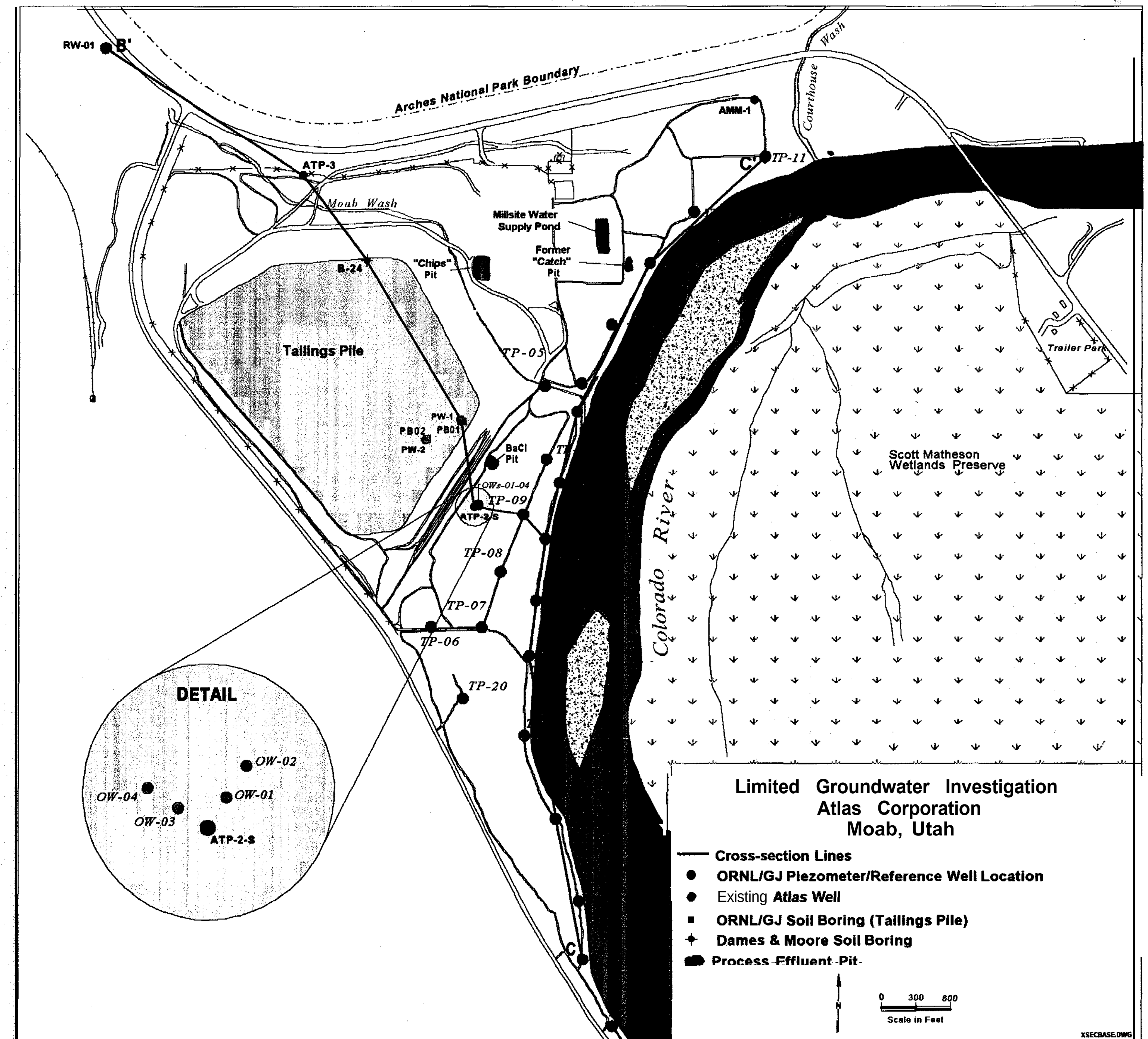


Fig. 3.3 Location of the temporary piezometers installed by ORNL/GJ and existing wells used for the investigation.

3.2.2.1 Piezometer Installation and Shallow Alluvial Hydrogeology

The piezometers and observation wells in Fig. 3.3 were installed using ORNL/GJ equipment. TPO 1 through TP05 were installed using Geoprobe® and GeoInsight™ assemblies. This combination of assemblies allowed for continuous lithologic evaluation with the Geoprobe® megabore sampler followed by 3/4-in casing installation with the GeoInsight™ assemblies. However, a breakdown of ORNL/GJ's AMS-16000 direct-push drilling rig required a different approach for the installation of wells TP6 through TP-21 and the four observation wells. Because ORNL/GJ's backup rig (U2CRT), lacks the power of the AMS - 16000, the remainder of the piezometers and observation wells were installed by augering a 2-in diameter hole 2 to 3 ft into the gravel zone. After retracting the augers, the GeoInsight™ assemblies were then used to drive a stainless steel well-point at least 5 ft into the gravel before exposing the screen and retracting the drive rod. Table 3.4 presents the construction data (state plane coordinates, casing elevations, depths, screen size, and current status) for the piezometers and other related boreholes and wells. At the request of Atlas and FWS, a number of the piezometers were left in place for future sampling.

Although the use of augering and GeoInsight™ assemblies does not yield the lithologic detail provided by the continuous Geoprobe® sampling, the top of the gravel unit was easily detected during drilling by the sound of gravel grinding against the augers. Thus, the top of the gravel unit is mapped with confidence in the cross-sections presented in Figs. 3.4 and 3.5. (The location of the cross-sections is provided in Fig. 3.3) The lithology above the gravel is presented as undifferentiated sands, silts, and minor gravels based on the limited data from TP-01 through TP05 as well as the available existing data. A potentiometric surface map is presented in Fig. 3.6 and the same potentiometric surface is superimposed over the cross-sections. The water level data used to construct the potentiometric surface is presented in Table 3.5.

3.2.2.2 Pump Test Results

Well ATP-2-S, which is screened from 28 to 38 ft, is an existing 2-in monitoring well that was selected for the 24-hr pump test. This well was selected due to its location and to save the cost of installing a new pumping well. Earlier studies (Canonie Environmental 1994) indicated a hydraulic conductivity value of approximately 5.1 ft/d in the shallow alluvium. Based on the, visual examination of the aquifer sediments during piezometer installation, this hydraulic conductivity value appeared to be low for the coarse sands and gravels comprising the aquifer. Two 3/4-in I.D. temporary observation wells (OW-3 and OW-4) were installed at 15 and 25 feet radial distance from the pumping well (see detail area in Fig 3.3) and screened

Table 3.4. Construction Data for Piezometers, Reference Well, and Soil Borings.

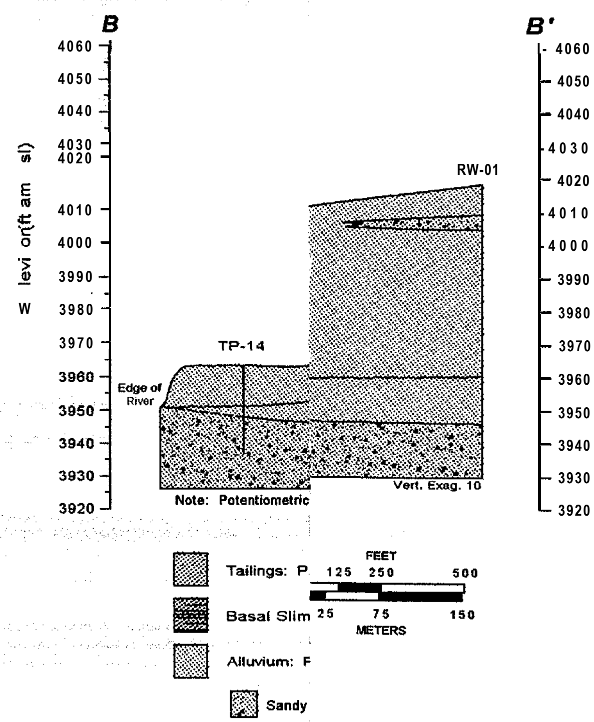
Location ID	Type	Easting[1]	Northing[1]	Elevation (Casing)[2]	Elevation (Ground)[2]	Date Installed	Date Abandoned	Total Depth[3]	Screened Interval[3]	Screen Slot Size
OW-1	0.75 in Observation Well	2545115.41	101746.85	3963.87	3961.38	11/21/1997	In-Service	30.0	20 to 30	.010 in
OW-2	0.75 in Observation Well	2545123.96	101753.79	3963.78	3961.37	11/21/1997	In-Service	30.0	20 to 30	.010 in
OW-3	0.75 in Observation Well	2545089.06	101735.96	3963.13	3961.60	12/8/1997	In-Service	40.0	30 to 40	.010 in
OW-4	0.75 in Observation Well	2545079.06	101735.96	3962.43	3961.30	12/8/1997	In-Service	40.0	30 to 40	.010 in
TP01	0.75 in Piezometer	2547004.60	104249.78	3966.29	NM	11/17/1997	In-Service	24.0	19 to 24	.010 in
TP02	0.75 in Piezometer	2546623.91	103816.19	3972.48	NM	11/18/1997	In-Service	32.0	27 to 32	.010 in
TP03	0.75 in Piezometer	2546288.28	103295.95	3961.11	NM	11/19/1997	In-Service	24.0	19 to 24	.010 in
TP04	0.75 in Piezometer	2546032.62	102789.25	3969.94	NM	11/19/1997	In-Service	24.0	19 to 24	.010 in
TP05	0.75 in Piezometer	2545712.12	102766.89	3960.82	NM	11/19/1997	12/14/1997	16.0	11 to 16	.010 in
TP06	0.75 in Piezometer	2544729.31	100717.48	3959.47	NM	11/20/1997	In-Service	32.0	27 to 32	.010 in
TP07	0.75 in Piezometer	2545168.28	100710.61	3962.87	NM	11/20/1997	In-Service	29.5	24.5 to 29.5	.010 in
TP08	0.75 in Piezometer	2545328.87	101187.01	3964.16	NM	11/20/1997	In-Service	31.5	26.5 to 31.5	.010 in
TP09	0.75 in Piezometer	2545526.35	101671.26	3964.75	NM	11/20/1997	In-Service	28.0	23 to 28	.010 in
TP10	0.75 in Piezometer	2545724.85	102143.53	3964.04	NM	11/20/1997	In-Service	26.0	21 to 26	.010 in
TP11	0.75 in Piezometer	2547618.64	104715.10	3964.38	NM	11/21/1997	In-Service	32.0	27 to 32	.010 in
TP12	0.75 in Piezometer	2545991.33	102548.25	3965.54	NM	11/21/1997	12/14/1997	20.0	15 to 20	.010 in
TP13	0.75 in Piezometer	2545842.15	101939.43	3965.88	NM	11/21/1997	12/14/1997	21.0	16 to 21	.010 in
TP14	0.75 in Piezometer	2545718.43	101464.92	3964.92	NM	11/21/1997	12/14/1997	21.0	16 to 21	.010 in
TP15	0.75 in Piezometer	2545637.76	100942.53	3963.94	NM	11/22/1997	12/14/1997	31.0	26 to 31	.010 in
TP16	0.75 in Piezometer	2545580.51	100468.26	3962.77	NM	11/22/1997	12/14/1997	27.0	22 to 27	.010 in
TP17	0.75 in Piezometer	2545539.67	99785.34	3961.60	NM	11/22/1997	In-Service	28.0	23 to 28	.010 in
TP18	0.75 in Piezometer	2545813.04	99074.73	3961.25	NM	11/22/1997	In-Service	24.0	19 to 24	.010 in
TP19	0.75 in Piezometer	2546013.80	98376.33	3959.79	NM	11/22/1997	In-Service	32.0	27 to 32	.010 in
TP20	0.75 in Piezometer	2545007.22	100102.4	3964.51	NM	11/23/1997	In-Service	36.0	31 to 36	.010 in
TP21	0.75 in Piezometer	2546048.52	97881.92	3961.60	NM	11/23/1997	In-Service	24.5	19.5 to 24.5	.010 in
RW-01	2 in Reference Well	2541899.45	105651.20	4018.63	4019.07	12/9/1997	In-Service	81.0	69 to 79	.010 in
PB-01	Soil Boring	2544991.92	102467.80	NM	4053.88	12/10/1997	In-Service	NA	NA	NA
PB-02	Soil Boring	2544691.94	102316.86	NM	4048.41	12/11/1997	In-Service	NA	NA	NA

[1]US Survey Feet: NAD 1927, Utah Central 4302

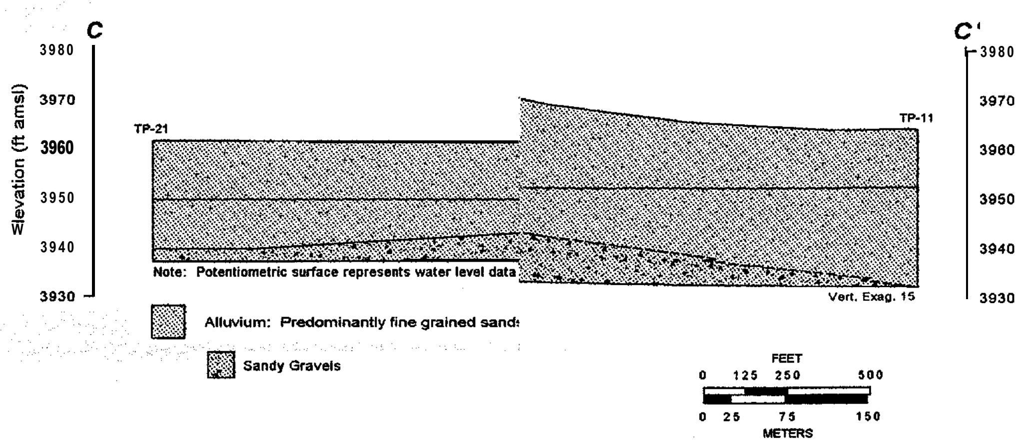
[2]Feet Above Mean Sea Level. Reference Elevation: Grand County Benchmark, 1987 (4021.88)

[3]Feet Below Ground Surface

NW: Not Measured



B
B'
4060
4050
4040
4030
4020
4010
4000
3990
3980
3970
3960
3950
3940
3930
3920
RW-01
TP-14
Edge of River
Note: Potentiometric
Vert. Exag. 10
Tailings: P
Basal Slim
Alluvium: F
Sandy
FEET
125 250 500
25 75 150
METERS



C
C'
3980
3970
3960
3950
3940
3930
Elevation (ft amsl)
TP-21
TP-11
Note: Potentiometric surface represents water level data
Vert. Exag. 15
Alluvium: Predominantly fine grained sand
Sandy Gravels
FEET
0 125 250 500
0 25 75 150
METERS
XSECBC.DWG

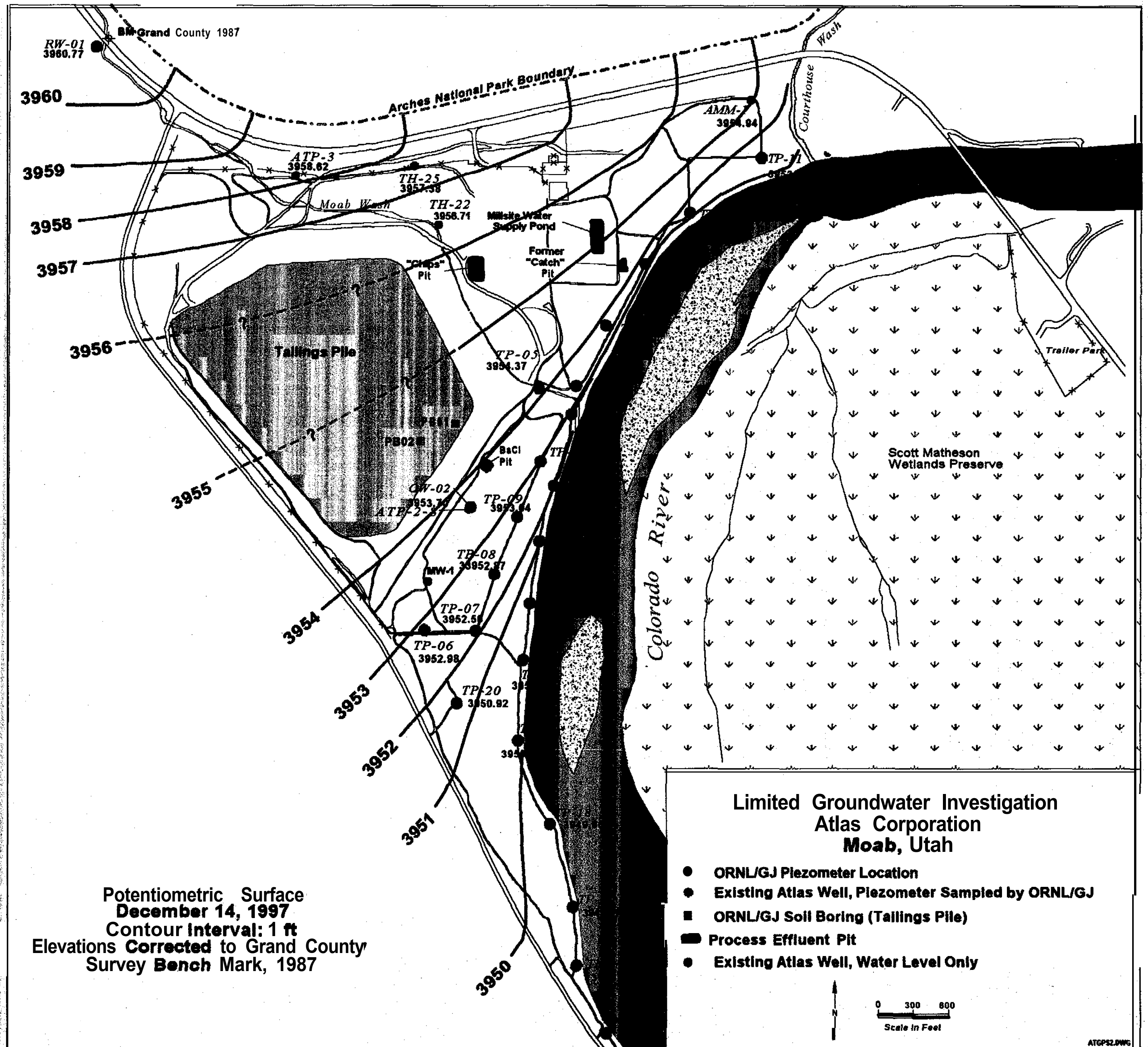


Fig. 3.6. Potentiometric surface map for shallow alluvial aquifer, December 14, 1997.

Table 3.5. Water Levels, December 14, 1997.

Location	Type	Easting[1]	Northing[1]	Casing Elevation[2]	Depth to water (ft)	Water Level[2]
OW-1	ORNL Observation Well	2545115.41	101746.85	3963.87	10.10	3953.77
OW-2	ORNL Observation Well	2545123.96	101753.79	3963.78	10.08	3953.70
OW-3	ORNL Observation Well	2545089.06	101735.96	3963.13	9.25	3953.88
OW-4	ORNL Observation Well	2545079.06	101735.96	3962.43	8.53	3953.90
TP01	ORNL Piezometer	2547004.60	104249.78	3966.29	13.12	3953.17
TP02	ORNL Piezometer	2546623.91	103816.19	3972.48	19.55	3952.93
TP03	ORNL Piezometer	2546288.28	103295.95	3961.11	7.90	3953.21
TP04	ORNL Piezometer	2546032.62	102789.25	3969.94	16.89	3953.05
TP05	ORNL Piezometer	2545712.12	102766.89	3960.82	6.45	3954.37
TP06	ORNL Piezometer	2544729.31	100717.48	3959.47	6.49	3952.98
TP07	ORNL Piezometer	2545168.28	100710.61	3962.87	10.31	3952.56
TP08	ORNL Piezometer	2545328.87	101187.01	3964.16	11.29	3952.87
TP09	ORNL Piezometer	2545526.35	101671.26	3964.75	11.71	3953.04
TP10	ORNL Piezometer	2545724.85	102143.53	3964.04	10.98	3953.06
TP11	ORNL Piezometer	2547618.64	104715.10	3964.38	10.78	3953.60
TP12	ORNL Piezometer	2545991.33	102548.25	3965.54	12.58	3952.96
TP13	ORNL Piezometer	2545842.15	101939.43	3965.88	13.43	3952.45
TP14	ORNL Piezometer	2545718.43	101464.92	3964.92	13.82	3951.10
TP15	ORNL Piezometer	2545637.76	100942.53	3963.94	12.93	3951.01
TP16	ORNL Piezometer	2545580.51	100468.26	3962.77	12.42	3950.35
TP17	ORNL Piezometer	2545539.67	99785.34	3961.60	11.32	3950.28
TP18	ORNL Piezometer	2545813.04	99074.73	3961.25	11.39	3949.86
TP19	ORNL Piezometer	2546013.80	98376.33	3959.79	10.48	3949.31
TP20	ORNL Piezometer	2545007.22	100102.4	3964.51	13.59	3950.92
TP21	ORNL Piezometer	2546048.52	97881.92	3961.60	11.81	3949.79
RW01	ORNL Reference Well	2541899.45	105651.20	4018.63	57.86	3960.77
SG1	ORNL River Gauge	2546045.30	102381.15	3948.56	2.60	3951.16
SG2	ORNL River Gauge	2545612.00	99675.42	3947.72	2.60	3950.32
HLSG1	Atlas River Gauge	2546876.56	104022.77	3966.13	14.37	3951.76
AMM1	Atlas Monitoring Well	2547524.08	105205.25	3968.86	14.27	3954.59
AMM2	Atlas Monitoring Well	2545669.75	102035.14	3964.64	11.68	3952.96
ATP2-D	Atlas Monitoring Well	2545104.06	101735.96	3963.97	12.72	3951.25
ATP2-S	Atlas Monitoring Well	2545104.06	101735.96	3963.97	10.20	3953.77
ATP3	Atlas Monitoring Well	2543613.59	104562.18	3995.13	36.51	3958.62
MW1-R	Atlas Monitoring Well	2544757.15	101128.95	3961.27	7.35	3953.92
PW1	Atlas Pump Well (Pile)	2544978.21	102482.76	4054.91	63.94	3990.97
PW2	Atlas Pump Well (Pile)	2544675.31	102309.04	4050.79	47.92	4002.87
PW4-OB-A	Atlas Pump Well (Pile)	2544710.48	102951.00	4051.64	28.88	4022.76
PW5	Atlas Pump Well (Pile)	2544482.84	102109.29	4050.22	27.40	4022.82
PW6	Atlas Pump Well (Pile)	2544819.42	102587.63	4049.91	41.43	4008.48
PW7	Atlas Pump Well (Pile)	2544992.30	102769.74	4055.23	67.37	3987.86
PW11	Atlas Pump Well (Pile)	2544299.48	101890.04	4047.89	27.57	4020.32
PW12	Atlas Pump Well (Pile)	2544777.28	102786.14	4050.06	29.21	4020.85
TH22	Atlas Piezometer	2544844.74	104143.95	3979.43	22.72	3956.71
TH25	Atlas Piezometer	2544634.01	104645.42	3986.93	29.55	3957.38

[1]US Survey Feet: NAD 1927, Utah Central 4302

[2]Feet Above Mean Sea Level. Reference Elevation: Grand County Benchmark, 1987 (4021.88)

from 28 to 38 ft. Initially, OW-1 and OW-2 had been installed for this purpose but were improperly constructed and had to be abandoned and replaced with OW-3 and OW-4.

Preliminary testing indicated that ATP-2-S was capable of producing over 20 gallons per minute (gpm) of water, Consequently, in order to stress the aquifer, a 3/4 H.P. centrifugal pump was used to pump the well. This pump yielded a steady flow rate for 6 hr. However, as the water levels dropped in ATP-2-S the pumping rate declined. Consequently, it was not possible to perform curve-matching analysis to evaluate the boundary conditions, storativity, and the leakage conditions of the aquifer.

However, after approximately l-hr of pumping, and for the ensuing six hours, water levels in the observation wells and the pumping rate remained relatively stable suggesting quasi steady-state conditions. Thus, the first 6-hrs of the test (Tables 3.6 and 3.7) can be used to calculate the hydraulic conductivity using the Theim method for steady-state conditions. As shown in Fig. 3.7, the data from the first six hours of the test yields a hydraulic conductivity (K) of 22 ft/d. The field observations are explained by the fact that the aquifer is initially under confined conditions but, under the influence of pumping, the water-level in the pumping well drops below a clayey-silt confining unit located at 15 ft (bgs) resulting in unconfined conditions for the duration of the test.

There is a fine-to-medium-grained sand layer at a depth of 55ft in ATP-2-S. The fact that there was so little drawdown in ATP-2-D during the pumping test indicates that this sand unit restricts flow from the lower aquifer such that the two aquifer units are essentially hydraulically isolated. The thickness of the shallow aquifer at this location, therefore, is interpreted to be 40 ft.

The pump test K value of 22.0 ft/d is significantly higher than the average of 5.1 ft/d as reported by Canonie (1994) based on the results from open-end casing permeability testing performed by Dames & Moore (1973). The pump test-derived K value of 22 ft/d does, however, agree with the upper end of the range (0.60 to 22 ft/d) reported by Dames & Moore (1973) and Canonie (1994).

To compare the previously reported K value of 5.1 ft/d with the pump test-derived K value of 22 ft/d, the average linear velocity of the ground water was calculated using both values. Both calculations used an assumed effective porosity of 30% (Freeze and Cherry 1979) and a hydraulic gradient of 0.004 (from the potentiometric map in Section 3.2.2.4). Using the lower and higher K values, linear velocities of 24.8 and 107 ft/yr were calculated. The tailings impoundment began receiving tailings in 1956 resulting in 41 years for contaminants to migrate. Thus contaminants could migrate 1017 ft using the lower K value, or 4390 ft for the higher K value. The Colorado River is approximately 1000 ft from the southern downgradient edge

Table 3.6. Water-level measurements for observation well OW-3 during pump test

Time At, min	Water level, ft	Time At, mill	Water level, ft
0	9.22	35	9.73
0.25	9.22	40	9.74
0.5	9.23	50	9.76
	9.26	60	9.76
1.5	9.29	70	9.76
2	9.31	80	9.77
2.5	9.34	90	9.78
3	9.37	100	9.78
4	9.41	120	9.78
4.5	9.43	140	9.78
5	9.44	160	9.78
6	9.48	180	9.77
7	9.50	210	9.77
8	9.53	330	9.76
11	9.58	550	9.75
13	9.61	640	9.74
15	9.64	790	9.70
18	9.67	910	9.68
21	9.68	1060	9.62
25	9.70	1270	9.63
30	9.72	1440	9.55

Table 3.7. Water-level measurements for observation well OW-4 during pump test

Time At, min	Water level, ft	Time At, min	Water level, ft
0	8.49	35	8.77
0.5	8.49	40	8.79
1.5	8.49	50	8.80
2	8.49	60	8.81
2.5	8.50	70	8.82
3	8.51	80	8.83
3.5	8.52	90	8.83
4	8.53	100	8.84
4.5	8.54	120	8.84
5	8.55	140	8.84
6	8.57	160	8.82
7	8.59	180	8.84
8	8.61	210	8.84
9	8.63	330	8.85
10	8.64	550	8.85
11	8.65	640	8.84
13	8.67	790	8.82
15	8.69	910	8.78
18	8.71	1060	8.75
21	8.73	1270	8.78
25	8.74	1440	8.70
30	8.76		

$$K = \frac{\ln(r_2/r_1)\,Q}{\pi\,(h_2^2 - h_1^2)}$$

$K = 22.0$ ft/d

$Q = 11.1$ gpm

$r_1 = 15$ ft

$r_2 = 25$ ft

$h_1 = 38$ ft $-0.56 = 37.44$ ft

$h_2 = 38$ ft $- 0.35 = 37.65$ ft

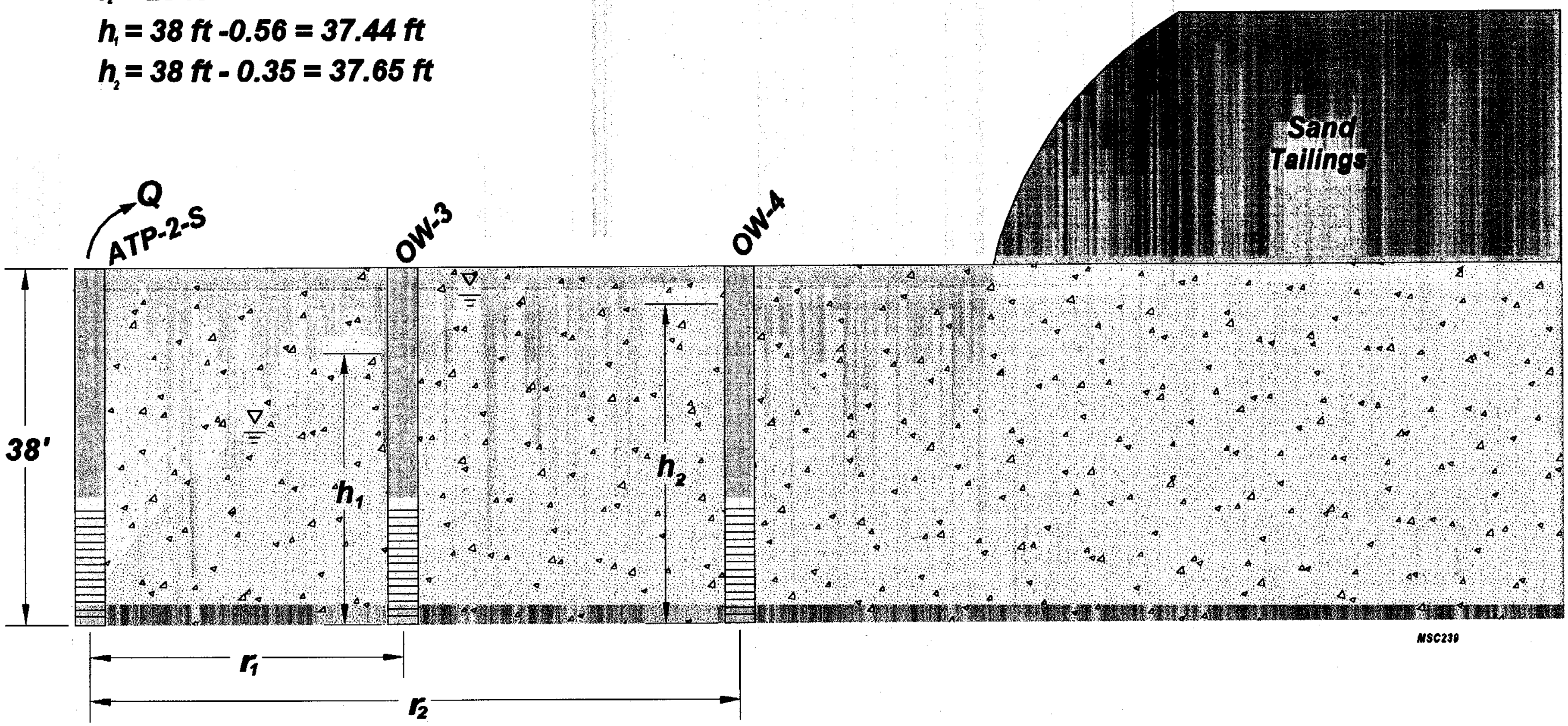


Fig. 3.7. Pump test results.

of the pile. 'The **lower K value** suggests that the leading edge of the plume is just now reaching the river. **In** contrast, the plume distribution maps in Section 3.2.2.4 indicate that the **contaminant** plumes are mature and have been discharging to the river for a number of years, thereby supporting the higher **value** for the hydraulic conductivity.

To summarize, the pump test-derived value appears to be representative of the actual hydraulic conductivity of the alluvial aquifer based on the following information:

- Visual analysis of the aquifer sediments indicate that the coarse, sand **and** gravel comprising the alluvial aquifer should have a **K** value on the order of 10^2 based on published values (Freeze and Cherry 1979).

- The single-well test data used by Dames **&** Moore (1973) and Canonie (1994) tend to underpredict the hydraulic conductivity **(Kearl** et al. 198 8).

- The distribution of contaminants at the edge of the Colorado River suggest mature plumes that have been discharging to the river for a number of years.

- Mixing calculations presented in Section 3.2.2.5 indicate that **insufficient recharge** from the pile occurs to the groundwater **if the** lower hydraulic conductivity value is used.

Based on this evidence, the **K** value of 22 ft./d appears to be representative of the shallow alluvial aquifer.

3.2.2.3 Groundwater Sampling

Groundwater samples were collected from the temporary piezometers and selected existing wells using the methods described in Section 2.1.1. The plume delineation study was guided by **performing** field analysis of **alkalinity,** sulfate, chloride, and ammonia. Additionally, samples for expedited uranium analysis were submitted for plume delineation purposes. **Confirmatory** groundwater samples for laboratory analysis of arsenic, selenium, molybdenum, vanadium, copper, and nitrate were also collected. To provide an additional measure of confidence **in** the **field** screening data, a total of four samples were also analyzed for ammonia, sulfate, and chloride by the GJO analytical laboratory as previously discussed in Section 2.1.5. The field and laboratory analytical data are presented in Table 3.8.

Table 3.8. Analytical Results from Groundwater Samples, page 1 of 2.

Wells and Piezometers Installed by ORNL/GJ								
Location	Sample Date	Alkalinity[ORNL] (mg/L)	Ammonia[ORNL] (NH_4-N, mg/L)	Chloride[ORNL] (Cl, mg/L)	Molybdenum[GJO] (ug/L)	Nitrate[GJO] (NO_3, mg/L)	Selenium[GJO] (ug/L)	Sulfate[ORNL] (SO_4, mg/L)
OW-2	11/25/1997	1268	1566.0	1025	NA	NA	NA	16220
RW-01	12/10/1997	NA	NA (0.145[GJO])	156[GJO]	4.6 B	10.3	9.9	NA (131.0[GJO])
TP-1	11/18/1997	214	0.41 (0.0088[GJO])	3490 (4860[GJO])	26.2 B	12.1	9.6	2920 (2880[GJO])
TP-2	11/18/1997	660	4.0	392	250.0	8.3	3.6 B	2810
TP-3	11/19/1997	388	8.5	1200	598.0	826.0	18.9	7020
TP-4	11/19/1997	718	485.0	780	2060.0	534.0	19.9	7380
TP-5	11/20/1997	880	381.0	685	778.0	282.0	24.8	8190
TP-6	11/20/1997	550	25.5	5250	334.0	547.0	2.9 B	10960
TP-7	11/20/1997	834	38.0	2675	355.0	0.079 B	1.0 U	7890
TP-8	11/21/1997	888	409.0	1737	977.0	39.5	1.0 U	8990
TP-9	11/21/1997	1278	1895 (1850[GJO])	1125 (1130[GJO])	1230.0	715.0	95.3	16010 (15400[GJO])
TP-10	11/21/1997	880	700.0	1870	1290.0	440.0	38.4	9320
TP-11	11/22/1997	310	1.5	3510	23.8 B	0.064 B	1.0 U	1720
TP-12	11/22/1997	652	382 (322[GJO])	630 (696[GJO])	1420.0	315.0	12.5	5310 (4710[GJO])
TP-13	11/22/1997	856	710.0	2240	1100.0	226.0	8.3	8990
TP-14	11/22/1997	1126	1285.0	2990	386.0	344.0	3.8 B	14900
TP-15	11/23/1997	1300	430.0	1400	491.0	163.0	1.0 U	19730
TP-18	11/23/1997	378	7.1	34800	198 B	0.081 B	1.0 U	5320
I-P-17	11/23/1997	220	7.3	53000	8.1 B	0.014 u	1.0 U	4890
TP-18	11/23/1997	198	8.4	80700	5.8 B	0.014 U	1.0 U	4710
TP-19	11/24/1997	200	10.2 (3.32[GJO])	52600 (60700[GJO])	5.0 U	0.014 U	1.0;	4770 (4340[GJO])
TP-20	11/24/1997	170	9.2	54500	5.0 u	0.014 u	1.0 U	4730
TP-21	11/24/1997	240	4.91	39000	7.7 B	0.014 U	1.0 U	3730

Existing Atlas Wells								
Location	Sample Date	Alkalinity[ORNL] (mg/L)	Ammonia[ORNL] (NH_4-N, mg/L)	Chloride[ORNL] (Cl, mg/L)	Molybdenum[GJO] (ug/L)	Nitrate[GJO] (NO_3, mg/L)	Selenium[GJO] (ug/L)	Sulfate[ORNL] (SO_4, mg/L)
AMM-1	11/25/1997	NA	NA (5.0 U[GJO])	NA (3080[GJO])	8.1 B	12.7	18.3	NA (995[GJO])
ATP-2-S	11/25/1997	1044	1130 (1270[GJO])	1700 (1440[GJO])	842.0	79.0	15.8	12810 (12400[GJO])
ATP-3	11/24/1997	188	0.20 (0.216[GJO])	480 (542[GJO])	4.1 B	0.10 U	2.4 B	NA (237.0[GJO])
PW-1	11/25/1997	1324	1070.0	915	NA	NA	NA	15790
PW-2	11/25/1997	1932	2470.0	550	NA	NA	NA	23680
PW-6	11/24/1997	2360	3940.0	733	NA	NA	NA	31480
PW-9	11/24/1997	1934	1800.0	612	NA	NA	NA	18500

Verification Sample Results Shown in Parenthesis
[ORNL] Analysis by ORNL/GJ
[GJO] Analysis by GJO Analytical Laboratory
B: Estimated Value
U: Undetected/Detection Limit
OR: Overrange
NA: Not Analyzed

Wells and Piezometers Installed by ORNUGJ							
Location	Sample Date	Uranium[GJO] total, (mg/L)	Uranium[GJO] dissolved, (mg/L)	Vanadium[GJO] (ug/L)	Conductivity (umhos/cm)	pH	Temp (°C)
OW-2	11/25/1997	4.83	NA	NA	OR	6.60	16.40
RW-01	12/10/1997	NA	0.013	12.3 B	780	7.40	18.60
TP-1	11/18/1997	0.41	0.38	10.0 U	NA	NA	NA
TP-2	11/18/1997	23.3	26.0	20.0 U	NA	NA	NA
TP-3	11/19/1997	19.9	16.8	20.0 U	5200	7.84	17.60
TP-4	11/19/1997	3.59	3.30	208.0	5210	7.44	17.25
TP-5	11/20/1997	1.61	1.45	529.0	OR	7.08	17.15
TP-6	11/20/1997	3.79	5.64	20.0 U	OR	6.67	19.65
TP-7	11/20/1997	2.86	2.70	20.0 U	5030	7.87	15.69
TP-8	11/21/1997	2.66	2.59	20.0 U	9770	6.71	14.30
TP-9	11/21/1997	6.76	6.70	20.0 U	OR	6.62	14.12
TP-10	11/21/1997	2.68	2.48	34.2 B	7790	6.92	14.73
TP-11	11/22/1997	0.002	0.001 B	10.0 U	6930	8.34	15.76
TP-12	11/22/1997	1.68	1.46	482.0	4760	7.12	15.39
TP-13	11/22/1997	2.48	2.53	20.0 U	500	6.98	15.20
TP-14	11/22/1997	4.79	4.98	20.0 U	OR	7.66	14.31
TP-15	11/23/1997	4.28	4.71	50.0 U	9596	7.75	13.49
TP-16	11/23/1997	0.248	0.213	50.0 U	OR	8.18	13.00
TP-17	11/23/1997	0.011	0.010 B	50.0 U	OR	7.06	13.05
TP-18	11/23/1997	0.013	0.012 B	50.0 U	OR	7.04	13.97
I-P-19	11/24/1997	0.001	.0005 u	50.0 u	OR	6.35	13.35
TP-20	11/24/1997	0.003	0.005 u	50.0 u	OR	6.76	17.47
I-P-21	11/24/1997	*0.011*	0.010 B	50.0 u	OR	8.70	13.03

Existing Atlas Wells							
Location	Sample Date	Uranium[GJO] total, (mg/L)	Uranium[GJO] dissolved, (mg/L)	Vanadium[GJO] (ug/L)	Conductivity (umhos/cm)	pH	Temp (°C)
AMM-1	11/25/1997	NA	0.005 B	10.0 u	OR	6.60	18.63
ATP-2-S	11/25/1997	3.76	4.02	20.0 u	OR	6.60	18.83
ATP-3	11/24/1997	0.003	0.005	10.0 U	2330	7.50	18.50
PW-1	11/25/1997	26.50	NA	NA	OR	6.96	19.45
PW-2	11/25/1997	19.80	NA	NA	OR	6.80	16.87
PW-6	11/24/1997	21.90	NA	NA	OR	6.55	17.20
PW-9	11/24/1997	25.70	NA	NA	OR	7.20	16.40

Verification Sample Results Shown in Parenthesis
[ORNL] Analysis by ORNL/GJ
[GJO] Analysis by GJO Analytical Laboratory
B: Estimated Value
U: Undetected/Detection Limit
OR: Overrange
NA: Not Analyzed

3.2.2.4 Contaminant Distribution

Groundwater samples collected from the piezometers and existing wells'were used to prepare plume diagrams for eight constituents (alkalinity, ammonia, chloride, molybdenum, nitrate, selenium, sulfate, and uranium). Because vanadium copper, and arsenic concentrations do not show development of a contaminant plume, they are not depicted.

The limits imposed on the scope of the investigation (lack of groundwater data under the tailings pile and a fixed number of piezometers on the flood plain), account for the uncertainties which are denoted with question marks in the plume diagrams. It should be noted that the data from the tailings pore-water wells (PW series wells in Table 3.8) were not used in the preparation of the plume diagrams because the tailings pile is considered to be a separate hydrologic system. However, the connection between groundwater and tailings pore water is known to exist and is confirmed by the historically higher constituent concentrations in the tailings pile wells (e.g. PW-6 in Table 3.8). Therefore, the rationale used for the plume diagrams is that the tailings pile continues to provide the source of groundwater contamination. The data used in the plume maps' preparation are presented in Table 3.8. Following are discussions on the distribution of each of the aforementioned eight constituents.

Alkalinity

The distribution of the alkalinity data in Fig. 3.8 suggests that milling operations and the tailings impoundment have influenced this water quality parameter. The highest alkalinity values are bracketed by wells ATP-2-S, OW-2, TP-09, TP-14 and TP-15 in Fig. 3.8 and illustrate a band of uniform concentration of about 1300 mg/L present between the foot of the tailings pile and the Colorado River.

Ammonia

The ammonia distribution is shown in Fig. 3.9. The highest ammonia values are bracketed by wells ATP-2-S, OW-2, TP-09, TP-14 and TP-15. The ammonia value in TP-09 is the highest measured in the floodplain piezometers. TP09, however, is not represented as the focal point of the ammonia plume for two reasons. First, ammonia data collected from the tailings pile wells (PW-2 and PW-6 in Table 3.8), combined with water level data from the tailings pile, suggests that more concentrated ammonia, driven by the significant head differential (tailiis water vs. groundwater) may continue to leach into the groundwater. Secondly, although OW-2 is generally upgradient of TP-09, review of the potentiometric

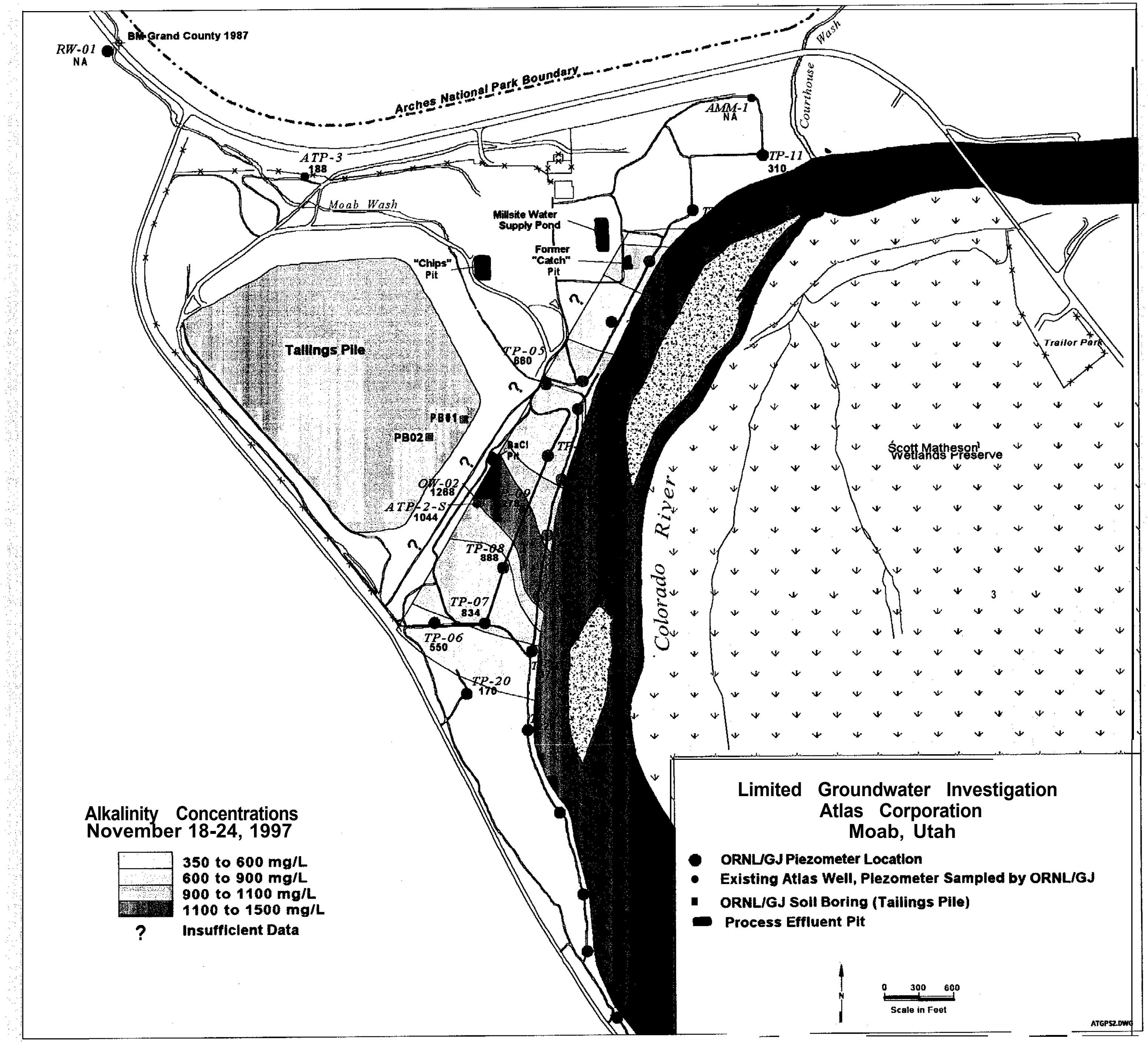


Fig. 3.8. Distribution of alkalinity concentrations in groundwater, November 24, 1997.

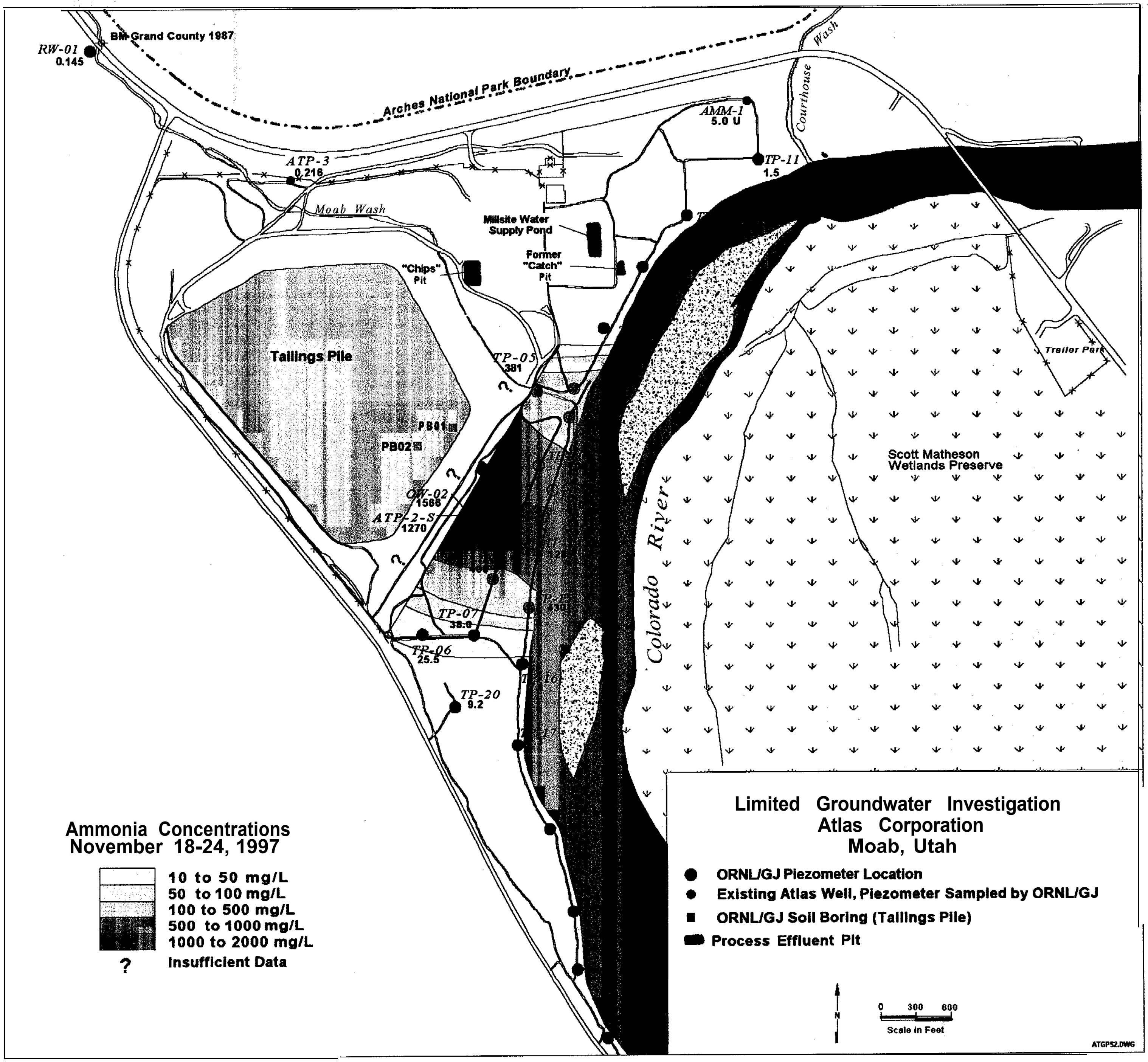


Fig. 3.9. Distribution of ammonia concentrations in groundwater, November 24, 1997

surface map (Fig. 3.6) indicates that OW-2 is south of the flow line, for TP-09. Therefore, the higher ammonia in TP-09 could be passing to the north of OW-2.

Chloride

The distribution of the chloride data in Fig. 3.10 suggests that neither the mill tailings impoundment nor mill operations have influenced this water quality parameter. In fact, the high chloride concentrations in groundwater south of the tailings pile are associated with the salt beds of the Paradox Member that have, either through faulting or dissolution, come in contact with the shallow alluvial system (Blanchard 1990).

Molybdenum

The distribution of molybdenum is shown in Fig.3.11. The broad band of molybdenum concentrations in the1000 to 2000 ug/L range covers a sizeable potion of the floodplain in front of the tailings pile. The high molybdenum value (2060 ug/L) observed in TP-04 is difficult to evaluate without additional data. It should be noted, however, that TP-04 is located at the downgradient edge of the "bone yard"; an area where many different materials were disposed of during mill decommissioning efforts (personal communication between Frank Gardner and Dale Edwards on December 16, 1997).

Nitrate

The distribution of nitrate data in Fig. 3.12 suggests that the millsite operation and the mill tailings impoundment have influenced this water quality parameter. The higher nitrate value associated with TP-03 could result from the use of nitric acid in the regeneration of the resin used the in the uranium milling process (personal communication between Frank Gardner and Dale Edwards on December 16, 1997). The higher values downgradient of the tailings impoundment may be a result of microbial oxidation of ammonia. The higher nitrate in TP-06 has been contoured to show a separate connection with the southwest corner of the tailings impoundment. It should be noted that well AMM3 is located generally upgradient of TP-06 but is screened in a deeper interval of the gravel and would not yield a good comparison. Therefore, AMM-3 was not included in the sampling program conducted by ORNL/GJ.

Selenium

The distribution of selenium is shown in Fig. 3.13. The rather narrow distribution of selenium is cons&tent with the fact that selenium is not highly enriched in the tailings (Table 3.3). Selenium also tends to be somewhat less mobile than uranium and molybdenum (DeVoto 1978).

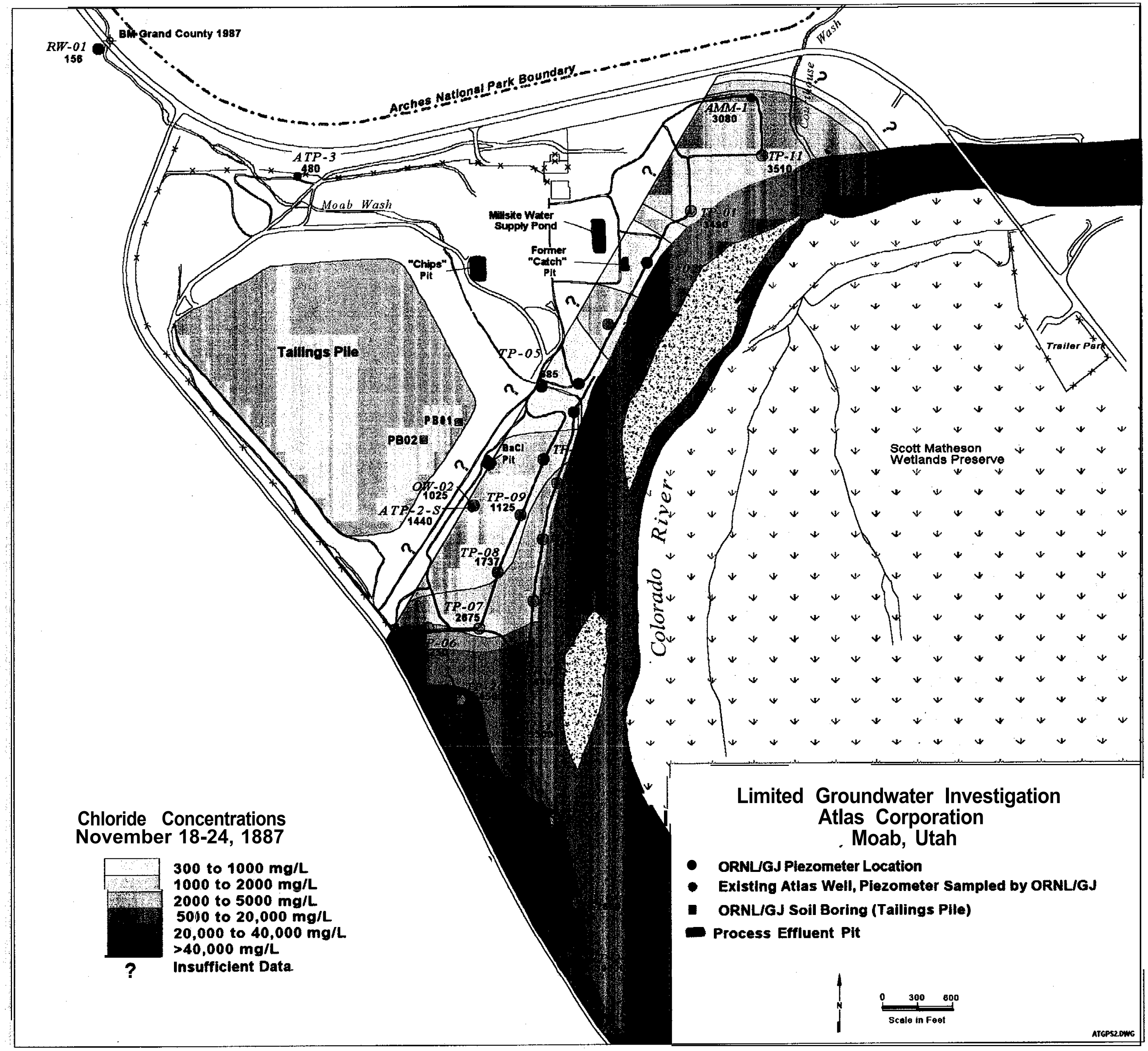


Fig. 3.10. Distribution of chloride concentrations in groundwater, November 24, 1997

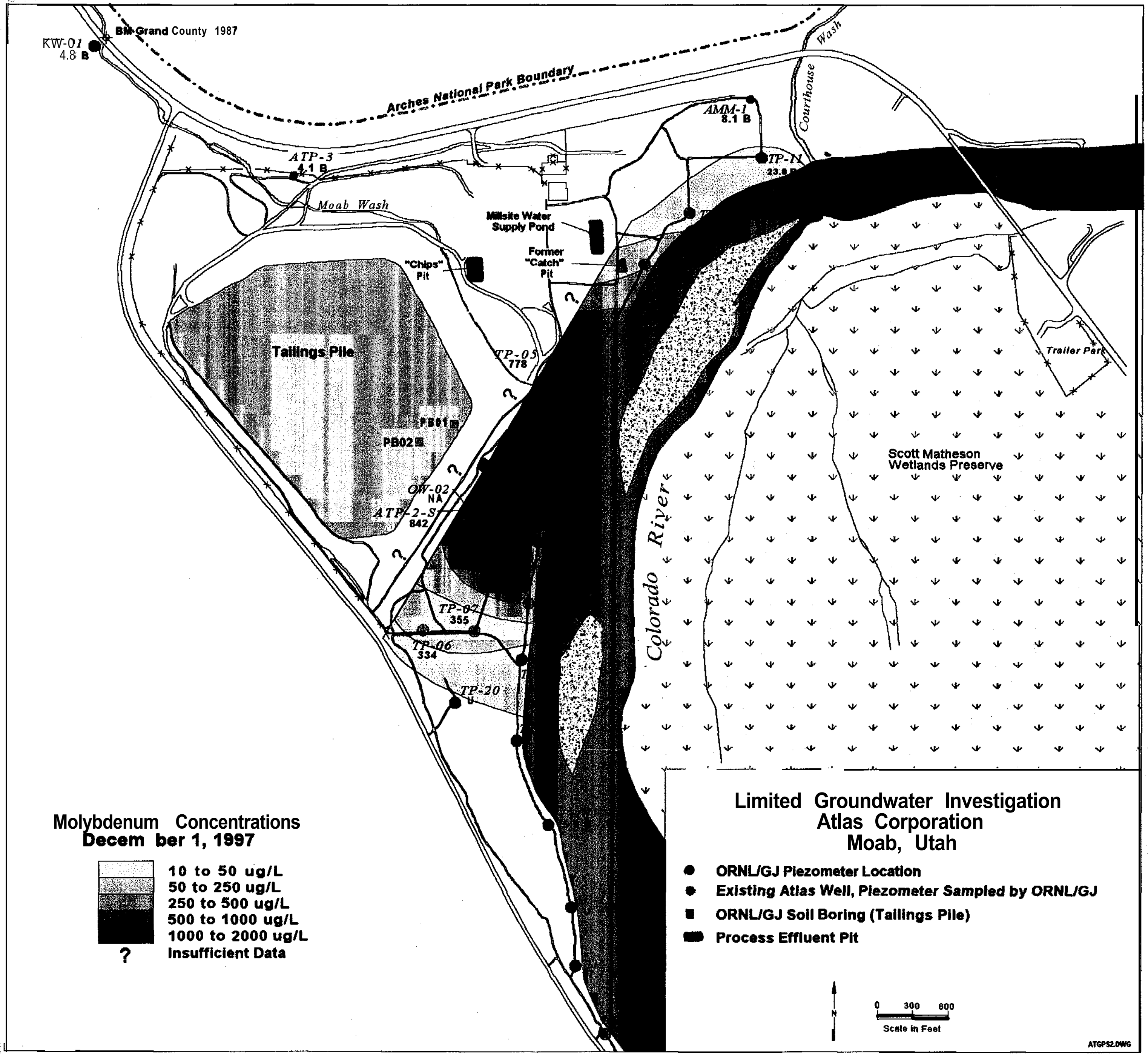


Fig. 3.11. Distribution of molybdenum concentrations in groundwater, December 1, 1997.

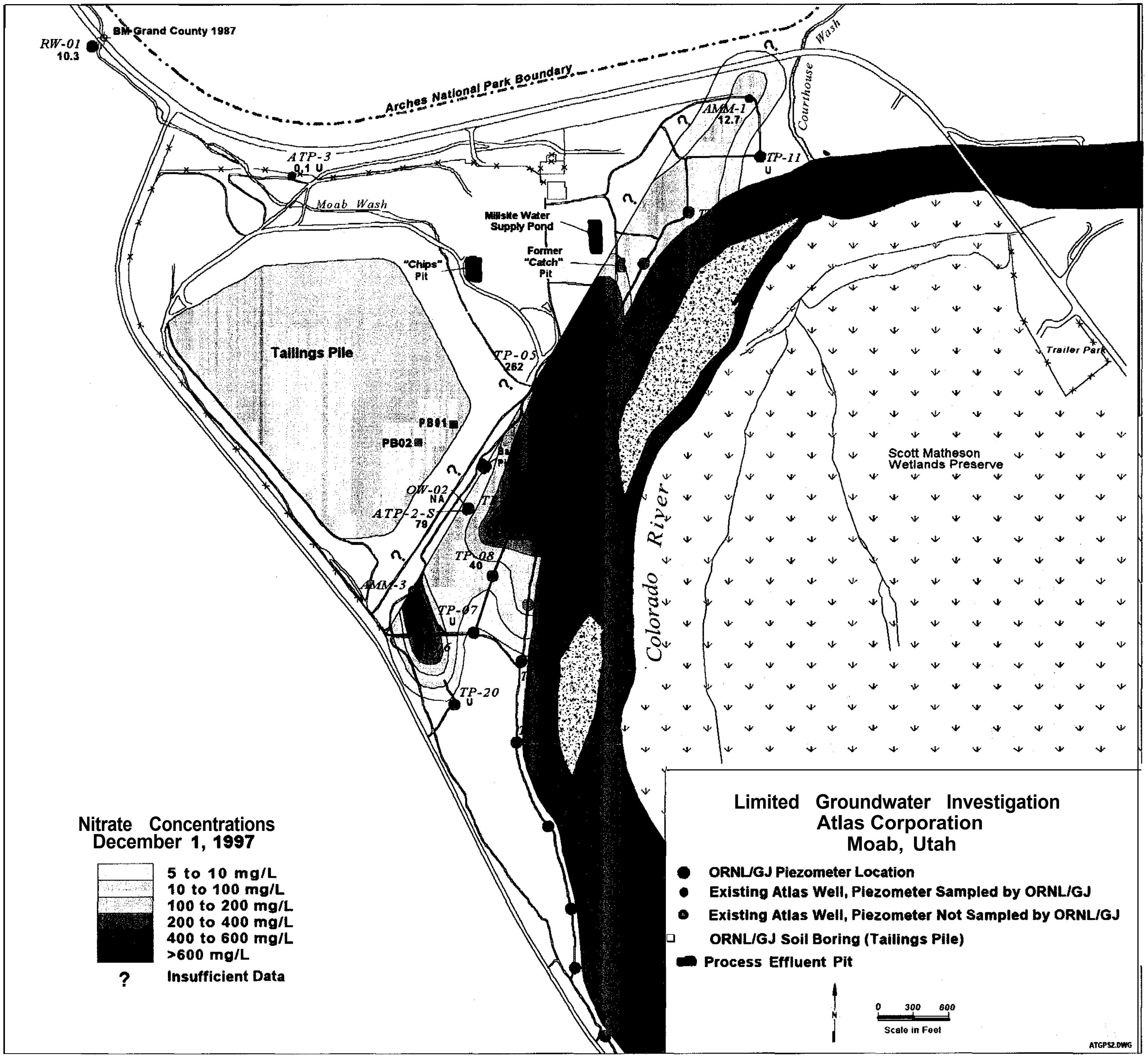


Fig. 3.12. Distribution of nitrate concentrations in groundwater, December 1, 1997.

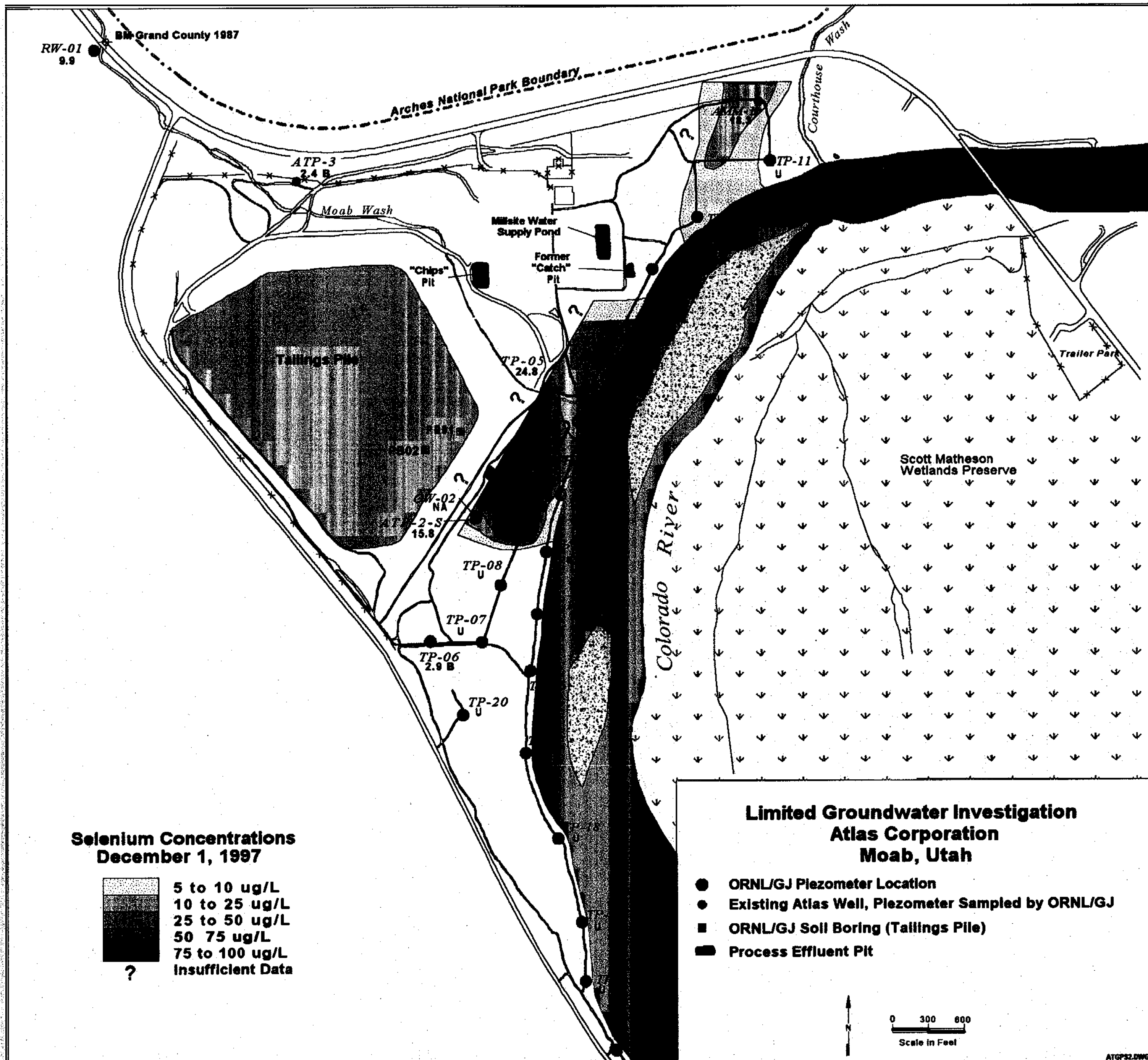


Fig. 3.13. Distribution of selenium concentrations in groundwater, December 1, 1997.

Sulfate

The distribution of sulfate in Fig. 3.14 suggests that the mill tailings impoundment has had a significant effect on this constituent. The broad band of sulfate concentrations greater than 12,000 mg/L extends to the Colorado River.

Uranium

The distribution of uranium is shown in Fig. 3.15. The presence of the high uranium values in TP-02 and TP-03 suggest the presence of a separate source from the tailings pile. A potential souree could be the former "catch pit" adjacent to TP-02, which was, according to site personnel, the first such pit used during the early operation of the mill. Reportedly, the pit received effluent from the mill operations such as the nitric acid used during resin regeneration (personal communication between, Frank Gardner and Dale Edwards on December 16, 1997). It is likely that the nitric solution was impregnated with uranium. The distribution of uranium on the floodplain is consistent with the distribution of the other mobile constituents (sulfate and ammonia) previously discussed.

3.2.2.5 Contaminant Mixing Simulations

By comparing contaminant concentrations in the tailings pile, with concentrations in the groundwater immediately downgradient, and estimating groundwater flux rates, it is possible to calculate the flux of water being contributed by the pile under present conditions. This estimate provides a baseline for assessing the magnitude of the discharge from the pile to the groundwater system and the amount of recharge to the pile from precipitation. This estimate also provides insight on future contributions of contamination from the pile to the underlying groundwater system. The accuracy of this estimate relies on the assumptions of a uniform flux rate through the aquifer and that contaminant concentrations in the pile and the downgradient monitoring wells are accurate. Quasi-steady state conditions are also assumed.

A simple mixing equation is used as follows:

$$C_{DG} = \frac{C_p Q_p + C_{gw} Q_{gw}}{Q_p + Q_{gw}}$$

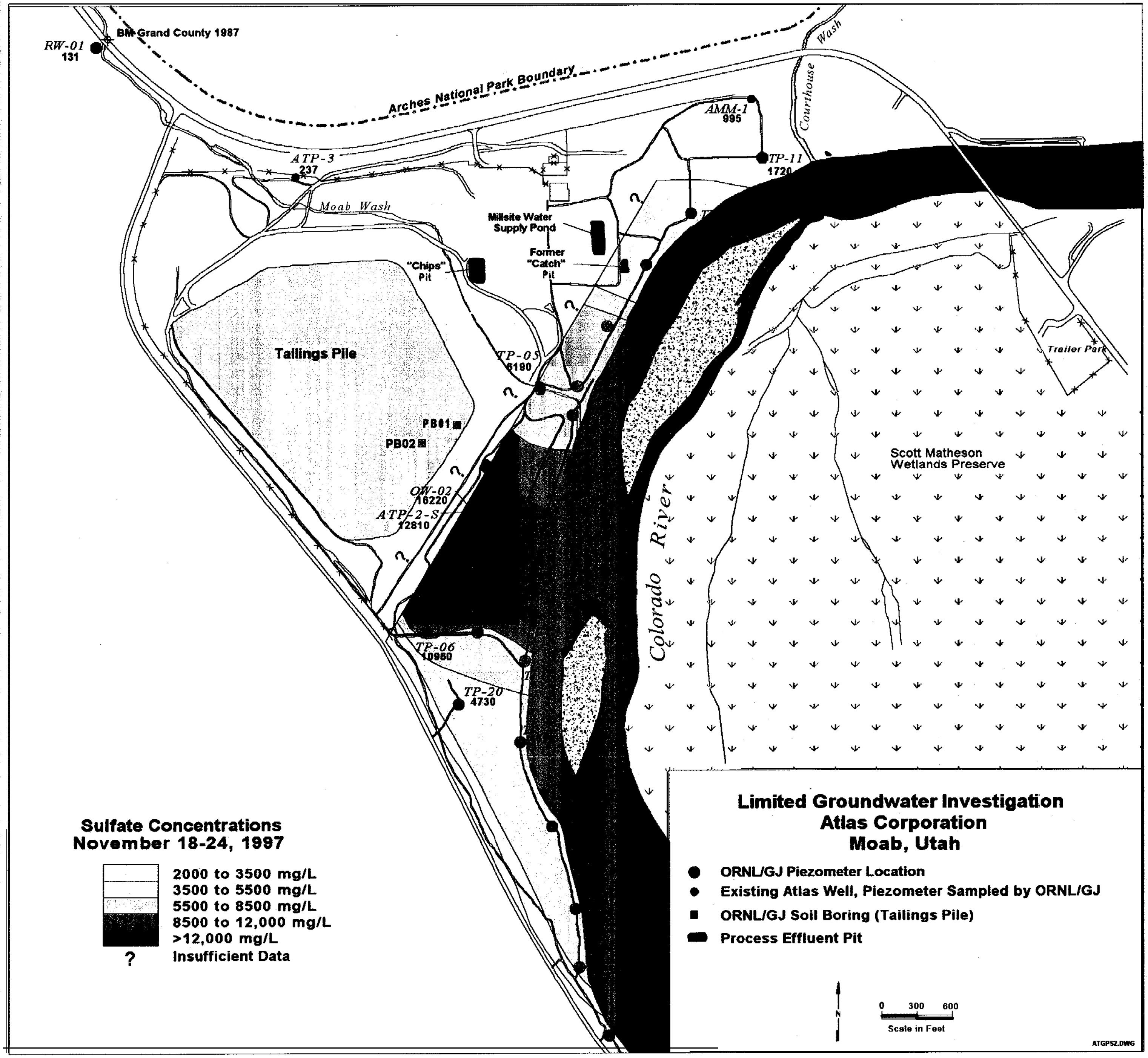


Fig. 3.14. Distribution of sulfate concentrations in groundwater, November 24, 1997.

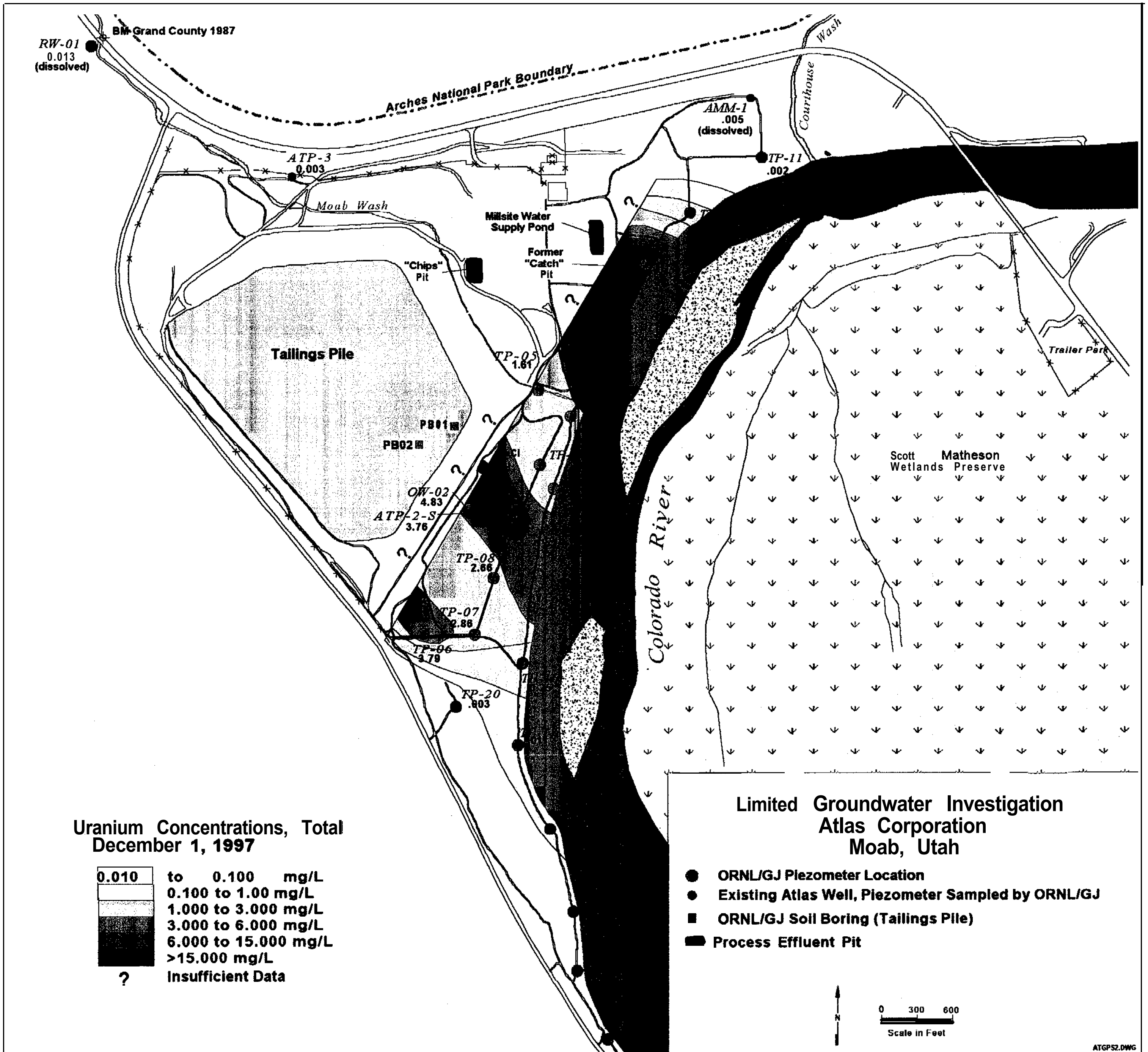


Fig. 3.15. Distribution of uranium concentrations in groundwater, December 1, 1997.

where:

C_{DG} = contaminant concentration in groundwater downgradient of the pile
C_p = contaminant concentration in tailings pile water
Q_p = flux of water discharging from the tailings pile
C_{gw} = concentration of contaminant in groundwater upgradient of tailings pile
Q_{gw} = flux of groundwater underneath the pile

It is possible, therefore, to estimate the unknown discharge of contaminated water from the tailings pile (Q_p) to the underlying alluvial aquifer based on the flux of groundwater in the alluvial aquifer beneath the tailings pile and contaminant concentrations in the pile water and downgradient groundwater. Average concentrations for uranium, sulfate, and ammonia from selected wells completed in the tailings pile and downgradient within the heart of the contaminant plume are presented in Table 3.9. Background contaminant concentrations were based on water quality information from well RW-1 (See Table 3.8) located upgradient of the tailings pile.

Using the above equations for the three analytes, mixing calculations yield a discharge from the pile of 6.7 gpm for uranium, 66.3 gpm for sulfate and 20.9 gpm for ammonia. The mixing calculation for uranium has been provided as an example in Table 3.10. Of these three analytes, uranium is the most reliable based on the uniformity of concentrations from the tailings pile wells and the conservative nature of the uranyl carbonate ion in the geochemical environment at the site. Sulfate is not reliable for this calculation because the solubility limits of several of its salts are probably exceeded. Ammonia is probably retarded by aquifer sediments and also oxidized to nitrate to some extent.

Using the results of the mixing simulations, the volume of water presently in the pile, unsaturated hydraulic characteristics of the tailings , and the drainage rate of residual water in the pile, it is possible to estimate the time required for the pile to drain. As discussed in the companion report for the NRC, recharge through the tailings pile resulting from precipitation and subsequent infiltration is estimated to be 3.7 gpm for the entire pile. Subtracting the recharge due to precipitation from the total recharge of 6.7 gpm based on the uranium mixing calculations, yields a residual drainage from water in the pile of 3.0 gpm. Based on an estimated tailings volume of 7.5 x 10^6 cubic yards (NRC 1997), a porosity of 0.66 (Klute and Heerman. 1978), and a residual moisture content of 0.57 (Klute and Heerman 1978), (percent of pore volume that will not drain under gravitational or capillary influences), there are approximately 426 million gallons of water under saturated conditions that are available for drainage from the pile. The pile may not be fully saturated but considering that water from the pumping operation has been discharged on the top of the pile and that there is a large lake from recent rains, it appears likely that the moisture content of the pile is high. Using the vohune of drainable water divided by the drainage rate of 3.0 gpm estimated above, 270 years

Table 3.9 Contaminant concentrations from selected wells ysed in the mixing calculations			
Tailings Pile Wells			
Well	**Uranium (mg/L)**	**Sulfate (mg/L)**	**Ammonia (mg/L)**
PW-1	26.5	15786	1070
PW-2	19.8	23679	2470
PW-6	21.9	3 1484	3940
PW-9	25.7	18505	1800
Average	23.5	22363	2320
Downgradient Wells			
Well	**Uranium (mg/L)**	**Sulfate (mg/L)**	**Ammonia (mg/L)**
TP-08	2.67	10250	409
TP-09	**6.76**	**16005**	**1895**
TP-14	4.79	14909	1285
TP-15	**4.28**	**22500**	**430**
Average	4.62	15916	1005

Table 3.10. Example mixing calculated for estimating discharge from tailings pile based on uranium concentrations

---

$$C_{DG} = \frac{C_p Q_p + C_{gw} Q_{gw}}{Q_p + Q_{gw}}$$

$$Q_p = \frac{C_{gw} Q_{gw} - Q_{gw} C_{DG}}{C_{DG} - C_p}$$

$$Q_p = \frac{(0.013)(27.4) - (27.4)(4.62)}{(4.62) - (23.5)}$$

$$Q_p = 6.7gpm$$

where:

Q_{gw} = – KiA

Q_{gu} = (22 ft/d)(0.004)(2000 ft)

Q_{gw} = 5,280 ft^3/d (27.4 gpm)

K = hydraulic conductivity based on pump test

i = hydraulic gradient based on potentiometric map

A = thickness of aquifer (based on borings B-l, B-2, B-3, B-4, B-14, and B-17) multiplied by the width of the pile (2000 ft)

C_{DG} = 4.62 mg/L (from Table 3.9)

C_p = 23.5 mg/L (from Table 3.9)

C_{gw} = 0.0 13 mg/L (from reference well)

Q_{gw} = 27.4 gpm

Q_P = ?

would be required to drain the pile. Because the 3.0 gpm drainage rate represents a maximum rate under the assumptions listed above, this time estimate is a minimum value. Under actual conditions, the drainage rate would decrease exponentially yielding a significantly higher time estimate for the complete drainage of the pile.

The results of the mixing simulations can also be used to estimate the concentration of contaminants in the groundwater after the tailing pile has fully drained and steady-state conditions exist. The mixing simulation calculation used to estimate the concentration of uranium in the groundwater downgradient of the pile is presented in Table 3.10. Using a discharge rate from the tailings pile of 3.7 gpm, based on the yearly recharge from precipitation, the average concentration of uranium in the groundwater downgradient of the pile is calculated to be 2.8 mg/l– a concentration level that can be expected to persist indefinitely.

3.2.2.6 Contaminant Flux Calculation

Based on the hydraulic properties of the alluvial aquifer and the contaminant distributions illustrated in Figs. 3.8 through 3.15, it is possible to estimate the flux of contaminants discharging from the groundwater system into the nearby Colorado River. Groundwater flow rates were. calculated using results from the pumping test discussed in Section 3.2.2.2 and the hydraulic gradient determined from the potentiometric map based on recent water level measurements from existing and recently installed wells. Contaminant discharge values are based on the width and concentration of the plume at the river and the thickness of the aquifer.

The coarse-grained portion of the shallow aquifer that contains the bulk of contamination was estimated to average approximately 40 ft in thickness based on the following data:

- The boring log for well ATP-2-S (Appendix C), indicates that coarse sand and gravel make up the lithology between 15 and 55 ft below ground surface.

- In addition, the pump test discussed in Section 3.2.2.2, showed minimal drawdown in the lower completion (ATP-2-D) suggesting that the shallow gravel aquifer is hydraulically isolated from the deeper aquifer by the finer-grained sand unit denoted at 55 ft m the boring log for ATP-2-S.

- It is also assumed that the contamination is distributed uniformly with depth. This assumption is supported by wells OW-2 and ATP-2S that are screened in the upper (20 to 30 ft) and lower (28 to 38 ft) portions of the shallow aquifer and show similar contaminant concentrations. For example, uranium is 4.83 and 3.76 mg/l in wells OW-2 and ATP-2-S, respectively.

ORNL/GJ is aware that the estimation of aquifer thickness and the use of average concentrations introduces error. However, the use of average concentrations and an estimate of 40 ft for the alluvial aquifer thickness is the most reasonable approach based on 'the limited data now available. Table 3.11, which presents the raw data used in the flux calculation for uranium, requires some explanation. First, the width values presented in Table 3.11 were determined by measuring the width of each concentration range depicted in Fig. 3.15 where it intersects the Colorado River. Second, the average concentration values listed in Table 3.11 are representative of the median value for each of the concentration ranges shown in Fig. 3.15. In other words, for the concentration range shown as 0.1 to 1 mg/L in fig. 3115, the median value listed in Table 3.11 is 0.5 mg/L. It should be noted that the lowermost concentration range in Fig. 3.15 was omitted. The mass flux of uranium for each of the width values was then calculated using the equation presented in Table 3.11. All of the resulting flux values were then. added together to yield the total mass flux of uranium in grams per day (g/d) that is discharging to the Colorado River. The same approach was used to calculated the flux values for molybdenum, ammonia, and sulfate. The calculated flux values are presented below:

Analvte	Estimate Mass Flux (gram/day)
Uranium	283
Molybdenum	290
Ammonia	150,000
Sulfate	11,000,000

3.2.3 Task B/C Conclusion

The results of the plume delineation and riverside groundwater quality assessment tasks indicate that former mill operations and the existing tailings impoundment have adversely affected groundwater quality and that the groundwater discharges to the Colorado River. Calculating the effects of the contaminant discharge on river water quality and the river ecology was not included in the scope of the task. It should be noted that Atlas personnel did collect water samples from the river concurrent to the groundwater samples

Table'3.11. Example calculation for uranium discharge from alluvial aquifer to the Colorado River

Uranium width, ft	Depth, ft	Darcian velocity, ft/d	Average conc., mg/L	Mass flux, gm/d
450	40	0.088	0.5	22.4
150	40	0.088	2	2.9
900	40	0.088	4.5	40
850	40	0.088	2	16.9
250	40	0.088	4.5	'11.2
120	40	0.088	11.5	13.7
1050	40	0.088	15	156
100	40	0.088	11.5	11.5
75	40	0.088	4.5	3.3
125	40	0.088	2	2.5
200	40	0.088	0.5	0.9
			Total Mass Discharging to River:	282.5

Mass flux = [width of contaminant zone] [aquifer thickness] [Darcian groundwater velocity] [uranium concentration]

Width of contaminant zone: Based on plume map, average concentration of uranium

Aquifer thickness: Assumed to be 40 ft based on well ATP-2-S

Darcian groundwater velocity:

$q = -Ki$
$q = (22 \text{ ft/d}) (0.004)$
$q = 0.088 \text{ ft/d}$

samples collected by **ORNL/GJ**. The river sample results, however, were not available when this report was completed and, therefore, could not be part of the evaluation

3.3 Reference Well Installation (Task D)

The drilling of this well was included based on concerns expressed at the Sept. 9 meeting at NPS offices in Moab. At that time, meeting participants from FWS, NPS and the State of Utah expressed concerns about the adequacy of wells being used to assess background conditions at the pile. Apparently, ATP-3 (Fig. 3.6) had been installed originally as the background well. At some point, data were obtained that led Atlas to decide that ATP-3 might be contaminated. In addition, the well is apparently dry on occasion. Hence, AMM-1 was installed. Concern was still expressed, however, that AMM-1 was contaminated and that the northern extent of the plume was not known. Concern was also expressed that contamination might have migrated to NPS property to the north. To address these concerns, the initial letter proposal fi-om ORNL-GJ (Appendix A) proposed installation of a new background well. At the October 23 meeting, however, participants from Atlas and NRC stated that this well was not necessary from a technical standpoint, but that they favored installation because of the need to. address criticisms of the existing sampling program. The term "background" well, however, was deleted from the revised ORNL statement of work because Atlas and NRC were skeptical that the well could be installed in the same geologic unit as the alluvium in question. For that reason, the term "reference" well was applied.

3.3.1 Task Planning

The final location of the reference well (RW-1) was determined after the field work was in progress. To avoid possible influences from former uranium ore storage areas, the well was located to the northwest of the intersection of the Potash Road (Hwy. 279) and the Moab Hwy. (Hwy. 191). The well is located on land administered by the Bureau of Land Management but currently under a right-of-way agreement with the NPS. Additionally, a Utah Department of Transportation permit (No. 97-274-44) was obtained as the well is located within the 200-ft right-of-way adjacent to Hwy. 191 and is include in Appendix D. Finally, utility clearances were obtained by contacting Utah Blue Stake (Reference number 3360030) and arranging for a meeting with various utility representatives. Afer fiualizing the location, the applicant card for monitoring well 97-O 1-00 1-M was filed with the State of Utah Division of Water Rights. A copy of the well driller's report filed with the State of Utah Division of Water Rights is included in Appendix D.

3.3.2 Data Collection

The reference well was installed using the methods described in section 3.1. Well development efforts comprised pumping and surging with a Grundfos **Rediflo ®** submersible pump. Approximately 350 gallons of water and sediment were removed from the **well before** a **sample** of clear water was collected for the laboratory analyses described in Sections 2.1.5 and 3.2.2.2.

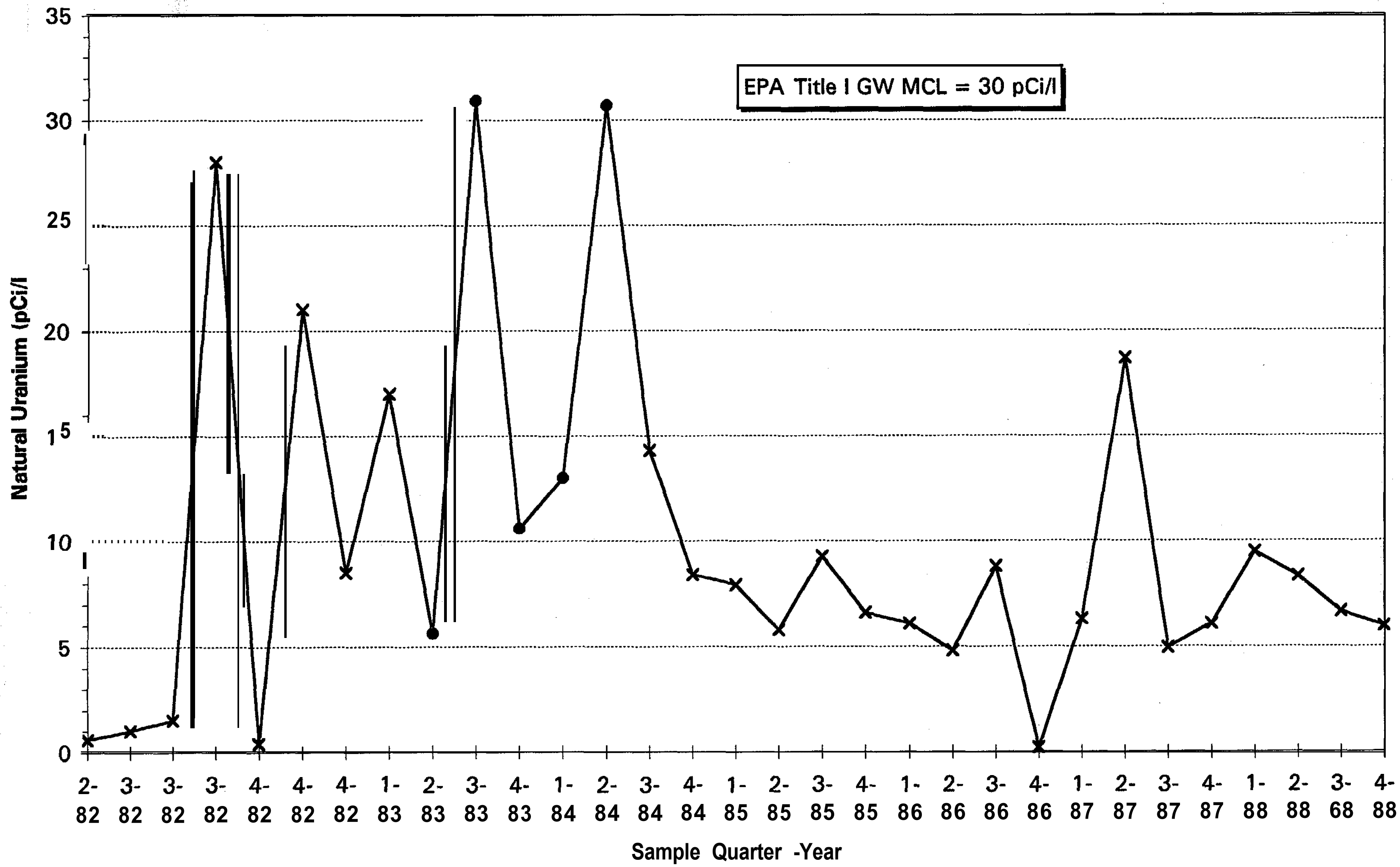
3.3.2.1 Data Analysis

Water from RW-1 was analyzed, as was water from AMM-1 and ATP3.. A review of the data in Table 3.8 and the plume delineation maps presented in Section 3.2, indicates that **AMM-1 is not contaminated**. For example, results **from** TP-O 1 and TP-11 show that the uranium and molybdenum contamination associated with TP-02 and TP-03 does not extend to AMM-1. The selenium result for AMM-1 is elevated but high background concentrations of selenium are common throughout the local area. AMM-1 is located near Courthouse Wash and the elevated selenium is probably a consequence of natural deposits in that area. The elevated nitrate result is unexpected but, in the absence of other analytes suggestive of the **millsite** operations, cannot be attributed to the tailings pile.

It is also instructive to review data from ATP3. Uranium data provided **from** 1982 through 1988 (Table 3.12) revealed rather erratic results that reportedly ranged from approximately 1 to slightly more than 30 **pCi/l (1.5** to 44 **ug/L).** Data were very erratic in the 1982 **- 1984-time frame** but **from** 1984 until 1988, results were mostly recorded as between 5 and 10 **pCi/l (7.3** to 14.6 **ug/L).** These samples were analyzed at the Atlas in-house laboratory. Although it could not be verified, an inspection of the in-house laboratory suggests that the samples were run by the pellet flurometric method, This method is prone to erratic results, especially with low-level samples. The precision of the method is also very operator dependent. Thus, the few high results are likely to be a consequence of the analytical method. In **summary,** the uranium, ammonia and molybdenum results, all indicate that ATP-3, at least for this sampling period, is not affected by conditions at the **millsite.**

The reference well (RW-1) was installed **northeast of the millsite on land administered** by the Bureau of Land Management. The well is located between Arches **National** Park and the millsite. A boring log for the reference well is included in Appendix C. Inspection of **Fig 3.4 and** the boring log for RW-1 in Appendix C, shows that RW-1 is in the same hydrogcologic unit as the wells on the millsite. Analytical

Table 3.12 Uranium data for well ATP-3 for the period from 1982 to 1988



Source: Data provided by Utah Department of Environmental Quality results for RW- 1 (Table 3.8), demonstrate that the well is not contaminated with uranium, ammonia or molybdenum.

3.3.3 Task D Conclusion

The above discussion indicates that the **reference** well is sampling background and provides a useful reference point between the millsite and Arches National Park. It should be noted that **RW-1 does have unexpectedly high nitrate**. **As with AMM-1, the appearance of nitrate, without** the other tailings-related **contaminants, does not indicate any connection to the millsite.**

4.0 References

Blanchard, Paul J. 1990. *Ground-Water Conditions in the Grand County Area, Utah, With Emphasis on the Mill Creek-Spanish Valley Area.* Technical Publication No. 100, State of Utah, Department of Natural Resources. Prepared by the United States Geological Survey in cooperation with the Utah Department of Natural Resources Division of Water Rights.

Canonie Environmental 1994. *NRC Technical Information Request, Atlas Corporation Ground Water Corrective Action Plan Uranium Mill Tailings Disposal Area. Moab, Utah.* Project 88-067. July 1994. Canonie Environmental Services Corporation, Englewood, Colorado.

Dames & Moore 1973. *Supplement to Environmental Report, Moab, Utah Facility for Atlas Minerals.* Job No. 5467-003-06.

Dames & Moore 1981. *,&port of Engineering Design Study Additions to Tailings Pond - embankment System. Moab, Utah for Atlas Minerals.* Job No. 5467-018-06. February 15, 1978. New printing May 26, 1981.

DeVoto, R. H. 1978. Uranium Geology and Exploration. Colorado School of Mines, Golden, Colorado.

Freeze, R.A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc. Englewood Cliffs, New Jersey *07632.*

Gilbert, R. 0. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold, ISBN O-442-23050-8, New York.

Kearl, P.M., R. J. Zinkl, J. J. Dexter, J.E. Price, and P. R. Engelder. 1988. Procedure, analysis, and comparison of groundwater velocity measurement methods for unconfined aquifers. DOE/ID/12584-10, UNC/GJ-37 (TMC), NTIS, Springfield, VA.

Klute, A., and D. F. Heerman. 1978. Water movement in uranium tailings profiles. Tech. Note, ORP/LV/78-8, EPA Office of Radiation Programs, Las Vegas, NV.

NRC 1997. NUREG-1532, Final Technical Evaluation Report--For the proposed revised reclamation plan for the Atlas Corporation Moab Mill; Source Material License No. SUA-917, Docket No. 40-3453, Atlas Corporation. U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, March 1997.

Appendix A

Appendix A presents the initial and final letter proposals prepared by ORNL/GJ. The initial proposal is dated September 17, 1997 and the final proposal is dated October 29, 1997.

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

PHONE: (970) 248-6210
FAX: (970) 248-6147

INTERNET: kortene@ornl.gov

2597 B 3/4 Road
Grand Junction, Colorado 81503

September 17, 1997

Mr. R. Bruce Rodgers
Chief, Division of Resource Management
National Park Service
Department of the Interior
2282 S. West Resource Blvd.
Moab, Utah
84532

Dear Bruce:

Enclosed please find the requested information regarding our proposed work at the Atlas Millsite. The first attachment is an annotated task list and cost estimate for the work. We have separated the work into specific tasks such that you can prioritize them if necessary. In addition, we have added narrative discussion to describe the expected benefit from the proposed work along with some pros and cons. Note our assumption, based on the September 9, 1997 meeting, that the State of Utah will provide the laboratory analytical support. We can provide the laboratory support at additional cost if necessary.

The second attachment is some descriptive material on our group. Our emphasis has been to solve hydrologic and sampling problems that are typically beyond that provided by private contractors. We have also been at the forefront of developing and using on-site analytical capability — although such an approach is now relatively common.

For your information, two grab samples of surface water were collected when the reconnaissance trip was performed on September 15, 1997. River stage was estimated by Park Service personnel in attendance at approximately 8,000 cfs. Our sample from a seepage face (surface flow) in Moab wash contained 3580 ppm sulfate and 190 ppm ammonia (as N). A sample collected from the river's edge at the confluence of the wash arid the river contained 437 ppin sulfate and 2.4 ppm ammonia.

As I recall, early next week there will be a meeting in Washington regarding this proposed work. I will be out of the office Monday through Wednesday but Frank Gardner will be able to answer any questions. In addition, please keep us appraised of developments regarding timing and funding. If we have advance notice, we can ensure that the necessary equipment and personnel are available and, more importantly, we can facilitate the movement of funds by alerting various people within the DOE system. The latter activity can often save a month or more in initiating a project.

If you have any questions, please feel free to call either me (970-248-6210) or Frank Gardner (970-248-6238) who will manage and direct the field work.

Sincerely,

Nic Korte
Group Leader, Restoration Technology

NEK: kah

Enclosures

c: F. G. Gardner (w/o attachment 2)
D. K. Halford (w/o attachment 2)
B. Hedden (w/o attachment 2)
B. H. Waddell (w/o attachment 2)

Attachment 1 - Description of Proposed Tasks/Cost Estimate

Although the tasks below are inter-related, each could be performed independently. Thus, the cost estimate is provided on a task-by-task basis. A final report is not shown as a specific task but is included in the cost estimate through the project management functions. That report will encompass all of the tasks and include all documentation that is typically expected for a project of this type.

P?

Task A: Installing a well through the pile to determine the connection between the tailings and the underlying water table.

Drilling through a waste site is often avoided because of the fear of cross-contamination. Unfortunately, drilling methods that provide assurance that cross-contamination cannot occur make,. sampling difficult and expensive. We have addressed this problem on numerous occasions and have provided two approaches for the Atlas site. Our preferred approach is to use a conventional auger rig. Hollow-stem augering with a continuous sampler provides the best samples and will yield the most assurance in determining the tailings/water table interface. Augering will cause a small amount of cross-contamination, but the quantity will be incidental and dwarfed by the amount of contamination already leached (and continuing to leach) through the pile.

An alternate approach is to use a dual-wall, reverse-circulation air rotary rig instead of augering. With this method, we can prevent cross-contamination but drilling and sampling are more expensive — approximately double the cost of using a hollow-stem auger. Our experience, however, has shown that the cost and time required for the dual-wall approach is not justified for a site such as this. Whichever drilling method is used, the visual and analytical data will be augmented with borehole gamma logging to verify the results from other measurement and visual techniques. In addition, in either case, the well will be constructed such that there will not be a conduit for cross-contamination down the borehole.

The attached cost estimate for this task assumes a single, 150-R well on the pile. Additional wells would cost approximately 20K each. If the dual-wall method were needed, the drilling cost shown in the cost estimate would increase from 12K to 24K.

Before drilling is initiated, existing data (photos, maps) will be reviewed extensively in order to determine the optimum location for the well(s).

Pros:

1) Provides direct observation of the relationship of the water table and the base of the tailings.

Cons:

1) Expensive.

2) Requires equipment not owned by ORNL. Thus, project initiation cannot be immediate because of the need to establish a drilling contract.

3) The bottom of the pile is probably not uniform. Because only a liited number of boreholes can be drilled, the data obtained may not be conclusive.

4) Many of the tailings contaminants are mobile in oxygenated groundwater. Leaching from rainfall and the spraying on top of the pile may have redistributed considerable quantities of the contaminants to the underlying aquifer whether or not tailings lie below 'the water table. These" circumstances are difficult to prove or disprove with a limited number of boreholes.

5) Health, safety, and access requirements that might be added by Atlas or NRC are unknown. Their requirements may be above and beyond ORNL rules and procedures and increase cost.

Task B: Plume delineation (Fig. 1).

Using an approximate spacing of 500 ft, we can delineate the plume with approximately 15 to 20 temporary piezometers using our small, mobile drilling rig. Two or three 2-inch permanent wells will be installed to obtain some data regarding the hydraulic conductivity. The permanent well locations will be selected based on field observations. Existing data will be reviewed initially. This review could result in some modification to the sampling plan. In addition, wells already present at the site may be sufficient for obtaining the necessary hydrologic data — assuming access is permitted.

Pros:

1) The width of the plume can be accurately determined while in the field using ammonia and sulfate as indicators.

2) The hydraulic connection of the plume and the river can be more accurately described.

- The hydraulic conductivity can be accurately measured.
- A potentiometric surface can be obtained that is much more accurate than those obtained previously.

(The latter two activities provide the gradient and flow rate of the plume. In addition, preferential pathways will be identified.)

3) The work can be initiated on short notice-because personnel and equipment are resident in Grand Junction.

4) Subsequent analyses of the groundwater, to be performed by the State of Utah, will show which contaminants are migrating and permit a more accurate calculation of the mass flux into the river.

Cons:

1) The proposed plan would provide a limited number of permanent wells. (More of them could be installed permanently if desired.)

Task C: Evaluate riverside water quality in the groundwater.

Seepage meters or mini-piezometers (3/4 in. ID) will be installed along the riverbank as a means of obtaining the quality of the water where it enters the river.

Pros:

1) These data will confirm (or not) the "grab" river samples collected by the State of Utah.

2) These samples will provide direct evidence of the location and quantity of contamination entering the river.

3) Rapid and inexpensive.

4) Because the sampling is through a well-casing, standard, approved sampling and analysis procedures can be used.

Cons:

None

Task D: Install new background well northeast of Atlas property.

Pros:

1) The installation of this well would alleviate continuing questions regarding the background water quality. Atlas believes that the background water has some of the same contaminants as those contributed by the pile. However, Atlas's background well is located in close proximity to a former ore storage area. The new well would be sufficiently upgradient, yet still in the same flow system to ensure an accurate description of background Water quality.

Cons:

1) ORNL's mobile rigs may not be capable of drilling this hole because the location may contain too many cobbles. To ensure successful completion of the hole, a drilling contract is necessary. (If Task A is included, drilling this well can be added easily and at relatively low additional cost.)

Task E: Modeling drainage from the pile.

This task was not discussed during the scoping meeting held in Moab. However, upon review of the data and the site, we learned that Atlas has been pumping water on top of the pile for sometime. Thus, the pile will continue to drain contaminated water even after it is capped. This drainage can continue for many years or even decades. Thus, we are proposing site specific calculations to show the long-term effects of the pile drainage. In other words, even if the pile is isolated from the groundwater by a cap, downward leaching of water within the unsaturated pile remains a source of contamination to the groundwater.

Pros:

1) Inexpensive estimate of the length of time that the pile will continue to contaminate the groundwater after capping is completed.

Cons:

None

Attachment 2 - Description of ORNL Grand Junction Office Capabilities

Appended are examples of work we have performed that is relevant to the problem posed by the Atlas Millsite.

Following those examples are sonie fact sheets that highlight other mill tailings related projects and the diversity of **geohydrologic** projects with which we have been involved.

OAK RIDGE NATIONAL LABORATORY
MANAGED BY LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
FOR THE U.S. DEPARTMENT OF ENERGY

PHONE: (970) 248-6238
FAX: (970) 248-6147

INTERNET: gardnerfg@ornl.gov

2597 B 3/4 Road
Grand Junction, Colorado 81503

October 29, 1997

Mr. Reed Harris
U.S. Fish and Wildlife Service
Lincoln Plaza, Suite 404
Salt Lake City, Utah 84 115

Dear Reed:

Enclosed please find the requested information regarding our revised proposed work at the Atlas Millsite. The first attachment is an annotated task list and cost estimate for the work. We have separated the work into specific tasks such that you can prioritize them if necessary. In addition, we have added narrative discussion to describe the expected benefit from the proposed work along with changes to the scope resulting from the meeting held in Denver last Thursday, October 23.

You will notice a marked increase in the attached cost estimate. This results from increasing scope of drilling activities on the tailings pile, use of more expensive drilling methods, and increased scope for the tailings pile drainage model. The latter task was included at the request of NRC following the meeting last week. Increased costs also result from a new fiscal year cost center rate which reflects an increase of $6 per hour.

We find ourselves in a tenuous situation as the players and agendas unfold. While it is our intent to deliver the findings of the testing program with unbiased objectivity, we also feel our credibility is at risk due to factors beyond our control at this point. We made verbal commitments to a 60-day schedule last week in Denver assuming a relatively quick starting date (i.e., a week or two). However, the outstanding or unresolved issues (off site access, funding source, approval of expanded scope, etc.) looming in light of the existing commitments we have in December will require that we caveat the schedule. We will need to be activated (i.e., ORNL charge number in hand) by November 10 in order to meet the mid-January time frame for report delivery. We are hopeful that these issues will be worked through so that we may get into the field by November 10. Please keep us appraised of developments regarding timing and funding. If we have advance notice, we can facilitate the movement of funds by alerting various people within the DOE system.

If you have any questions, please feel free to call either me (970-248-6238) or **Nic** Korte (970-248-6210).

Sincerely,

Frank Gardner
Group Leader, Characterization Technology
Environmental Technology Section
Life Sciences Division

FGG: kah

Enclosures

c: R. E. Blubaugh (Atlas Corporation),
B. M. Campbell (CEQ)
M. H. Fliegel (NRC)
D. K. Halford (ORNL)
N. E. Korte (ORNL)
M. McUsic (DOI)
G. L. Ohland (HLA)
R. B. Rodgers (NPS)
B. H. Waddell (FWS)

Attachment 1 - Description of Proposed Tasks/Cost Estimate

Although the tasks below are inter-related, each could be performed independently. Thus, the cost estimate is provided on a task-by-task basis. A final report is not shown as a specific task but is included in the cost estimate through the project management functions. That report will encompass all of the tasks and include all documentation that is typically expected for a project of this type.

The following tasks reflect modifications resulting from a meeting held October 23, 1997 where representatives from interested parties (Atlas, NRC, FWS, and ORNL) were present.

Task A: Installing borehole(s) through the pile to determine the connection between the tailings and the underlying water table.

The purpose of this task is to confirm or deny the presence of tailings or slimes within the alluvial deposits under the tailings pile. The originally proposed well in the center of the tailings pile was changed by group consensus to a borehole to meet this objective and thus prevent the potential for a contamination conduit into the alluvial aquifer presented by a well. The presence of a pond in the center of the tailings pile may require an angled drilling approach where the rig would be better supported by drier sediments along the periphery. Following additional group discussion, a second borehole in the tailings pile was proposed to verify the validity of an earlier allegation placing tailings in the alluvium. If the review of the existing data do not support the allegation, the second borehole will not be drilled. However, the task is included in the cost estimate at this time.

Research and discussion carried out since the submittal of the original proposal has determined that drilling will be performed using the more expensive option (dual wall reverse circulation) for several reasons. Primarily, drilling in saturated tailings with a hollow stem auger could lead to problems associated with fine sands flowing up into the auger string. If this occurs, soil sampling and angle drilling is not feasible with hollow stem augers to the projected depth. Secondly, review of data on the alluvial composition has determined the presence of boulders and cobbles that would hinder auger drilling. Therefore, the drilling will be performed with a dual wall reverse circulation (DWRC) rig to prevent foreseeable problems associated with auger drilling. Soil samples (wire line split spoon) will be collected on 5ft intervals and the samples will be analyzed in the field for radium using ORNL's opposed crystal scanning (OCS) system. Two or three samples of the alluvial material below the tailings will additionally be analyzed for uranium (U), vanadium (V), arsenic (As), Copper (Cu), molybdenum (MO), and selenium (Se) as an additional measure of potential slimes migration, A lithologic log of the borehole using the United Soil Classification System will be prepared by the field geologist. Based on the results of the group discussion, gamma logging of the borehole will not be performed as the tailings material should be readily distinguished from the underlying alluvium by visual examination and the OCS radium analysis. All drilling and sampling generated waste (solid and liquid) will be recharged to the top of the tailings pile. Finally, a location/elevation survey will deliver state-plane coordinate data and ground surface elevations for the borehole location(s).

The attached cost estimate for this task assumes two, 150-R boreholes on the pile using a DWRC rig. Additional line items required for site access are grouped under training /medical requirements in the cost estimate. Atlas will require approximately one half of one day for site orientation for all personnel in addition to urinalysis testing for uranium for those working directly on the tailings pile. Lastly, analytical costs were also included to cover soil sample analyses previously discussed.

Before drilling is initiated, existing data (photos, maps) will be reviewed extensively in order to determine the optimum location for the boreholes. ORNL is working the Health and Safety issues with Atlas so that the field work can begin without delay.

Task B: Plume delineation (Fig. 1).

The purpose of this task is to delineate the lateral extent of groundwater contamination emanating from the tailings pile. These data will subsequently be used to locate the temporary piezometers proposed to evaluate groundwater quality where it discharges to the Colorado River (Task C). Locating the riverside piezometers without the lateral extent of the plume defined would be of limited benefit. Therefore, these tasks are inter-related and required to provide the comprehensive objective of the testing plan which is to assess contaminant flux into the Colorado River.

As a result of the group meeting on October 23, the first phase of plume delineation effort will begin on Atlas property as issues related to access to the adjoining private property to the south are resolved. ORNL is looking to NRC and the licensee for assistance with the property access issue as we are not in a position to negotiate with a private land owner. However, if the access issue is not pursued and the first phase of plume delineation indicates an off site problem, the comprehensive objective of the testing plan will be thwarted. Therefore, the temporary piezometers (1 in. OD) illustrated in Figure 1 have been grouped into two categories: those on Atlas property and those on private property. Review of existing data may result in some modification to the delineation approach by reducing the number of temporary piezometers proposed between the tailings pile and the river. Field screening parameters for plume delineation will include testing for ammonium (N) sulfate (SO,) alkalinity , conductivity, pH, and temperature. Confirmatory groundwater sample analysis will be limited to U, V, As, Cu, MO, and Se. One round of groundwater sampling is proposed. All drilling and sampling generated waste (solid and liquid) will be recharged to the top of the tailings pile. Permitting issues related to clearing of vegetative cover on the flood plain are also being resolved by FWS personnel.

As part of the plume delineation effort, two or three 2-inch permanent wells will be installed to obtain some data regarding the hydraulic conductivity of the alluvium. While ORNL recognizes that some existing data on aquifer characteristics (permeability and conductivity) has been collected in the past, we want to have utmost confidence on the basis used for groundwater/contaminant discharge calculations to the Colorado River. Additionally, use of existing hydraulic conductivity data collected using a variety of methods (slug tests and lab measurements) creates a range that can vary by an order of magnitude or more. Therefore, ORNL will collect hydraulic conductivity measurements based on pumping tests performed on the proposed two inch wells. The permanent well locations will be selected based on field observations and a review of existing data. This review could result in reducing the number of two inch wells if existing wells can be used to obtain the hydraulic conductivity data. ORNL has requested access to the most recent data from Atlas and Harding Lawson Associates. We do not have these data in hand and cannot make the necessary adjustments in the sampling plan until they are available.

Finally, a location/elevation survey will deliver state-plane coordinate data, ground surface and top of casing elevations for the piezometers and wells.

Mobilization charges for ORNL equipment (direct push drill rig) had previously not been included because it was originally felt that our equipment currently in Ohio could be brought back to Grand Junction by leveraging associated travel costs with other projects. However, in light of the uncertainty in this project schedule and the potential conflict with planned December field work in Ohio, a line item for mobilization has been added to the cost estimate.

Task C: Evaluate riverside water quality in the groundwater.

The objective of this task is to provide groundwater quality data as it discharges to the Colorado River. The final location of the proposed piezometers in Figure 1 will be determined by the results of the plume delineation effort. This may result in a different spacing than shown in Figure i . As previously discussed, if access to the proposed sampling points along the river on the private property is denied, the comprehensive objective of the testing plan is jeopardized..

Temporary piezometers (1 in.) will be installed along the riverbank as a means of evaluating the quality of the water where it enters the river. It was agreed at the October 23 meeting that FWS personnel would coordinate permitting issues associated with the clearing of vegetation to allow access to all sampling points on the flood plain. Furthermore, as a result of the group meeting, the number of sampling points along the river bank northeast of Moab Wash has been expanded to address potential impacts to groundwater quality from milling operations. (Fig. 1). It should be noted that the riverside sampling locations northeast of Moab Wash will be located on a 500 ft spacing and will not benefit from the plume delineation efforts associated with the other riverside piezometer locations to the southwest of Moab Wash.

Field screening parameters for plume delineation will include testing for ammonium (N) sulfate (SO,) alkalinity, conductivity, pH, and temperature. Confirmatory groundwater sample analysis will be limited to U, V, As, Cu, MO, and Se. One round of groundwater sampling is proposed. All drilling and sampling generated waste (solid and liquid) will be recharged to the top of the tailings pile. Finally, a location/elevation survey will deliver state-plane coordinate data, ground surface and top of casing elevations for the piezometers.

Overall, the scope of this task has increased but the cumulative scope of plume delineation and riverside quality assessment remains the same as a total of 23 temporary sampling points are still being proposed between both tasks. Analytical costs have also been included in the attached cost estimate for this task.

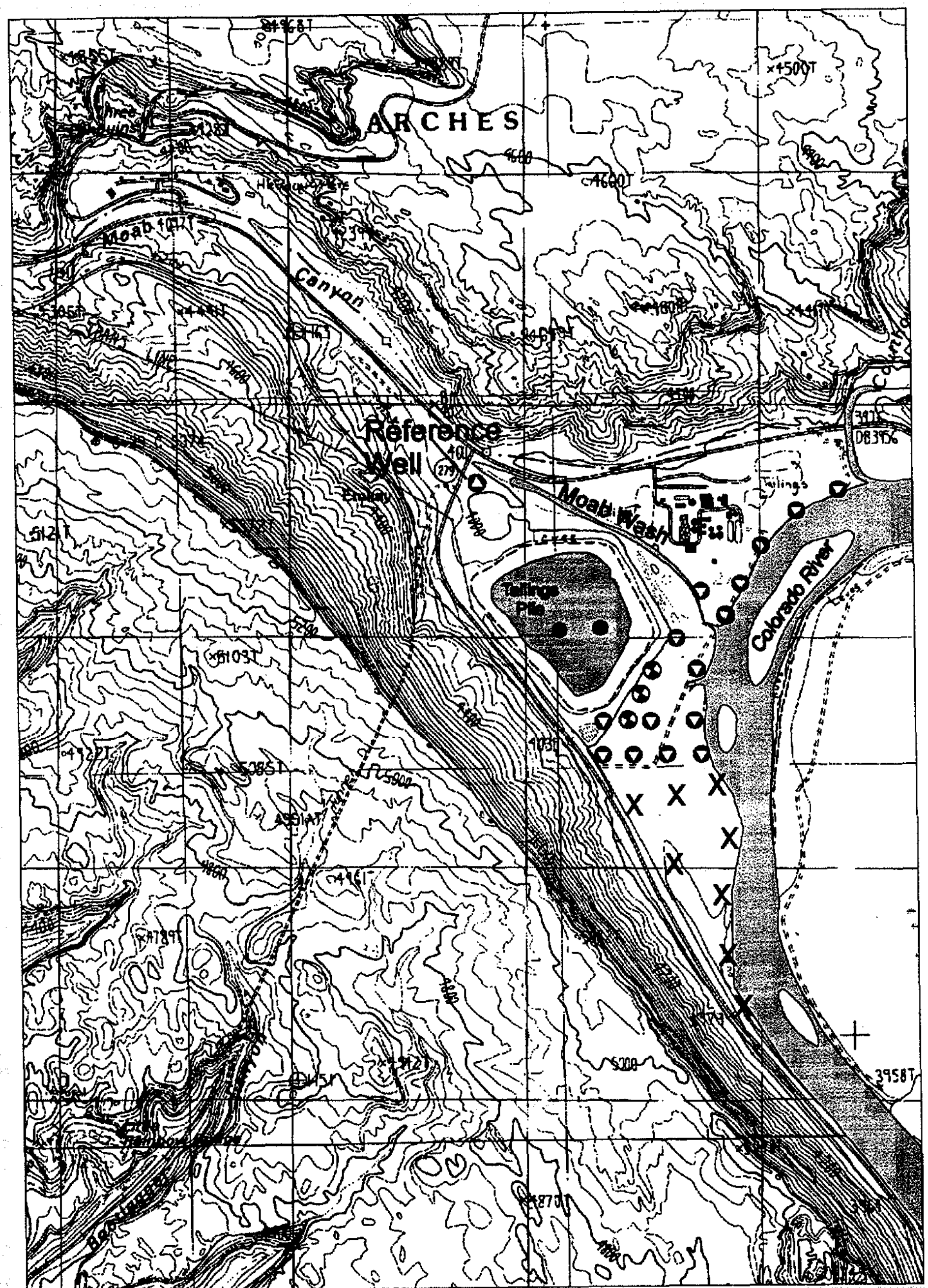
Task D: Install new reference well north of Atlas property.

This task was originally included to alleviate continuing questions regarding the background water quality. Although Atlas's current background well is located in close proximity to a former ore storage area, the proposed well would be sufficiently upgradient, but in a different flow system. Discussion regarding a new background well on Atlas property was entertained but location of the NRC licensee's new background well was determined to be beyond the scope for FWS and ORNL. However, it was agreed that the proposed location would serve as a new "reference well" to establish ground water quality between the Atlas site and Arches National Park.

The cost estimate for this well also reflects an increase due to the selection of DWRC drilling methods for reasons previously stated. Additionally, analytical costs have also been included in the cost estimate for this task.

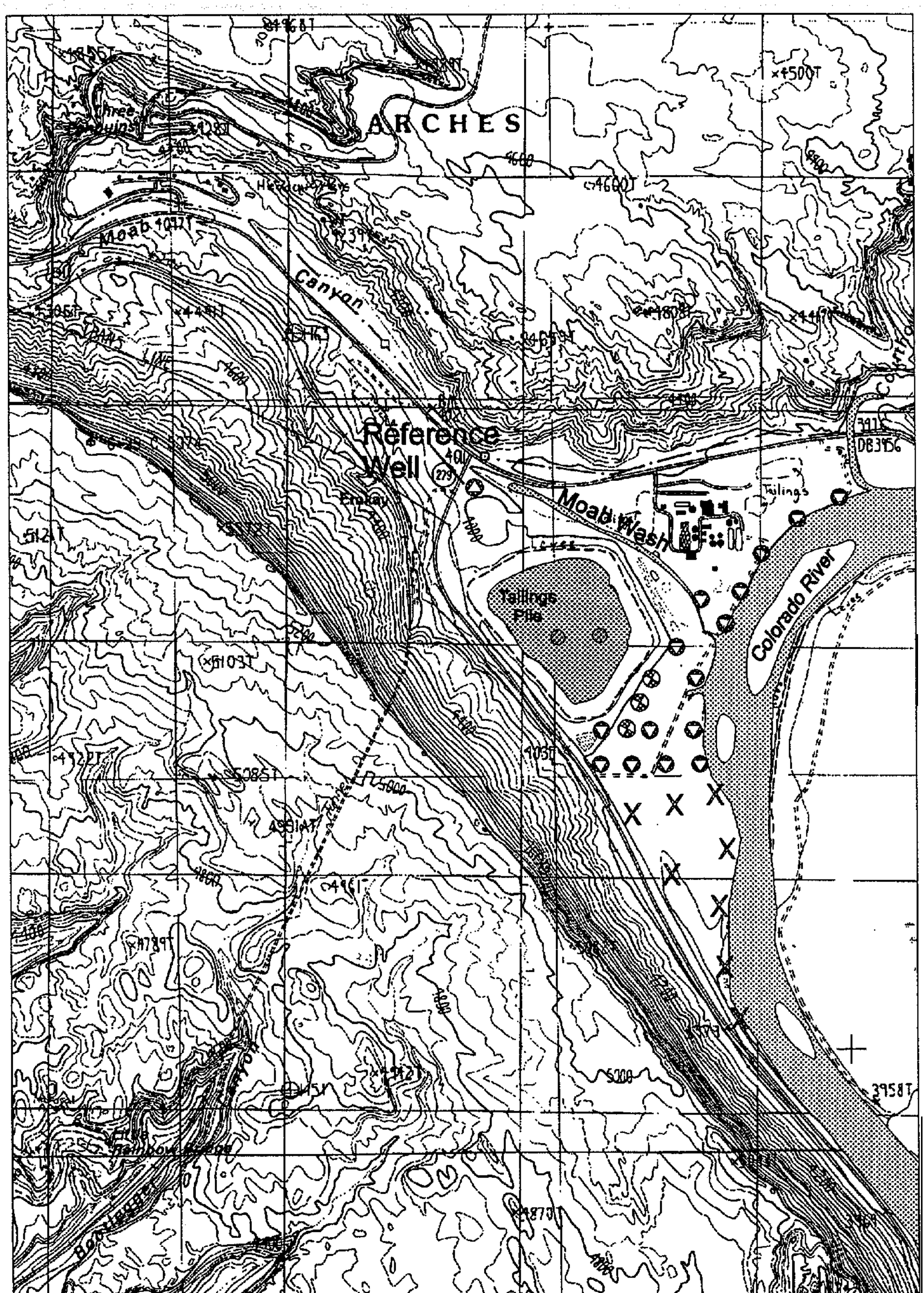
Task E: Modeling drainage from the pile.

The original objective of this task was to provide a simple analytical solution to pile drainage using previously collected data. However, during the October 23 meeting, NRC indicated that a numerical solution using an unsaturated code would be of greater benefit and would be pursued with DOE's Grand Junction office. However, the most recent dialogue with NRC has ORNL preparing a the model. Therefore, the cost estimate for this task has increased dramatically to accommodate NRC modeling requirements. ORNL is proposing to use a proprietary code **(PORFLO)** capable of saturated and'unsaturated flow modeling.



Atlas Mill
Proposed monitoring points

- 2" PVC Monitoring well
- Reference well
- 1" temp. piezometers (Atlas property)
- X 1" temp. piezometers (Private property)
- Soil boring



Atlas Mill

Proposed monitoring points

2" PVC Monitoring well

Reference well

1" temp. piezometers
(Atlas property)

X 1" temp. piezometen
(Private property)

Soil boring

Appendix B

This appendix presents the analytical results for all soil and water samples submitted to the U.S. Department of Energy's Grand Junction **Office** Analytical Laboratory. To facilitate review, a sample cross reference sheet and a definition of data qualifiers sheet have been included. The water sample data have been grouped by sampling location and are presented in sequential order. Thus all of the water sample data for sample location TP-01 is shown first followed by TP02, TP03, etc. The soil sample data is presented in the same fashion. Thus soil sample data from **PB-**01 **is** presented first followed by PB-02 data.

SAMPLE CROSS REFERENCE

GRAND JUNCTION OFFICE ANALYTICAL LABORATORY

REQUISITION(S): 15769

CUSTOMER ID	LAB ID	
TP-1	248567	
TP-2	248568	
TP-3 (DUP)	248569	
TP-3	248570	
TP-4	248571	
TP-5	248572	
TP-6	248573	
TP-7	248574	
TP-8	248575	
TP-9	248576	
TP-10	248577	
TP-11	248578	
TP-12	248579	
TP-13	248580	
TP-14	248581	
TP-14 (DUP)	248582	
TP-15	248583	
TP-16	248584	
TP-17	248585	
TP-18	248586	
TP-19	248587	
TP-20	248588	
TP-21	248589	
ATP-2-S	248590	
AMM-1	248591	
FB-01	248592	
RW-1	248641	
ATP-3	248640	

DEFINITION OF QUALIFIERS

C (Concentration) Qualifiers

- **B** The reported value was obtained from a reading that was less than the Required Detection Limit (RDL) but greater than or equal to the actual Detection Limit (DL).
- **U** The analyte was not detected. The value reported is the DL corrected for any dilution in the sample preparation process and for percent solids if the sample is a solid.

Q Qualifiers

- **E** The reported value is estimated because of the possible presence of interference. The E qualifier is present if the result for the ICP serial dilution is not within control limits or if the analytical (post-digestion) spike recovery for graphite furnace is less than 40% on both the original and the diluted sample.
- **M** Duplicate injection precision for graphite furnace was not met. This qualifier is present if the result is greater than the RDL and the relative standard deviation of the duplicate injections was greater than 20% for both the original analysis and the repeated analysis.
- **N** Spiked sample recovery is not within control limits.
- **S** The reported value was obtained by the Method of Standard Additions (MSA).
- **W** Analytical (post-digestion) spike recovery for graphite furnace analysis is out of the control limits (85-115%), while the sample concentration is less than 50% of spike concentration.
- ***** Duplicate analysis is not within control limits.
- **+** Correlation coefficient for the MSA is less than 0.995.

The "S", "W", and "+" qualifiers are mutually exclusive. No combination of these qualifiers can appear in the same field for an analyte.

M (Method) Qualifiers

P	ICP Atomic Emission Spectroscopy or Optima ICP-AES
PM	ICP Mass Spectrometry
F	Graphite Furnace Atomic Absorption Spectroscopy
CV	Cold Vapor Atomic Absorption Spectroscopy
A	Flame Atomic Absorption Spectroscopy or Hydride
C	Spectrophotometric
IC	Ion Chromatography
IR	Infrared Spectrophotometer
M	Microwave Digestion
MC	Miscellaneous
NR	The analysis is not required.

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248567
TP-1

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	1.5	B		A_
7440-39-3	Barium___	26.5	B		P_
7440-50-8	Copper___	4.9	B		P_
7439-98-7	Molybdenum	26.2	B		PM
7782-49-2	Selenium__	9.6	_		A_
7440-61-1	Uranium___	380	_		PM
7440-62-2	Vanadium__	10.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248567 TP1

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	7.7	B		C
	Chloride	4850000			IC
	NO3	12100			IC
	NO2	341			IC
	Sulfate	2660000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248568 TP-2

SDG No.: _248567__   Matrix: WATER__

Date Received: _12/02/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	4.0	B		A
7440-39-3	Barium	30.5	B		P
7440-50-8	Copper	8.0	U		P
7439-98-7	Molybdenum	250			PM
7782-49-2	Selenium	3.6	B		A
7440-61-1	Uranium	26000			P
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248568

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	8290			IC
	NO2	56.3	B		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248570
TP-3

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	12.1	B		P
7440-50-8	Copper	8.0	U		P
7439-98-7	Molybdenum	598			P
7782-49-2	Selenium	18.9			A
7440-61-1	Uranium	16100			P
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248570
TP-3

SDG No.: _248567__   Matrix: WATER__

Date Received: _12/02/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	826000			IC
	NO2	60.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248569
TP-3 Duplicate

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	9.5	B		P
7440-50-8	Copper	8.0	U		P
7439-98-7	Molybdenum	595			P
7782-49-2	Selenium	19.2			A
7440-61-1	Uranium	16800			P
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO. 248569 TP-3 -Duplicate

SDG No.: _248567__   Matrix: WATER__

Date Received: _12/02/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	809000			IC
	NO2	60.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248571
TP-4

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	6.3	B		A
7440-39-3	Barium	19.6	B		P
7440-50-8	Copper	4.0	U		P
7439-98-7	Molybdenum	2060			P
7782-49-2	Selenium	19.9			A
7440-61-1	Uranium	3330			P
7440-62-2	Vanadium	208			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248571
TP-4

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	534000			IC
	NO2	8050			IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248572
TP-5

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	31.5	B		A
7440-39-3	Barium	35.8	B		P
7440-50-8	Copper	4.0	U		P
7439-98-7	Molybdenum	778			P
7782-49-2	Selenium	24.8			A
7440-61-1	Uranium	1450			P
7440-62-2	Vanadium	529			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248572
TP-5

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	262000			IC
	NO2	30.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248573
TP6

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	20.4	B		P
7440-50-8	Copper	8.1	B		P
7439-98-7	Molybdenum	334			PM
7782-49-2	Selenium	2.9	B		A
7440-61-1	Uranium	5640			P
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248573
TP 6

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	547000			IC
	NO2	30.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248574
TP7

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	2.8	B		A_
7440-39-3	Barium___	16.2	B		P_
7440-50-a	Copper___	a.0	U		P_
7439-98-7	Molybdenum	355	_		PM
7782-49-2	Selenium__	1.0	U		A_
7440-61-1	Uranium___	2700	_		PM
7440-62-2	Vanadium__	20.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248574
TP-7

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	78.7	B		IC
	NO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248575
TP-8

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	12.2	B		P
7440-50-8	Copper	8.6	B		P
7439-98-7	Molybdenum	977			P
7782-49-2	Selenium	1.0	U		A
7440-61-1	Uranium	2590			PM
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248575
TP 8

SDG NO.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	39500			IC
	NO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

TP-9

SDG No.: _248567__ Matrix: WATER

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	2.1	B		A
7440-39-3	Barium	18.6	B		P
7440-50-8	Copper	11.5	B		P
7439-98-7	Molybdenum	1230			P
7782-49-2	Selenium	95.3			A
7440-61-1	Uranium	6700			P
7440-62-2	Vanadium	20.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248576
TP-9

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	1850000			C
	Chloride	1130000			IC
	NO3	715000			IC
	NO2	60.0	U		IC
	Sulfate	15400000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248577
TP-10

SDG No. : _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	3.1	B		A_
7440-39-3	Barium____	15.2	B		P_
7440-50-8	Copper____	12.8	B		P_
7439-98-7	Molybdenum	1290	_		P_
7782-49-2	Selenium__	38.4	_		A_
7440-61-1	Uranium___	2480	_		PM
7440-62-2	Vanadium__	34.2	B		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248577
TP-10

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	440000			IC
	NO2	30.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248578
TP-11

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	58.3	B		P
7440-50-8	Copper	4.0	U		P
7439-98-7	Molybdenum	23.8	B		PM
7782-49-2	Selenium	1.0	U		A
7440-61-1	Uranium	1.0	B		PM
7440-62-2	Vanadium	10.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248578
TP-11

SDG No.: _248567__   Matrix: WATER__

Date Received: _12/02/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	63.5	B		IC
	NO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248579
TP-12

SDG No.: _248567__

Matrix: WATER__

Date Received: _12/04/97

% Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	\rsenic___	14.3	_		A_
7440-39-3	3arium___	25.6	B		P_
7440-50-8	:opper___	5.8	B		P_
7439-98-7	4olybdenum	1420	_		P_
7782-49-2	3elenium__	12.5	_		A_
7440-61-1	Jranium___	1460	_		PM
7440-62-2	/anadium__	482	_		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248579
TA-12

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	322000			C
	Chloride	696000			IC
	NO3	315000			IC
	NO2	713	B		IC
	Sulfate	4710000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248580
TP-13

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	1.1	B		A_
7440-39-3	Barium___	29.0	B		P_
7440-50-8	Copper___	8.0	U		P_
7439-98-7	Molybdenum	1100	_		P_
7782-49-2	Selenium__	8.3	_		A_
7440-61-1	Uranium___	2530	_		PM
7440-62-2	Vanadium__	20.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248580
TP-13

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	226000			IC
	NO2	3080			IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248581
TP-14

SDG No.: _248567__

Matrix: WATER__

Date Received: _12/04/97

% Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	1.8	B		A_
7440-39-3	Barium___	36.3	B		P_
7440-50-8	Copper___	8.0	U		P_
7439-98-7	Molybdenum	386			P_
7782-49-2	Selenium__	3.8	B		A_
7440-61-1	Uranium___	4980			P_
7440-62-2	Vanadium__	20.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248581
TP 14

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	344000			IC
	NO2	30.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM I
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248582
TP-14 duplicate

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.8	B		A
7440-39-3	Barium	31.6	B		P
7440-50-8	Copper	21.5	B		P
7439-98-7	Molybdenum	381			P
7782-49-2	Selenium	3.8	B		A
7440-61-1	Uranium	4710			P
7440-62-2	Vanadium	50.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248582
TP-14 duplicate

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	335000			IC
	NO2	30.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248583
TP-15

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

:AS No.	Analyte	Concentration	C	Q	M
7440-38-2	\rsenic	1.3	B		A
7440-39-3	3arium	20.0	U		P
7440-50-8	:opper	20.0	U		P
7439-98-7	1olybdenum	491			PM
7782-49-2	3elenium	1.0	U		A
7440-61-1	Jranium	4300			PM
7440-62-2	Janadium	50.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO. 248583
TP-15

SDG No.: 248567

Matrix: WATER

Date Received: 12/04/97

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L

CAS No.	Analyte	Concentration	C	Q	M
	NH_3-N				NR
	Chloride				NR
	NO_3	168000			IC
	NO_2	288	B		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248584
TP-16

SDG No.: _248567__ Matrix: WATER

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	3.4	B		A_
7440-39-3	Barium____	113	B		P_
7440-50-8	Copper____	21.6	B		P_
7439-98-7	Molybdenum	198	B		PM
7782-49-2	Selenium__	1.0	U		A_
7440-61-1	Uranium___	213			PM
7440-62-2	Vanadium__	50.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248584
TP-16

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	80.6	B		IC
	NO2	30.9	B		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248585
TP-17

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	3.4	B		A_
7440-39-3	Barium___	63.6	B		P_
7440-50-8	Copper___	23.6	B		P_
7439-98-7	Molybdenum	8.1	B		PM
7782-49-2	Selenium__	1.0	U		A_
7440-61-1	Uranium___	9.5	B		PM
7440-62-2	Vanadium__	50.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248585
TP-17

SDG No.: _248567__

Matrix: WATER__

Date Received: _12/04/97

% Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	14.0	U		IC
	NO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248586
TP-18

SDG No.: _248567__   Matrix: WATER__

Date Received: _12/04/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	7.8	B		A
7440-39-3	Barium	88.8	B		P
7440-50-8	Copper	26.8	B		P
7439-98-7	Molybdenum	5.8	B		PM
7782-49-2	Selenium	1.0	U		A
7440-61-1	Uranium	11.5	B		PM
7440-62-2	Vanadium	50.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248586
TP-18

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	14.0	U		IC
	NO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248587
TP-19

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	____1.0	U		A_
7440-39-3	Barium___	51.4	B		P_
7440-50-8	Copper___	20.0	U		P_
7439-98-7	Molybdenum	____5.0	U		PM
7782-49-2	Selenium__	____1.0	U		A_
7440-61-1	Uranium___	____5.0	U		PM
7440-62-2	Vanadium__	50.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248587
TP-19

SDG No.: _248567__ Matrix: WATER

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	3320			C
	Chloride	60700000			IC
	NO3	14.0	U		IC
	NO2	3.0	U		IC
	Sulfate	4340000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248588
TP-20

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic___	1.0	U		A_
7440-39-3	Barium___	41.7	B		P_
7440-50-8	Copper___	20.0	U		P_
7439-98-7	Molybdenum	5.0	U		PM
7782-49-2	Selenium___	1.0	U		A_
7440-61-1	Uranium___	5.0	U		PM
7440-62-2	Vanadium___	50.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248588
TP-20

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	IH3-N				NR
	Chloride				NR
	IO3	14.0	U		IC
	IO2	3.0	U		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248589
TP-21

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.5	B		A
7440-39-3	Barium	71.0	B		P
7440-50-8	Copper	20.0	U		P
7439-98-7	Molybdenum	7.7	B		PM
7782-49-2	Selenium	1.0	U		A
7440-61-1	Uranium	10.3	B		PM
7440-62-2	Vanadium	50.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248589
TP-21

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N				NR
	Chloride				NR
	NO3	14.0	U		IC
	NO2	12.2	B		IC
	Sulfate				NR

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248591
AMM-1

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	18.6	B		P
7440-50-8	Copper	4.0	U		P
7439-98-7	Molybdenum	8.1	B		PM
7782-49-2	Selenium	18.3			A
7440-61-1	Uranium	4.9	B		PM
7440-62-2	Vanadium	10.0	U		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248591
A mm-1

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	IH3-N	5.0	U		C
	Chloride	3080000			IC
	IO3	12700			IC
	IO2	3.0	U		IC
	Sulfate	995000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248590
ATP-25

SDG No.: _248567__ Matrix: WATER

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	1.0	U		A
7440-39-3	Barium	17.2	B		P
7440-50-8	Copper	8.0	U		P
7439-98-7	Molybdenum	842			P
7782-49-2	Selenium	15.8			A
7440-61-1	Uranium	4020			P
7440-62-2	Vanadium	20.0	U		P

Comments:

73

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248590
A -i/6+-

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/02/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	1270000			C
	Chloride	1440000			IC
	NO3	79000			IC
	NO2	14.8	B		IC
	Sulfate	12400000			IC

Comments:

GJO ANALYTICAL LABORATORYINORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248640
ATP-3

DG No.: _248640__ Matrix: WATER__

Date Received: _12/10/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	6.4	B		P_
7440-39-3	Barium	46.5	B		P_
7440-50-8	Copper	4.0	U		P_
7439-98-7	Molybdenum	4.1	B		PM
7782-49-2	Selenium	2.4	B		P_
7440-61-1	Uranium	5.5	_		PM
7440-62-2	Vanadium	10.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM I
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248640
ATP-3

SDG No.: 248640

Matrix: WATER

Date Received: 12/10/97

% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	216			C
	chloride	542000			IC
	NO3	100	U		IC
	NO2	22.0	U		IC
	Sulfate	237000			IC

Comments:

a

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

am

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248641
Rw-1

OG No.: _248640__   Matrix: WATER__

Date Received: _12/10/97   % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	3.4	B		P
7440-39-3	Barium	33.7	B		P
7440-50-8	Copper	4.0	U		P
7439-98-7	Molybdenum	4.6	B		PM
7782-49-2	Selenium	9.9			P
7440-61-l	Uranium	12.8			PM
7440-62-2	Vanadium	12.3	B		P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM I
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248641
RW-1

DG No.: _248640__ Matrix: WATER__

Date Received: _12/10/97 % Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	145			C
	Chloride	156000			IC
	NO3	10300			IC
	NO2	22.0	U		IC
	Sulfate	131000			IC

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

FB-01

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	a	M
7440-38-2	Arsenic___	1.0	U		A_
7440-39-3	Barium_____	4.0	U		P_
7440-50-8	Copper_____	4.0	U		P_
7439-98-7	Molybdenum	1.0	U		PM
7782-49-2	Selenium__	1.0	U		A_
7440-61-1	Uranium___	1.0	U		PM
7440-62-2	Vanadium__	10.0	U		P_

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248592
FB-01

SDG No.: _248567__ Matrix: WATER__

Date Received: _12/04/97 % Solids:__0.0

Concentration Units (ug/L or mg/kg dry weight): ug/L_

CAS No.	Analyte	Concentration	C	Q	M
	NH3-N	5.0	U		C
	Chloride	2450			IC
	NO3	14.0	U		IC
	NO2	3.0	U		IC
	Sulfate	320	B		IC

Comments:

Grand Junction Office Analytical Laboratory

Sample Login Sheet

Received by (Print Name): L.M. DAVIS

Received by (Signature): L.M. Davis

Requisition/Case #: 15775

Page 1 of 1 V2.08

Login date: 12-15-97

Requestor: NIC KORTE

Project number: L30105050

PER M. YOLLENBACH

1. Custody Seal(s):
   Shipping Container: Absent/Intact/Broken
   Sample Container: Absent/Intact/Broken
2. Custody Seal No(s): ____
3. Chain of Custody Recs: Present/Absent
4. Traffic Rpt, Pack Lst, Analytical Req: Present/Absent
5. Freight Bill: Airbill/Sticker Present/Absent
6. Freight Bill No(s).: ____
7. Sample Tags: Present/Absent
8. Sample Labels on Chain of Cust.: Listed/Not listed
9. Does information on custody records, traffic reports & sample labels agree?: Yes/No
10. Shipping Cont. Temp.: and Condition ____
11. Sample pH: Accept/Not Accept Not Applicable

----------Analysis Requested - Data Due ----------

#	Test-Due Date
1	AS -
2	BA -
3	CL -
4	CU -
5	M1 -
6	MO -
7	NH3N -
8	NO2 -
9	NO3 -
10	SE -
11	SO4 -
12	SOL -
13	U -
14	V -

No.	Ticket	Customer ID	Lab #	ST	Date Sampled	Condition Received	Date Rec'd
1		ATP-3	248640	W	03DEC97	GOOD	10DEC97
2		RW-1	248641	W	10DEC97	GOOD	10DEC97
3		PB-1-83	248717	MD		GOOD	15DEC97
5		PB-1-85	248718	MD		GOOD	15DEC97
6		PB-1-89	248719	MD		GOOD	15DEC97
		PB-1-94	248720	MD		GOOD	15DEC97
7		PB-1-101	248721	MD		GOOD	15DEC97
8		PB-2-45	248722	MD		GOOD	15DEC97
9		PB-2-74	248723	MD		GOOD	15DEC97
10		PB-2-76	248724	MD		GOOD	15DEC97
11		PB-2-78.5	248725	MD		GOOD	15DEC97
12		PB-2-90	248726	MD		GOOD	15DEC97
13		PB-2-100	248727	MD		GOOD	15DEC97

Reviewed by: ____

Date: ____

GJO ANALYTICAL LABORATORY - **INORGANIC ANALYSIS REPORT**

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248717
PB-1-83

:G No.: 248640 Matrix: SOIL-

ate Received: 12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

:AS -No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	12.9			P
7440-39-3	3arium	343		EN	P
7440-50-8	:opper	29.4			P
7439-98-7	Molybdenum	71.9			PM
7782-49-2	3elenium	0.40	B		P
7440-61-l	Jranium	103			PM
7440-62-2	Vanadium	525			P

:omments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248718
PB-1-85

G No.: 248640 Matrix: SOIL

ate Received: 12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	13.2			P
7440-39-3	Barium	206		EN	P
7440-50-8	Copper	45.4			P
7439-98-7	Molybdenum	65.3			PM
7782-49-2	Selenium	0.20	U		P
7440-61-1	Uranium	176			PM
7440-62-2	Vanadium	649			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248719
PB-1-89

G No.: 248640

Matrix: SOIL-

ate Received: 12/15/97

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	14.8			P
7440-39-3	Barium	267		EN	P
7440-50-a	Copper	95.6			P
7439-98-7	Molybdenum	105			PM
7782-49-2	Selenium	0.20	U		P
7440-61-l	Uranium	163			PM
7440-62-2	Vanadium	1510			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248720
PB-1-94

?G No.: _248640__ Matrix: SOIL-

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	3.1			P
7440-39-3	Barium	75.8		EN	P
7440-50-a	Copper	15.4			P
7439-98-7	Molybdenum	20.5			PM
7782-49-2	selenium	0.62			P
7440-61-l	Uranium	52.3			PM
7440-62-2	Vanadium	17'20			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248721
-?&1 -101

G No.: _248640__ Matrix: SOIL-

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	5.5			P
7440-39-3	Barium	187		EN	P
7440-50-a	Copper	10.7			P
7439-98-7	Molybdenum	0.98	B		PM
7782-49-2	Selenium	0.20	U		P
7440-61-l	Uranium	5.4			PM
7440-62-2	Vanadium	31.2			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248722
PB-2-45

G No. : 248640

Matrix: SOIL

late Received: 12/15/97

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	113			P
7440-39-3	Barium	1290		EN	P
7440-50-a	Copper	832			P
7439-98-7	Molybdenum	78.8			PM
7782-49-2	Selenium	3.7			P
7440-61-l	Uranium	338			PM
7440-62-2	Vanadium	597			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1

INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248723
PB-2-74

G No.: _248640__ Matrix: SOIL___

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	9.2			P
7440-39-3	Barium	340		EN	P
7440-50-a	Copper	21.5			P
7439-98-7	Molybdenum	27.6			PM
7782-49-2	Selenium	0.34	B		P
7440-61-l	Uranium	65.8			PM
7440-62-2	Vanadium	496			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248724
PB-2-76

G No.: _248640__ Matrix: SOIL___

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	7.7			P
7440-39-3	Barium	276		EN	P
7440-50-a	Copper	36.1			P
7439-98-7	Molybdenum	68.3			PM
7782-49-2	Selenium	0.31	B		P
7440-61-l	Uranium	231			PM
7440-62-2	Vanadium	489			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248725
PB-2-78.5

G No.: _248640__ Matrix: SOIL-

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	78.9			P
7440-39-3	Barium	365		EN	P
7440-50-a	Copper	306			P
7439-98-7	Molybdenum	133			PM
7782-49-2	Selenium	1.2			P
7440-61-l	Uranium	158			PM
7440-62-2	Vanadium	2460			P

:omments:

4

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.

248726
PB-2-90

G No.: _248640__ Matrix: SOIL___

ate Received: _12/15/97 % Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	2.5			P
7440-39-3	Barium	92.4		EN	P
7440-50-a	Copper	8.6			P
7439-98-7	Molybdenum	1.3	B		PM
7782-49-2	Selenium	0.31	B		P
7440-61-l	Uranium	3 . 6			PM
7440-62-2	Vanadium	33.2			P

Comments:

GJO ANALYTICAL LABORATORY - INORGANIC ANALYSIS REPORT

FORM 1
INORGANIC ANALYSES DATA SHEET

LAB SAMPLE NO.
248727
PB-2-100

G No.: -248640

Matrix: SOIL

ate Received: 12/15/97

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): mg/kg

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	5.5			P
7440-39-3	Barium	195		EN	P
7440-50-8	Copper	10.3			P
7439-98-7	Molybdenum	1.3	B		PM
7782-49-2	Selenium	0.30	B		P
7440-61-1	Uranium	8.3			PM
7440-62-2	Vanadium	22.3			P

Comments:

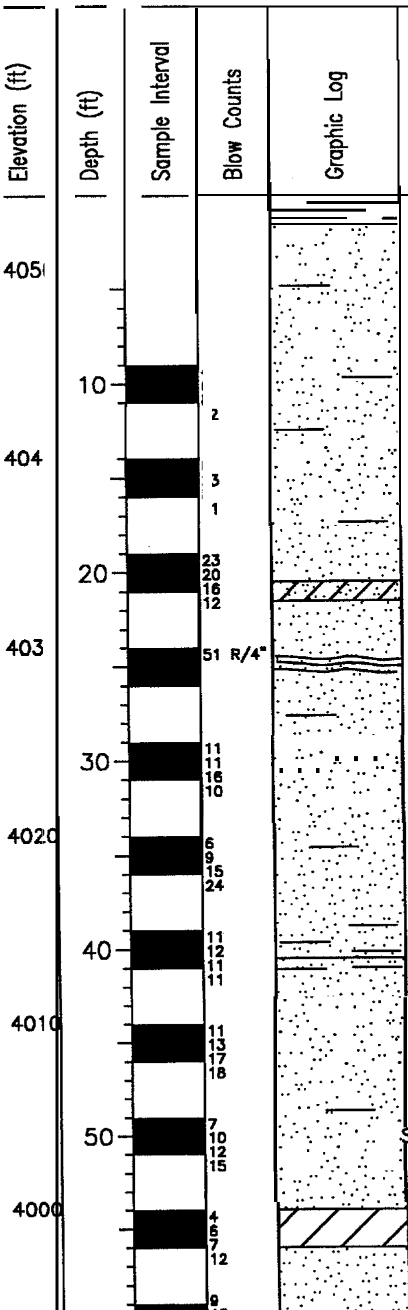
Appendix C

Appendix C presents the boring logs and construction records for all of the drilling performed by **ORNL/GJ**. These include: 2 soil boring logs **(PB01** and **PB02),** 21 piezometers logs **(TP01** through **TP21),** 4 observation well logs (OW-01 through OW-04) and the reference well log (RW-01). Also attached at the end of the appendix are the relevant soil boring/well logs for existing locations logs used during the investigation **(AMM-1,** AMM-2, **AMM-3,ATP-1,** ATP-2, ATP3, B-l, B-10, B-18, B-19, B-21, B-24, PW-1, and PW-2).

Oak Ridge National Laboratory
Environmental Technology Section
2597 B3/4 Road
Grand Junction, CO 81503

Borehole Summary

'roject Name: Atlas Groundwater Investigation	Remarks:
late(s): 12/10/97 – 12/10/97	Site Id: PB–01
:ontractor: Layne Christensen	Total Depth: 111.00'
levation: 4053.88'	Drilling Method: Dual Wall Reverse Circulation/Percussion Hammer
itate Plane North: 102467.80	Logged By: M.E. Mumby
itate Plane East: 2544991.92	Certified By: F.G. Gardner



Material Description

Fill: Red fine grained sand and gravel.

Tailings

SP Sand: light gray (2.5Y 7/1) fine grained, subround, slightly moist, based on cuttings.

SP Sand: light gray grading to a light yellowish brown (10YR 6/4), very fine to fine grained subround, occasional dark accessory minerals, slightly moist, slight clay content <10%.

SP Sand: light yellowish brown (10YR 6/4), with some light gray zones, fine grained, subround with scattered medium round grains, scattered dark accessory minerals, slightly moist, occasional brown lenses of fat clay from 15.5 to 16.0 ft, 1–3mm occasionally to 1cm thick.

SP Sand: as above becomes clayey from 20.5 to 21.5 ft, clay is dark yellowish brown, slightly moist with moderate to high plasticity, becomes fairly stiff in some zones, occasional interbedded medium grained sand lenses 1–2cm are present from 20.5–21.0 ft.

SP Sand: yellowish brown (10YR 5/4), predominantly fine grained, subround with scattered medium well rounded grains, slightly moist, occasionally slightly clayey vith clay content <10%, sand is lithified to some degree from 24–25 ft difficult to pound split spoon.

SP Sand: pale brown (10YR 6/3), very fine grained, subround, very well sorted, clean, slightly moist.

SP Sand: as above becoming light brownish gray (10YR 6/2), clay zone from 34.5–35.0 ft, clay is reddish brown to dar reddish brown (5YR 4/4–3/4), soft, fat, moist, grades back to a clean sand below 35.0 ft.

SP Sand: light brownish gray (10YR 6/2), very fine grained, subangular to subround, very well sorted, slightly moist, interbedded sand and clay zone from 40.5 to 41.0 ft, sand is wet above the interbedded sand and clay zone (approx 4").

SP Sand: brown (10YR 5/3), predominantly fine grained with common very fine grains, subround to subangular, slightly moist, occasional zones with some clay, clay content <10%.

SP Sand: as above, very fine to fine grained, clean, wet entire interval.

Increasing clay content at approximately 53'.

CL Sandy Clay: gray (5YR 5/1), soft, medium to low plasticity, wet, sands are very fine to fine grained, (s lime tailings).

Site Id: PB-01	

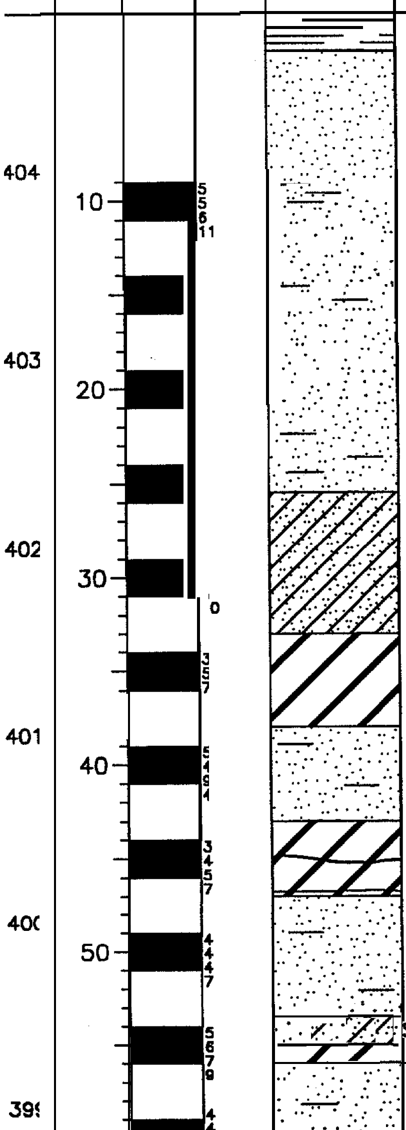
Elevation (ft)	Depth (ft)	Blow Counts	Material Description
		10, 8	SP Sand: gray (5Y N5/5), predominantly fine grained, some very fine grained <15%, subround to subangular, with the very fine grains being predominatly subangular, clean, scattered dark accessory minerals 2–3%, wet.
3990		5, 6, 10, 13	SP Sand: as above with some interbedded sandy clay, wet, clay exhibits medium to low plasticity.
	70	2, 5, 9, 19	CH Clay: gray (5Y 5/1), soft, fat, wet, slightly sandy in some zones, sand is fine gained, grades back to a light reddish brown fine grained sand below 70.5 ft. (slime tailings).
3980		10, 10, 13, 20	SC Clayey Sand: gray (5YR 5/1), very fine to fine grained, subangular to subround, moderately sorted, common medium to fine grained subrounded, red (chert?) grains and black accessory minerals, wet.
			SP Sand: as above with brownish yellow (10YR 5/6) oxidized streaks, failry clean, clayey in some zones, wet, predominantly fine grained, subround, some very fine grained, becomes fine to medium grained from 81 to 83 ft.
	80	79–81 4,7,8,12	
		81–83 2,2,4,7	Top of basal slime tailings 83 ft.
3970		83–85 16,21,21,23	
		85–87 10,17,19,24	CL Clay: reddish gray (5YR 5/2) stiff, moist, slight to low plasticity, occasional interbedded fine grained sand, evident laminations, becomes very stiff from 85 to 89 ft, grade to a sandy clay from 89 to 91 ft, sand is very fine grained, scattered brown oxidized zones 1–2mm from 90 to 91 ft, very hard drilling from 91 to 93 ft. (slime tailings).
		87–89 10,15,16,32	
	90	89–91 16,18,27,46	
3960		24, 35, 39, 43	Top of red sand (alluvium) 95 ft.
			SW Sand: red (2.5YR 4/8), very fine to coarse grained with medium grained predominant, subangular to well rounded with coarser grains being more rounded, clean, slightly moist, scattered gravels to 2cm from 95.5 to 96 ft.
	100	6, 6, 6, 13	SW Sand: as above becoming wet at 99.5 ft.
			ML Silt: dark grayish brown (10YR 4/2), soft, wet, slighly sandy.
3950		7, 18, 28, 31	ML Silt: color as above grades to a predominantly light gray silty clay from 104.5 to 106 ft, firm to stiff very moist.
	110	20, 35, 40, 44	GW Sandy Gravel: reddish brown (5YR 4/3), subrounded to well rounded gravels to 6cm in a sand matrix, saturated, sand is medium to very coarse grained, subround, clean.
			Pipe T.D. 109 ft. Split Spoon T.D. 111 ft.
3940			
	120		
3930			
	130		
3920			
	140		
3910			

Oak Ridge Notional Laboratory
Environmental Technology Section
2597 B3/4 Road
Grand Junction, CO 81503

Borehole Summary

roject Name: Atlas Groundwater Investigation	Remarks:
ate(s): 12/1 1/97 – 12/11/97	Site Id: PB–02
ontractor: Lavne Christensen	Total Depth: 111.00'
levation: 4048.41'	Drilling Method: Dual Wall Reverse Circulation/Percussion Hammer
tate Plane North: 102316.86	Logged By: M.E. Mumby
tate Plane East: 2544691.94	Certified By: F.G. Gardner

Elevation (ft) | Depth (ft) | Sample Interval | Blow | Graphic Log | Material Description



Fill: Gravel and sand, dry, grades to tailings sand from 2 to 4 ft.

Tailings

SP Sand: yellowish brown (10YR 5/4), predominantly fine grained with common medium grained sand, moderately well sorted, subround, clean, slightly moist, scattered dark accessory minerals, scattered lenses of brown fat clay.

SP Sand: light brownish gray(10YR (6/2)› brownish yellow (10YR 6i/i), fine grained subrounded, ve ry well sorted, clean, slightly moist, occasional lenses of brown to grayish brown fat clay (slime tailings) ranging in thickness from 1–2 cm.

SP Sand : as above, with no visible clays.

SP Sand: yellowish brown (10YR 5/6), predominantly fine to medium grained with some very fine grained, subround, moderately welll sorted, clean, becomes interbedded with very fine grained clayey sand from 25.5 to 26 ft., sand above clayey sand zone is wet from approximately 23 to 26 ft.

SC Clayey Sand: light brownish gray (10YR 6/2), very fine grained, subrounded, wet, grades to a predominantly fine grained sand at approximately 30 ft, wet, color change at approximately 30.25 ft. to a reddish brown (2.5YR 3/3), sand in this interval is fine to medium grained with some very fine grained sand, subrounded, moderately well sorted, wet, scattered dark accessory minerals, occasional lenses of reddish brown fat clay.

CH Clay: reddish brown (2.5YR 4/4), soft, wet, fat, interbedded thin lenses of very fine grained gray sand ranging in thickness from 1–2mm, decreasing with depth (slime tailings).

SP Sand: grayish brown (2.5Y 5/2), very fine grained, subround, well sorted, slightly clayey with clay content < 10%, occasional interbedded very fine grained clayey sands, saturated.

CH Clay: light olive brown, (2.5Y 5/4), soft, wet, fat, evident laminations, distinct layer of black sand (reduced?) at 45 ft., sand is predominantly very fine grained with scattered fine grained sand in a black clayey matrix, wet, another small zone present right above 46 ft increasing sand content at 46 ft. (slime tailings).

SP Sand: gray (5Y 6/1), very fine to fine grined, subrounded, moderately well sorted, fairly clean with clay content <10%› 50 ft., re ddih brown fat clay layer from 50 to 50.5 ft, grading back to a very fine grained clayey sand from 50.5 to 51 ft.

SC Clay Sand: gray (2.5Y N6/6), soft, wet, sand is very fine grained, grades to a gray, soft, fat clay from 55 to 56 ft., with occasional interbedded very fine grained sand (slime tailings).

Elevation (ft)	Depth (ft)	Sample Interval	Blow Counts	Graphic Log	Material Description
			5 10		SP Sand: grayish brown (2.5Y 5/2), very fine grained, subround, well sorted, fairly clean above 60.5 ft., some interbedded gray silty clay from 60.5 to 61 ft., wet.
			5 7 7 13		CL Sandy Clay: grayish brown (2.5YR 5/2), soft, wet, exhibits moderate plasticity, grades to a grayish brown sand by 65 ft., sand is fine grained, subrounded, well sorted, slightly clayey spots.
398	70		69–71 5,7,15,20		SP Sand: as above, fat clay layer from 70.5 to 71 ft.
			71–73 2,3,4,15		Top of basal slime tailings 72.5 ft.
			73–75 7,14,16,20 75–77 12,16,26,40 77–79 10,15,20,45		CL Clay: predominantly gray (5YR 6/1) with scattered interbedded reddish gray (5YR 5/2), stiff, slightly moist, distinct bedding planes visible, scattered interbedded layers of gray silt ranging in thickness from 1–2mm, grades to a silty clay from 74 to 75 ft. (slime tailings).
397	80		79–81 17,24,35, 51/0"		CL Clay: as above, very stiff, small wet zone from 77.5 to 78.5 ft., rest of interval is only slightly moist, grades to a reddish gray from 80 to 81 ft. (slime tailings).
			12 14 27 51 R/5"		CL Silty Clay: gray (5YR 6/1), stiff, moist, bedding planes becoming less distinct, occasional interbedded very fie grained sand below 86 ft.
					Top of red sand (alluvium) approximately 88 ft.
396	90		16 25 23 23		SP Sand: red (2.5YR 4/8), predominantly fine grained with scattered medium grained, subround, moderately well sorted, scattered dark accessory minerals, slightly moist.
					SP Sand: as above, based on cuttings.
			5 7 13 9		ML Sandy Silt: red (2.5YR 4/6), soft, wet, grades to a silty sand in some zones, sand is very fine to fine grained, subrounded, very micaceous.
395	00		34 4 8 13		ML Silt: brown to dark brown (10YR 4/3), soft, wet, slightly sandy, slightly micaceous.
			6 11 11 21		ML Silt: as above grades to a dark brown sand at 105.5 ft., sand is fine grained with scattered medium grains, subround, moderately well sorted, decreasing silt content with depth.
					Top of gravel approximately 108 ft.
394	10		17 30 38 51 R/4"		SW Gravelly Sand: reddish brown (5YR 4/3), fine to coarse grained, subrounded to round, with gravels to 1.5 in., saturated.
					Split Spoon T.D. 111 ft.
					Pipe T.D. 109 ft.
393	20				
392	130				
391	140				
390					

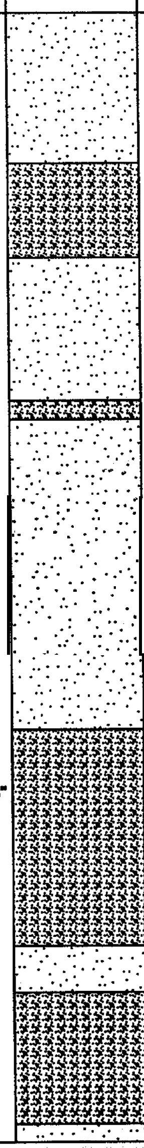
Oak Ridge' National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks: 2" O.D. 0.010" Slotted Pre-Packed PVC Screen
Screened Interval 69–79', Pre-Pack Sand 8–16
Natural Pack 70–79', 8–16 Silica Sand to 64'
Natural Pack to 59', Hole Caving
Bentonite Seal 56.4–59', Grout to 3' Conc to Surf

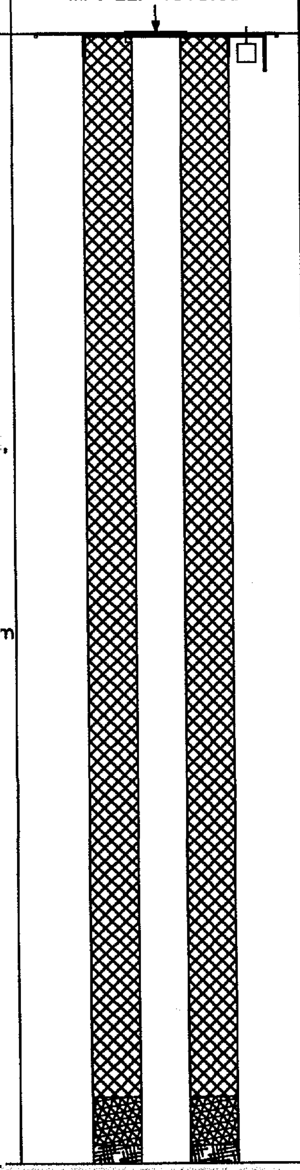
Project Name: Atlas Groundwater Investigation	Site Id: RW-01
Date(s): 12/09/97 – 12/09/97	Total Depth: 81.00'
Contractor: Layne Christensen	Borehole Dia.: 9.00in
Elevation: 4018.63'	Drilling Method: Dual Wall Reverse Circulation/Percussion Hammer
State Plane North: 105651.20	Logged By: M.E. Mumby
State Plane East: 2541899.45	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Sample Interval	Blow Counts	Graphic Log	Material Description
					SP Sand: red (10R 4/8), fine grained subround, moderate to well sorted, moist to approximately 2 ft., slightly moist below 2 ft., scattered sandstone cobbles to 10 cm, based on cuttings.
4010	10		41 34 37 32		SW Gravelly Sand: red (10R 4/8), dry very fine to coarse grained, subround to subangular, predominantly quartz with common igneous and metamorphic grains, igneous and metamorphic gravels to 1.3 cm, some limonite staining present on the gravels.
					SW Sand: as above occasional very large cobbles > 13 cm, fining with depth.
4000	20		11 18 24 25		SP Sand: color as above, fine to medium grained in upper 1 ft. of sampler, interbedded well graded sand in bottom 1 ft. of sampler, well graded sand is fine to coarse grained subangular to subround, predominantly quartz with common igneous and metamorphic grains, occasional gravels to 2 cm, grades back to a well graded sand below 21.5 ft.
3990	30		10 13 18 20		SP Sand: red (2.5YR 4/6), very fine to fine grained, subangular, well sorted, scattered dark accessory minerals, limonite stained, occasional gravels to 7.5 cm, slight increase in grain size at bottom of sampler.
					Increasing gravels and cobbles, up to 15 cm at cyclone.
3980	40		14 32 51 R/5"		SW Sand: red (10R 4/8), fine to coarse grained, subangular to subround, common fine gravels, gravels are predominantly quartz with scattered igneous and metamorphic fragments, slightly moist in the finer grained intervals.
3970	50		23 26 26 30		SW Sand: as above, interbedded fine grained, well sorted sand from 49.5 to 50.5 ft., slight increase in moisture content in the fine grained sands, scattered cobbles to 12.5cm, grades back to a well graded sand at approximately 52 ft.
					Water at Approximately 57 ft.
3960			10 13		

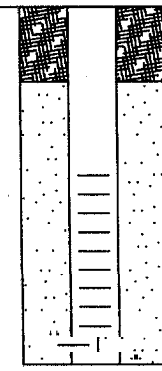


Well Construction

MP. EL. 4018.63



Elevation (ft)	Depth (ft)	Sample Interval	Blow Counts	Graphic Log	Material Description	Well Construction
			25 50		SP Sand: red (2.5YR 4/6), fine grained with scattered medium grains, subangular to subround, scattered dark accessory minerals, slightly micaceous, wet, increasing grain size below 62 ft.	
			8 22 30 40		SW Sand: dark reddish brown (2.5YR 3/4),fine to medium grained with scattered coarse grains, subround to subangular, wet, increasing gravels from 67 to 69.5 ft..	
3950	70		8 25 51 R/5"		SW Sand: as above, becoming increasingly coarse grained with increasing gravels, grades to a sandy gravel at approximately 72 ft., wet.	
3940	80		15 42 51 R/3"		GW Sandy Gravel: dark reddish brown (2.5YR 4/8), angular to round gravels from .25 to 4 in. in a slightly silty sand matrix, sand ranges in size from very fine to coarse grained, saturated.	
					9 in. pipe T.D. 79.0 ft. Pounded Split Spoon from 70 to 81 ft for lithologic sample.	
3930	90					
3920	100					
3910	110					
3900	120					
3890	130					
3880						



Environmental Technology ornl Section

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

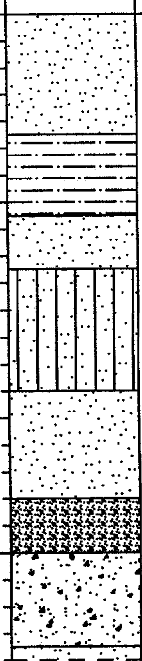
Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 19–24'
Natural Pack from 18–24'
8–12 Sand from 16–18'
1/4" Bentonite Pellets from 14–16'

roject Name: Atlas Groundwater Investigation	Site Id: TP-01
ate(s): 11/17/97 – 11/17/97	Total Depth: 24.00'
ontractor: ORNL/GJ	Borehole Dia.: 2.00in
levation: 3966.29'	Drilling Method: Direct Push
tate Plane North: 104249.78	Logged By: M.E. Mumby
tate Plane East: 2547004.60	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction

Elevation (ft): 3960, 3950, 3940, 3930
Depth (ft): 10, 20, 30



SP Sand: grayish brown, slightly moist, dry in some zones, very fine to fine grained, subangular.

ML Silt: dark grayish brown, soft, moist, sandy zone at approximately 5 ft., scattered very small roots 1mm or less, sharp contact with underlying sand.

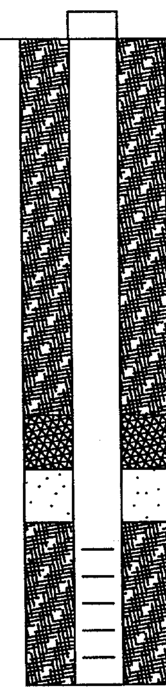
SP Sand: red, slightly moist, fine grained, with some very fine grained, subround, moderately well sorted, occasional dark accessory minerals.

SM Silty Sand: very dark grayish brown, soft, saturated, common organic debris and small roots 1mm or less, sands are very fine grained.

SP Sand: red, wet, predominantly fine grained with some very fine and medium grains, subround, clean.

SW Gravelly Sand: color as above, fine to coarse grained, subangular to round, with angular to round gmvels to 2cm. grades to a sandy gravel at approximately 19.5 ft.

GW Sandy Gravel: reddish gray angular to round gravels to 2.5cm in a sand matrix, sands are very fine to coarse grained, clean, saturated, grades back to a red fine grained sand from 23.5 to 24 ft.



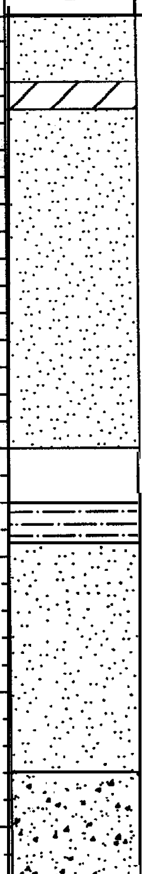
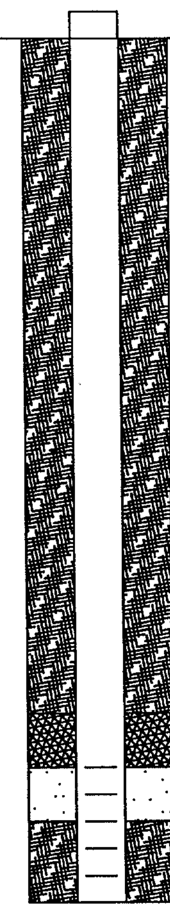
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

ENVIRONMENTAL TECHNOLOGY ornl SECTION

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 27–32'
Natural Pack from 27–32'
8–12 Sand from 27–29'
1/4" Bentonite Pellets from 25–27,

'roject Name: Atlas Groundwater Investigation	Site Id: TP–02
late(s): 11/18/97 – 11/18/97	Total Depth: 32.00'
:ontractor: ORNL/GJ	Borehole Dia.: 2.00in
:levation: 3972.48'	Drilling Method: Direct Push
itate Plane North: 103816.19	Logged By: D.A. Pickering
itate Plane East: 2546623.91	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			SP Sand: reddish brown, very fine grained, subangular, dry, occasional gravel <1.5cm.	
3970			CL Sandy Clay: brownish gray, sand is fine grained, dry.	
	10		SP Sand: reddish brown, very fine grained, dry.	
3960				
			Lost Recovery	
			CL Silty Clay: reddish brown, slight plasticity, wet.	
	20			
3950			SP Sand: as above, wet.	
	30		GW Sandy Gravel: reddish brown, subangular to subrounded gravels to 3.8cm in a sand matrix, sand is very fine to coarse grained, saturated.	
39·40				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

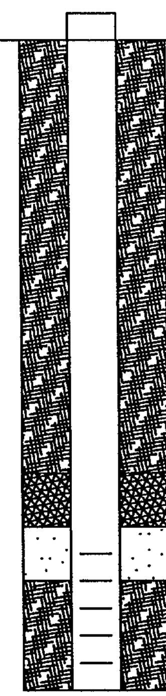
Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 19–24'
Natural Pack from 20–24'
8–12 Sand from 18–20'
1/4" Bentonite Pellets from 16–18'

Project Name: Atlas Groundwater Investigation	Site Id: TP-03
Date(s): 11/19/97 – 11/19/97	Total Depth: 24.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3961.11'	Drilling Method: Direct Push
State Plane North: 103295.95	Logged By: F.G. Gardner
State Plane East: 2546288.28	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description
3960			SP Sand: red to reddish brown, predominantly fine to very fine grained, well sorted, occasional gravel to 2.54cm, some fill debris.
3950	10		SW Sand: reddish brown to red , well graded sand with angular gravels, moist at 7 ft.
			No Samples Collected: Sampler stuck, overdrilled sampler with hollow stem augers, augered to 20 ft, sampled from 20 ft to T.D.
3940	20		SP Sand: brown to grayish brown, very fine with some medium grained, very wet.
			SW Gravelly Sand: brown sand with well rounded to angular gravels up to 3cm.
3930	30		

Well Construction



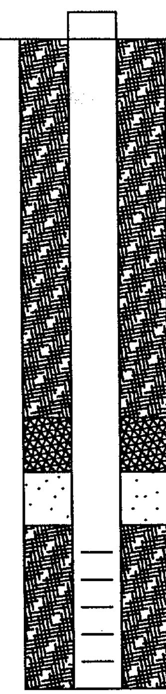
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 19–24'
Natural Pack from 18–24'
8–12 Sand from 16–18'
1/4" Bentonite Pellets from 14–16'

Project Name: Atlas Groundwater Investigation	Site Id: TP–04
Date(s): 11/19/97 – 11/19/97	Total Depth: 24.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3969.94'	Drilling Method: Direct Push
State Plane North: 102789.25	Logged By: F.G. Gardner
State Plane East: 2546032.62	Certified By: M.E. Mumby

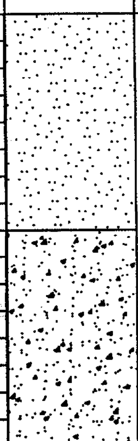
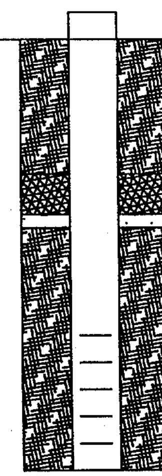
Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			SP Sand: red fine grained, with abundant fill debris, debris is light gray sandstone (ore?).	
			SP Sand: red, fine grained, slightly moist.	
3960	10			
			CL Silty Clay: red, soft, scattered very silty zones, becoming wet at 15 ft.	
			SM Silty Sand: brown, wet, some clay zones, saturated.	
			SP Sand: reddish brown to red, very fine to fine grained, well sorted, wet.	
3950	20		GW Gravel: red, gravels to 3cm in a very fine grained red sand matrix, saturated.	
			GW Gravel: red, gravels up to 5cm in a brown sandy matrix with lots of fines, saturated.	
3940	30			
3930				



Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Project Name: Atlas Groundwater Investigation	Remarks: 1" O.D. Slotted PVC Screen 11-16' Natural Pack from 7-16' 8-12 Sand from 6.5-7' 1/4" Bentonite Pellets from 5-6.5'
	Site Id: TP-05
Date(s): 11/19/97 - 11/19/97	Total Depth: 16.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3960.82'	Drilling Method: Direct Push
State Plane North: 102766.89	Logged By: F.G. Gardner
State Plane East: 2545712.12	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			SP Sand: red, abundant stream debris (black ash, cinders, and small limestone fragments.	
			SP Sand: color as above, increasing coarse grained sand at 6 ft.	
			GW Gravel: wet at 7.0 ft.	
3950	10			
			GW Gravel: reddish brown, grades to a well graded sand at 15 ft.	
3940	20			
3930	30			

Oak Ridge National Laboratory
Environmental Technology Section
2597 El 3/4 Road
Grand Junction, CO 81503

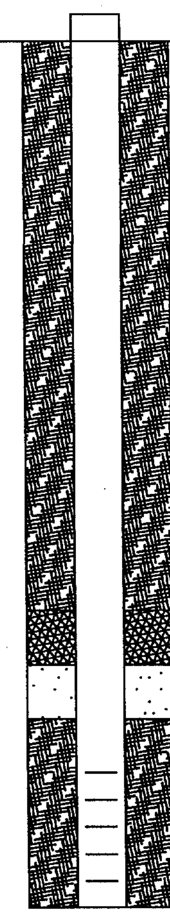
ENVIRONMENTAL TECHNOLOGY ornl SECTION

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 27-32
Natural Pack from 25-32'
8-12 Sand from 23-25'
1/4" Bentonite Pellets from 21-23'

Project Name: Atlas Groundwater Investigation	Site Id: TP-06
Date(s): 11/20/97 - 11/20/97	Total Depth: 32.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3959.47'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 100717.48	Logged By: J.L. Zutman
State Plane East: 2544729.31	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2-in hole to top of gravel, descriptions based on auger cuttings.	
			ML Clayey Silt: brownish gray.	
			Wet at 7 ft.	
3950	10			
3940	20			
			Top of Gravel approximately 29 ft.	
3930	30		Pounded Geo-Insight rod to 32 ft to set well.	
3920				



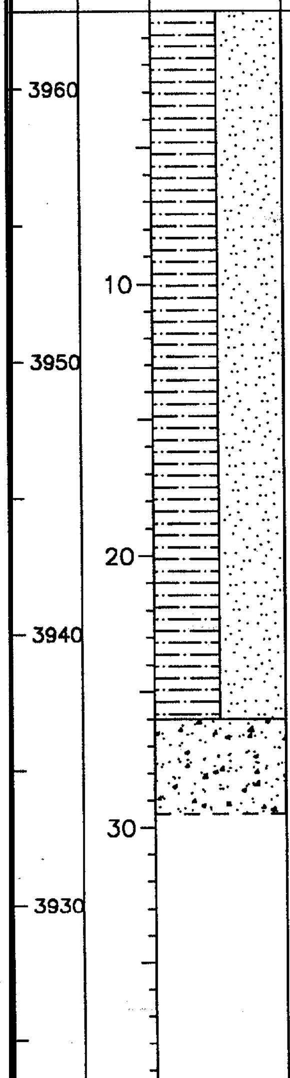
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 24.5–29.5
Natural Pack from 25–29.5'
8–12 Sand from 23–25'
1/4" Bentonite Pellets from 21–23'

Project Name: Atlas Groundwater Investigation	Site Id: TP–07
Date(s): 11/20/97 – 11/20/97	Total Depth: 29.50'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3962.87'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 100710.61	Logged By: J.L. Zutman
State Plane East: 2545168.28	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction



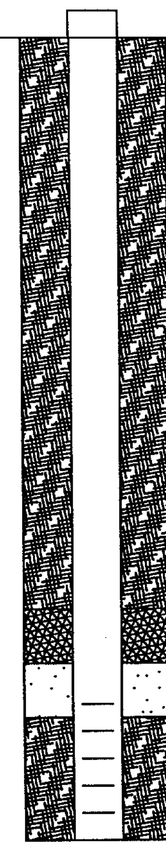
Auger 2 in hole to top of gravel, descriptions based on auger cuttings.

ML–SP Clayey Silt/Sand

Wet at 7 ft.

Top of Gravel approximately 26 ft, auger to 27 ft.

Pounded Geo–Insight rod to 29.5 ft to set well.



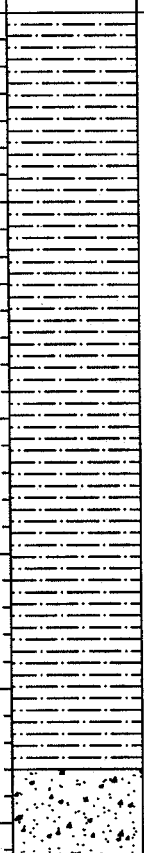
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

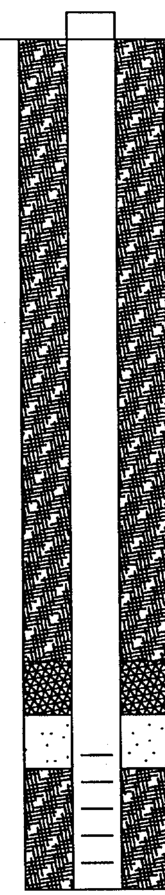
Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 26.5–31.5'
Natural Pack from 27–31.5'
8–12 Sand from 25–27'
1/4" Bentonite Pellets from 23–25

Project Name: Atlas Groundwater Investigation	Site Id: TP–08
Date(s): 11/20/97 – 11/20/97	Total Depth: 31.50'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3964.16'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101187.01	Logged By: J.L. Zutman
State Plane East: 2545328.87	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960				
	10		ML Clayey Silt.	
3950				
	20			
3940				
			Top of Gravel approximately 28 ft, auger to 31 ft.	
	30		Pounded Geo–Insight rod to 31.5 ft to set well.	
3930				





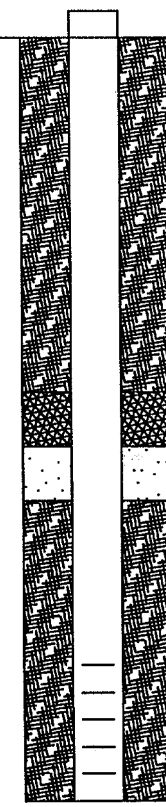
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

ENVIRONMENTAL TECHNOLOGY ORNL SECTION

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 23–28'
Natural Pack from 17–28'
8–12 Sand from 15–17'
1/4" Bentonite Pellets from 13–15'

Project Name: Atlas Groundwater Investigation	Site Id: TP-09
Date(s): 11/20/97 – 11/20/97	Total Depth: 28.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3964.75'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101671.28	Logged By: J.L. Zutman
State Plane East: 2545526.35	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960				
	10		SM Silt/Sand	
3950				
			Gravel Stringer from 17–18 ft.	
			Top of Gravel approximately 19 ft, auger to 21 ft.	
	20			
3940			Pounded Geo-Insight rod to 28 ft to set well.	
	30			
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

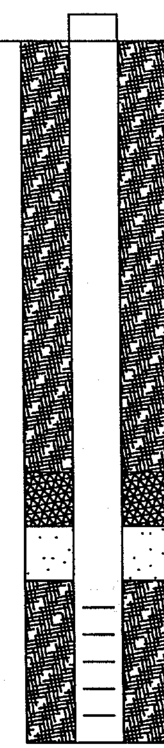
ENVIRONMENTAL TECHNOLOGY ornl SECTION

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 21-26'
Natural Pack from 20-26'
8-12 Sand from 18-20'
1/4" Bentonite Pellets from 18-20'

roject Name: Atlas Groundwater Investigation	Site Id: TP-10
ate(s): 11/20/97 - 11/20/97	Total Depth: 26.00'
ontractor: ORNL/GJ	Borehole Dia.: 2.00in
levation: 3964.04'	Drilling Method: Solid Stem Auger/Direct Push
tate Plane North: 102143.53	Logged By: J.L. Zutman
tate Plane East: 2545724.85	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960				
			SM Silt/Sand	
	10			
3950			Scattered gravel Stringers from 15-18 ft.	
	20			
			Top of Gravel approximately 21 ft, auger refusal at 21 ft.	
3940			Pounded Geo-Insight rod to 26 ft to set well.	
	30			
3930				

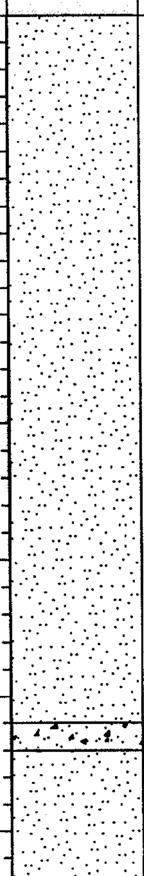
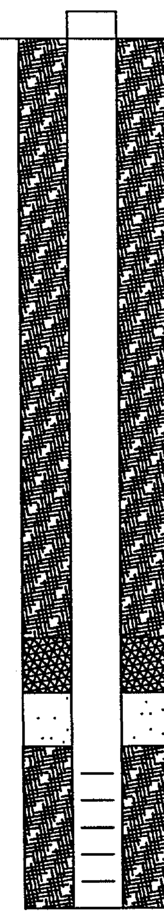


Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 27–32'
Natural Pack from 26–32'
8–12 Sand from 24–26'
1/4" Bentonite Pellets from 22–24'

Project Name: Atlas Groundwater Investigation	Site Id: TP–11
Date(s): 11/21/97 – 11/21/97	Total Depth: 32.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3964.38'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 104715.10	Logged By: J.L. Zutman
State Plane East: 2547618.64	Certified By: M.E. Mumby

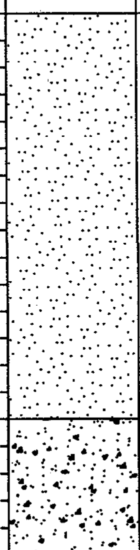
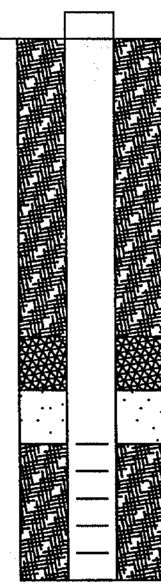
Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960				
	10			
3950			SP Sand with some silt.	
	20			
3940			Gravel Stringer at 26 ft. Auger refusal at 26 ft.	
	30		Pushed Geo–Insight rod to 32 ft to set well, very soft (fine sand?).	
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 15–20'
Natural Pack from 15–20'
B-12 Sand from 13–15'
1/4" Bentonite Pellets from 11–13'

Project Name: Atlas Groundwater Investigation	Site Id: TP–12
Date(s): 11/22/97 – 11/22/97	Total Depth: 20.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3965.54'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 102548.25	Logged By: J.L. Zutman
State Plane East: 2545991.33	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960			SP Sand with some silt.	
	10			
3950			Top of gravel approximately 15 ft.	
			Pounded Geo–Insight rod to 20 ft to set well.	
	20			
3940				
	30			
3930				

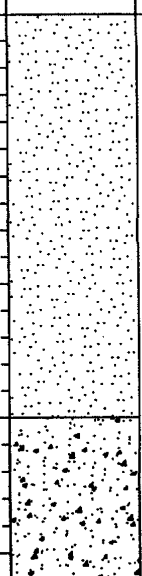
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

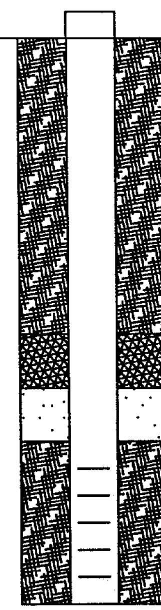
Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 16–21
Natural Pack from 15–21'
8–12 Sand from 13–15
1/4" Bentonite Pellets from 11–13,

Project Name: Atlas Groundwater Investigation	Site Id: TP–13
Date(s): 11/22/97 – 11/22/97	Total Depth: 21.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3965.88'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101939.43	Logged By: M.E. Mumby
State Plane East: 2545842.15	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960			SP Sand with some silt.	
	10			
3950			Top of gravel approximately 15 ft, auger to 16 ft.	
			Pounded Geo–Insight rod to 21 ft to set well.	
	20			
3940				
	30			
3930				



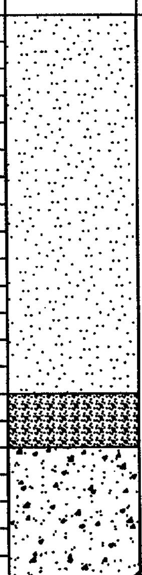
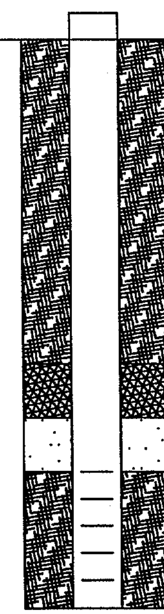


Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 16–21'
Natural Pack from 16–21'
8–12 Sand from 14–16'
1/4" Bentonite Pellets from 12–14'

Project Name: Atlas Groundwater Investigation	Site Id: TP–14
Date(s): 11/22/97 – 11/22/97	Total Depth: 21.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3964.92'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101464.92	Logged By: M.E. Mumby
State Plane East: 2545718.43	Certified By: F.G. Gardner

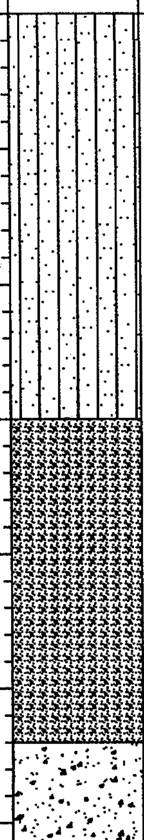
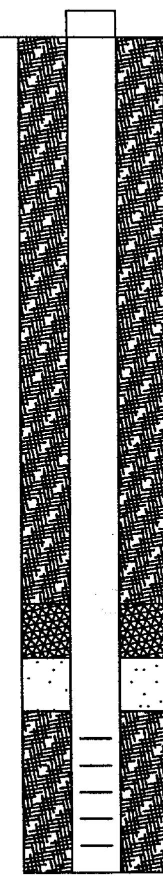
Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3960				
			SP Sand with some silt.	
	10			
3950			SW Sand, wet	
			Top of gravel approximately 15 ft, auger to 16 ft.	
			Pounded Geo–Insight rod to 21 ft to set well.	
	20			
3940				
	30			
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 26–31'
Natural Pack from 25–31'
8–12 Sand from 23–25'
1/4" Bentonite Pellets from 21–23'

Project Name: Atlas Groundwater Investigation	Site Id: TP–15
Date(s): 11/22/97 – 11/22/97	Total Depth: 31.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3963.94'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 100942.53	Logged By: J.L. Zutman
State Plane East: 2545637.76	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
	10		SM Silty Sand with some clay.	
3950				
	20		SW Sand, coarse grained, wet.	
3940			Top of gravel approximately 27 ft.	
	30		Pounded Geo–Insight rod to 31 ft to set well.	
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 22–27'
Natural Pack from 22–27'
8–12 Sand from 20–22'
1/4" Bentonite Pellets from 18–20'

roject Name: Atlas Groundwater Investigation	Site Id: TP–16
ate(s): 11/23/97 – 11/23/97	Total Depth: 27.00'
ontractor: ORNL/GJ	Borehole Dia.: 2.00in
levation: 3962.77'	Drilling Method: Solid Stem Auger/Direct Push
tate Plane North: 100468.26	Logged By: J.L. Zutman
tate Plane East: 2545580.51	Certified By: M.E. Mumby

Elevation (ft) | Depth (ft) | Graphic Log | Material Description | Well Construction

Elevation 396 — Auger 2 in hole to top of gravel, descriptions based on auger cuttings.

SM Silty Sand with some clay.

Depth 10 — Elevation 395

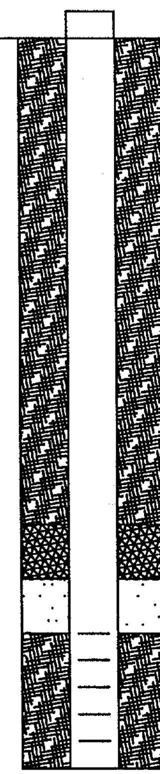
SW Sand, coarse grained, wet.

Depth 20 — Elevation 394

Top of gravel approximately 23 ft.

Pounded Geo–Insight rod to 27 ft to set well.

Depth 30 — Elevation 393

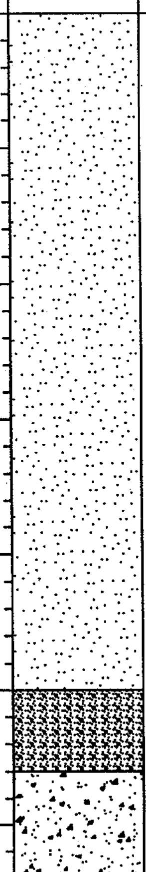


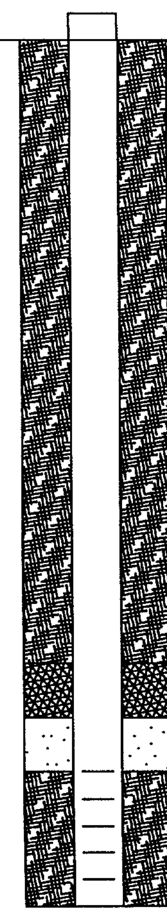
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Project Name: Atlas Groundwater Investigation	Remarks: 1" O.D. Slotted PVC Screen 27–32' Natural Pack from 27–32' 8–12 Sand from 25–27' 1/4" Bentonite Pellets from 23–25'
Date(s): 11/23/97 – 11/23/97	Site Id: TP–17
ontractor: ORNL/GJ	Total Depth: 32.00'
levation: 3961.60'	Borehole Dia.: 2.00in
tate Plane North: 99785.34	Drilling Method: Solid Stem Auger/Direct Push
tate Plane East: 2545539.67	Logged By: J.L. Zutman
	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			Auger 2 in hole to 27 ft., descriptions based on auger cuttings.	
3950	10		SP Sand, fine grained, some silt.	
3940	20			
			SW Sand, coarse grained, wet.	
			Top of gravel approximately 28 ft.	
3930	30		Pounded Geo–Insight rod to 32 ft to set well.	



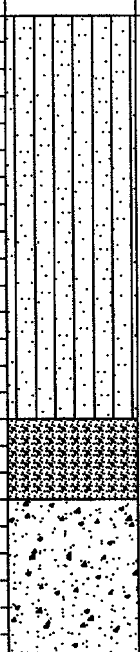
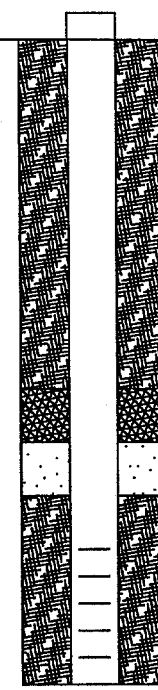


Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction', CO 81503

Monitoring Well Summary

Remarks:
1" Slotted PVC Screen 19–24'
Natural Pack from 17–24'
8–12 Sand from 15–17'
1/4" Bentonite Pellets from 13–15'

Project Name: Atlas Groundwater Investigation	Site Id: TP–18
Date(s): 11/23/97 – 11/23/97	Total Depth: 24.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3961.25'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 99074.73	Logged By: J.L. Zutman
State Plane East: 2545813.04	Certified By: M.E. Mumby

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3950	10		SM Silty Sand	
			SW Sand, coarse grained, wet.	
			Top of gravel approximately 18 ft.	
3940	20		Pounded Geo–Insight rod to 24 ft to set well.	
3930	30			

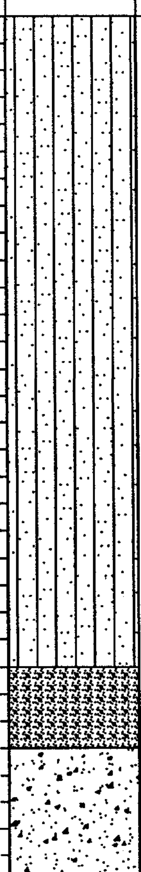
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

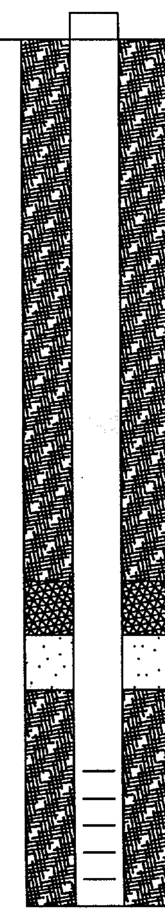
Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 27–32'
Natural Pack from 24–32'
8–12 Sand from 22–24'
1/4" Bentonite Pellets from 20–22'

roject Name: Atlas Groundwater Investigation	Site Id: TP–19
ate(s): 11/24/97 – 11/24/97	Total Depth: 32.00'
ontractor: ORNL/GJ	Borehole Dia.: 2.00in
levation: 3959.79'	Drilling Method: Solid Stem Auger/Direct Push
tate Plane North: 98376.33	Logged By: M.E. Mumby
tate Plane East: 2546013.80	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
3950	10			
			SM Silty Sand	
3940	20			
			SW Sand, coarse grained, wet.	
			Top of gravel approximately 27 ft.	
3930	30		Pounded Geo–Insight rod to 32 ft to set well.	
3920				



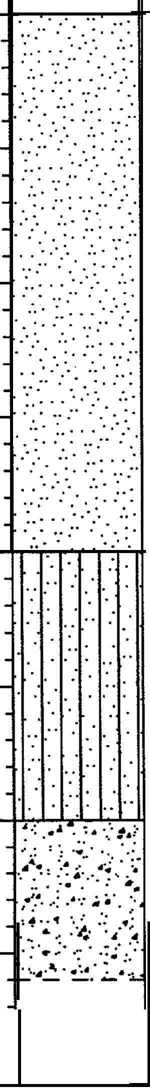


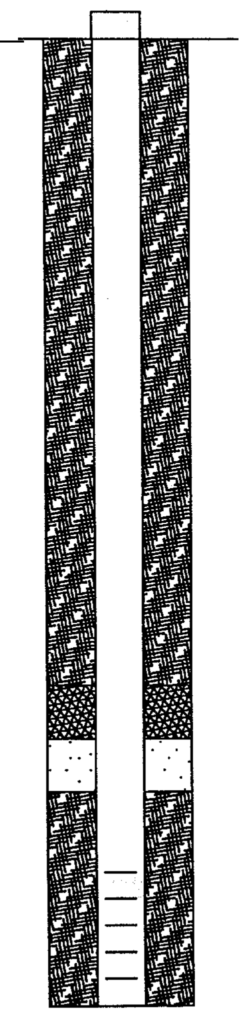
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

'roject Name: Atlas Groundwater Investigation	Remarks: 1" O.D. Slotted PVC Screen 31–36' Natural Pack from 28–36' 8–12 Sand from 26–28' 1/4" Bentonite Pellets from 24–26'
late(s): 11/24/97 – 11/24/97	Site Id: TP–20
;ontractor: ORNL/GJ	Total Depth: 36.00'
levation: 3964.51'	Borehole Dia.: 2.00in
itate Plane North: 100102.40	Drilling Method: Solid Stem Auger/Direct Push
itate Plane East: 2545007.22	Logged By: M.E. Mumby
	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
			Auger 2 in hole to 27 ft., descriptions based on auger cuttings.	
396				
	10		SP Sand, red, fine grained, wet at approximately 14–15 ft.	
395				
	20			
394			SM Silty Sand	
	30		Top of gravel approximately 30 ft., based on Geo–Insight penetration rate.	
			Pounded Geo–Insight rod to 32 ft to set well.	
393				



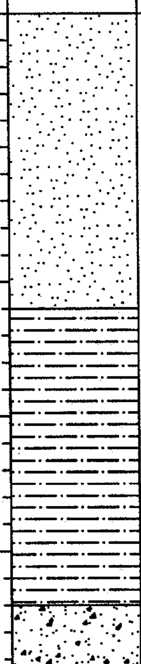
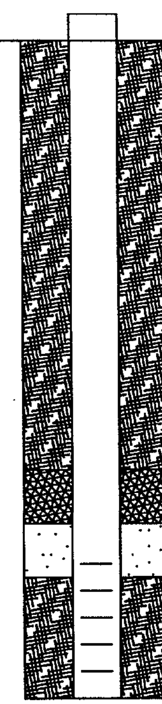


Oak Ridge Nationol Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 19.5–24.5'
Natural Pack from 20–24.5'
8-12 Sand from 18–20'
1/4" Bentonite Pellets from 16–18'

Project Name: Atlas Groundwater Investigation	Site Id: TP-21
Date(s): 11/24/97 – 11/24/97	Total Depth: 24.50'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3961.60'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 97881.92	Logged By: M.E. Mumby
State Plane East: 2546048.52	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
			SP Sand	
3950	10			
			ML Sandy Silt	
3940	20		Top of gravel approximately 22 ft.	
			Pounded Geo-Insight rod to 24.5 ft, large cobble cannot pound through, set well at 24.5 ft.	
3930	30			

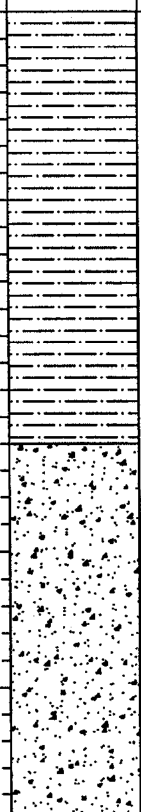
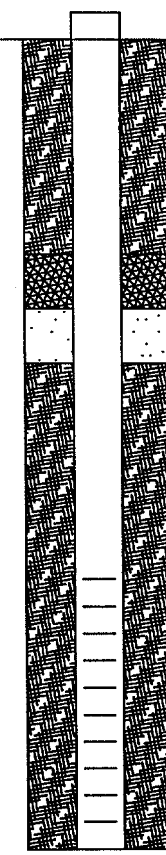
Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

ENVIRONMENTAL TECHNOLOGY ornl SECTION

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 20–30'
Natural Pack from 12–30'
8–12 Sand from 10–12'
1/4" Bentonite Pellets from 8–10

Project Name: Atlas Groundwater Investigation	Site Id: OW–01
Date(s): 11/21/97 – 11/21/97	Total Depth: 30.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3963.87'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101746.85	Logged By: J.L. Zutman
State Plane East: 2545115.41	Certified By: M.E. Mumby

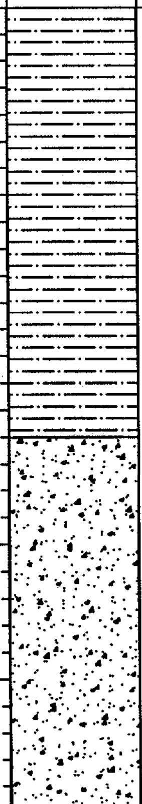
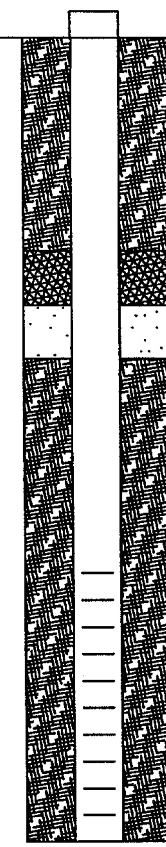
Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
3960			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
			ML/CL Silt and Clayey Silt.	
	10			
3950			Top of gravel approximately 16 ft.	
	20			
3940			Pounded Geo–Insight rod to 30 ft to set well.	
	30			
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" Slotted PVC Screen 20–30'
Natural Pack from 12–30'
8–12 Sand from 10–12'
1/4" Bentonite Pellets from 8–10'

Project Name: Atlas Groundwater Investigation	Site Id: OW–02
Date(s): 11/21/97 – 11/21/97	Total Depth: 30.00'
Contractor: ORNL/GJ	Borehole Dia.: 2.00in
Elevation: 3963.78'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101753.79	Logged By: J.L. Zutman
State Plane East: 2545123.96	Certified By: M.E. Mumby

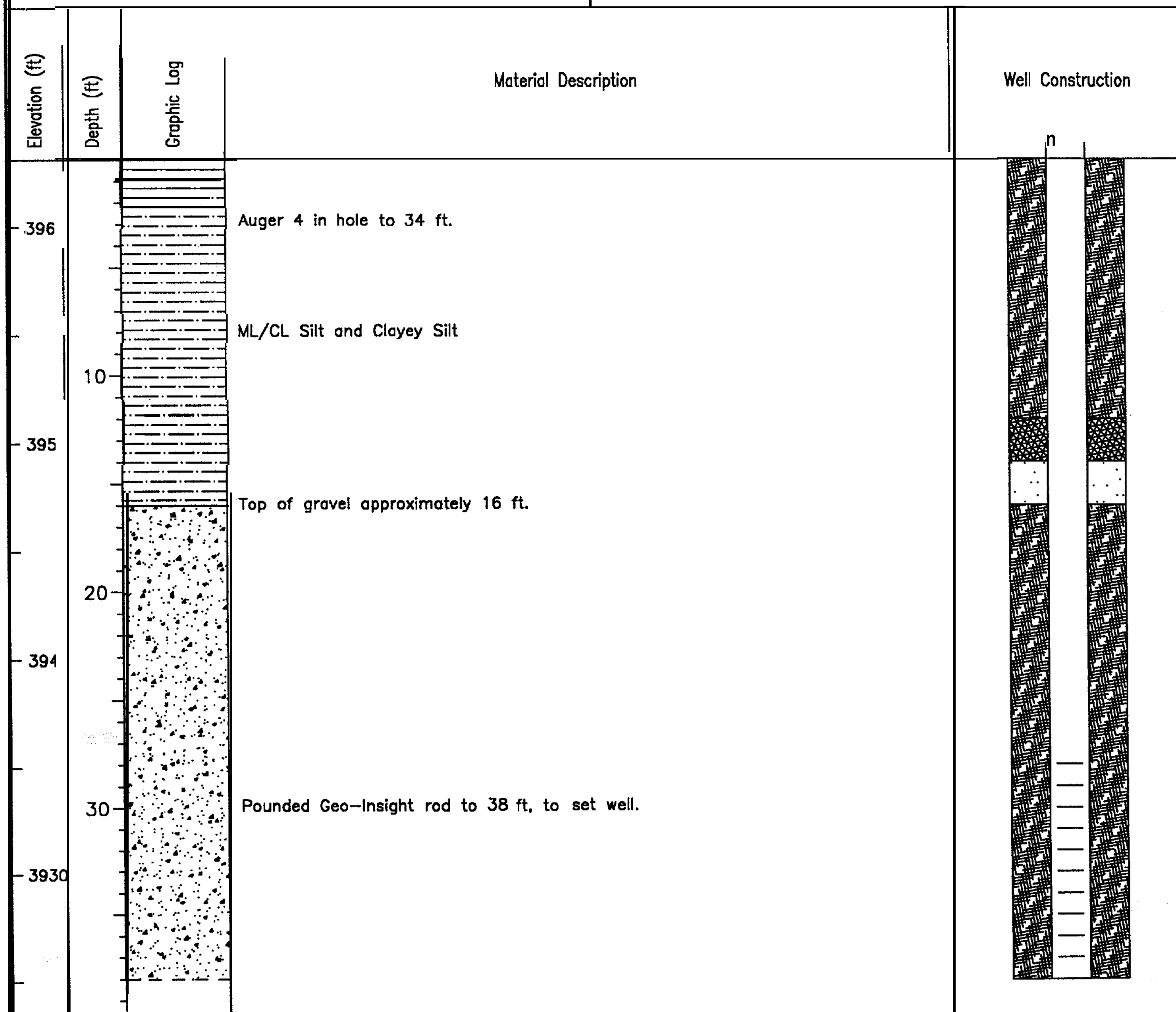
Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction
				
3960			Auger 2 in hole to top of gravel, descriptions based on auger cuttings.	
			ML/CL Silt and Clayey Silt	
	10			
3950			Top of gravel approximately 16 ft.	
	20			
3940			Pounded Geo–Insight rod to 30 ft, to set well.	
	30			
3930				

Oak Ridge National Laboratory
Environmental Technology Section
2597 B 3/4 Road
Grand Junction, CO 81503

Monitoring Well Summary

Remarks:
1" O.D. Slotted PVC Screen 28–38'
Natural Pack from 16–38'
8–12 Sand from 14–16'
1/4" Bentonite Pellets from 12–14'

Project Name: Atlas Groundwater Investigation	Site Id: OW-03
Date(s): 12/02/97 – 12/02/97	Total Depth: 38.00'
Contractor: ORNL/GJ	Borehole Dia.: 4.00in
Elevation: 3963.13'	Drilling Method: Solid Stem Auger/Direct Push
State Plane North: 101735.96	Logged By: M.E. Mumby
State Plane East: 2545089.06	Certified By: F.G. Gardner

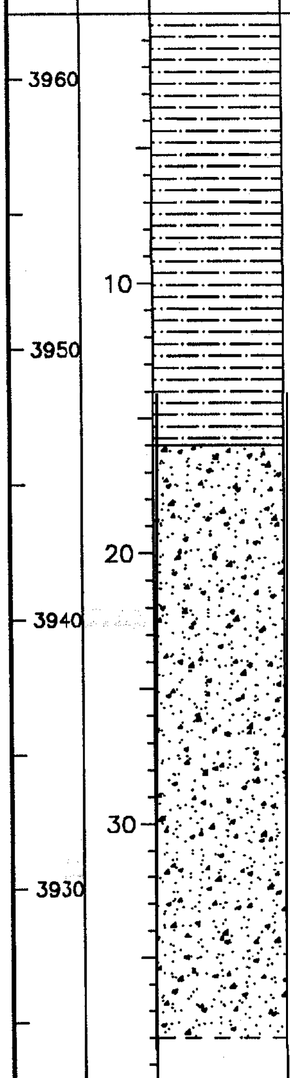


Oak Ridge National Laboratory
Environmental Technology Section
2597 El 3/4 Road
Grand Junction', CO 81503

Monitoring Well Summary

'roject Name: Atlas Groundwater Investigation	Remarks: 1" O.D. Slotted PCV Screen 28–38' Natural Pack from 16–38' 8–12 Sand from 14–16' 1/4" Bentonite Pellets from 12–14'
	Site Id: OW–04
iate(s): 12/02/97 – 12/02/97	Total Depth: 38.00'
;ontractor: ORNL/GJ	Borehole Dia.: 4.00in
:levation: 3962.43'	Drilling Method: Solid Stem Auger/Direct Push
itate Plane North: 101735.96	Logged By: M.E. Mumby
itate Plane East: 2545079.06	Certified By: F.G. Gardner

Elevation (ft)	Depth (ft)	Graphic Log	Material Description	Well Construction

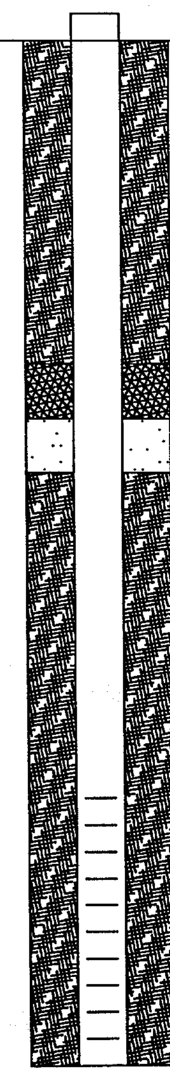


Auger 4 in hole to 38 ft.

ML/CL Silt and Clayey Silt

Top of gravel approximately 16 ft.

Pushed Geo-Insight rod to 38 ft, to set well.



GEOLOGIST DRILL HOLE REPORT

WESTERN TECHNOLOGIES INC.

Project: 219-0K-011 Hole No.: PW-2

State: Utah County: Grand

T. 25 S R. 27 E S. SW ¼ 27

Client: Atlas Minerals

Coordinates: 3975.44 N 5885.30 E

Geologist: G. Curtiss

Elevation: 4050.90 FTC

Driller: R. Sharp

Drilling Contractor: Boyles Brothers

Date Started: 3/25/90

Date Completed: 3/26/90

Drilling Method: Hollow Stem Auger (6½)

Diameter: noininal 10"

Geophysical Logs: None

Comments: cuttings descriptions unless otherwise designated

DEPTH From	DEPTH To	LITHOLOGY
0	2.0	Fill; brown & reddish-brown sand & gravel, very fine grain, dry.
2.0	5.0	TAILINGS: Sand; light brown, very fine to coarse grain, poorly sorted, loose & unconsolidated, dry.
5.0	9.0	Sand; darker brown, fine to coarse grain, moderately well sorted, predominantly fine grained, soft, dry.
9.0	10.0	Argillaceous sand; brown, fine grain, abundant clay, balls up, soft, moisr.
10.0	20.0	Sand; brown, very fine to medium grain (90-95% very fine), moderate to poor sorting, soft, wet, gets wetter fron 19-20', grain size decreases with depth.
20.0	25.0	Argillaceous sand; light brown to brown, very fine to fine grain (60-70% fine), wet (not as wet as 15-20' except from 24-25').
25.0	26.5	SPLIT SPOON SAMPLE #PW-21 blow counts = 7 blows (90% recovery)
25.0	25.5	Sand; light brown, very fine to fine grain, sub-rounded to sub-angular, poorly sorted, soft, very wet.

WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: PW-2

DEPTH From	DEPTH To	LITHOLOGY
25.5	26.3	Sand; light brown, fine grain, sub-rounded, well sorted, not as wet as above.
26.3	26.5	Sand; light greenish-brown, very fine to fine grain, poorly sorted, wet.
26.5	40.0	Sand; light brown, very fine to fine grain, argillaceous in spots, very soft, very wet (80% fine grain @ 35-40').
40.0	41.5	SPLIT SPOON SAMPLE #PW22 blow counts = 20,23,17 (90% recovery)
40.0	40.5	Sand;light brown, very fine to fine grain (50%-50%), moderately well sorted, very soft, very wet.
30.5	41.2	Sandy siltstone; gray, argillaceous, somewhat plastic, soft, wet.
41.2	41.5	Sandy siltstone as above with slight increase in water, wet.
41.5	50.0	Sand; brown, fine grain, silty, sub-angular to sub rounded, soft, wet.
50.0	51.5	SPLIT SPOON #PW-23 blow counts = 3,4,2 (100% recovery) Sand; gray, slightly argillaceous (becomes more argillaceous with depth), very fine grain, sub-rounded to sub-angular, fairly well sorted, homogeneous sample, no sights of layering in this sample, wet.
51.5	60.0	Sand; grayish brown, very fin: to fine grain (50%-50%), moderate sorting, soft, wet, grain size decreases with depth to 100% very fine grain.
60.0	61.5	SPLIT SPOON SAMPLE #PW-24 blow counts = 3,3,5 (100% recovery) Sand; light gray, very fine grain, slightly silty, well sorted, sub-angular, soft and semi-plastic, becomes a silty clay in bottom 4" inter-layered with sand, wet.
61.5	70.0	Sand; light brown, very fine to fine grain, moderate sorting, soft, less than 1% dark grains (black, green and red) in lower 5 feet. wet.

WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: PW-2

DEPTH From	DEPTH To	LITHOLOGY
70.0	71.5	SPLIT SPOON SAMPLE #PW-25 blow counts = 1,1,2 (60% recovery) Silty sand; very light gray, very fine grain with abundant silt. soft, very wet.
71.5	77.5	Sand; light brownish-gray to light brown, very fine grain, silty. soft, wet.
77.5	80.0	Clay - see PW-26 below
80.0	81.5	SPLIT SPOON SAMPLE #PW-26 blow counts = 40,60,100 Clay; grey with thin interlayers of reddish color throughout. stiff, looks very tight, moist.
81.5	90.0	No samples recovered, driller thought he was still in clay described above until 88.5' where drilling rate changed.
90.0	91.1	SPLIT SPOON SAMPLE #PW-27 blow counts = 70,140,50 (Formation hard and resisted split spoon sampler, drove sampler 1.1') Alluvium - sand; red and brownish-red, fine grain, fairly well sorted, sub-angular to sub-rounded, abundant iron oxide stain, slightly argillaceous, moist.
91.1	100.0	No samples recovered.
100.0	101.5	SPLIT SPOON SAMPLE #PW-28 blow counts = 7,14,18 (100% recovery)
100.0	100.5	Sand; red to brownish-red, very silty and argillaceous, very fine grained, moderately sorting, fairly tight, wet to moist.
100.5	101.5	Sandy silt; greenish-grey, argillaceous, 2-3% black streaks, tight, moist.
101.5	110.0	No samples recovered
110.0	111.5	SPLIT SPOON SAMPLE #PW-29 blow counts = 17,16,20
110.0	111.1	Sand; light brown, very fine to fine grain (95% vfg), mostly quartz with minor feldspar, approx. 3% dark grains increasing to 20% at bottom of interval, soft, very wet.

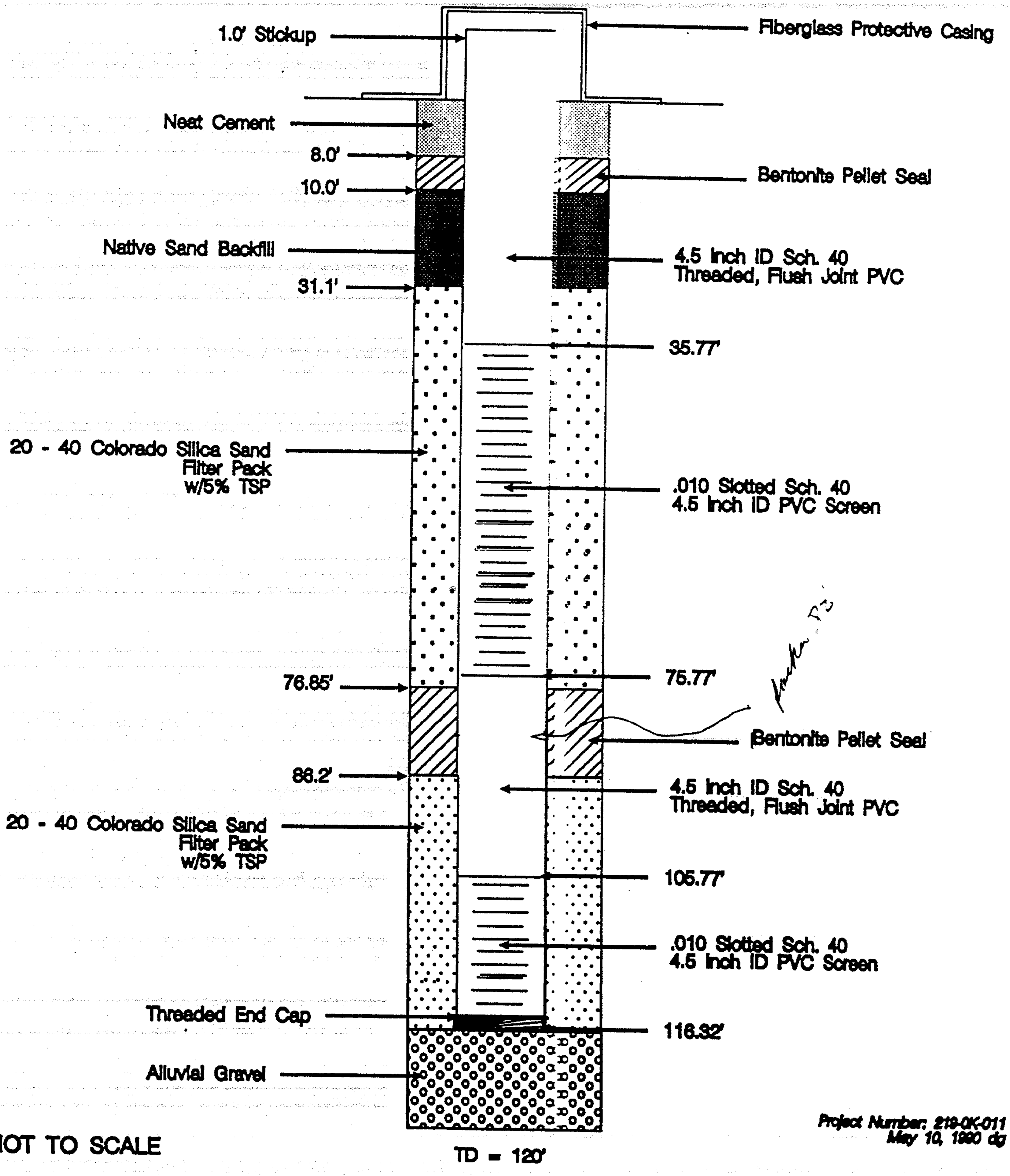
WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: ____________

DEPTH From	DEPTH To	LITHOLOGY
111.1	111.3	Gravel and sand, pinkish-brown with local pebbles (Entrada fm.? and igneous origin), some clay.
111.5	120.0	No samples recovered.
120.0	121.1	SPLIT SPOON SAMPLE #PW-210 blow counts = 8,60,62 (less than 20% recovery) Sand; light brown, very fine to coarse grain, 3% dark grains, slight arkosic, wet.
		T.D.

WELL COMPLETION DIAGRAM
PW-2



NOT TO SCALE

Project Number: 219-0K-011
May 10, 1990 dg

GEOLOGIST DRILL HOLE REPORT

WESTERN TECHNOLOGIES INC.

Project: 21g-OK-01 1 Hole No.: PW-1

State: Utah County: Grand

T. 25 S R. 21 E S. SW 1/4 27

Client: Atlas Minerasl

Coordinates: 4142.30 N 6191.99 E

Geologist: G. Curtiss

Elevation: 4,054.71 (FTC)

Driller: R. Sharp

Drilling Contractor: Boyles Brothers

Date Started: 3/16/90

Date Completed: 3/23/90

Drilling Method: Hollow Stem Auger (6¼")

Diameter: Nominal 10"

Geophysical Logs: None

Comments: cuttings description unless otherwise designated

DEPTH From	DEPTH To	LITHOLOGY
0	2.0	Fill, dark brown to red, fine graih, dry
2.0	4.4	Tailings: Sand; light tan, dry, fine to medium grain (90% f.g.), sub rounded, quartz.
4.4	9.0	Sand; tan, very fine to fine grain, slightly argillaceous, slightly damp, (50% f.g., 50% v.f.g.)
9.0	21.0	Sand; tan, fine grain, sub-rounded to sub-angular, slightly clayey (less than 2% clay), slightly damp, becomes more fine grained with depth.
21.0	24.0	COLOR CHANGE; hard, resistant layer Sand and clay; grey, approx. equal portions and described below. Sand is grey, fine grained, sub-rounded, argillaceous, moderately hard to soft. Clay is grey, sandy.
24.0	25.5	SPLIT SPOON SAMPLE #PW-11 blow counts=61,100,116
24.0	24.5	Sand; grey, hard and well indurated, fine grain, sub-angular to sub-rounded, dry, less than 3% dark grains.

WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: PW-1

DEPTH From	DEPTH To	LITHOLOGY
21.5	24.9	Sand; reddish-brow, slightly hard, much softer than 24.0 - 25.5, fine grain, well sorted, sub-angular to sub-rounded, slightly argillaceous, slightly damp.
24.9	25.5	Sand; tan, fine grain, well sorted, less than 1% dark grains, 30-40% Fe Ox stain, soft, slightly damp to dry.
25.5	29.0	Sand; light brown, fine grain, well sorted, sub-rounded to sub-angular, slightly damp, soft.
29.0	34.0	HIT WATER BETWEEN 29 & 34. Sand, as above, slightly argillaceous, soft; driller believes he hit water at 31-33'.
34	39	Sand, brown, very fine to fine grain (approx. 50%50%) soft, slightly argillaceous, moderate to poor sorting, wet.
39	40.5	SPLIT SPOON SAMPLE #PW-12 (driller pushed spoon du: to mechan. problems) Sand; grey, soft, very fin: grain, well sorted, sub-rounded, quartz, wet.
40.5	44.0	Sand; brow, very fine grain, well sort:?, sub-rounded, soft, wet.
44.0	49.0	Sand; as above with less than 20% silt, sub-rounded to sub-angular, more poorly sorted than above, wet.
49.0	50.5	SPLIT SPOON SAMPLE #PW-13 (pushed spoon) Sand; grey, soft, very fine to fine grtined, finer at top, well sorted, quartz, less than 1% dark grains.
50.5	59.0	Sand; brown, very fine grained, less than 2% black grains, soft, wet.
59.0	60.5	SPLIT SPOON SAMPLE #PW-14 (pushed spoon) Sand; light grey, very fine grain, well sorted, sub-rounded, soft, wet, ground water parametters: pH=6.34 Conduct.=19,500 μ S/cm T=72.9 °F
60.5	64.0	No sample recovery.
64.0	69.0	Sand; light brownish-grey, very fine grain to fine grain, sub-angular to sub-rounded, soft, less well sorted than above, wet.

WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: PW-1

DEPTH From	DEPTH To	LITHOLOGY
69.0	70.5	SPLIT SPOON SAMPLE #PW-15 (pushed spoon) Sand and clay as described below: Sand; light grey, very fine grain, sub-rounded, soft, wet grades downward into clay. Clay; light brownish-grey, silty, plastic, fills bottom 0.5' of tube (70.0' -70.5').
70.5	79.0	No sample recovery.
79.0	80.5	SPLIT SPOON SAMPLE #PW-16 (pushed, spoon) Top 1.0 is sand; light grey, fine grain with minor very fine grains, sub-angular to sub-rounded, soft, moderately well sorted, wet. Bottom 0.5' is sandy clay; light grey, moderately soft, moist.
80.5	84.0	Sand; light brown, very fine grain, minor fine grains, slightly argillaceous, moderately well sorted, soft, wet.
84.0	89.0	No sample recovery.
89.0	90.5	SPLIT SPOON SAMPLE #PW-17 (pushed spoon) Sandy clay; gray w/brown oxide streaks, sand is very fin: grain, approx. 30-40% of total sample. Clay and siltstone - 60-70% of sample, modtrately plastic, moist, soft.
90.5	99.0	No samples recovered.
99.0	100.5	SPLIT SPOON SAMPLE #PW-18 (pushed spoon) Sandy clay; brownish-grey, some brown oxide staining, moderately rigid to plastic, moist to wet, soft.
100.5	109.0	No sample recovery.
109.0	110.5	SPLIT SPOON SAMPLE #PW-19 (pushed spoon) Alluvium - sand; brown, very fine to course grain with some gravel, sub-angular to sub-rounded, mostly quartz, poorly sorted, soft, very wet, this is the alluvial material which underlies the tailings, (note: 30% recovery in split spoon).

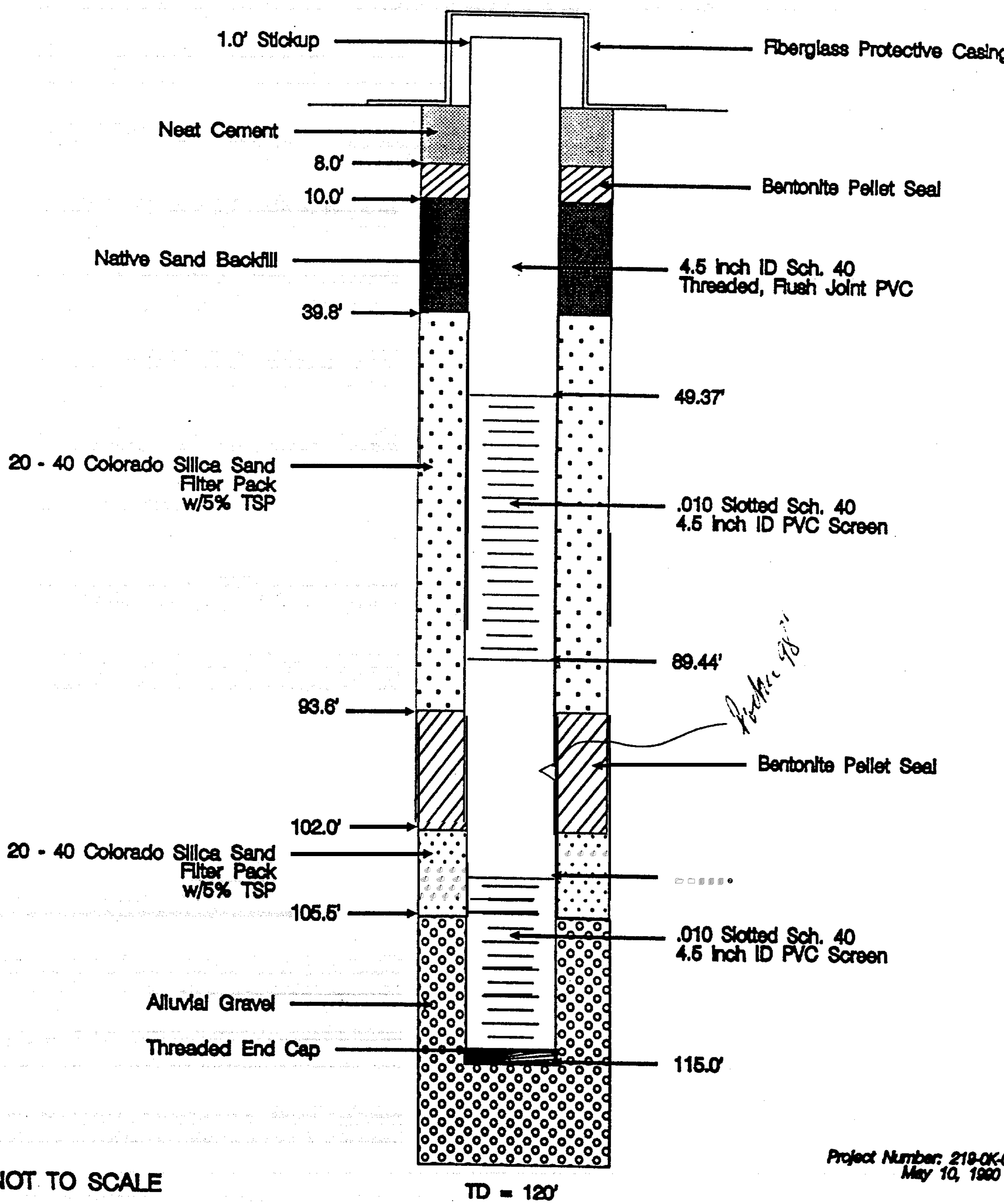
WESTERN TECHNOLOGIES INC.

GEOLOGIST DRILL HOLE REPORT

Hole No.: PW-1

DEPTH		LITHOLOGY
From	To	
110.5	120.0	Alluvium - (gravel and flowing sands) No samples recovered; however, driller had trouble making connections with auger due to the flowing sand.
120.0	121.5	SPLIT SPOON SAMPLE =1 10 (pushed spoon) Gravel as above - 30% recovery in spoon.
		TD

WELL COMPLETION DIAGRAM
PW-1

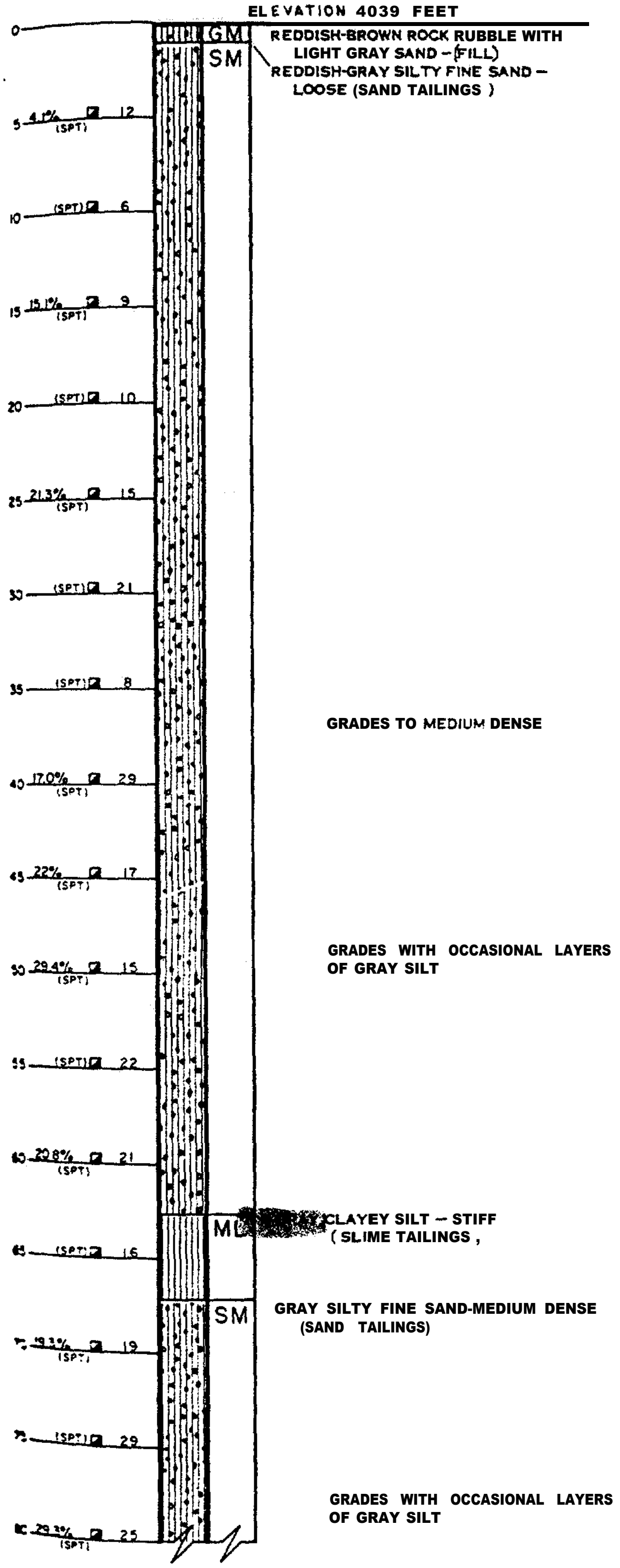


NOT TO SCALE

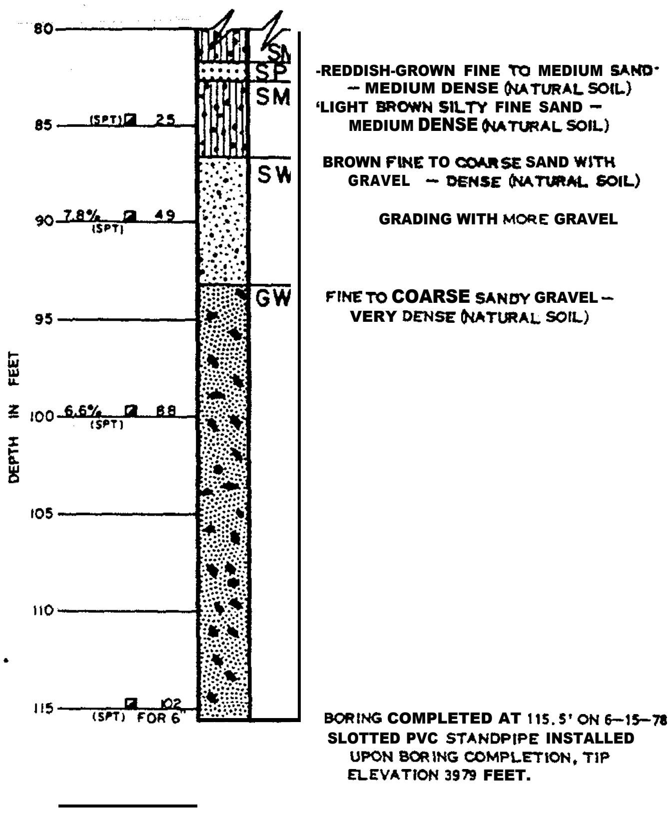
Project Number: 219-0K-011
May 10, 1990 dg

BORING B-I

COORDINATES, N4346.2 E6996.0
ELEVATION 4039 FEET



BORING B-I (CONTINUED)



KEY

A - B ■ C
D
E

A FIELD MOISTURE EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF SOIL
B DRY DENSITY EXPRESSED IN LBS. PER CUBIC FOOT
C GLOWS PER FOOT OF PENETRATION USING A 140 LB. HAMMER DROPPING 30 INCHES
D TYPE OF TESTS PERFORMED ON SAMPLE
- A.L. - ATTERBERG LIMITS
- G. S. - GRAIN SIZE ANALYSIS
- K - PERCOLATION (PERMIABILITY) TEST
- CONSOL - CONSOLIDATION TEST
- Tx - TRIAXIAL COMPRESSION TEST
- D Tx - DYNAMIC TRIAXIAL COMPRESSION TEST

E TYPE OF SAMPLER
- (SPT) - STANDARD PENETRATION TEST
- (SH) - SHELBY SAMPLER
- (PT) - PITCHER SAMPLER
- (P) - DAMES & MOORE PISTON SAMPLER
- (U) - DAMES & MOORE U TYPE SAMPLER
- (C) - ROTARY WASH CUTTINGS SAMPLED

■ DEPTH AT WHICH UNDISTURBED SAMPLE WAS EXTRACTED
☒ DEPTH AT WHICH DISTURBED SAMPLE WAS EXTRACTED
□ UNDISTURBED SAMPLING ATTEMPT WITH NO RECOVERY
◪ STANDARD PENETRATION TEST
◩ STANDARD PENETRATION TEST WITH NOT RECOVERY

NOTE
THE DISCUSSION IN THE TEXT UNDER THE SECTION TITLED. "SITE CONDITIONS. SUBSURFACE", IS NECESSARY TO A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

LOG OF BORINGS

DAMES & MOORE

BORING B-IO

COORDINATES N3633.6 E5917 9
ELEVATION 4045.1 FEET

Depth (feet)	Sample	Blows	Symbol	Description
0			SP	REDDISH-BROWN FINE SAND WITH TRACE SILT AND SAND AN3 GRAVEL SIZED ROCK FRAGMENTS – DENSE (FILL)
5	(SPT)	77		
10	(SPT)	47	SP	LIGHT GRAY FINE SAND WITH A TRACE MEDIUM SAND AND SILT – DENSE (SAND TAILINGS)
15	(SPT)	9		GRADES TO BROWNISH – GRAY
	27.9%-91 (P)			
20	(SPT)	10		GRADES WITH MORE SILT AND TO MEDIUM DENSE
25	(SPT)	15		
	27.3%-99 (P)			
30	(SPT)	11		
			SM	BROWNISH-GRAY SILTY FINE SAND WITH SOME CLAY-LOOSE SAND TAILINGS)
35	(SPT)	3		
				CLAY GRADES OUT
	28.8%-92 (P)			
40	(SPT)	23		GRADES TO MEDIUM DENSE
45	(SPT)	12		GRADES WITH LESS SILT
	[illegible]-93			
50	(SPT)	17		
55	(SPT)	18		
60	(SPT)	9		GRADES TO LOOSE
65	(SPT)	15		GRADES TO MEDIUM DENSE
70	(SPT)	20		
			MH	BROWNISH-GRAY CLAYEY SILT WITH A TRACE FINE SAND – HARD SLIME TAILINGS)
75	(SPT)	26		
80	(SPT)	29		

BORING B-IO (CONTINUED)

DEPTH IN FEET

Depth (feet)	Sample	Blows	Symbol	Description
80			MH	
85	(SPT)	36		
			SM	REDDISH-BROWN SILTY FINE AND MEDIUM SAND – MEDIUM DENSE (NATURAL SOIL)
	20.5%-103 (U)	64		GRADES TO DENSE
90	(SPT)	41		
95	(SPT)	58		
	24.8%-99 (U)	34		GRADES WITH MORE SILT AND A TRACE TO SOME CLAY
100	(SPT)	21	ML	REDDISH-BROWN FINE SANDY SILT WITH A TRACE TO SOME SILT – MEDIUM DENSE
105	(SPT)	8		GRADES TO GRAY IN COLOR
	24.7%-100 (U)	71	SP	GRAY FINE SAND WITH TRACE SILT AND MEDIUM SAND – DENSE
110	(SPT)	34		
115	(SPT)	54		
120				

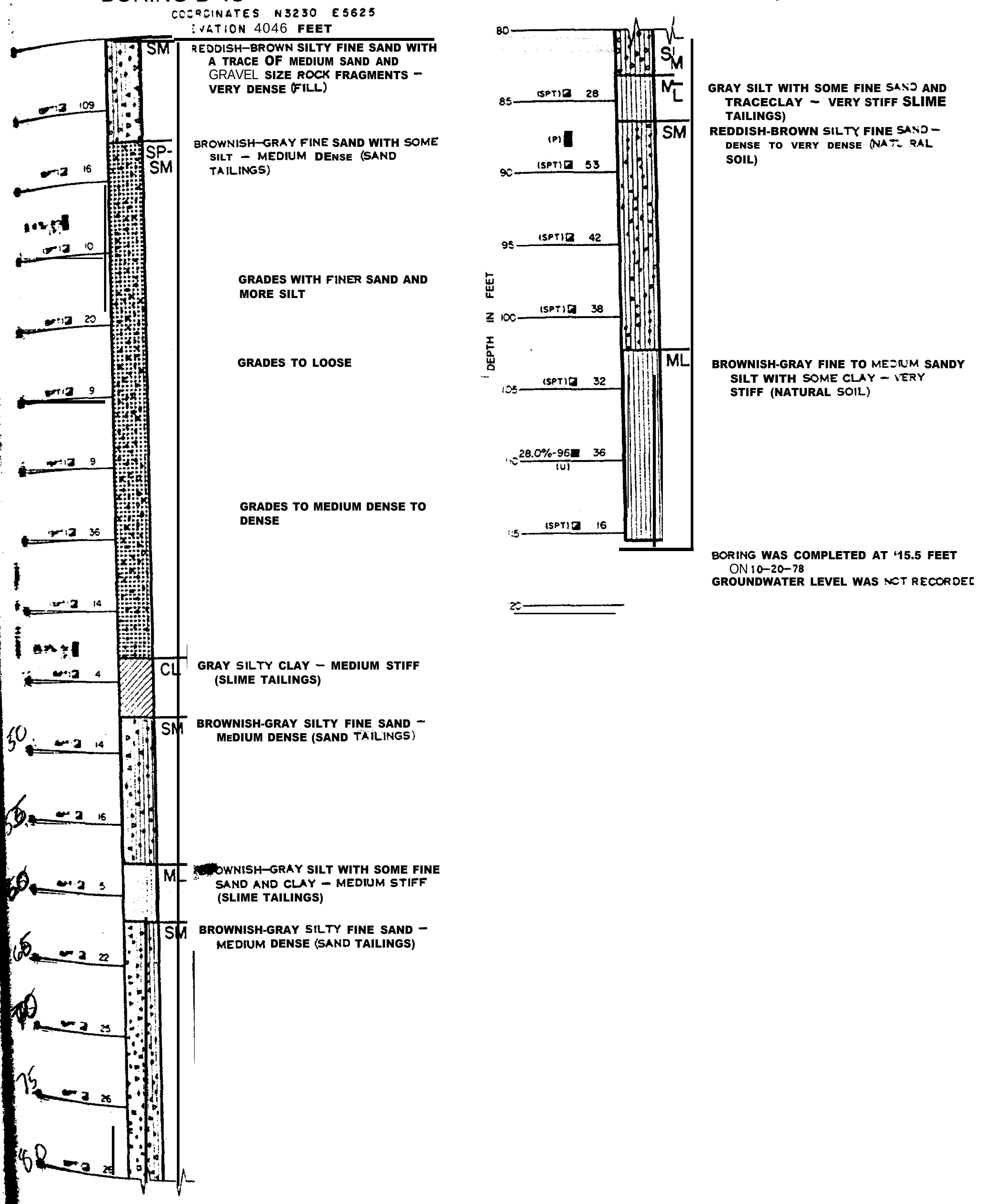
BORING COMPLETED AT 115.5 FEET ON 11 – 6 – 78
PIEZOMETER INSTALLED UPON BORING COMPLETION. TIP ELEVATION 3964. I'

LOG OF BORINGS

DAMES & MOORE

BORING B-18

BORING B-18 (CONTINUED)



LOG OF BORINGS

DAMES & MOORE

BORING B-19

COORDINATES N3410 E5755
ELEVATION 4046 FEET

Sample	Blows	Symbol	Description
		SM	REDDISH-BROWN SILTY FINE AND MEDIUM SAND WITH A TRACE OF GRAVEL SIZE ROCK FRAGMENTS — VERY DENSE (FILL)
(SPT)	78		
23.5% 103 (PT)			
(SPT)	13	SM	GRAY FINE SAND WITH SOME MEDIUM SAND AND A TRACE OF SILT — MEDIUM DENSE (SAND TAILINGS) GRADES TO BROWNISH-GRAY IN COLOR
(SPT)	9		
(SPT)	7		
(SPT)	14		
		ML	GRAY SILT WITH SOME FINE SAND — STIFF (SLIME TAILINGS)
(SPT)	10		
		SM	BROWNISH-GRAY SILTY FINE SAND — MEDIUM DENSE (SAND TAILINGS)
(SPT)	25		
(SPT)	13		
		ML	GRAY SILT WITH A TRACE OF FINE SAND — STIFF (SLIME TAILINGS)
[illegible]			
(SPT)	15		
(SPT)	12		
		SM	BROWNISH-GRAY SILTY FINE SAND — MEDIUM DENSE (SAND TAILINGS)
(SPT)	12		
(SPT)	9		
		ML	63' BROWNISH-GRAY SILT WITH A TRACE TO SOME FINE SAND — VERY STIFF (SLIME TAILINGS)
(SPT)	20		
(SPT)	[illegible]		
(SPT)	5		
(SPT)	[illegible]		

BORING B-19 (CONTINUED)

DEPTH IN FEET

Depth	Sample	Blows	Symbol	Description
80			ML	GRADES TO HARD AND GRAY IN COLOR
85	(SPT)	35		
90	(SPT)	37	SM	REDDISH-BROWN SILTY FINE SAND WITH A TRACE OF MEDIUM SAND — DENSE (NATURAL SOIL)
95	(SPT)	33		
100	(SPT)	43		GRADES TO GRAY IN COLOR
	(U)	74		
105	(SPT)	23		
	(U)	32		
110	(SPT)	20		
115	(SPT)	38		
120				

BORING COMPLETED AT 115.5 FEET ON 10-23-78
GROUNDWATER LEVEL WAS NOT RECORDED

APPENDIX B

LOG OF BORINGS

DAMES & MOORE

BORING B-21

COORDINATES N4570 E6208
EVATION 4046 FEET

Sample	Blows	Symbol	Description
		SM	REOOISH-BROWN SILTY FINE SAND WITH A TRACE OF MEDIUM SAND AND GRAVEL SIZE ROCK FRAGMENTS – VERY DENSE (FILL)
(SPT)	60		
		SP	GRAY FINE SAND WITH A TRACE OF MEDIUM SAND AND SILT – MEDIUM DENSE (SAND TAILINGS)
(SPT)	18		
8.7%-90 (P)			GRAOES TO LIGHT BROWN IN COLOR
(SPT)	27		
			MEDIUM SAND GRADES OUT GRADES WITH MORE SILT
(SPT)	19		
			GRADES TO BROWNISH-GRAY IN COLOR
(SPT)	20		
(SPT)	12		
12.5%-88 (P)			
(SPT)	18		
(SPT)	29		
(SPT)	19		
(SPT)	16		
(P)			
(SPT)	21		
(SPT)	22		
(SPT)	22	ML	OWNISH-GRAY SILT WITH A TRACE TO SOME FINE SAND AND CLAY – VERY STIFF (SLIME TAILINGS)
(SPT)	27		
		SM	GRAY SILTY FINE SAND WITH A TRACE OF MEDIUM SAND – MEDIUM DENSE (SAND TAILINGS)
(SPT)	22		
		SM	REDDISH–BROWN SILTY FINE AND MEDIUM SAND – VERY DENSE (NATURAL SOIL)
(SPT)	87		

BORING B-21 (CONTINUED)

DEPTH IN FEET

Depth	Sample	Blows	Symbol	Description
80	(C)		SM	GRAMS WITH SOME COARSE SAND AND GRAVEL SIZE ROCK FRAGMENT6
	(SPT)	163		
85	(SPT)	32		GRAOES TO GRAY IN COLOR COARSE SAND GRADES CUT GRADES WITH SANDY SILT SEAMS
	20.5%-93 (U)	58		
90	(SPT)	42		
			GM	REDDISH–BROWN SILTY SAND AND GRAVEL – VERY DENSE (NATURAL SOIL)
95	(SPT)			
100				
	(C)			

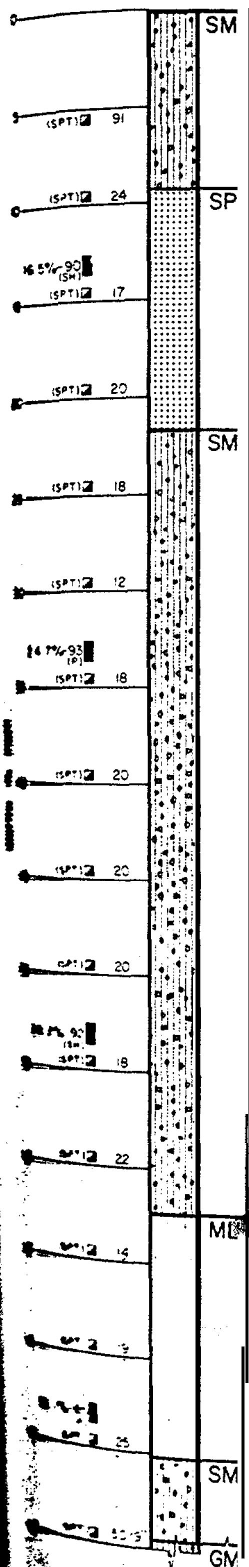
BORING COMPLETED AT 102.5 FEET ON 10–26–78
GROUNOWATER LEVELWASNOTRECOROED

LOG OF BORINGS

DAMES & MOORE

BORING B-22

ORDINATES N4795 E4098
.EVATION 4046 FEET



REDDISH-BROWN SILTY FINE SAND WITH A TRACE OF MEDIUM SAND AND GRAVEL SIZE ROCK FRAGMENTS — VERY DENSE (FILL)

BROWNISH-GRAY FINE SAND WITH A TRACE OF SILT — MEDIUM DENSE (SAND TAILINGS)

GRADES TO BROWN IN COLOR

GRAY SILTY FINE SAND — MEDIUM DENSE (SAND TAILINGS)

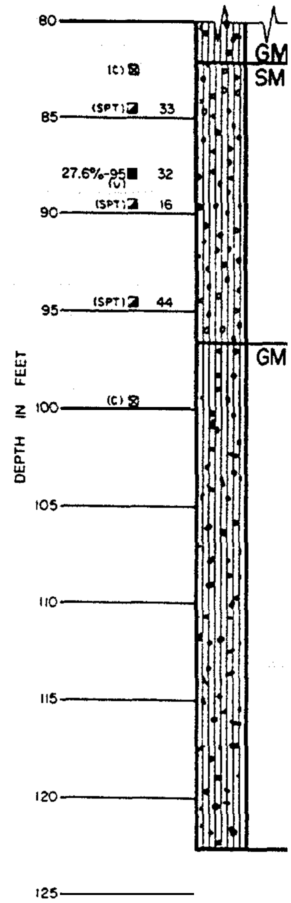
62.5

GRAY SILT WITH A TRACE TO SOME FINE SAND AND CLAY — VERY STIFF (SLIME TAILINGS)

REDDISH-BROWN SILTY FINE AND MEDIUM SAND WITH A TRACE OF GRAVEL SIZE ROCKFRAGMENTS — VERYDENSE (NATURAL SOIL)

REDDISH-BROWN FINE AND COARSE GRAVEL WITH FINE TO COARSE SAND — VERY DENSE (NATURAL SOIL)

BORING B-22 (CONTINUED)



REDDISH-BROWN SILTY FINE SAND WITH A TRACE OF MEDIUM SAND AND SOME GRAVEL — DENSE (NATURAL SOIL)

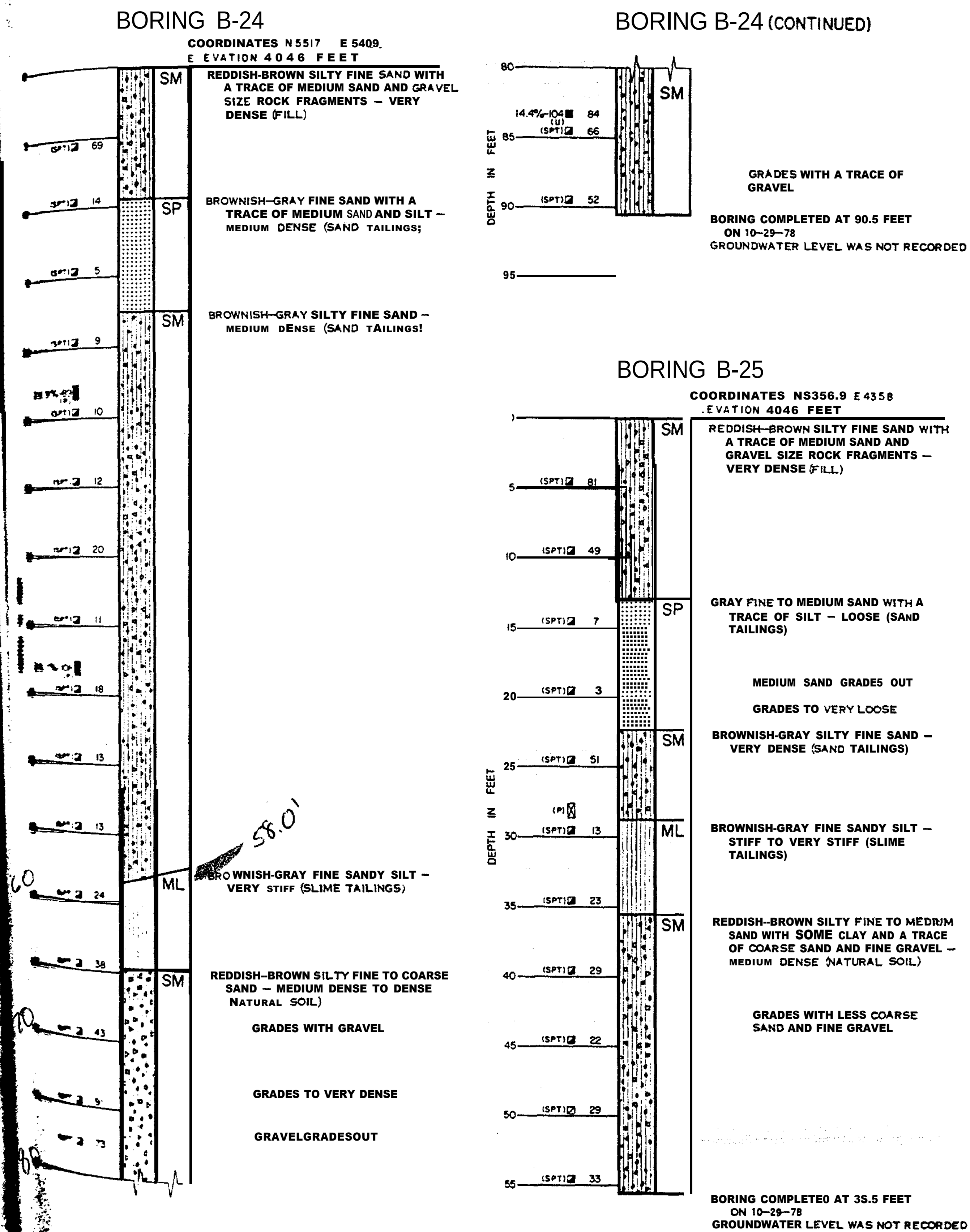
GRADES WITH LAYERS OF GRAY FINE SANDY SILT

REDDISH-BROWN SILTY SAND AND GRAVEL — VERY DENSE (NATURAL SOIL)

BORING COMPLETED AT 122.5 FEET ON 10-20-78

GROUNDWATER LEVEL WAS NOT RECORDED

LOG OF BORINGS



LOG OF BORINGS

WELL/PIEZOMETER COMPLETION DIAGRAM

Project Atlas Minerals

Location Moab, Utah

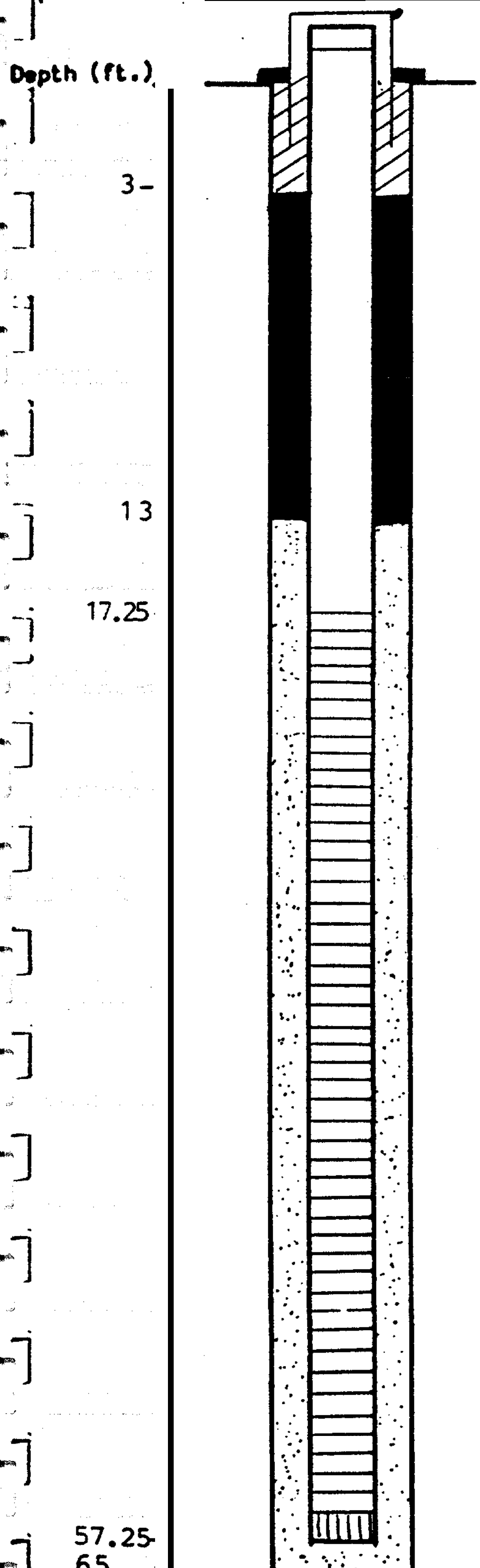
Geologist Barb Ford

Depth to Water 13.02 feet (G.L.)

Well Number AMM-1

Date(s) of Installation 9-14-88 - 9-15-88

Elevation from Measuring Point 3966.5



DRILLING SUMMARY:

Driller Zimmerman Well Service

Rig Type Bucyrus Erie

Drilling Method Cable Tool

Bit(s) Yes

Drilling Fluid Water(from approved source)

Surface Casing None

Hollow Stem/Drive Casing I.D. (in.) 8

Total Depth of Boring (ft.) 65

Borehole Diameter (in.) 8

WELL DESIGN:

Completion Above Grade X Below Grade

Basis: Geological Log Geophysical Log

Type

Total Depth of Well (ft.) 57.25

Casing String(s): C=casing S=screen

+ - 17.25	C		-		
17.25 - 37.25	S		37.25 - 57.25		S

Casing: Schedule 80 threaded, flush-joint 4" Aardvark PVC

Screen: .020 inch slotted, schedule 80, threaded flush-joint 4" Aardvark PVC

Centralizers None

Gravel/Sand Pfeet 65 to 13

Colorado Silica Sand 10-20

Bentonite Seal(s) 13 to 3 feet

to feet

Bentonite (type) Benseal - granular

Backfill (cuttings) to feet

Cement Seal(s) 3 to 0 feet

to feet

Cement Composition 7% bentonite to 93% Portland Type 2 cement

Protective Casing to feet

Protective Casing Type 8 inch steel

Other Concrete pad to. 6 inches above ground surface

WELL DEVELOPMENT:

Method Bailing and Surging

Duration 2.5 hrs Estimated production gpm 8

Water Appearance murky brown

Remarks: pH, conductivity, salinity and temperature stabilized at 7.65, 9995 umhos/cm, 6.4% and 19°C during development.

DRILL LOG

PROJECT Atlas Minerals
ELEVATION 3966.5
DATE 9-13-88 - 9-14-88
WELL/BORING AMM-1
LOCATION Northeast area of Mill
LOGGER Barb Ford
DRILL METHOD Cable Tool

WATER LEVEL FIRST ENCOUNTERED 20 feet
FINAL 13.07

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL		LITHOLOGIC DESCRIPTION	NOTES
				0-2.5	Sand; fine, well sorted dry red sand	
				2.5-5	Sand with gravel; red, fine sand with few fine gravels	
5				5-25	Sand with gravel; poorly sorted, fine to very coarse, red sand with some fine to very coarse, sub-angular to subrounded gravels up to 1" in diameter	
10						
15				@ 15	increase grain size of gravels up to 3" in diameter; subrounded to rounded	
				@18	Color change to medium brown	
20				@20	Water seeping into borehole	
25						

DRILL LOG

PROJECT Atlas Minerals | ELEVATION 3966.5 | DATE 9-13-88 - 9-14-88

WELL/BORING AMM-1 | LOCATION Northeast of mill | LOGGER Barb Rord

DRILL METHOD Cable Tool | PAGE 2 a 3

WATER LEVEL FIRST ENCOUNTERED 20 feet | FINAL 13.02

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
25				25-28 Sand with gravel; very silty, brown sand with some, fine to medium gravels	
				28-30 Sand and gravel; many medium coarse, subangular to subrounded gravels in a silty, well sorted, fine, brown sand	
30				30-50 Sand and gravel; many (40%) fine to medium coarse, angular to subrounded gravels up to ¼" in diameter in a very fine to coarse sand matrix	Conductivity: 3370 umHos/cm @ 17°C
35				@35 Color change to reddish brown; decrease gravel content to 15%	
40				@40 Increase gravel content to 45%	(Water added to hole)
45					Conductivity: 1550 umHos/cm @ 17°C
				@48 Decrease gravel content to 20%	
50					

DRILL LDC

PROJECT Atlas Minerals ELEVATION DATE 9-13-88 - 9-14-88

WELL/BORING AMM-1 LOCATION Northeast area of Mill LOGGER Barb Ford

DRILL METHOD Cable Tool PAGE 3 of 3

WATER LEVEL FIRST ENCOUNTERED 20 feet FINAL 13.02

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
50				50-54 Sand and clay; dense, red clay in very fine to medium sand with few to some, subrounded gravels grades finer, red, silty	
55				54-60 Clay with gravels; red silty clay with few, fine angular gravels	
60				60-65 Bedrock; clayey siltstone (Moenkopi Formation?) TD = 65ft.	Conductivity: 6500 umhos/cm @17°C

WELL/PIEZOMETER COMPLETION DIAGRAM

Project Atlas Minerals

Location Moab, Utah

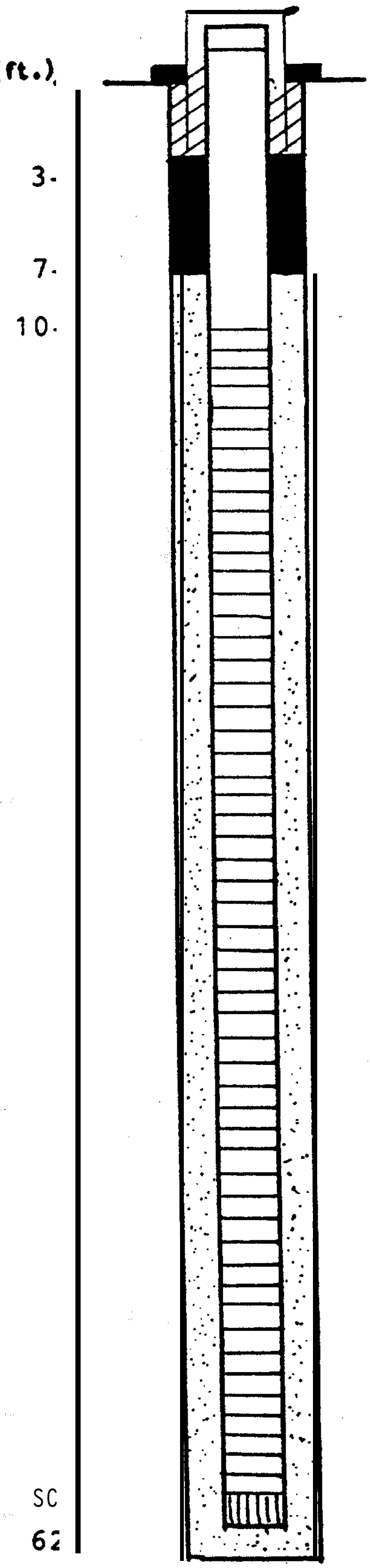
Geologist Barb Ford

Depth to Water 9.73 feet (G.L.)

Well Number AMM-2

Date(s) of Installation 9-20-88 - 9-21-88

Elevation from Measuring Point 3961.9



DRILLING SUMMARY:

Driller Zimmerman Well Service

Rig Type Bucyrus Erie

Drilling Method Cable T n n l

Bit(s) Yes

Drilling Fluid Water (from approved source)

Surface Casing None

Hollow Stem/Drive Casing I.D. (in.) 8

Total Depth of Boring (ft.)

Borehole Diameter (in.) 8

WELL DESIGN:

Completion Above Grade X Grade Below

Basis: Geological Log Geophysical Log Type

Total Depth of Well (ft.) 5 Ø

Casing String(s): C=casing . S=screen

+	-	10	C	20	- 30	S
10	-	20	S	30	- 50	S

Casing: Schedule 80, threaded, flush-joint 4" Aardvark PVC

Screen: .020 inch slotted schedule 80, threade flush-joint 4" Aardvark PVC

Centralizers None

Gravel/Sand Pack 62 t 7 feet Colorado Silica Sand 10-20

Bentonite Seal(s) to 7 6 feet

6 to 3 feet

Bentonite (type) Volclay ½" pellets/Benseal Granul

Backfill (cuttings) 62 to 50 feet

Cement Seal(s) 3 to 0 feet

to feet

Cement Composition 7 % Bentonite t n 93% Portland Type 2 Cement

Protective Coring to feet

Protective Casing Type 8 inch steel

Other Concrete pad to 6 inches above ground surface

WELL DEVELOPMENT:

Method Bailing and surging

Duration hrs 0 Estimated production 8 gpm

Water Appearance Murky Brown

Remarks: pH, conductivity, salinity and temperature stabilized at 7.24, 23,500 umhos/cm, 7.1 °/oo and 16°C during development

3

DRILL LOG

PROJECT Atlas Minerals ELEVATION 3961.9 DATE 9-16-88 – 9-21-88

WELL/BORING AMM-2 LOCATION Downgradient of Tailings Pond by Road LOGGER Barb Ford

DRILL METHOD Cable Tool PAGE 1 OF 3

WATER LEVEL FIRST ENCOUNTERED 18 FINAL 9.73

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
0				0-5 Sand; very fine, brown, very well sorted sand with some silt	
5				5-5.5 Sand with clay; very fine, deep red sand with little clay	Water added to hole
				5.5-13 Sand; very fine, brown, well sorted sand with some silt	
10					
				13-15 Sand and gravel; many (70%) poorly sorted, very fine to coarse, very angular to very well rounded gravel up to 3/4" in diameter in a fine, brown sand matrix	Conductivity: 8600 umHos/cm @18.5°C Water added to hole
15				15-20 Sand and gravel; increase gravel content to 85% and coarseness to 1" in a brown and black fine sand matrix @ 17 Water	
20				20-23 Sand with silt; brown, fine sand with silt and few, angular gravel (5-7%)	Conductivity: 5000 umHOS/cm @ 18.5°C
				23-62 Sand and gravel; increase gravel content to 50% of fine to medium, subangular to subrounded gravels up to ¼" in diameter in a silty, brown sand matrix	
25					

DRILL LOG

PROJECT Atlas Minerals
ELEVATION 3961.9
DATE 9-16-88 -9-21-88
WELL/BORING AMM-2
LOCATION Downgradient of Tailings Pond by road
LOGGER Barb Ford
DRILL METHOD Cable Tool
PAGE 2 OF 3
WATER LEVEL FIRST ENCOUNTERED 18
FINAL 9.73

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
25				@25 Color change to grey -brown	
				@27 Increase gravel content to 70%	Conductivity: 6500 umHos/cm @ 18.5°C Water added to hole
30				@30 Grey sand matrix is fine to coarse	Conductivity: 4400 umHOS/cm @ 18.5°C
35				@35 Decrease gravel content to 40%	Water added to hole Conductivity: 3000 umHOS/cm @ 18.5°
40					Water added to hole Conductivity: 3000 umHOS/cm @ 18.5°
45					
50				@ 50 Increase gravel content to 80%	Conductivity: 5200 umHOS/cm @ 18.5°

DRILL LOG

PROJECT Atlas Minerals
ELEVATION 3961.9
DATE 9-16-88 - 9-21-8
WELL/BORING AMM-2
LOCATION Downgradient of Tailings Pond of road
LOGGER Barb Ford
DRILL METHOD Cable Tool
PAGE 3 OF 3
WATER LEVEL FIRST ENCOUNTERED 18
FINAL 9.73

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
50					
55					Conductivity: 20,000 umHOS/cm @ 18.5°C
60					
62				TD = 62 ft.	

WELL/PIEZOMETER COMPLETION DIAGRAM

Project Atlas Minerals

Location Moab, Utah

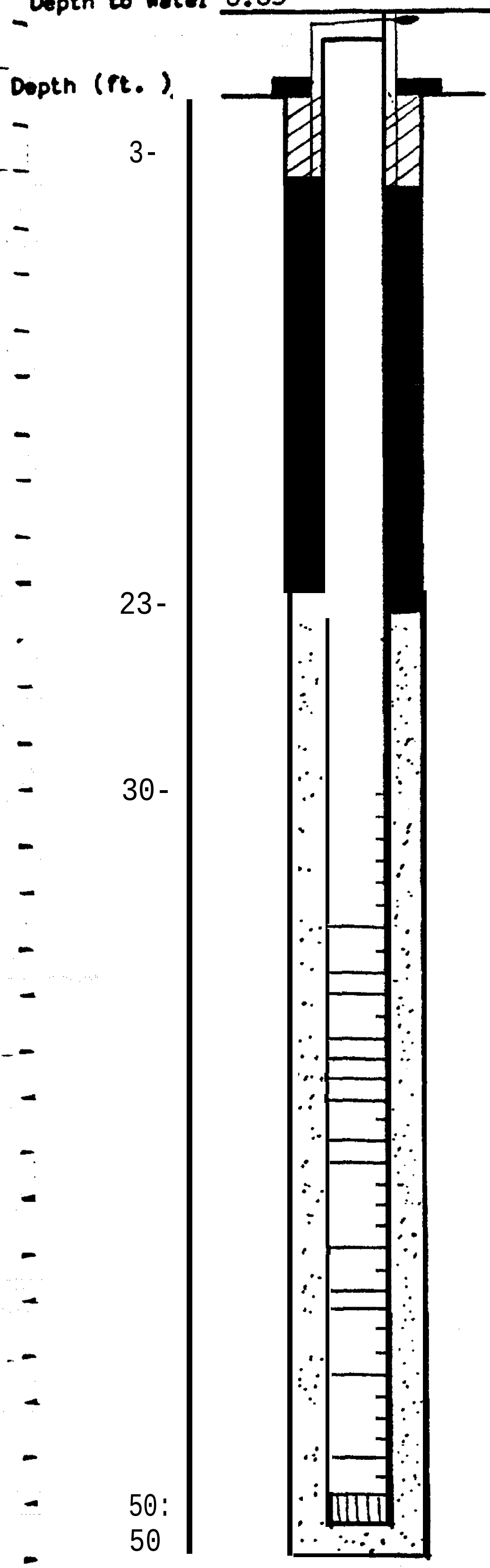
Geologist Barb Ford

Depth to Water 8.85 feet (G.L.)

Well Number AMM-3

Date(s) of Installation 9-23-88

Elevation from Measuring Point 3962.2



DRILLING SUMMARY:

Driller Zimmerman Well Service

Rig Type Bucyrus Erie

Drilling Method Cable Tool

Bit(s) Yes

Drilling Fluid Water (from approved source)

Surface Casing None

Hollow Stem/Dive Casing I.D. (in.) 8 inch

Total Depth of Boring (ft.)

Borehole Diameter (in.) 8

WELL DESIGN:

Completion Above Grade X Below Grade

Basis: Geological Log X Geophysical Log Type

Total Depth of Well (ft.) 50

Casing String(s): C=casing S=screen

+	-	30	C	-
30	-	50	S	

Casing: Schedule 80, threaded, flush-joint, 4" Aardvark PVC

Screen: slotted 0 Inch ed schedule 80, threaded, flush-joint 4" Aardvark PVC

Centralizers None

Gravel/Sand Pack 5.0 to 23 feet Colorado Silica Sand 10-20

Bentonite Seal(s) 23 to 20 feet

20 to 3 feet

Bentonite (type) Volclay ½" pellets/Benseal granu

Backfill (cuttings) to feet

Cement Seal(s) 3 to 0 feet

to feet

Cement Composition 7% Bentonite to 93% Portland Type 2 Cement

Protective Casing to feet

Protective Casing Type 8 inch steel locking casing

Other Concrete pad to 6 inches above ground surface

WELL DEVELOPMENT:

Method Compressed Air

Duration 1.5 hrs Estimated production 30 gpm

Water Appearance clear

Remarks: Difficulties encountered following completion necessitated development using compressed air.

DRILL LOG

PROJECT Atlas Minerals

ELEVATION 3962.2

DATE 9-22-88

WELL/BORING AMM-3

LOCATION Downgradient of Southern point of Tailings Pond

LOGGER Barb Ford

DRILL METHOD Cable Tool

WATER LEVEL FIRST ENCOUNTERED 6

FINAL 8.85

DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
0				0-30 Clay; red, silty clay with few, fine to medium gravels	Conductivity: 2300 umHOS/cm @ 18°C
5				@5 Increase brown sand in red clay	Conductivity: 4320 umHOS/cm @ 18°C
				@6 Very moist	
10					Conductivity: 5000 umHOS/cm @ 18°C
15					Conductivity: 3000 umHOS/cm @ 18°C
20				@ 20 Color change to brown	Conductivity: 2500 umHOS/cm @ 18°C
25				@25 Color change to grey - dark brown	

DRILL LOG

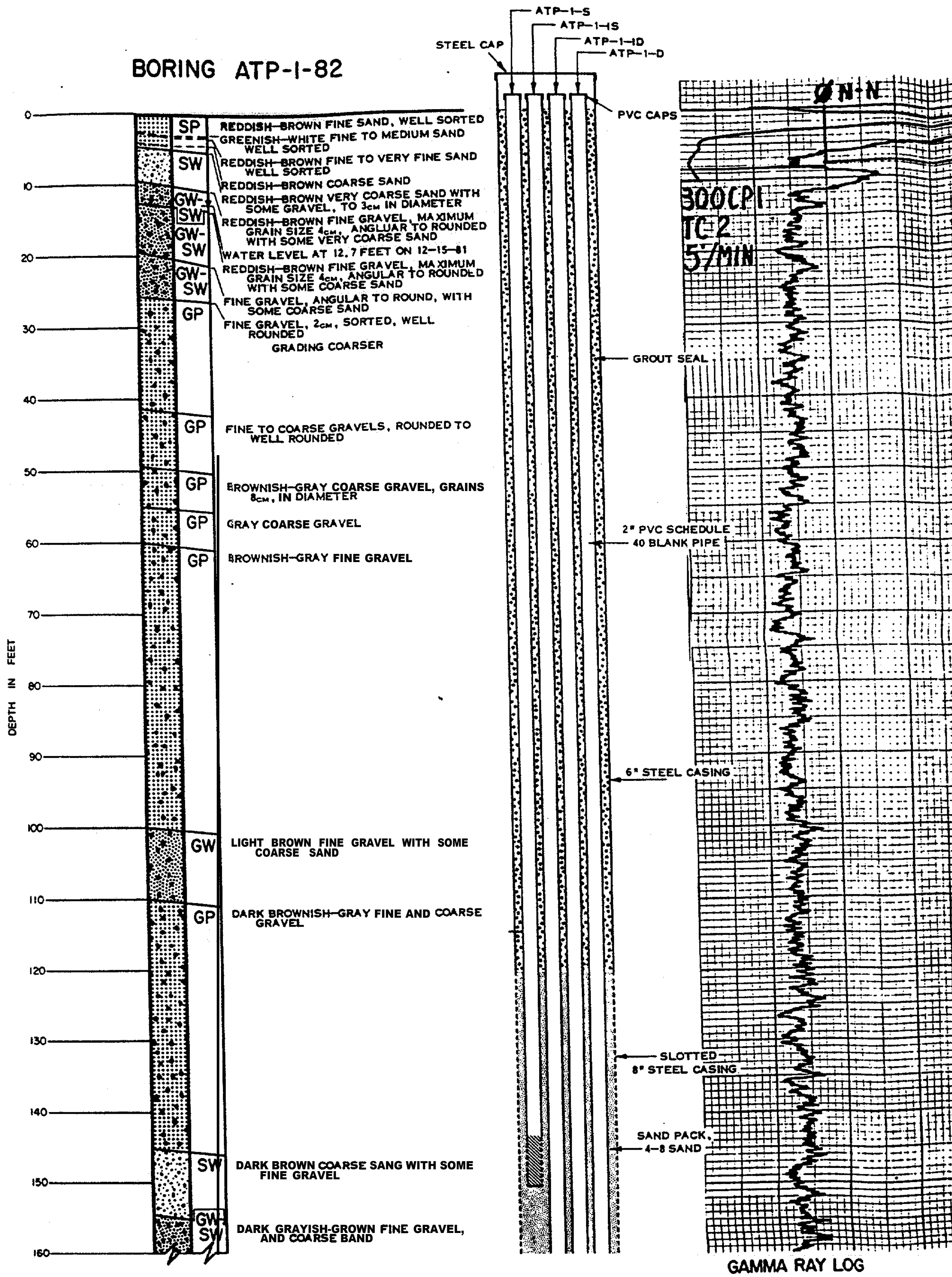
PROJECT Atlas Minerals | ELEVATION 3962 | DATE 9-22-88

WELL/BORING AMM-3 | LOCATION Downgradient of Southern point of Tailings Pond | LOGGER Barb Ford

DRILL METHOD Cable Tool | PAGE 2 OF 2

WATER LEVEL FIRST ENCOUNTERED 6 | FINAL 8.85

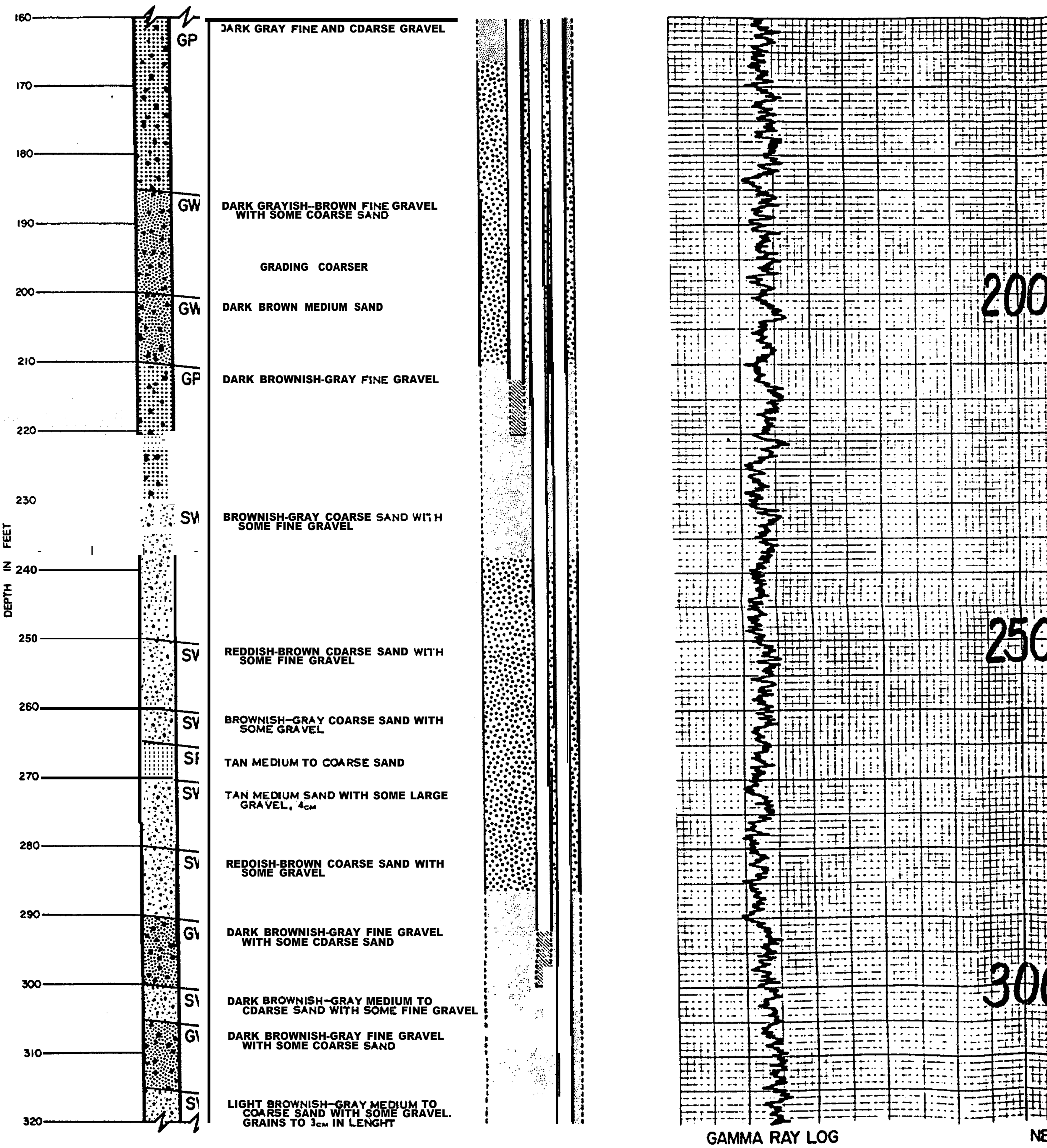
DEPTH IN FEET	LITH COL	SAMPLE TYPE IDENT.	MOISTURE CONTENT WATER LEVEL	LITHOLOGIC DESCRIPTION	NOTES
25					Conductivity: 2300 umHOS/cm @ 18°C
30				@ 30 Color change to grey 30-35 Sand with gravel; well sorted, fine grey sand with very few gravels	Conductivity: 2550 umHOS/cm @ 18°C
35				35-50 Sand and gravel; very fine to very coarse, poorly sorted, grey brown sand with 30%, fine to medium sub-rounded to rounded gravels up to ½" in diameter	Conductivity: 4500 umHOS/cm @ 18°C
40					
45				@ 47 Increase gravel grain size to 1.5"	
50				TD = 50 ft.	Conductivity: 20,000 umHOS/cm @ 18°C



WELL COMPLETION LOG

LOG OF BORING

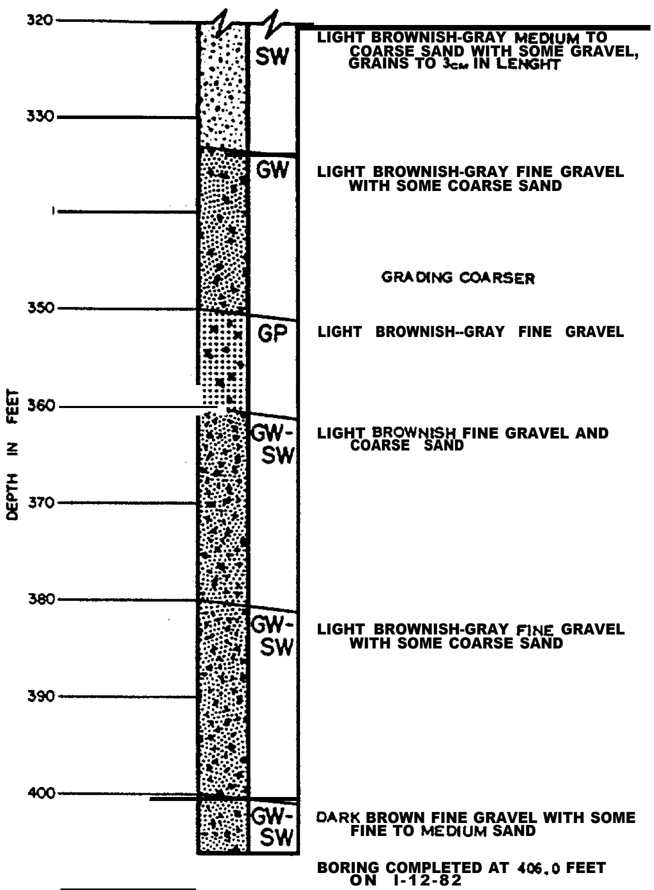
BORING ATP-I-82 (CONTINUED)

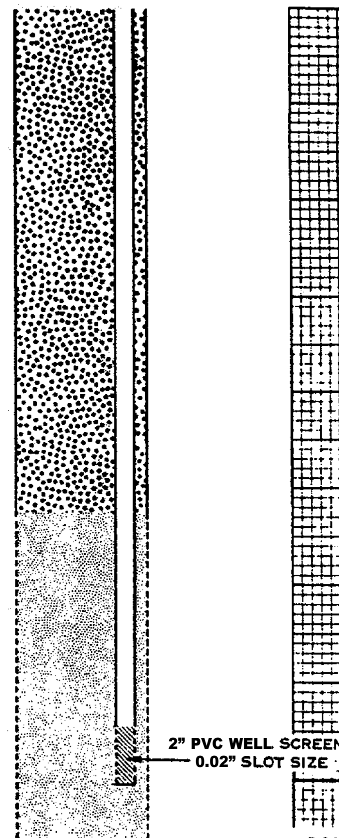


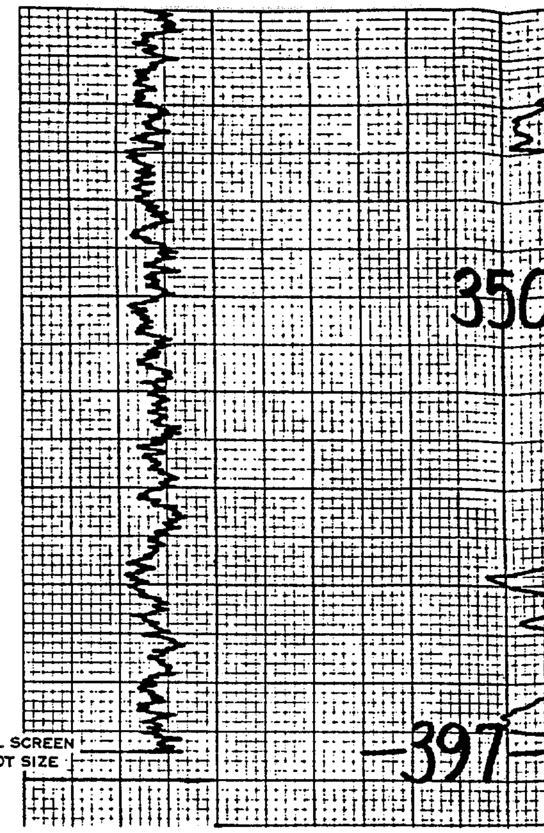
WELL COMPLETION LOG

LOG OF BORING

BORING ATP-I-82 (CONTINUED)







GAMMA RAY LOG

WELL COMPLETION LOG

LOG OF BORING

PLS PROFESSIONAL LOGGING SERVICES, INC.
Clifton, Colorado 81520

HOLE NO: ATP-1-82

CLIENT: ATLAS MINERALS — DATE: 01-13-8

AREA: MILL

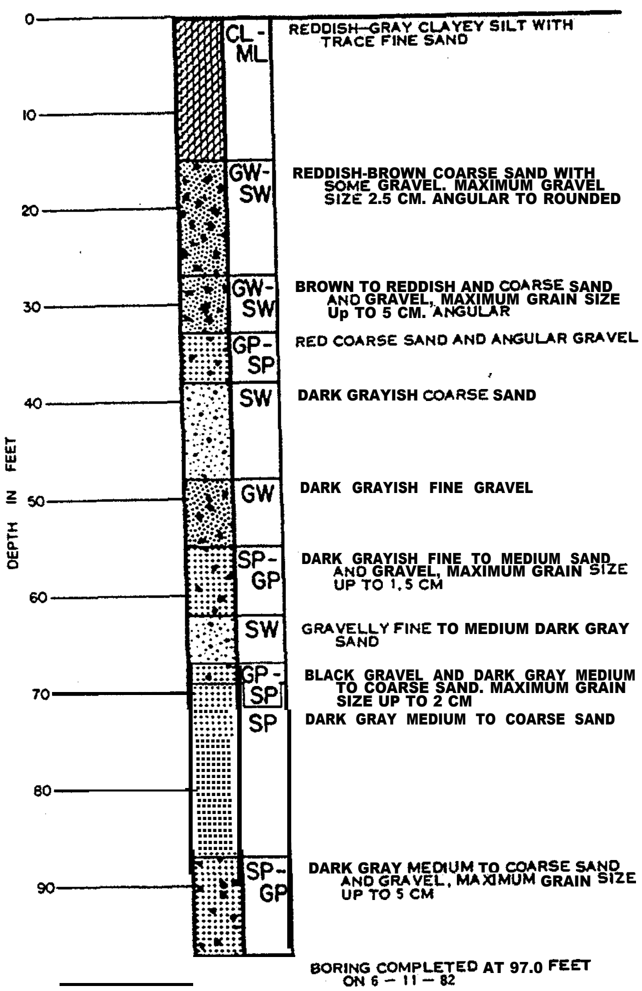
COUNTY: GRAND — STATE: UTAH

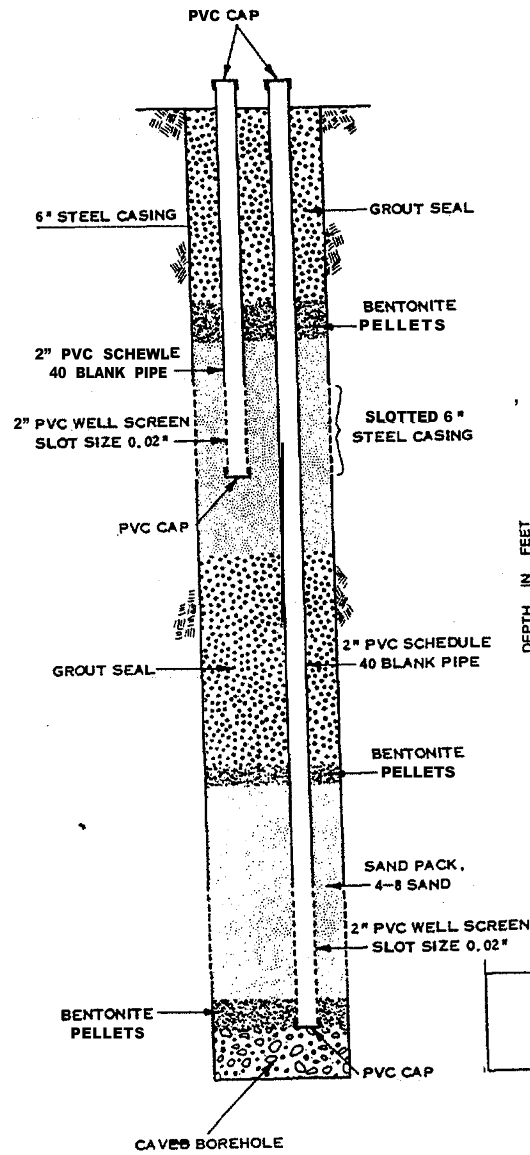
SECTION — TOWNSHIP — RANGE

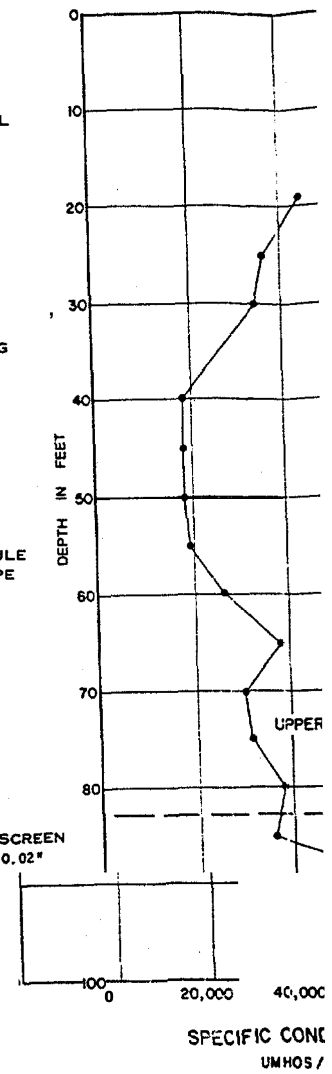
ELEVATION — DEPTH REFERENCE: XTAL @ GROUND LEVEL — GEOLOGIST

	INITIAL RUN	
PROBE NO: 1809		LOG: GAMMA
K FACTOR: 1.19X10⁻⁵ / DEAD TIME: 6.65 μsec	T.D. DRILLED: 406	RANGE: 300 CPS/IN
WATER FACTOR: 1.15 / AIR FACTOR: 1.00	T.D. LOGGED: 397	TC: 2 RATE: 5'/M
DETECTOR TYPE AND SIZE: XTAL 7/8 x 1 5/8	NATURAL GAMMA RANGE: 25 CPS /IN	FROM: 10'
CALIBRATION RANGE TC	TC: 2 RATE: 20'/MIN	TO: 0'
CALIBRATION SOURCE	SP RANGE: NA	TOTAL: 10'
SOURCE SN ACTIVITY TYPE: 113 1Ci Am²⁴¹Be	RES RANGE: NA	TAPE: 01-25-04A
TEST PIT DATA: DOE GJO 11-30-81	OTHER: BOTTOM @ 405'	TOTAL FOOTAGE LOGGED: 416

BORING ATP-2



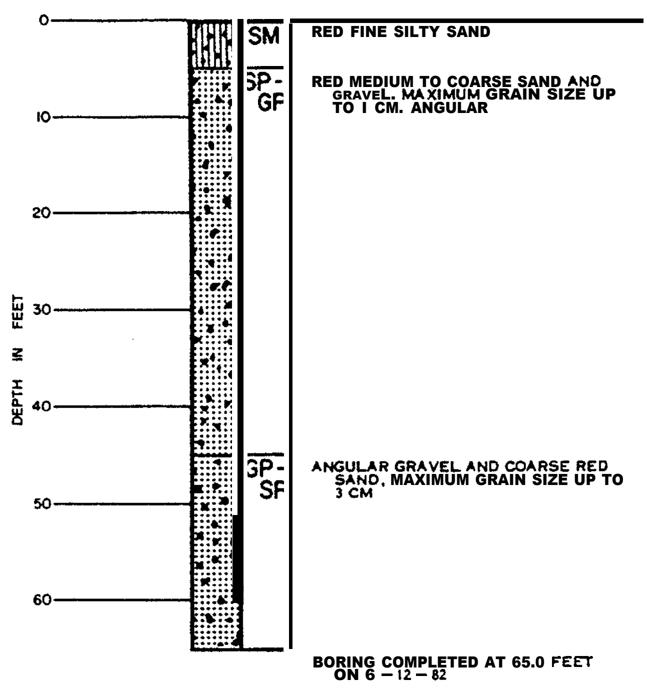


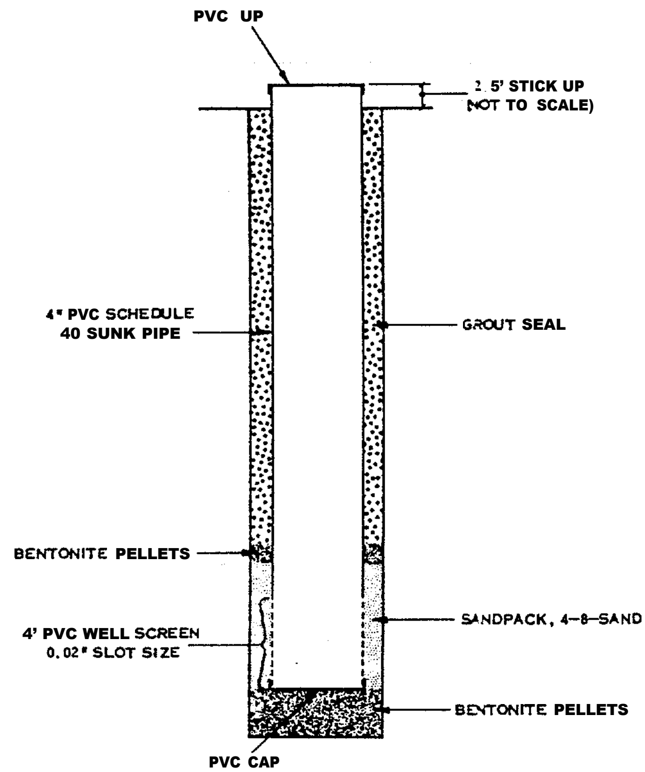


LOG OF BORING

WELL COMPLETION LOG

BORING ATP-3





WELL COMPLETION LOG

LOG OF BORING

Dames & Moore

Appendix D

Appendix D presents copies of the Well Driller's Report filed with State of Utah Division of Water Rights for the reference well (RW-1). Also presented is a copy of the highway right of way permit obtained **from** the Utah Department of Transportation need to install the RW- 1.

ORIGINAL

UTAH DEPARTMENT OF TRANSPORTATION

PERMIT

T-226(6/97)
HIGHWAY RIGHT OF WAY
ENCROACHMENT
Region 4
District: Price

97-274-44
Date: 12/8/97
Work Order No.________

Application of: O A K RIDGE NAT'L L A B **Phone:** 970-248-6238
By: FRANK GARDNER **Title:** PROJECT MANAGER
Address: 2597 B 3/4 ROAD, GRAND JCT., CO 81503

is hereby granted, subject to UDOT's Regulations For The Accommodation of Utilities on Federal Aid and Non Federal-Aid Highway Right of Way, Regulations for the Control and Protection of State Highway Rights of Way, Standard Specifications for Road and Bridge Construction, Specifications for Excavation of State Highways, State Occupational Safety and Health Laws, Manual on Uniform Traffic Control Devices, Instructions to Flaggers, the approved plans, and any special limitations set forth herein, permission for the purpose of DRILL TEST HOLE FOR BLM & NPS AND PROVIDE TRAFFIC CONTROL FOR SAME within the right of way limits of Highway No. 191 Milepost No. 130, in GRAND County, in the following locations: JUST NORTH OF JCT. 191 AND 270.

Receipt of $20.00 permit fee is hereby acknowledged.. The work permitted herewith. shall commence 12/9/97 and shall be diligently prosecuted to completion. The work shall be completed and all disturbed surfaces or objects restored on or before 12/15/97. In the event work is commenced under this permit and the permittee fails or refuses to complete the work, the Utah Department of Transportation may, at its election, fill in or otherwise correct any existing deficiencies at the expense of and subject to immediate payment by the permittee.

Permittee shall execute a bond in the minimum amount of $0.00, as determined by the Region Director/District Engineer, to insure faithful performance of the permittee's obligation. The bond shall remain in force for three years after completion of work.

Before work permitted herewith is commenced, the permittee shall notify Dale Stapley at 636-1402, permits officer, or Keith Kimball 259-7636 , and commencement of said work is understood to indicate that the permittee will comply with all instructions and regulations of the Utah Department of Transportation (as listed above) with respect to performance of said work, and that he will properly control and warn the public of said work to prevent accident and shall indemnify and hold harmless the Utah Department of Transportation from all damages arising out of any and all operations Performed under this Permit.

Permittee shall not perform any work on State Highway right of way beyond those areas of operations stipulated on this permit.

If permittee fails to comply with 'Utah Department of Transportation regulations, specifications, or instructions pertinent to this permit, the Region Director/District Engineer or his duly authorized representative, may by verbal order, suspend the work until the violation is corrected If permittee fails or refuses to comply promptly, the Region Director/District Engineer or his authorized representative may issue a written order stopping all or any part of the work. When satisfactory corrective action is taken, an order permitting resumption of work may be issued.

Special Limitations: This agreement and/or permit is UDOX approval only; You are responsible to obtain clearances from railroads, private property owners, and the local jurisdiction that you are working within. Warning signs and traffic control required a6 per MUTCD. Flaggers required if moving traffic out of traffic lane. Orange shirts or vests required of all workers within the right of way. Chek for other utilities in the area prior to excavation. If a suspected historic, archeological, or paleontological item or site is encounted, construction shall be immediately stoped and UDOT notified. Contractor responsible for repairing and/or restoring any portion of the roadway damaged during construction. No drill holes to be closer than 30 ft. from edge of pavement

See Signature on Map
(Signature of Permittee)

Approved By: Dale Stapley
for (Region Director/District Engineer)

Maintenance Station No. 424 Keith Kimball 259-7636

WLI

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification
MONITOR WELL: 97-01-001-M-01

Owner *Note any changes*

Lockheed Martin Energy Research Corporation
2597 B3/4 Road
Grand Junction, CO 81503

Contact Person/Engineer: FRANK GARDNER / LOCKHEED MARTIN

Well Location *Note any changes*

SOUTH 100 feet WEST 900 feet from the NE Corner of
SECTION 28, TOWNSHIP 25S, RANGE 21E, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #) ___ - I - - - - ___

Drillers Activity Start Date: 12-9-97 Completion Date: 12-m-97

Check all that apply: [X] New [ ] Repair [ ] Deepen [ ] Abandon [ ] Repltlur? [ ] Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	79	9	PERCUSSION HAMMER	AIR

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	79						X	X	X					

UNCONSOLIDATED / CONSOLIDATED

Static Water Level

Date 12-9-97 Water Level 72 feet Flowing? [ ] Yes [X] No

Method of Water Level Measurement WLI [redacted] If Flowing, Capped Pressure ___ PSI

Point to Which Water Level Measurement was Referenced GR

Height of Water Level reference point above ground surface N/A feet Temperature N/A [ ] °C [ ] °F

[redacted]

Construction Information

DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SCREEN ☒ SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	PERFORATIONS ☐ SCREEN TYPE OR NUMBER PERF (per round/interval)
0	69	2" SCH 40 PVC		2	69	79	.010	2	FACTORY SLOT
									PRE PACK

Well Head Configuration: ABOVE GRADE Access Port Provided? ☒ Yes ☐ No

Casing Joint Type FLUSH THREAD Perforator Used:

DEPTH (feet) FROM	TO	FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL: ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix. gal./sack etc.)
0	60	CEMENT BENTONITE	18 BAGS	
60	63	BENTONITE PELLETS	3 BUCKETS	
63	79	SILICA SAND	3 BAGS	

Well Development / Pump or Bail Tests

Date	Method	Yield	Units Check One GPM	CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)

Pump (Permanent)

Pump Description: Horsepower: Pump Intake Depth: feet

Approximate maximum pumping rate: Well disinfected upon completion? ☐ Yes ☐ No

Comments Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name LAYNE CHRISTENSEN COMPANY License No. 626

(Person, Firm or Corporation – Print or Type)

Signature Date 12-30-97

(Licensed Well Driller)