UMTRA PROJECT SITE OBSERVATIONAL WORK PLAN MEXICAN HAT, UTAH

September 1994

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**UMTRA PROJECT SITE
OBSERVATIONAL WORK PLAN
MEXICAN HAT, UTAH**

September 1994

**Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico**

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EXECUTIVE SUMMARY

The requirements for ground water compliance for Uranium Mill Tailings Remedial Action (UMTRA) Project sites, including the Mexican Hat processing site, are found in the Uranium Mill Tailings Radiation Control Act and Subparts B and Subpart C of the U.S. Environmental Protection Agency's Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings codified in 40 CFR 192, and the associated proposed 1987 standards published in 52 FR 36000. Subpart C of 40 CFR 192 describes specific conditions for which the U.S. Department of Energy may apply for supplemental standards for contaminated ground water rather than meeting background levels or numerical standards.

Surface cleanup activities at the Mexican Hat UMTRA processing site are nearing completion. Associated mill tailings and former mill buildings from the Mexican Hat site and the nearby Monument Valley UMTRA processing site have been consolidated in the Mexican Hat disposal cell. This Site Observational Work Plan (SOWP) addresses ground water compliance for the UMTRA Ground Water Project Mexican Hat processing site.

Ground Water contamination at the Mexican Hat site is a result of uranium milling operations. Uranium was concentrated from 2.2 million tons (2.0 million tonnes) of ore using the acid process. Waste water associated with the milling process and water used to place the mill tailings in the disposal cell contains process products and byproducts and are the primary sources of water found in the uppermost aquifer. The extent of this residual process water has been identified, and it is limited to the uppermost aquifer in the vicinity of the site. Deeper aquifers are not affected because of an upward hydraulic gradient and the presence of a confining unit (the deeper aquifers are protected by hydrogeologic isolation). The uppermost unit is returning to its pre-milling, mainly unsaturated state. The unit that contains the contaminated water is not a ground water resource because it qualifies as Class III (limited use) based on limited yield.

Ground water in the uppermost unit is currently not used and is not anticipated to be used as a ground water resource. The nearby San Juan River and a converted oil exploration well provide all of the water needs for the area. There are no current threats to human health or livestock; and, because the zone of contamination does not represent a ground water resource, none are anticipated in the future. There are, however, seeps where contaminated water is exposed at land surface. The seeps create potential exposure pathways for plants and wildlife. It is not known at this time if there is a risk to the environment. Additional investigations are needed and are described in this document to confirm the presence or absence of potential environmental risks. Additional hydrogeologic investigations are not required.

The proposed ground water compliance strategy for the site is no remediation, because the ground water in the uppermost aquifer (which is also the zone of contamination) qualifies for supplemental standards based on Class III, limited yield, and because there are no threats to human health. Domestic and agricultural water is pumped from a deeper aquifer that is isolated from the contaminated zone. Should the additional risk evaluation proposed in this SOWP indicate that there is an unacceptable environmental risk, appropriate mitigation measures will be undertaken.

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LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
ac	acre
cm	centimeter
DOE	U.S. Department of Energy
EA	environmental assessment
EPA	U.S. Environmental Protection Agency
ft	feet
ft ³	cubic feet
GWPP	Ground Water Project Plan
ha	hectare
km	kilometer
L	liter
m	meter
m ³	cubic meters
MCL	maximum concentration limit
mg/L	milligrams per liter
mi	mile
NEPA	National Environmental Policy Act
NRC	U.S. Nuclear Regulatory Commission
pCi/L	picocuries per liter
PEIS	Programmatic Environmental Impact Statement
RAP	Remedial Action Plan
SOWP	Site Observational Work Plan
SPEAR	Software Program for Environmental Analysis and Reporting
TAGR	Technical Approach to Ground Water Restoration
TDS	total dissolved solids
TER	Technical Evaluation Report
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act

1.0 INTRODUCTION

The Mexican Hat Uranium Mill Tailings Remedial Action (UMTRA) Project Site Observational Work Plan (SOWP) proposes site-specific activities to meet compliance with the proposed U.S. Environmental Protection Agency (EPA) ground water standards at this UMTRA Project site. The purpose of the SOWP is to recommend a proposed site-specific ground water compliance strategy at the Mexican Hat UMTRA processing site. The compliance strategy is supported through a comprehensive summary of all existing data in the site conceptual model. A site conceptual model describes the source of the existing contamination; defines the current conditions and potential environmental and health risks; and identifies data gaps in the site conceptual model. Depending on the type of site and revision of the SOWP, it also presents a plan for additional data collection to clarify the conceptual model and to support the selected compliance strategy, or it presents a plan for implementation of a field pilot program (observational approach) to clarify the conceptual model.

Revisions of the SOWP will be distributed to the affected stakeholders for comment. This Mexican Hat draft SOWP, Revision 0, presents a comprehensive summary of site hydrogeological data and a well-developed conceptual model of the presence and distribution of constituents from the milling process. It also defines the potential environmental and health risks and identifies a proposed compliance strategy.

1.1 PROPOSED GROUND WATER COMPLIANCE STRATEGY

The proposed ground water compliance strategy for the Mexican Hat UMTRA site is no remediation. Ground water in the uppermost aquifer, in the Halgaito Shale Formation, qualifies for supplemental standards, Class III, based on limited use because of limited yield. Beneficial uses of ground water from a deeper aquifer are protected because the contaminated zone is isolated.

1.2 RELATIONSHIP TO PROGRAMMATIC UMTRA GROUND WATER DOCUMENTS

Programmatic documents that provide guidance for the SOWP include the U.S. Department of Energy (DOE) UMTRA *Ground Water Project Plan* (GWPP) (DOE, 1993a), the *Programmatic Environmental Impact Statement* (PEIS) (DOE, In progress), and the *Technical Approach to Ground Water Restoration* (TAGR) (DOE, 1993b). The GWPP states the mission need and objectives for the UMTRA Ground Water Project and provides an overall technical plan and management approach for conducting the Project. The PEIS provides an objective programmatic decision-making framework for conducting the UMTRA Ground Water Project, assesses the potential programmatic impacts of conducting the Project, provides a method for determining the site-specific ground water compliance strategies, and provides data and information that can be used to prepare site-specific environmental impact analyses more efficiently. The TAGR provides general technical guidance concerning how the Ground Water Project will be conducted.

2.0 REGULATORY FRAMEWORK

This SOWP proposes a ground water compliance strategy for the Mexican Hat site to achieve compliance with Subpart B of the proposed EPA ground water standards applicable to Title I UMTRA Project processing sites. This section identifies the relationship of the Uranium Mill Tailings Radiation Control Act (UMTRCA), the proposed EPA compliance standards, the cooperative agreements, and the National Environmental Policy Act (NEPA) to the UMTRA Ground Water Project.

2.1 URANIUM MILL TAILINGS RADIATION CONTROL ACT

The U.S. Congress passed the UMTRCA (42 USC §7901 *et seq.*) in 1978 in response to public concerns about the potential health hazards from exposure to uranium mill tailings over long periods of time. The UMTRCA authorized the DOE to stabilize, dispose of, and control uranium mill tailings and other contaminated materials at 24 uranium mill processing sites.

The UMTRCA has three titles. Title I of the Act designates 24 inactive processing sites to undergo remediation; directs the EPA to promulgate standards; mandates remedial action in accordance with standards prescribed by the EPA; directs the U.S. Nuclear Regulatory Commission (NRC) to concur in the remedial actions; directs the NRC to license the disposal sites for long-term care; and directs the DOE to enter into cooperative agreements with the affected states and Indian tribes. Title II applies to studies of active uranium mills, and Title III applies to certain uranium mills in New Mexico. The UMTRA Project has responsibility for administering only Title I of UMTRCA.

In 1988, Congress passed the UMTRA Amendments Act (Amendments Act; Public Law 102-486; 42 USC §7923), authorizing the DOE to extend without limitation the time needed to complete ground water remediation activities at the processing sites. Section 108 of the UMTRCA requires that the DOE comply with the proposed EPA standards in the absence of final standards.

2.1.1 U.S. Environmental Protection Agency ground water compliance standards

The UMTRCA requires that the EPA promulgate standards for protecting public health and the environment from hazardous constituents associated with the processing of uranium and the resulting residual radioactive materials. On January 5, 1983, the EPA published standards (40 CFR 192) for the disposal and cleanup of residual radioactive materials. The EPA proposed new ground water standards (52 FR 36000) in response to remanded sections.

The proposed standards address two ground water contamination scenarios: the first addresses future ground water contamination that may occur from tailings piles after disposal, and the second addresses the cleanup of contamination that occurred at the processing sites before disposal of the tailing piles (52 FR 36000). Protection of the ground water at the disposal sites is

being addressed in the UMTRA Surface Project. The UMTRA Ground Water Project addresses the contamination that occurred at the processing sites before the surface remedial action was completed and is regulated by Subparts B and C of the proposed standards.

Subpart B, *Standards for Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites* (52 FR 36000), requires that remedial action at processing sites be conducted to ensure that the amounts of residual radioactive materials in ground water meet any one of three criteria specified.

- Background levels—concentrations of constituents in nearby ground water that was not contaminated by processing activities.
- Maximum concentration limits (MCL)—the EPA's maximum concentration of certain hazardous constituents in ground water, as proposed for the UMTRA Project (see Table 2.1).
- Alternate concentration limits—an alternate limit for a hazardous constituent that does not pose a substantial present or potential hazard to human health or the environment as long as the limit is not exceeded.

Table 2.1 Maximum concentrations of inorganic constituents for ground water protection at UMTRA Project sites^a

Constituent	Maximum Concentration ^b
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Molybdenum	0.1
Nitrate (as N)	10.0 ^c
Selenium	0.01
Silver	0.05
Combined radium-226 and radium-228	5 pCi/L
Combined uranium-234 and uranium-238	30 pCi/L ^d
Gross alpha-particle activity (excluding radon and uranium)	15 pCi/L

^a52 FR 36007.

^bMilligrams per liter (mg/L), unless otherwise noted.

^cEquivalent to 44 mg/L nitrate as nitrate.

^dEquivalent to 0.044 mg/L.

pCi/L = picocuries per liter.

Under certain specific conditions, the DOE may apply supplemental standards to contaminated ground water in lieu of background levels, maximum concentration limits, or alternate concentration limits (40 CFR Part 192, 52 FR 36000). Supplemental standards may be applied if any one of the following conditions is met:

- Remedial actions necessary to implement Subpart A or B would pose a significant risk to workers or members of the public.
- Remedial actions to meet the standards would directly produce environmental harm that is clearly excessive compared to the health benefits of remediation to persons living on or near the sites, now or in the future.
- There is no known remedial action.
- The remediation of ground water quality at any processing site is technically impracticable from an engineering standpoint.
- The ground water is classified as limited use ground water. Subpart B of the proposed standards defines limited use ground water as ground water that is not a current or potential source of drinking water because total dissolved solids (TDS) exceed 10,000 mg/L; there is widespread ambient contamination that cannot be cleaned up using treatment methods reasonably employed in public water supply systems; or the quantity of water available is less than 150 gallons (570 liters [L]) per day (40 CFR §192.11(e)). When limited use ground water applies, "supplemental standards shall ensure that current and reasonably projected uses of the ground water are preserved (EPA, 1994)."
- Radiation from radionuclides other than radium-226 and its decay products is present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials.

Subpart B also provides for selecting natural flushing as a means to meet the proposed standards. Natural flushing means allowing natural ground water processes to reduce the contamination in ground water to the standards (background levels, maximum concentration limits, or alternate concentration limits). Natural flushing must allow the standards to be met within 100 years. In addition, ground water must not currently, or be projected to become, a source of drinking water during the period of natural flushing. Institutional controls (measures that restrict access to contamination and satisfy beneficial uses of ground water) that protect human health must be established and maintained during the period of natural flushing.

Subpart C, *Implementation*, provides guidance for implementing methods and procedures to provide reasonable assurance that the provisions of Subpart B are satisfied. Subpart C requires the following: the conditions of Subpart B should

be met on a site-specific basis, using information gathered from site characterization and monitoring; and the plan to meet the conditions of Subpart B should be stated in the compliance strategy plan or remedial action plan that contains the compliance strategy, a demonstration of effectiveness, and a monitoring program.

2.1.2 Cooperative agreements

The UMTRCA requires that remedial action be accomplished with the full participation of the states and Indian tribes on whose lands the uranium mill tailings are located. The UMTRCA also directed the DOE to enter into cooperative agreements with the states and Indian tribes.

2.2 NATIONAL ENVIRONMENTAL POLICY ACT

Implementation of the UMTRCA represents a major federal action subject to the requirements of the NEPA of 1969 (42 USC §4321 *et seq.*). The Council on Environmental Quality's regulations that implement the NEPA are codified in 40 CFR 1500-1508. The regulations require that each federal agency develop its own implementing procedures (40 CFR §1507.3). The DOE NEPA regulations are contained in 10 CFR 1021, *Environmental Policy Act Implementing Procedures*. DOE guidance is provided in *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE, 1993c).

Pursuant to the NEPA, the DOE drafted a PEIS in 1994 for the UMTRA Ground Water Project to analyze potential impacts of implementing four programmatic alternatives for conducting ground water compliance at the UMTRA Project processing sites. The preferred alternative will be selected by the DOE and published in a Record of Decision. All subsequent actions on the UMTRA Ground Water Project must comply with the Record of Decision.

The environmental impacts from implementing the proposed compliance strategy presented in the final Mexican Hat SOWP will be assessed in an environmental assessment (EA) that will meet the requirements of the NEPA and tier off (incorporate by reference) applicable issues discussed in the PEIS.

3.0 SITE CONDITIONS

This section of the Mexican Hat UMTRA site SOWP describes site location, surrounding land use, surrounding water use, hydrogeologic conditions, the nature and extent of contamination, and risks to human health and the environment. The information is summarized in the site conceptual model.

3.1 SITE BACKGROUND INFORMATION

A uranium processing mill and sulfuric acid plant were built in 1957 at the Mexican Hat site by the Texas-Zinc Minerals Corporation, which operated the facility from 1957 until 1963. It was then sold to Atlas Corporation, which operated it until 1965 when uranium processing ceased. Approximately 5700 tons (5200 tonnes) of uranium oxide concentrate were produced and sold to the U.S. Atomic Energy Commission. The sulfuric acid plant, initially built to support the requirements of the uranium mill, operated from 1957 to 1970.

Location

The Mexican Hat UMTRA site is in San Juan County, Utah, east of US Route 163, between the towns of Halchita and Mexican Hat (Figure 3.1). It is approximately 18 miles (mi) (29 kilometers [km]) south of Bluff, Utah, and 10 mi (16 km) north of the Arizona border. The site is within the Navajo Reservation, at 37° 07' 54" north latitude and 109° 52' 30" west longitude.

Surrounding land use

The town of Mexican Hat had an estimated population of 259 in 1990 (DOC, 1990). The population of Halchita was estimated at 500 in 1985, roughly equivalent to the 1980 population (DOE, 1987). There are no residences in the area of the disposal cell, between the disposal cell and seeps, or in the area of contaminated seeps. Land use in the vicinity of the tailings site is controlled by the Utah Navajo Development Corporation and is limited to livestock grazing.

Surrounding water use

Water contaminated by the former uranium mill is not used and does not affect community water supplies. There are no recorded uses of ground water within a 2-mi (3-km) radius of the site, based on results of a well inventory (DOE, 1993d).

The water supply for the community of Halchita is from a treatment plant that obtains water from the San Juan River. The community of Mexican Hat derives its water supply from the San Juan River and a converted oil exploration well. Results from water samples show that the quality of water in the San Juan River is unaffected by the Mexican Hat UMTRA site (DOE, 1993d).

FIGURE 3.1
MEXICAN HAT, UTAH, UMTRA PROJECT SITE LOCATION

Well completion details are unavailable for the converted oil exploration well, but it is in a geologic formation unaffected by and isolated from site constituents. This conclusion is based on the following: a) site constituents are present only in the uppermost aquifer at the site, the Halgaito Shale; b) contaminated residual process water within the shale is isolated from deeper units due to an upward hydraulic gradient and low permeability beds; and c) the areal extent of site contamination is limited by deeply incised arroyos that intercept all flow from the shale. The San Juan River is more deeply incised than the arroyos and is between the site and the converted oil well. Therefore, no flow paths between the contaminated water and the converted oil well exist.

Contaminant sources

The majority of Mexican Hat UMTRA site contamination was caused by the discharge of waste water and tailings from uranium milling. Contamination is present in this residual process water within the uppermost aquifer, the Halgaito Shale. Although in operation for a longer period of time, the sulfuric acid plant probably contributed little additional contamination when compared to the uranium mill process. Constituent sources did not exist prior to plant startup in 1957 because the site was vacant land.

Uranium concentration was the purpose of the processing at the Mexican Hat site. Approximately 2.2 million tons (2.0 million tonnes) of uranium-bearing ore were processed by crushing and grinding and then removal of the uranium through a chemical process (DOE, 1993d). The operations resulted in the production of a relatively small amount of uranium concentrate (5700 tons [5200 tonnes]) and a relatively large amount of wastes, consisting of waste water and mill tailings. Site contamination resulted from discharge of waste water, hydraulic placement of mill tailings, and infiltration of the water through the tailings.

Mill tailings are the fine-grained materials (sand, silt, and clay) resulting from the uranium removal process. Because the uranium represented only a small portion of the ore, the volume of tailings is approximately equal to the amount of ore processed (i.e., approximately 2.2 million tons [2.0 million tonnes]). The tailings were mixed with water from the San Juan River and waste water from the chemical concentration process. The tailings and water mixture was pumped through pipes to the upper and lower tailings piles a short distance from the processing plant (the former upper tailings pile and former lower tailings pile shown on Figure 3.2). The current disposal cell is located at the former lower tailings pile.

The acid process for uranium concentration was used at the Mexican Hat site. Process materials contributing to site contamination were uranium ore, sulfuric acid, nitric acid, magnesium hydroxide, manganese, ammonium nitrate, and ammonia. Constituents resulting from the process materials and byproducts were copper, vanadium, molybdenum, ammonium, sulfate, nitrate, magnesium, calcium, and uranium.

LEGEND

- 251 SEEP
- 909 MONITOR WELL
- 163 U.S. HIGHWAY
- ===== IMPROVED ROADS
- ==== DIRT ROAD
- EPHEMERAL STREAM

NOTE: WELLS AND SEEP LOCATIONS ARE APPROXIMATE

**FIGURE 3.2
CURRENT CONFIGURATION OF THE MEXICAN HAT UMTRA PROJECT SITE**

The removal of copper from the ore and the operation of the sulfuric acid plant were important components of the uranium milling process. Because of the relatively high copper content and its interference with the uranium concentration process, copper was removed from the ore prior to uranium removal. Sulfuric acid was produced from sulfur trucked to the site from Wyoming.

Waste products from the copper and sulfuric acid operations were similar to the uranium mill waste products. The amount of waste produced from these operations is assumed to be included in the overall waste water generated from the mill.

Waste water was produced from the mill at a rate of 1 to 5 tons (0.9 to 4.5 tonnes) for every ton (0.9 tonnes) of ore processed (Merritt, 1971). Therefore, from 2.2 to 11 million tons (2.0 to 9.9 million tonnes) of waste water was produced during the 8 years of operation. This is equivalent to between 71 and 350 million cubic feet (ft³) (2.0 and 10 million cubic meters [m³]) or from 0.53 to 2.6 billion gallons (2.0 to 10 billion L) of waste water. Waste water was disposed of with the tailings.

Mill tailings and the former mill buildings from the Monument Valley UMTRA site were relocated to the disposal cell at the Mexican Hat UMTRA site. This operation was completed in January 1994. Because the processes and ore used at the former mills were similar, the characteristics of the Monument Valley wastes are similar to those at Mexican Hat. The addition of the Monument Valley wastes adds to the size of the disposal cell and to the amount of water that will temporarily drain from the Mexican Hat cell, but does not influence the chemical characteristics of the tailings or tailings pore fluids.

Site status

The site was leased from the Navajo Nation by the site operators from 1957 until 1970, when the lease expired. Control of the site and all structures and materials then reverted to the Navajo Nation (DOE, 1993d).

Surface remediation activities at the site are nearing completion and consist of consolidating the former mill buildings, windblown contaminated materials, and the tailings pile from the Monument Valley and Mexican Hat UMTRA sites into the disposal cell at the Mexican Hat UMTRA site. Construction of the final cover is scheduled for completion by the fall of 1994.

3.2 SOURCE OF DATA

Section 3.0 of the SOWP presents information evaluated and interpreted by the authors and obtained from a number of sources. The information includes observations from site visits by the authors and documentation available at the UMTRA Project Document Control Center in Albuquerque, New Mexico.

Pre-milling site conditions, construction of the mill, and mill processes were described by Banks (1959). Additional details regarding the process of uranium concentration, mill byproducts, and process waste streams are provided in Merritt (1971).

Site hydrogeologic conditions are described in detail in the *Remedial Action Plan* (RAP) (DOE, 1993d) and the *Technical Evaluation Report* (TER) prepared by the NRC (NRC, 1992). Additional information was obtained through a review of geologic and hydrologic reports cited in the RAP, an examination of monitor well completion reports, and water chemistry data contained in the Software Program for Environmental Analysis and Reporting (SPEAR) system. The SPEAR system contains the results from laboratory and field analyses of water samples collected as part of the UMTRA Project (DOE, 1992).

3.3 GEOLOGY AND HYDROLOGY

3.3.1 Physical setting

The site is approximately 1 mi (1.6 km) south of the San Juan River, on the northern boundary of the Navajo Uplands section of the Colorado Plateau physiographic province. The topography of the Navajo Uplands section has been influenced primarily by erosion from the Colorado River and its tributaries, which include the San Juan River (DOE, 1987).

The tailings are on a relatively flat mesa at an elevation of about 4300 feet (ft) (1300 meters [m]). Surface drainage from the site and surrounding areas is to the San Juan River, which is at an elevation of about 4100 ft (1200 m) at a point nearest the site. Bounding the relatively flat mesa to the north and east are North Arroyo and Gypsum Creek, which are ephemeral drainages (surface water flow is present only after significant rainfall). The arroyo and creek are relatively narrow with near vertical walls 30 to 100 ft (9 to 30 m) deep. South of the site is a ridge that extends about 100 ft (30 m) above the site; west of the site the topography is similar to the North Arroyo and Gypsum Creek areas, relatively flat but with deeply incised arroyos (Figure 3.3).

3.3.2 Geology

The geologic unit exposed at ground surface is the Halgaito Shale, the lowermost formation of the Cutler Group. Soil is thin to nonexistent in the area due to climate and geologic conditions. Beneath the Halgaito Shale is the Honaker Trail Formation, the uppermost formation of the Hermosa Group.

The Halgaito Shale consists primarily of interbedded silty sandstone, siltstone, and shale. Calcareous, well cemented beds alternate with less cemented beds. There are also some thin lenticular beds of limestone and conglomerate (DOE, 1993d). The conglomerate consists of siltstone and limestone pebbles in a silty matrix. The unit is 80 to 215 ft (25 to 65 m) thick in the vicinity of the site, based on 16 wells drilled for the UMTRA Project (Figures 3.4 through 3.8). Well

FIGURE 3.3
SITE TOPOGRAPHIC MAP, MEXICAN HAT
UMTRA PROJECT SITE

LEGEND

NOTE: THERE IS AN ABANDONED BOREHOLE AND AN EXISTING WELL AT LOCATION 910.

- ABANDONED HALGAITO SHALE FORMATION WELL OR BORING
- EXISTING HALGAITO SHALE FORMATION WELL
- ▣ ABANDONED HONAKER TRAIL FORMATION WELL OR BORING
- ◇ EXISTING HONAKER TRAIL FORMATION WELL
- 923 SEEP
- 163 U.S. HIGHWAY
- == IMPROVED ROADS
- === DIRT ROAD
- EPHEMERAL STREAM

NOTE: WELLS AND SEEP LOCATIONS ARE APPROXIMATE

FIGURE 3.4
LOCATIONS OF MONITOR WELLS, ABANDONED WELLS, AND BORINGS,
MEXICAN HAT UMTRA PROJECT SITE

LEGEND

- ABANDONED HALGAITO SHALE FORMATION WELL OR BORING
- EXISTING HALGAITO SHALE FORMATION WELL
- ◼ ABANDONED HONAKER TRAIL FORMATION WELL OR BORING
- ◇ EXISTING HONAKER TRAIL FORMATION WELL
- A---A' LINE OF CROSS SECTION
- 923 SEEP
- 163 U.S. HIGHWAY
- ===== IMPROVED ROADS
- ===== DIRT ROAD
- EPHEMERAL STREAM

FIGURE 3.5
LOCATIONS OF HYDROGEOLOGIC CROSS SECTIONS,
MEXICAN HAT UMTRA PROJECT SITE

FIGURE 3.7
HYDROGEOLOGIC CROSS SECTION B – B', MEXICAN HAT SITE

FIGURE 3.8
HYDROGEOLOGIC CROSS SECTION C - C', MEXICAN HAT SITE

logs are in Appendix A. Two sets of nearly vertical fractures (trending east-west and northeast-southwest) and fractures along bedding planes (which dip toward the east) are present in the upper portion of the Halgaito Shale at the site (Figure 3.9). The presence and size of the fractures decrease significantly with depth (DOE, 1993d).

The Honaker Trail Formation consists of interbedded siltstone, limestone, shale, and sandstone. Chert and limestone nodules are found throughout the siltstone beds. The limestone units are predominantly fine- to very-fine grained and crystalline. The sandstone units are very fine- to fine-grained. The total thickness of the unit is greater than 300 ft (100 m). No wells at the site fully penetrate the Honaker Trail Formation (DOE, 1993d).

3.3.3 Ground water hydrology

Halgaito Shale

The uppermost aquifer, the Halgaito Shale, was dry or nearly dry prior to milling operations. The majority of water presently contained in the Halgaito Shale is a result of former milling operations (discharge of process water and water used to place the tailings) and, to a lesser degree, transient drainage from the disposal cell. Information to support the source of the water being primarily from former milling operations is in Section 3.4, Geochemistry.

Ground water within the Halgaito Shale is primarily contained in fractures and is perched on lower permeability zones within the unit, because the unit exhibits very little primary hydraulic conductivity (due to the fine-grained nature of the sediments and presence of intergranular calcium and silica cement). Although there are conglomerate units within the Halgaito Shale, the hydraulic conductivity of those units is also low due to the fine-grained matrix and cements. The hydraulic conductivity of the unit decreases with depth because of a decrease in the number and size of the fractures. The lower portion of the Halgaito Shale acts as a confining unit.

Testing of the Halgaito Shale showed a horizontal hydraulic conductivity of between 0.75 and 0.19 ft per day (2.6×10^{-4} and 7×10^{-5} centimeters [cm] per second) in the upper portion and 0.014 ft per day (5×10^{-6} cm per second) in the lower portion (DOE, 1993d). Therefore, the lower portion of the Halgaito Shale is a very effective confining unit, significantly limiting the vertical exchange of water between the Halgaito Shale Formation and the Honaker Trail Formation. Calculations of hydraulic conductivity are in Appendix B.

Recharge to the Halgaito Shale is limited by low annual rainfall (6.1 inches [16 cm]) and high evaporation (84 inches [210 cm]) (DOE, 1993d). Annual evaporation exceeds precipitation every month except January, when average rainfall is 0.5 inches (1.0 cm) and evaporation is 0.35 inches (0.89 cm). Some recharge does occur, as evidenced by a noncontaminated seep from the Halgaito Shale (seep 261, see Figure 3.2, and Section 3.4, Geochemistry).

LEGEND

STRIKE AND DIP OF FRACTURES AND BEDDING PLANES
 (A dip of 90° along the fractures indicates that the fractures are vertical. A dip of 3°-4° along the bedding planes indicates that the spaces between the bedding planes are nearly horizontal.)

GROUNDWATER FLOW DIRECTION

U.S. HIGHWAY

IMPROVED ROADS

DIRT ROAD

EPHEMERAL STREAM

FIGURE 3.9
ORIENTATION OF FRACTURES IN THE HALGAITO SHALE FORMATION
MEXICAN HAT UMTRA PROJECT SITE

Discharge is through the fractures and on low permeability beds as water travels toward the seeps in North Arroyo and Gypsum Creek.

In addition to limited recharge and very low hydraulic conductivity, ground water within the Halgaito Shale affected by the site is limited in areal extent and has no potential use as a water resource. As shown on Figure 3.4 and on the well logs in Appendix A, nine borings were installed completely or mainly in the Halgaito Shale Formation.

Each of the borings shown as being completed in the Halgaito Shale Formation were installed completely within the Halgaito Shale Formation with the exception of the borings for 933 and 935. The borings for those two wells completely penetrated the Halgaito Shale Formation but also extend into the uppermost 6 to 10 ft (2 to 3 m) of the Honaker Trail Formation. Although the borings for wells 933 and 935 extend partially into the Honaker Trail Formation, they are useful for evaluating the presence or absence of ground water within the Halgaito Shale Formation.

Of the nine borings installed completely or mainly within the Halgaito Shale Formation, ground water was not encountered in three of them (905, 910, and 933). The six remaining borings were completed as wells: two have gone dry since their installation (906 and 911) and one has never contained a sufficient amount of water to obtain a sample (935). The remaining three wells have contained a sufficient amount of water to obtain samples (910A, 912, and 934).

Please note that the borings for 910 and 910A were drilled within approximately 10 ft (3 m) of each other. Boring 910 was installed and abandoned due the absence of ground water. The boring for 910A was installed in close proximity to 910, and it was decided to complete the boring as a well. The well completion logs in Appendix A refer to the well as "Well 910A." However, information contained in the SPEAR data base refers to this well as "Well 910." Other sections of this report reference the well consistent with the SPEAR data base; i.e., the well is referenced as "Well 910."

As described in Section 3.4.3 of this report, well 910A (referred to as well 910 in Section 3.4.3) was sampled on only one occasion and was capable of producing only a few liters of muddy water. The other two remaining wells that contain water (912 and 934) only have about a 6-ft (2-m) column of water, thus limiting their suitability for water supply. (Water level records are in Appendix B). Because the depth to ground water in the wells exceeds 20 ft (6 m) below land surface, an above-ground centrifugal pump cannot be used. A submersible pump could not be used either, due to the limited water column within those wells. Therefore, although wells 910A, 912, and 934 contain water, using them as a source of water is not possible.

The drilling methods employed for the installation of borings within the Halgaito Shale Formation (air rotary and air hammer) are appropriate for evaluating the

presence of ground water and are typically used for installation of water supply wells in the region of the site. The results from the drilling program described above, combined with records of water level measurements, demonstrate the limited extent and yield of ground water from the Halgaito Shale Formation. Therefore, ground water within the Halgaito Shale Formation meets the criteria for supplemental standards because of limited use.

A water table map for the Halgaito Shale cannot be constructed because of the limited extent of water and because water is contained only in fractures. However, the orientation of the nearly vertical fractures and the fractures along the bedding planes that control the ground water flow direction have been adequately identified to determine that the direction of ground water flow is to the seeps in Gypsum Creek and North Arroyo.

Honaker Trail Formation

Below the Halgaito Shale is the aquifer contained within the Honaker Trail Formation. The unit is isolated from ground water in the Halgaito Shale because the lower portion of the Halgaito Shale acts as a confining unit, limiting vertical water movement; and there is an upward hydraulic gradient in the Honaker Trail Formation, preventing ground water in the Halgaito Shale from entering the Honaker Trail Formation. Water levels in Honaker Trail Formation are above water levels in the Halgaito Shale, and in some cases ground water flowed at ground surface (Figures 3.7 and 3.8). When drilling at locations 907 and 932 and upon entering the Honaker Trail Formation, water from the Honaker Trail Formation was above ground surface.

Ground water in the Honaker Trail Formation flows northeast, toward the San Juan River. Recharge to the unit is limited and may occur as rainfall in areas to the southwest where the unit is closer to or present at ground surface. Recharge may also occur as upward flow from deeper units. The discharge area for water contained in the unit is the San Juan River.

Although ground water is not contaminated from the mill tailings, the natural water quality of the Honaker Trail Formation in the vicinity of the site is likely unsuitable for consumption. Three of the monitor wells (910, 932, and 936) showed the presence of hydrogen sulfide during drilling and were abandoned due to the potential health hazard of the hydrogen sulfide gas. Naturally-occurring petroleum was also present in wells 908, 910, 931, 932, and 936 (see the well logs in Appendix A). A limited amount of oil is produced from the Honaker Trail Formation and Halgaito Shale in the nearby Mexican Hat oil field (located in the town of Mexican Hat).

3.3.4 Surface water hydrology

The disposal cell is located within an arroyo that originally flowed northeastward to Gypsum Creek. Drainage channels were constructed upslope and downslope

from the disposal cell, and other local drainages were improved to divert surface water away from the cell. The surface drainage pattern is shown on Figure 3.2.

Surface water is sometimes present in unlined ponds west of the tailings pile. The ponds were originally constructed as sewage treatment ponds for the mill community and now serve the same purpose for the community of Halchita. Water either evaporates or infiltrates into the Halgaito Shale and discharges to an unnamed arroyo that drains to the northwest into the San Juan River. Seepage from the ponds does not affect site-related seeps in the North Arroyo or Gypsum Creek; the ponds are in a drainage basin separate from the site drainage basin. These seeps have not been sampled because they are in a separate drainage basin and are unaffected by site activities.

Ground water and surface water interactions are limited to the small amount of recharge to the Halgaito Shale from rainfall events. The lack of surface water in North Arroyo and Gypsum Creek show that these surface water features do not act as ground water discharge areas, except for the small amount of seep water that discharges to them from the walls of the arroyos. The San Juan River acts as a regional ground water recharge and discharge area.

Under normal conditions (i.e., between rainfall events), discharge from the seeps represents the total contribution of surface water to the creek and arroyo. Seep discharge is not sufficient to support a continuous flow of surface water. Significant rainfall events can cause relatively large, but short-term flow in the creek and arroyo. During these high-flow periods, the contribution of seep flow to total flow is insignificant.

The zone of contamination within the Halgaito Shale is not affected by the San Juan River. The deeply incised walls of the arroyo and creek act as ground water divides, isolating the contaminated portions of the Halgaito Shale from connection with the river and limiting the areal extent of contamination by intercepting seep flow. Ground water within the Halgaito Shale cannot flow under the arroyo or creek because the lower portion of the Halgaito Shale acts as a confining unit.

North Arroyo seeps

Three seeps in the North Arroyo were identified and evaluated during the construction of the disposal cell. These are identified as seep 251, seep 249, and seep 255. As shown in Figure 3.10, seep 251 is on the south bank of the North Arroyo some 400 to 500 ft (120 to 150 m) north of the disposal cell. Seep 249 is at the base of the southeast bank of Gully No. 2 some 800 ft (240 m) northeast of the toe of the disposal cell and 100 ft (30 m) upslope from the confluence of the gully with the North Arroyo. Seep 255 is further downgradient in the North Arroyo some 1300 ft (400 m) from the disposal cell. Seep 255 is directly below a runoff retention dam constructed as part the remedial activities.

LEGEND

- 251 SEEP
- ◇ 909 EXISTING HONAKER TRAIL FORMATION WELL
- 163 U.S. HIGHWAY
- == IMPROVED ROADS
- DIRT ROAD
- EPHEMERAL STREAM

NOTE: WELLS AND SEEP LOCATIONS ARE APPROXIMATE

FIGURE 3.10

APPROXIMATE FOOTPRINT OF CONTAMINATION, MEXICAN HAT UMTRA PROJECT SITE

Seep 251 was first noticed in December 1989 during the first phase of remedial action activities involving the relocation of the upper pile materials to the lower pile. A french drain was installed in February 1990 to collect water samples and measure flow rates (MKES, 1990). The flow rate was measured at 4 gallons per hour (15 L per hour). The flow decreased over the next several months until it stopped in May 1990 (see Figure 3.11). Although there was no evidence of a seep at this location during the site characterization prior to remediation, dense green vegetation noted in aerial photographs taken as early as 1974 provided evidence of the earlier occurrence of near-surface water at this location. The seep was observed to be flowing in a sampling round taken during the final phase of the surface remediation activities in May 1994. Based on the historical performance of this seep, it is expected that the seep will cease flowing soon after completion of the construction of the disposal cell.

Flow rates at seep 249 were measured at 0.5 gallons per minute (2 L per minute) in March 1990 and decreased to 0.35 gallons per minute (1.3 L per minute) in July 1990 (see Figure 3.12). A spring in this area was documented and sampled by Snelling in 1968 (Snelling, 1971). There is no documentation that the seep has ever fully stopped since the relocation of the upper tailings pile to the lower tailings pile. The seep was observed to be flowing in a sampling round taken during the final phase of the surface remediation activities in May 1994. It is not possible to predict when flow from this seep will cease.

Water has been observed flowing at the location of seep 255 as far back as March 1976. The seep was observed from 1988 through 1990. The seep was observed to be flowing in a sampling round taken during the final phase of the remediation activities in May 1994. No flow rates have been taken. It is also not possible to predict when flow from this seep will cease.

Gypsum Creek seeps

The locations of all seeps in Gypsum Creek near the disposal cell have been identified. Flow rates from the seeps have not been determined, but they are insufficient to support a continuous flow of surface water.

3.4 GEOCHEMISTRY

Water quality data were collected from 14 locations during the period from 1985 to 1993. At various times, these included 3 wells in the deeper Honaker Trail Formation (wells 907, 908, 909, Figure 3.5) and 11 wells for sampling water contained in the Halgaito Shale. Water sampling locations in the Halgaito Shale included 4 monitor wells (wells 910, 911, 912, and 934; Figure 3.5) and 11 seeps located along North Arroyo, Gypsum Creek, and Halgaito Wash. Locations of the seeps in North Arroyo and Gypsum Creek are shown in Figure 3.10. The seep on Halgaito Wash (seep 256) is located 2.5 mi (4 km) southwest of the processing site and is shown on Figure 3.5.

FIGURE 3.11
SEEP 251 FLOW ANALYSIS, NORTH ARROYO FRENCH DRAIN, MEXICAN HAT SITE

FIGURE 3.12
SEEP 249 FLOW ANALYSIS, GULLY NUMBER 2, MEXICAN HAT SITE

Both filtered and unfiltered data were collected and analyzed for constituents indicative of contamination by uranium processing. In addition, tailings leachate data were collected from four suction lysimeters located within the tailings. These data were used to determine background water quality and the distribution of residual process water in the Halgaito Shale. All data are provided in Appendix B.

3.4.1 Uranium processing and process solutions

As discussed in Section 3.1, the milling process produced solutions containing nitrate, ammonium, sulfate, manganese, magnesium, calcium, and several metals and non-metals leached from the ores, including vanadium, selenium, copper, and uranium. Lysimeter data from the tailings (collected at four locations in 1990 and 1991) displayed a wide variation in pH, from acid (pH of 3) to near neutral (pH of 6.5), reflecting a mix of neutralized raffinates and acid tailings. All of the constituents related to the ores and process solutions listed above were identified in the tailings solutions. In addition, several constituents derived from leaching of the ore were found, including aluminum, iron, boron, arsenic, cadmium, cobalt, fluoride, and nickel. Nitrate was at notably low concentrations (<0.2 to 6.5 mg/L) when compared to the contaminated ground water below the tailings (<1 to 286 mg/L), suggesting that the nitrate-bearing process solutions were disposed of in limited areas within the tailings piles such as the pond once located at the north end of the lower tailings pile.

3.4.2 Background water quality

Background water quality was determined for two hydrogeologic units at the site, the Halgaito Shale and underlying Honaker Trail Formation. Background water quality data for the Honaker Trail was collected from monitor well 909, located off-site and upgradient of the tailings piles (Figure 3.10).

The Halgaito Shale contains only minor amounts of naturally occurring water in fractures and in perched zones above the lower permeability units. This makes it difficult to establish background water quality using monitor wells. Updip monitor wells that would normally define background water quality were dry. Instead, two seeps were used to define background water quality in the Halgaito Shale. One seep is located in Halgaito Wash and is 2.5 mi (4.0 km) upgradient of the site (location 256). This seep issues from a zone near the contact between the Halgaito Shale and underlying Honaker Trail. The second location, seep 261, is in Gypsum Creek, upstream and on the southeast side of the creek. This seep issues from alluvium atop and adjacent to Halgaito Shale. Water quality from both seeps is very similar. Both seeps are isolated from site-related contamination.

Both the Honaker Trail and Halgaito Shale appear to contain calcium sulfate (as the mineral gypsum, which has been positively identified in outcrops of the Halgaito Shale, and this is reflected in the background water quality.

Background ground water from both units contain relatively high concentrations of sulfate as the dominant anion (2000 to 3300 mg/L) balanced by nearly equal equivalents of sodium, calcium, and magnesium. The pH of waters from both units is slightly alkaline, and limited Eh measurements as well as the general presence of sulfate demonstrate that the waters in both units are oxidizing. TDS in both units range from 3170 to 5330 mg/L (Tables 3.1 and 3.2). Background water quality in both units is generally similar because both units are lithologically similar and contain the same minerals.

Several other constituents commonly found in the processing solutions are also naturally present in the background seeps. The concentrations of these constituents, however, are at levels below those in the tailings solutions. In the background seeps, naturally occurring constituents that are also found in the process solutions include ammonium, boron, magnesium, manganese, molybdenum, nitrate, silica, sulfate, and uranium (Table 3.1).

3.4.3 Nature and extent of contamination

Hydrologic data demonstrate that the Honaker Trail Formation is isolated from site-related contamination by an upward vertical hydrologic gradient. Geochemical data support this. Specifically, no concentrations of uranium and nitrate in excess of background (monitor well 909) were observed in any monitoring wells completed in the Honaker Trail Formation, including downgradient monitor wells 907 and 908, Table 3.2, and Figure 3.13.

Analyses of water quality data from monitor wells located directly beneath the lower tailings pile and completed within the Halgaito Shale (monitor wells 911 and 912, Figure 3.5 and Table 3.1) indicate that nitrate and uranium are generally elevated above background and indicative of contamination. The limited sulfur isotope data base (discussed below) was also used for identifying contamination. Because major element concentrations and TDS are similar to or only slightly greater than levels found in the background seeps, they are not useful as indicator parameters.

Water sampling records for the period 1985 through 1988 document that four monitor wells in the Halgaito Shale (wells 910, 911, 912, and 934) produced some water after completion. However, three of these (wells 910, 911, and 934) were capable of producing only small amounts (less than 16 gallons [73 L]) of muddy water before being bailed dry.

In downgradient well 934, the initial pH of 7 climbed to 11 during the first five samplings, indicating contamination of the well by water from grouting. The initial nitrate from this well (62 mg/L) suggests some contamination in this downgradient area (Figure 3.5). However, the grout contamination makes all data from this well suspect since the water may be derived from drilling operations.

Table 3.1 Comparison of filtered water quality in the tailings to contaminated and background water quality in the Halgaito Shale Formation, 1985-1994 data

Constituent	Tailings lysimeters ^a	Downgradient			
		Halgaito ^b below tailings	North Arroyo ^c seeps	Gypsum Creek ^d seeps	Background seeps ^e
Alkalinity	8 - 240	294 - 1124	190 - 820	53 - 583	189 - 289
Aluminum ^f	0.2 - 24	<0.1 - 0.4	<0.1	<0.05 - 0.3	<0.05
Ammonium ^g	7 - 94	<0.1 - 54	<0.1 - 35	<0.1 - 3.4	<0.01 - 0.5
Antimony	<0.003 - 0.03	<0.003 - 0.1	<0.003 - 0.02	<0.003 - 0.04	<0.02
Arsenic ^f	<0.01 - 5.4	<0.01 - 0.03	<0.01	<0.05	<0.01
Barium	<0.1	<0.01 - 0.2	<0.1	<0.01 - 0.03	<0.002 - 0.02
Beryllium	<0.005 - 0.009	<0.01	<0.01	<0.01	<0.005
Boron	0.1 - 1.3	0.1 - 1.8	0.6 - 0.9	0.1 - 1.3	0.3 - 0.4
Bromide	0.1 - 0.3	<2	0.3 - 0.9	0.3 - 1.1	0.5 - 0.9
Cadmium ^f	<0.001 - 0.11	<0.001	<0.001	<0.002 - 0.002	<0.001
Calcium ^g	410 - 596	174 - 610	367 - 640	419 - 656	410 - 555
Chloride	22 - 40	76 - 100	90 - 440	113 - 246	109 - 181
Chromium ^f	<0.01 - 0.13	<0.01 - 0.16	<0.01	<0.003 - 0.12	<0.01
Cobalt ^f	1.5 - 3.9	<0.05	<0.03	<0.03 - 0.04	<0.03
Copper ^{f,g}	<0.01 - 14	0.02 - 0.05	<0.01	0.006 - 0.04	<0.01
Fluoride	0.2 - 5.1	0.4 - 0.7	0.4 - 1.1	0.4 - 0.8	0.4 - 2.2
Iron ^f	<0.03 - 732	<0.03 - 0.12	<0.03 - 0.13	<0.005 - 0.3	<0.03 - 0.2
Lead	<0.03	<0.01 - 0.02	<0.01	<0.03	<0.005
Lead-210 (pCi/L)	NA	1.1 - 1.3	0.2 - 1.2	0.0 - 1.1	0.0 - 1.0
Magnesium ^g	199 - 362	348 - 550	157 - 515	170 - 880	44 - 265
Manganese ^{f,g}	29 - 136	0.4 - 3.1	<0.01 - 2.4	<0.01 - 1.59	<0.01 - 0.66

Table 3.1 Comparison of filtered water quality in the tailings to contaminated and background water quality in the Halgaito Shale Formation, 1985-1994 data (Continued)

Constituent	Tailings lysimeters ^a	Downgradient			
		Halgaito ^b below tailings	North Arroyo ^c seeps	Gypsum Creek ^d seeps	Background seeps ^e
Mercury	<0.0001 - 0.0003	<0.0002 - 0.0006	<0.0002	<0.0002	<0.0002
Molybdenum ^{f,g}	<0.01 - 0.14	<0.01 - 0.15	0.02 - 0.45	<0.01 - 0.23	<0.01 - 0.02
Nickel ^f	1.4 - 2.6	<0.04 - 0.25	0.02 - 0.13	<0.04 - 0.29	<0.04
Nitrate ^g	<0.2 - 6.5	<1 - 286	30 - 676	<1.0 - 994	<1.0 - 8.9
pH	3.0 - 6.6	6.2 - 7.7	6.4 - 8.05	6.7 - 8.6	7.1 - 8.0
Phosphate ^f	0.1 - 2.8	<0.1 - 0.2	<0.1 - 0.1	<0.1 - 0.1	<0.01 - 0.01
Polonium-210 (pCi/L)	NA	0.0 - 0.4	0.0 - 0.1	0.0 - 0.2	0.5 - 0.7
Potassium	10 - 46	20 - 28	6 - 25	2 - 28	6 - 15
Radium-226 (pCi/L)	NA	0.2 - 1.1	0.0 - 0.5	0.0 - 0.9	0.0 - 1.5
Radium-228 (pCi/L)	NA	0.0 - 0.6	0.0 - 1.3	0.0 - 7.8	0.0 - 6.0
Selenium	<0.03	<0.05	0.003 - 0.015	<0.005 - 0.31	<0.03
Silica ^f	32 - 101	20 - 36	19 - 37	11 - 50	16 - 25
Silver ^f	<0.01 - 0.08	<0.01	<0.01	<0.01	<0.01
Sodium	90 - 145	190 - 600	270 - 520	420 - 1500	270 - 740
Strontium	3.3 - 7.3	<0.1	9 - 14	<0.1 - 15	10 - 13
Sulfate ^g	498 - 4150	3100 - 3910	1950 - 3500	2600 - 4800	2200 - 3300
Sulfide	<0.8	<0.1	<0.1 - 28	<0.1 - 27	<0.1 - 4.4
Thallium	<0.03	NA	<0.01	<0.01	<0.03
Thorium-230 (pCi/L)	NA	0 - 7.2	0.0 - 0.2	0.0 - 0.5	0 - 1.7
Tin	<0.005 - 0.008	<0.005	<0.03 - 0.07	<0.03	<0.05
Total dissolved solids	3500 - 6500	2000 - 6700	3000 - 6600	3200 - 7800	3700 - 5300
Uranium ^{f,g}	0.005 - 1.5	0.60 - 0.78	0.18 - 1.29	0.02 - 0.78	0.01 - 0.05

Table 3.1 Comparison of filtered water quality in the tailings to contaminated and background water quality in the Halgaito Shale Formation, 1985-1994 data (Concluded)

Constituent	Tailings lysimeters ^a	Downgradient			
		Halgaito ^b below tailings	North Arroyo ^c seeps	Gypsum Creek ^d seeps	Background seeps ^e
Vanadium ^{f,g}	<0.01 - 0.67	<0.01 - 0.40	<0.01 - 0.03	<0.01 - 0.08	<0.01 - 0.02
Zinc ^f	0.4 - 6.9	0.03 - 0.06	<0.03	0.008 - 0.05	<0.005 - 0.01

^aLysimeters HAT-01-241, -242, -243, and -244; 1990-1991 data.

^bMonitor wells HAT-01-911 and -912; 1985 and 1988 data.

^cSeeps HAT-01-249, -251, and -255; 1990-1994 data.

^dSeeps HAT-01-248, -253, -254, -922, -923, and -925; 1985-1994 data.

^eSeeps HAT-01-256 and -261; 1990-1994 data.

^fDissolved constituents in the tailings that are more than 5 times background levels and probably derived from dissolution of the ore.

^gConstituents known to have been present in processing solutions or uranium ores. All data in mg/L unless noted as pCi/L.

NA—Not applicable.

Values given as less than (<) are below the minimum detection limit for the analysis.

**Table 3.2 Summary of water quality in upgradient and downgradient wells
in the Honaker Trail Formation**

Constituent	Honaker Trail Formation		
	Upgradient ^a		Downgradient
	Well 909	Well 930 ^b	Wells 907 and 908 ^c (mg/L)
Alkalinity	133 - 159	34 - 61	92 - 137
Aluminum	<0.1 - 0.3	<0.1 - 0.2	<0.1 - 0.4
Ammonium	<0.1 - 0.4	<0.1 - 0.3	<0.1 - 0.1
Antimony	<0.003 - 0.006	<0.003	<0.003 - 0.007
Arsenic	<0.01 - 0.02	<0.01 - 0.02	<0.01 - 0.05
Barium	<0.01 - 0.1	<0.1 - 0.2	<0.1 - 0.2
Boron	0.1 - 1.0	0.05	0.1 - 4.7
Cadmium	<0.001 - 0.005	<0.001	<0.001
Calcium	330 - 445	153 - 173	410 - 600
Chloride	93 - 110	36 - 40	210 - 260
Chromium	<0.01 - 0.09	<0.01 - 0.06	<0.01 - 0.10
Cobalt	<0.05	0.07	<0.05
Copper	<0.01 - 0.04	<0.02	<0.02 - 0.05
Fluoride	1.3 - 1.5	1.2 - 1.4	1.2 - 1.5
Iron	<0.03 - 0.13	<0.03 - 0.04	0.14 - 0.24
Lead	<0.01	<0.01	<0.01
Magnesium	141 - 190	47 - 62	163 - 200
Manganese	0.01 - 0.02	0.01 - 0.02	0.03 - 0.15
Mercury	<0.0002	<0.0002	<0.0002 - 0.0008
Molybdenum	<0.01 - 0.20	0.03 - 0.04	<0.01 - 0.12
Nickel	<0.04 - 0.11	<0.04 - 0.06	<0.04 - 0.20
Nitrate	0.8 - 11.1	<1.0	<1.0 - 2.0
pH	7.1 - 7.4	9.1 - 10.2	7.3 - 7.8
Phosphate	<0.1 - 0.1	<0.1 - 0.1	<0.1 - 0.2
Polonium-210 (pCi/L)	0.0	0.0	0.0 - 0.3
Potassium	5.4 - 8.5	3.0 - 5.6	9.5 - 11.1
Radium-226 (pCi/L)	0.0 - 0.3	0.1 - 1.2	0.7 - 4.8
Radium-228 (pCi/L)	0.0 - 8.5	0.0 - 2.3	0.0 - 1.4

**Table 3.2 Summary of water quality in upgradient and downgradient wells
in the Honaker Trail Formation (Concluded)**

Constituent	Honaker Trail Formation		
	Upgradient ^a		Downgradient
	Well 909	Well 930 ^b	Wells 907 and 908 ^c (mg/L)
Selenium	<0.005 - 0.04	<0.005	<0.005
Strontium	<0.1 - 9.2	0.4	<0.1
Silver	<0.01	<0.01	<0.01
Silica - SiO ₂	14 - 16	15 - 22	12 - 14
Sodium	397 - 470	291 - 350	922 - 1230
Sulfate	1980 - 2380	1180 - 1230	3580 - 4090
Sulfide	<0.1 - 64.4	<0.1	<0.10
Thorium-230 (pCi/L)	0.0 - 0.30	0.0 - 1.6	0.0 - 0.40
Tin	<0.005	<0.005	<0.005
Total dissolved solids	3170 - 3730	1810 - 1920	5830 - 6580
Total organic carbon	<1 - 31	32	16 - 25
Uranium	0.04 - 0.06	<0.003 - 0.01	0.001 - 0.004
Vanadium	<0.01 - 0.49	<0.01 - 0.19	<0.01 - 0.60
Zinc	<0.01 - 0.03	<0.005	<0.01 - 0.20

^aData collected from 1985 - 1993.

^bUpgradient monitor well 930 data provided; however, pH values of 9 to 10 in this well suggest the well is grout-contaminated. Monitor well data for 909 are therefore considered to be more representative of background. Well 930 data collected in 1985 and 1988.

^cData collected in 1985 and 1988.

Note: All data in mg/L unless noted as pCi/L.

LEGEND

- ◇ 909 EXISTING HONAKER TRAIL FORMATION WELL
- 932 ABANDONED HONAKER SHALE FORMATION WELL OR BORING
- 4260 WATER LEVEL ELEVATION (FT. MSL)
- - - 4300 EQUIPOTENTIAL CONTOUR (ESTIMATED)
- ➔ GROUND WATER FLOW DIRECTION
- WELL FLOWS, OR FLOWED AT GROUND SURFACE
- 163 U.S. HIGHWAY
- ===== IMPROVED ROADS
- - - - - DIRT ROAD
- EPHEMERAL STREAM

NOTE: WELLS AND SEEP LOCATIONS ARE APPROXIMATE

FIGURE 3.13
POTENTIOMETRIC SURFACE OF THE HONAKER TRAIL FORMATION,
AUGUST 27-28, 1988

Monitor well 910, which is possibly crossgradient of the site (Figure 3.5), produced only a few liters of muddy water at a depth of about 150 ft (46 m) during one round of sampling. Nitrate concentrations (18 mg/L) and uranium (0.03 mg/L) suggest little if any contamination in this area.

Only one monitor well in the Halgaito Shale, monitor well 912 located directly below the tailings, produced significant amounts of water at a depth of 74 ft (13 m). The chemistry of this water (up to 286 mg/L nitrate and about 0.8 mg/L uranium) indicates that the water is tailings solution. Monitor well 911, also directly below the tailings, produced a small amount of water at a depth of 93 ft (28 m) before being bailed dry. Uranium concentrations (0.6 mg/L) indicate that this is also tailings solution at this depth. Data from these two wells are summarized in Table 3.1.

Chemical data, in conjunction with sampling records on the amount of water produced, demonstrate that the Halgaito Shale is capable of producing very little natural ground water. Where significant amounts of water do exist, they are from the uranium recovery operations.

The following geochemical data from the seeps issuing from the Halgaito also support the conclusion that zones of saturation in the Halgaito were created by uranium recovery operations. Seeps issuing from the Halgaito Shale into North Arroyo, located north of the tailings pile, have a geochemical signature indicating that these are essentially pure tailings solutions. Uranium and nitrate concentrations are about the same as those found within or directly below the tailings, ranging up to 1.29 mg/L of uranium and up to 676 mg/L of nitrate (Table 3.1). Table 3.1 provides the concentrations of constituents above background in these seeps as compared to the same constituents in background seeps.

Sulfur isotopes also indicate that the North Arroyo seeps are pure tailings solutions. Sulfur isotopic data collected from the lower tailings pile show that dissolved sulfate in the tailings solutions is depleted in sulfur-34 ($\delta^{34}\text{S}$ values of 5.8 to 8.1 per mil; DOE, 1990). In contrast, natural sulfate from both the Honaker Trail ground water and the Halgaito Shale bedded gypsum deposits is relatively enriched in sulfur-34 ($\delta^{34}\text{S}$ values of 15.1 and 14.6, respectively). Sulfur isotopes in the North Arroyo seeps had $\delta^{34}\text{S}$ values of 5.7 to 6.8 per mil, indicating that these are tailings solutions without any component of natural sulfate.

Downgradient water produced from seeps in Gypsum Creek also have elevated concentrations of nitrate and/or uranium relative to background, indicative of contamination (Table 3.1). The distribution of the tailings solution seeps in Gypsum Creek is consistent with contaminant water flow to the east following both the dip of bedding and the strike of the major fracture system affecting the Halgaito Shale.

Sulfur isotopic data indicate that approximately 60 to 100 percent of the dissolved sulfate in the Gypsum Creek seeps is derived from the tailings. The remaining 0 to 40 percent is derived from natural sulfate sources (gypsum). Thus the geochemical data demonstrate that ground water in the Halgaito Shale is primarily due to saturation by tailings solutions from the processing site downgradient of the site.

Constituents in the Gypsum Creek seeps, determined to be above background at the 0.05 level of significance, are listed in Table 3.3. These include several of the constituents known to be associated with process solutions and ore, including ammonium, magnesium, manganese, molybdenum, nitrate, selenium, sulfate, uranium, and vanadium. Other constituents, which were identified as being above background and which are probably the result of dissolution of the ore, are boron, nickel, potassium, silica, and sodium.

3.4.4 Contaminant fate and transport mechanisms

Most constituents in the contaminated water seeps within the Halgaito Shale are at levels that are at the same order of magnitude as background. Major (tenfold or greater) decreases in constituent concentrations are not expected to occur with transport or with time. This is true of boron, magnesium, molybdenum, nickel, potassium, silica, sodium, sulfate, and vanadium. These constituents are all naturally present and naturally equilibrated to processes of precipitation, rock-water reactions, adsorption, and cation exchange. These processes will have little effect on the slightly greater concentrations present in the tailings solutions migrating through fractures in the Halgaito Shale.

Nitrate (up to about 110 times background), selenium (up to about 10 times background), and uranium (up to about 16 times background) are present in the contaminated water seeps at concentrations greater than ten times background. These three constituents are mobile and stable under the relatively oxidizing, slightly alkaline water conditions at the site and will probably persist in the tailings solutions within the Halgaito Shale.

Ammonium is also present at concentrations greater than ten times background in North Arroyo seeps. This constituent is unstable in oxidizing environments because of denitrification (conversion to nitrogen by naturally occurring bacteria in soils). Ammonium also tends to be exchanged for sodium, calcium, or magnesium present in clays. Thus, ammonium is generally not construed to be a mobile constituent. This explains why ammonium is present at much lower concentrations in the Gypsum Creek seeps than in the North Arroyo seeps. With time, ammonium concentrations will decrease in all seeps due to denitrification.

3.5 RISK EVALUATION

A screening level risk evaluation was conducted for the seeps at the Mexican Hat site to determine whether potential exposure to the seep water poses risks

Table 3.3 Statistical comparison of 1990-1994 water quality in downgradient seeps with background levels

Constituent ^a	Background level ^b	Downgradient seeps in North Arroyo ^c	Downgradient seeps in Gypsum Creek ^d
Ammonium	<0.1 - 0.5	<0.1 - 35	<0.1 - 3.4
Boron	0.3 - 0.4	0.6 - 0.9	0.7 - 1.3
Magnesium	44 - 265	157 - 515	170 - 880
Manganese	<0.01 - 0.66	<0.01 - 2.4	<0.01 - 1.59
Molybdenum	<0.01 - 0.02	0.02 - 0.45	<0.01 - 0.12
Nickel	<0.04	0.02 - 0.13	<0.04 - 0.29
Nitrate	<1.0 - 8.9	30 - 676	2 - 994
Potassium	6 - 15	6 - 25	2 - 28
Selenium	<0.03	0.003 - 0.015	<0.005 - 0.31
Silica	16 - 25	19 - 37	23 - 50
Sodium	270 - 740	270 - 520	420 - 1500
Sulfate	2200 - 3300	1950 - 3500	2600 - 4800
Uranium	0.01 - 0.05	0.18 - 1.29	0.02 - 0.78
Vanadium	<0.01 - 0.02	<0.01 - 0.03	<0.01 - 0.08

^aConstituents determined to be, on average, above background levels (at the 0.05 level of significance).

^bSeeps 256 and 261.

^cSeeps 249, 251, and 255.

^dSeeps 248, 253, 254, 922, and 923.

to humans, livestock, and wildlife. Constituents considered in the human health evaluation included inorganics and radionuclides. The data considered for the evaluation of potential adverse effects to livestock and wildlife focused only on inorganics. The radionuclide data were not considered for animals because of the paucity of information on the effects of ionizing radiation on relatively short-lived organisms such as the wildlife species that occur, or potentially occur, in the vicinity of the site.

The evaluation conducted for this SOWP is based on the results of two previous risk assessments (JEG, 1990; Duncan et. al, 1994) and on recent site-specific exposure pathway information collected in June and July of 1994. The screening-level risk assessment (Duncan et. al, 1994) used worst-case exposure scenarios for the preliminary risk calculations for humans, livestock, and wildlife. Based on recently collected site-specific information, several of the input parameters, such as frequency of exposure, have been revised in this document to provide a reasonable evaluation of potential risks to humans and livestock.

The data used in this evaluation were from filtered seep water samples collected during 1990-1993 from seeps 248, 249, 251, 253, 254, 255, 261, 922, and 923 (Figure 3.10). Seep 924 was not sampled during this period. The data were divided into three components based on their location: background (seep 261), North Arroyo (seeps 249, 251, and 255), and Gypsum Creek (seeps 248, 253, 254, 262, 922, and 923). As a conservative measure, maximum detected constituent concentrations were used to evaluate potential adverse effects to humans, livestock, and wildlife.

3.5.1 Constituents of potential concern

The seep water data were screened in accordance with EPA guidance (EPA, 1989a and 1989b) to develop the list of the constituents of potential concern for the assessment of human, livestock, and wildlife health.

The following were identified as constituents of potential concern in North Arroyo for the human health assessment: ammonium, antimony, bromide, chloride, lead-210, manganese, molybdenum, nitrate, radium-226, radium-228, silica, sulfate, sulfide, thorium-230, uranium, and uranium-238. This same list of constituents of potential concern, plus cobalt and selenium, was developed for Gypsum Creek.

For the ecological assessment, the constituents of potential concern are aluminum, ammonium, antimony, barium, beryllium, boron, bromide, cadmium, chloride, chromium, cobalt, copper, cyanide, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, potassium, selenium, silica, silver, sodium, strontium, sulfate, sulfide, tin, uranium, vanadium, and zinc.

3.5.2 Potential risk to humans

A schematic diagram of potential human exposure pathways is shown on Figure 3.14. Three potential exposure pathways were identified for humans: 1) direct exposure by ingestion of seep water; 2) indirect exposure by eating meat from sheep and cattle watered with seep water; and 3) indirect exposure by drinking milk from dairy cattle watered with seep water. No sediment or soil data have been collected at the seeps. For the indirect exposure pathways it is assumed that the livestock drink contaminated seep water and eat plants, which may have accumulated the constituents through root uptake, growing in the vicinity of the seep. The screening-level risk assessment (Duncan et. al., 1994) assumed, as a worst-case scenario, that humans and livestock would access the contaminated seeps every day, 365 days per year, to obtain all of their drinking water (humans and livestock) and all of their food (livestock only). As described below, these assumptions are not reasonable and were revised based on information collection during recent site visits.

Direct, long-term exposure to seep water in either North Arroyo or Gypsum Creek through use as a drinking water source is considered highly unlikely for the following reasons: 1) the nearest residence to the seeps is located in Halchita, which is over 1 mi (1.6 km) away; and 2) all drinking water for the residents in the town is supplied by the municipal system. It is unreasonable to assume that someone would travel over a mile to obtain water from the seeps when potable water is available in their homes. For these reasons, drinking seep water was not considered a complete exposure pathway for humans and was not evaluated further.

Livestock sometimes graze in the vicinity of the site and have been observed in North Arroyo and Gypsum Creek in the past. However, during the June 1994 site visit, no livestock were seen. No recent signs (tracks, scat) were observed at any of the seeps with the exception of seep 922 in Gypsum Creek. Livestock accessing North Arroyo and Gypsum Creek could accumulate the constituents in their meat and milk by ingesting seep water and associated vegetation. Using these livestock for food would create an exposure pathway for humans. This exposure pathway was quantitatively evaluated in accordance with EPA risk assessment guidance (EPA, 1989a).

It should be noted that livestock would not be exposed to vegetation at the seeps on a daily basis due to the limited areal extent of the seeps. The sum total size of the contaminated seeps (including the vegetated areas) in North Arroyo and Gypsum Creek is conservatively estimated to be 2.5 acres (ac) (1 hectare [ha]) and 5 ac (2 ha), respectively. For the type of rangeland that exists in the vicinity of the site, it would require approximately 60 to 240 ac (25 to 100 ha) per year for a cow and 12 to 48 ac (5 to 20 ha) per year for a sheep to obtain adequate forage (Curtis, 1994; Carling, 1994; Hanson, 1994). It was assumed for the risk calculations that livestock would roam an area of approximately one square mi (2.6 square km) over the course of a year in search of forage. A value of 600 ac (200 ha) was used for the potential foraging area.

POTENTIAL HUMAN EXPOSURE PATHWAYS

FROM DUNCAN ET AL., 1994

FIGURE 3.14
HUMAN HEALTH CONCEPTUAL SITE MODEL
MEXICAN HAT, UTAH

This acreage represents the approximate area of the major drainages in the site vicinity (DOE, 1993d). Based on information collected during the November 1993 and June 1994 site visits, the predominant vegetation growing in the vicinity of the seeps (salt cedar) is not a suitable forage for livestock. It is estimated that the amount of forage suitable for livestock (grasses) is less than 0.5 ac (0.2 ha) and less than 1 ac (0.4 ha) at the contaminated seeps in North Arroyo and Gypsum Creek, respectively. Thus, livestock could not derive their entire diet from vegetation potentially contaminated by the seeps; they would require food from a variety of other sources.

In terms of water intake, the variable nature of the seeps precludes the possibility for year-round exposure. Also, for most of the seeps where ponding occurs, the amount of water is not sufficient to meet the daily water requirements of livestock. The proximity of the San Juan River, a perennial water body, represents an important source of water for livestock. For purposes of the risk evaluation, it was assumed that livestock would drink water and eat vegetation impacted by the contaminated seeps 1 day per week, 52 weeks per year. This is considered a reasonable assumption because more frequent grazing pressure might result in damage to the vegetation (e.g., defoliation, physical trauma).

Risk calculations for ingestion of meat from sheep and cattle and ingestion of milk from dairy cattle indicate that the risk levels associated with potential noncarcinogenic and carcinogenic effects are below acceptable guidelines established by the EPA. Thus, ingestion of meat and milk from livestock exposed to the constituents in the seep water is not expected to result in adverse health effects in humans. The risk calculations are presented in Appendix C, Tables C.1 through C.4.

3.5.3 Potential risk to livestock

Risks to livestock (sheep and cattle) that drink the contaminated seep water and eat plants that may have accumulated constituents in the seep water were evaluated. The site-specific exposure pathway information (e.g., area of contaminated seeps relative to potential foraging area; how often livestock might access the contaminated seeps), described in Section 3.5.2, was incorporated into the risk calculations.

The results of the risk calculations indicate that exposure to the water and vegetation potentially affected by the seeps would not result in adverse effects to sheep or cattle. The risk calculations are presented in Appendix C, Tables C.5 through C.10.

3.5.4 Potential risk to wildlife

Several potential exposure pathways to the constituents in the seep water exist for aquatic and terrestrial organisms (Figure 3.15). For aquatic organisms, direct ingestion and absorption of seep water and/or sediments is a potential exposure

POTENTIAL ECOLOGICAL EXPOSURE PATHWAYS

AQUATIC

SOURCE MEDIUM EXPOSURE PATHWAY RECEPTOR

TERRESTRIAL

SOURCE MEDIUM EXPOSURE PATHWAY RECEPTOR

FROM DUNCAN ET AL., 1994

FIGURE 3.15
POTENTIAL CONCEPTUAL SITE MODEL
MEXICAN HAT, UTAH

pathway. Algae and riparian plants could be exposed through root uptake and/or absorption of constituents in water and sediment. The aquatic foodweb is also another potential exposure pathway. Aquatic herbivores, such as macroinvertebrates, may eat plants, such as algae, that have bioconcentrated constituents. These herbivores then may be eaten by predators that may be eaten by still other predators. The net effect of bioaccumulation through the foodweb may be significant.

Potential exposure pathways for terrestrial wildlife are similar to those for aquatic organisms (Figure 3.15). Constituents may be ingested and/or absorbed if exposure to water, sediment, and soil occurs. Bioaccumulation in the terrestrial foodweb may be important, as for aquatic organisms.

All of the potential exposure pathways discussed above were evaluated, with the exception of exposure to sediment and soil. No sediment or soil data are available, thus only pathways associated with seep water were evaluated. However, the contribution of these media to potential risks would be less than risks from exposure to seep water for most animals because exposure (e.g., ingestion) to sediments and soil would be incidental.

Several species of aquatic organisms have been observed in the seep water pools, including macroinvertebrates, beetles, toad tadpoles, and algae. No fish have been observed, which is not surprising considering the variable nature of seep flow and the shallow water depth. The only suitable habitat for fish is near the confluence of Gypsum Creek and the San Juan River during periods when the river water backs up into Gypsum Creek.

Several key receptor species were chosen for use in evaluating potential risks to terrestrial wildlife. The species were chosen based on ecological importance and protected status and included coyote, desert bighorn, desert cottontail, spotted bat, and southwestern willow flycatcher. These species have been observed in the site vicinity or they could potentially occur in the site vicinity based on habitat characteristics.

It should be noted that a few terrestrial wildlife species (birds, lizards, and ground squirrels) were observed in the vicinity of the seeps during recent reconnaissance level surveys (November 1993; June 1994) of North Arroyo and Gypsum Creek. However, additional species would be expected to occur if more detailed surveys were conducted. Also, no overt (visual) evidence of adverse ecological effects were noted during these visits.

Based on the results of the screening-level risk assessment (Duncan et al., 1994), which used worst-case exposure pathway assumptions (e.g., wildlife obtain all their water from the contaminated seeps and their food contains contaminants from the seeps), the potential exists for adverse effects to aquatic and terrestrial receptors in both North Arroyo and Gypsum Creek. This preliminary risk assessment also screens out analytes that pose little or no ecological risk and identifies areas where additional information is required to

more accurately evaluate ecological risks. The seep water constituents that were determined to pose little or no ecological risk to aquatic organisms are antimony, arsenic, barium, and thallium; and for terrestrial organisms are aluminum, arsenic, bromide, cadmium, calcium, chromium, fluoride, iron, lead, nickel, phosphate, silver, thallium, vanadium, and zinc. The risk calculations are presented in Appendix C (Tables C.11 and C.12 for aquatic organisms and Tables C.13 through C.22 for terrestrial organisms).

An enhanced understanding of the specific impacts, if any, that the constituents of potential concern have on the wildlife in the vicinity of the seeps could be achieved by collecting additional information that focuses on the constituents and the species that are likely to be exposed. The types of ecological information that could be collected is described in detail in Section 5.0.

3.5.5 Limitations of the risk evaluation

Inherent in any risk evaluation are the uncertainties associated with the quantification and analysis of its components. There are several factors that may have resulted in overestimation or underestimation of the risks associated with the seeps at the Mexican Hat site. This section provides a brief discussion of the more important limitations associated with this risk evaluation, which include the following:

- The use of maximum detected concentrations as surrogate values of the actual watershed concentrations may have led to overestimation of the potential risk posed by some constituents. Maximum concentrations were used to maintain a high degree of conservatism.
- The risk evaluation assumed that the constituents were totally bioavailable to the organisms encountering them. Bioavailability, and therefore toxicity, is dependent upon the chemical properties of the environmental media (e.g., water, sediment) and the constituents.
- The most important limitation is the lack of sufficient toxicity data to calculate ecological risk from several constituents of potential concern. For aquatic organisms, these constituents of potential concern are ammonium, bromide, calcium, fluoride, magnesium, nitrate, phosphate, potassium, silica, sulfate, sulfide, and tin. For terrestrial birds these are ammonium, antimony, barium, beryllium, chloride, nitrate, potassium, silica, sodium, sulfate, and sulfide. For mammals, these are ammonium, bromide, chloride, cyanide, magnesium, sodium, and sulfide.

An in-depth discussion of the limitations and uncertainty factors is presented in the draft screening-level risk assessment (Duncan et al., 1994).

3.5.6 Summary of the risk evaluation

A summary of the risk evaluation, which includes the receptors, potential exposure pathways associated with contaminants in the seep water, and whether the risks for each exposure pathway are within EPA's acceptable risk guidelines, is presented in Table 3.4.

Table 3.4 Risk evaluation summary

Receptor	Potential exposure pathway	Is exposure pathway complete?	Are risks within EPA's acceptable guidelines?
Humans	Ingestion of seep water	No	NA
Humans	Ingestion of meat and/or milk from livestock	Yes	Yes
Livestock	Ingestion of seep water and vegetation	Yes	Yes
Aquatic organisms	Direct exposure to seep water (ingestion/dermal absorption)	Yes	No
Terrestrial organisms	Ingestion of seep water and ingestion of food (plants and/or animals)	Yes	No

3.6 CONCEPTUAL SITE MODEL

The communities of Mexican Hat and Halchita are within 3 mi (5 km) of the site and derive their water supplies from the San Juan River and a former oil exploration well. These water sources currently provide and are anticipated to provide the total water demand for the area. Contaminated water from the former uranium mill does not affect the community supplies and the ground water resource. Therefore, site-related risks to human health from ingestion of contaminated ground water do not exist.

All contaminated solid materials have been encapsulated into a disposal cell, isolating them from direct human and animal contact. Current exposure to site-related contaminants potentially exists through direct contact with residual process water discharging from seeps and/or through ingestion of vegetation or animals that may have accumulated some of the contaminants. Although these potential exposure pathways exist, livestock are not threatened because the nearby San Juan River provides an adequate supply of good quality water and the seeps are found in only a small portion of the total area used for grazing.

Water in the uppermost aquifer, the Halgaito Shale, is present primarily as a result of milling operations. The presence of water is primarily due to artificial conditions; the extent of saturation is limited; and the unit is returning to its

natural, mainly unsaturated state. Furthermore, ground water within the Halgaito Shale does not represent a ground water resource, and the ground water in the aquifer meets the criteria for limited use based on limited yield.

The aquifer below the Halgaito Shale is contained within the Honaker Trail Formation. Site contaminants have not affected, and will not affect, ground water in the Honaker Trail Formation due to the upward hydraulic gradient and the confining properties of the lower portion of the Halgaito Shale. These physical properties provide hydrogeologic isolation. In addition, the presence of naturally-occurring petroleum and high levels of hydrogen sulfide in the Honaker Trail Formation likely cause ground water within the unit to be unfit for consumption.

Contaminated water does not pose a risk to human health, is not anticipated to cause risks in the future, and will not affect current or beneficial uses of a deeper, isolated aquifer. The potential for risks to plants and wildlife has been identified. Therefore, additional investigation to confirm the presence or absence of those risks are proposed in Section 5.0 of this report.

3.7 ASSESSMENT OF PRELIMINARY DATA NEEDS

The hydrogeologic site conceptual model is supported by a large amount of regional and site-specific data. The data include hydrogeologic reports prepared by state and federal agencies, site-specific and regional water quality data, and on-site and surrounding area well completion reports and well hydraulic testing. Because the data base is so extensive and indicates little variability in the hydrogeologic conditions, additional data are not needed.

The results of the risk evaluation indicate that potential exposure to contaminants in seep water does not represent a hazard to humans or livestock. However, because potential risks to wildlife have been identified, additional information is required to better define impacts, if any, to the environment.

3.8 EVALUATION OF INTERIM REMEDIAL ACTION

Interim remedial action is not required for the protection of human health and livestock because the estimated risks for these receptors are within EPA's acceptable levels.

An evaluation of interim remedial action for the contaminated seeps may be required to protect wildlife resources. However, before such an evaluation is conducted, additional site-specific ecological information must be collected to confirm or contradict the preliminary results of the screening-level risk assessment (Duncan et al., 1994).

4.0 GROUND WATER COMPLIANCE STRATEGY SELECTION

This section defines the ground water compliance strategy options; identifies the proposed ground water compliance strategy for the Mexican Hat site; explains the application of site-specific data to the ground water compliance selection framework; and analyzes deviations, contingencies, and decision rules.

4.1 GROUND WATER COMPLIANCE STRATEGIES

Proposed ground water compliance decisions at the Mexican Hat processing site were made by using the compliance selection framework shown in Figure 4.1. This compliance selection framework was developed in the UMTRA Ground Water PEIS. The proposed ground water compliance strategy is selected by applying site-specific data to the compliance selection framework. The three compliance strategies specified in the compliance selection framework are:

- No remediation—Application of the no-remediation strategy would mean that compliance with the proposed standards would be met without altering the ground water or cleaning it up in any way. This could be applied at sites that have no contamination above maximum concentration limits or background levels or at sites that have contamination above maximum concentration limits or background levels but qualify for supplemental standards or alternate concentration limits as described in Section 2.1.1.
- Natural flushing—Natural flushing allows for the natural ground water movement and geochemical processes to decrease the constituent concentrations to levels within regulatory limits within a given time period. This could be applied at sites where ground water compliance would be achieved with the application of natural flushing within 100 years, where effective monitoring and institutional controls could be maintained, and where the ground water is not currently and is not projected to be a drinking water source.
- Active ground water remediation—Active ground water remediation would require the application of engineered ground water remediation methods such as gradient manipulation, ground water extraction and treatment, and *in situ* ground water treatment to achieve compliance with the proposed standards.

4.2 SITE-SPECIFIC GROUND WATER COMPLIANCE STRATEGY

The proposed ground water compliance strategy for the Mexican Hat UMTRA site is no remediation. This is based on the application for supplemental standards because of limited use ground water. The compliance strategy was selected through application of site conditions to the compliance selection framework. Following is a justification for the selection of the compliance strategy for the Mexican Hat site.

FIGURE 4.1
MEXICAN HAT COMPLIANCE SELECTION FRAMEWORK

Analysis of ground water quality has revealed that there is contamination present in the uppermost aquifer that either exceeds MCLs or background levels (box 2 in Figure 4.1). The presence of this contamination is a direct result of past uranium milling operations.

The contaminated ground water in the uppermost aquifer qualifies for supplemental standards because it is limited use ground water. The site conceptual model provides a description of the limited extent of saturation and the low yield of wells completed (box 4 in Figure 4.1). The contaminated ground water does not currently, nor is it projected to, provide a beneficial use. At this time, there are no known human health and environmental risks of applying supplemental standards (box 5, Figure 4.1). As discussed in Section 3.5.4, there is a potential for environmental risk that needs to be examined. For the purpose of this revision of the SOWP, it will be assumed that risks of applying supplemental standards are acceptable and the proposed compliance strategy for Mexican Hat will be no remediation (box 7, Figure 4.1).

4.3 DEVIATIONS, CONTINGENCIES, AND DECISION RULES

The appropriate proposed ground water compliance strategy is no remediation based on supplemental standards as discussed above. Strategy selection is based on contamination of the uppermost aquifer which is Class III, limited use based on limited yield, and continued protection of other aquifers through hydrogeologic isolation. Additionally, adverse effects to human health or livestock are not expected to occur from site-related contamination (i.e., the contaminated seeps in Gypsum Creek and North Arroyo).

The hydrogeologic portion of the site conceptual model is based on and supported by a large amount of regional and site-specific data. Therefore, significant deviations from the hydrogeologic model are not expected. Information used for the human health and livestock risk evaluation scenarios is reasonable, therefore significant deviations are not expected.

The only potential deviation is in the risk conceptual model. The risk conceptual model identifies the possibility of risk to plants and wildlife. The contingency, should the additional risk evaluation indicate that there is an unacceptable environmental risk, would be to recommend appropriate mitigation measures.

5.0 DATA COLLECTION AND ASSESSMENT

Additional data collection activities are not required to evaluate hydrologic conditions, but are required to better define potential impacts, if any, to the environment resulting from the contaminated seeps.

5.1 DATA COLLECTION OBJECTIVES

The objective of collecting exposure pathway information is to provide reasonable and realistic input parameters that can be used to estimate risks to the organisms likely exposed at the site. Some of the input parameters that are important in calculating ecological risks include: how often a particular animal visits the site, how much it eats and drinks on a daily basis, whether the majority of its life is spent in the vicinity of the seeps, or it is migratory and requires a large home range. Currently, the screening-level risk assessment uses worst-case assumptions to calculate risks to wildlife (i.e., all of the organisms spend their entire lives at the seeps and derive all or the majority of their food and water from the seeps). These assumptions must be confirmed and revised, if necessary, to reflect actual conditions at the site.

5.2 DATA COLLECTION ACTIVITIES

To meet the data collection objectives for evaluating potential risks to wildlife, additional activities are required. These activities might involve gathering species-specific exposure pathway information from: 1) the scientific literature; 2) local residents and wildlife experts, such as university professors; and 3) noninvasive observational methods, such as conducting a visual observation program to monitor usage of the seeps by wildlife. This type of information would provide a more focused and realistic evaluation of potential ecological risks.

6.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this document.

Name	Contribution
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R. Meyers	Author, engineering design
A. Miller	Author, hydrology and hydrogeology; primary authorship
C. Burt, A. Holm, J. Gibb, J. McBee, R. Saar	Peer review
D. Thalley, J. Jones	Technical editing
J. Martin, L. Keith	Text processing
T. Gagliano, J. Wimmer	Graphic design

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CODE OF FEDERAL REGULATIONS

- 10 CFR Part 1021, *Compliance with the National Environmental Policy Act*, U.S. Department of Energy, 1994.
- 40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, U.S. Environmental Protection Agency, 1994.

40 CFR Part 1500, *Purpose, Policy, and Mandate* (Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act), Council on Environmental Quality, 1994.

FEDERAL REGISTER

52 FR 36000, "Standards for Remedial Actions at Inactive Uranium Processing Sites; Proposed Rule," September 24, 1987.

UNITED STATES CODE

42 USC §4321, *National Environmental Policy Act*, January 1, 1970.

42 USC §7901, *et seq.*, *Uranium Mill Tailings Radiation Control Act*, November 8, 1978.

42 USC §7923, *et seq.*, *Comprehensive National Energy Policy Act*, October 24, 1992.

APPENDIX A

LITHOLOGIC LOG, WELL COMPLETION RECORDS, AND WELL CONSTRUCTION LOGS MEXICAN HAT UMTRA PROJECT SITE

WELL 905

SITE ID: HAT 01 LOCATION ID: 905-
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: Hollow Stem Auger
DRILLER: SHB
DATE STARTED: 12/10/94
DATE COMPLETED: 12/11/94
FIELD REP.: J. David Beets

DATE	TIME	DEPTH (ft.)

SITE CONDITION Noted to lag in the first 1.5' of dig area - comp

[illegible]

COMMENTS: Switched to cor. no. @ 3.5 ft. b/s.

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

Page 2 of 2

see p. 1

APPROX. SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: 4" x 5' core barrel (3.98) "

DRILLER: SHB (6' barrel w/b.t.)

DATE STARTED: 12/10/84

DATE COMPLETED: 12/11/84

FIELD REP.: J. David Bets, II

DATE	TIME	DEPTH (ft.)
------	------	-------------

SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES						WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS			
						SPACING					ORIENTATION				CONDITION		
						WIDE		CLOSE			HORIZ.					VERT.	
						1	2	3	4	5	H					50°	V
0																	
1	H	NA	NA	NA	NA					H →	→ NA						SEE SOIL BORINGS ON P01
2																	SANDS FINE
3																	COLOR FROM RED BROWN TO TAN
3.5	S			H ₂ O				X		H → V			1	WR 56			START CORING @ 3.5' WATER
4	NV							X			X						
5									X		X						coring rate 2 1/4"
6									X		X						bedrock fractures, thick w/ clay, cracks - 1 visible
7									X		X						fracture size ~ 1/8"
8	X							X				X					hardness = II (hard)
9	NV	100%	9/10					X	X			X					as above w/ numerous vert fractures; 2, 1-2"
9.0	GB										X	X					of high fractured sub-surface to slightly rounded pits - fine crystalline rock

COMMENTS: NOTE HOLE CAVED @ 2' AFTER DRILLING TO ROCK @ 5.5'
AFTER DRILLING CORE TO 9', HOLE CAVED TO 8.5'.

BORING OPERATION
 M - 8 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGR
 GB - GEAR BIT
 NX - NX ROCK CORING
 NO - NO WIRELINE ROCK CORING

JEG-AL-ENG-2A (3/84)

$$\frac{2'' \times 4''}{60''} = RQD \text{ (example)}$$

JE JACOBS ENGINEERING GROUP INC.
 ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

 SITE ID: HAT-01 LOCATION ID: 925 DATE INSTALLED: 12/11/84

 APPROX. SITE COORDINATES: (FT.) N 10006.344 E 9544.200

 OPEN AREA PER LINEAL FT. (IN²/FT.) 0.440

 FORMATION OF COMPLETION: SS

 FIELD REP.: J.P. Belsill DRILLER: SHK - Jim Carter

 COMMENTS: cored to 9' kls w/ 4" rock core. Switched to 3" u"
traverse bit (gear bit) & drilled to 12' kls (total depth)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT-01 LOCATION ID: 905 FIELD REP: J.D. Betts, II
APPROX. SITE COORDINATES (FT.): N 10006,344 E 9544,200
GROUND ELEVATION (FT. MSL): 4294.13 COMPLETION DATE: 12/11/84

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>SHB - Jim Carter</u> RIG TYPE: <u>CME-75</u>				ACTIVITY	START		END TIME
					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	12/10/84	1:45 pm	5 pm
					12/11/84	9 am	10:50 am
<u>2 1/2" Tri-cone</u>	<u>4</u>	<u>9</u>	<u>Water</u>	CASING	12/11/84	11:00	11:05
<u>3/4" Tri-cone</u>	<u>3 1/4</u>	<u>12</u>	<u>Water</u>		FILTER PACK	12/11/84	
				SEAL		12/11/84	
				BACKFILL	12/11/84		11:15
				DEVELOPMENT			
				OTHER	12/11/84		11:30
				<u>installed protective cap</u>			
* P-Protective B-Screen S-Blank O-Open N-None							
* Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION		END DEPTH (ft.)	COMMENTS: _____ _____ _____ _____			
<u>S</u>	<u>grout</u>		<u>2.25</u>				
<u>S</u>	<u>bentonite pellets</u>		<u>3.0</u>				
<u>B</u>	<u>silica sand</u>		<u>12</u>				
* B - Backfill S - Seal F - Filter Pack							
* Depth from Ground Surface							

WELL 906

Page 1 of 2

LOCATION MAP:

Hand-drawn location map showing a 'Tailings Pile' on the left, a 'Burn' area in the center, and a 'Wash' area on the right. The 'Wash' area contains two points labeled '907- deep' and '906 shallow'. A north arrow is in the top right corner.

SITE ID: HAT-01 LOCATION ID: 906-
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: HSA
DRILLER: SAB- Jim Gorter
DATE STARTED: 12/12/84
DATE COMPLETED: 12/12/84
FIELD REP.: J. David Lett

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION In wash E. of berm 3 miles N.E.
SITE CONDITION much wind blown debris on floor - no sign

[illegible]

COMMENTS: switched to tri-cone roller bit
@ 3.25' bls

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

See p. 1

SITE ID: HAT-01 LOCATION ID: 906

APPROX. SITE COORDINATES (ft.):

N _____ **E** _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: ~~Hand~~ / Tr-core 40' x 1"

DRILLER: SNB - Jim Carter

DATE STARTED: 12/12/84

DATE COMPLETED: 12/2/84

FIELD REP.: W. David E. Smith

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION see p. 1
SITE CONDITION _____

[illegible]

COMMENTS: _____

BOREING OPERATION
 M - 6 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGLR
 GD - GEAR BIT
 NX - NX ROCK CORING
 NO - NO WHIRLLINE ROCK CORING

WELL COMPLETION RECORD

SITE ID: HAT-01 LOCATION ID: 906 DATE INSTALLED: 12/12/84
APPROX. SITE COORDINATES: (FT.) N 10137.485 E 11703.097
OPEN AREA PER LINEAL FT. (IN²/FT.) 0.440
FORMATION OF COMPLETION: Sandstone
FIELD REP.: J. David Betzall DRILLER: SHB - Jim Corlier

COMMENTS: _____

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT-01 LOCATION ID: 906 FIELD REP: J. David B. et al
APPROX. SITE COORDINATES (FT.): N 10137.485 E 11703.097
GROUND ELEVATION (FT. MSL): 4220.83 COMPLETION DATE: 12/12/84

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>SHB - Jim Carter</u> RIG TYPE: <u>CME-75</u>				ACTIVITY	START		END TIME
					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	12/12/84	9 am	11:15 am
3 1/4" tri-cone	3 1/4"	11.9'	water				
6" auger	6"	3.25'	none				
CASING SUMMARY				CASING	12/12/84	11:15	
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)	FILTER PACK	12/12/84	11:15	
B	2" PVC	2	3.1	SEAL	12/12/84	11:15	
S	0.01" slot size PVC	2	8.1	BACKFILL	12/12/84	11:15	
B	PVC blank w/end cap	2	10.1	DEVELOPMENT			
				OTHER			
* P-Protective S-Screen B-Blank O-Open N-None							
* Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)	COMMENTS:				
B	grout	2					
S	bentonite pellets	3					
B	silica sand (size 20)	11.75					
* B - Backfill S - Seal F - Filter Pack							
* Depth from Ground Surface							

WELL 907

LOCATION MAP:

SITE ID: HAT - 01 LOCATION ID: 907 -
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: HSA
DRILLER: SAB - J. m Carter
DATE STARTED: 12/11/84
DATE COMPLETED: _____
FIELD REP.: J. David Betts III

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION In wash = 2' below surface

SITE CONDITION *Wet, wind, rain, no ice at night etc.*[illegible]

COMMENTS: _____

SAMPLE TYPE

- SAMPLE TYPE**
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (ROCK)

Page 2 of 10

LOCATION MAP:

See pg. 1

SITE ID: HAT-01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: SHR - Jim Carter
DATE STARTED: 12/11/94
DATE COMPLETED: _____
FIELD REP.: J. David Beigel

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION See pg. 1
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
113	100	25	0						X	X	X			WH	SS	Sandstone, dk. colored, dark reddish gray, 0.3' fractured @ 5-6.3'. Se		
	100	100	0						X							horiz. fractures throughout		
	100	100	0					X								horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0						X	X				WH	SS	horiz. fractures throughout		
	100	100	0															

COMMENTS:

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NO ROCK CORING
NQ - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 3 of 10

LOCATION MAP:

See pg. 1

SITE ID: HAT 01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: Jim Carter (SH13)
DATE STARTED: 12/11/84
DATE COMPLETED: _____
FIELD REP.: J. David Betts, II

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION See pg. 1
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
10	NR	100	80	90				X	Y		X				W-SS	looking more what is a core some are not		
11									X	X	Y					Not a core		
12									X	X	X					SS as in		
13									X	X	X							
14	NR	100	80	90				X	X	X	X				W-SS			
15	NR	100						X		X	X				W-SS	Dark red mudstone w/ red. ss in		
16		100	90					X		Y	Y					ss in		
17			50						X		X	Y						
18			80					Y	X		Y	X						
19			40						Y		Y				SS	Sandstone, v. fine, reddish bn w/ some red. nodules of cov. ss in. This grade is more uniform dark reddish bn ss w/ dr.		
20			100						Y		X							
21			50						X		Y					Hardness is IV to I becoming harder w/ depth		
22			100					X	Y		Y							
23			70					X	Y		X							
24			100					Y										
25	NR	100	0					X			Y				W-SS			

COMMENTS: switched to new NR core barrel @ 34.5'. This gives a core 1.80" in d.p.

BORING OPERATION
M - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 4 of 10

LOCATION MAP:

See pg. 1

SITE ID: HAT 01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: SHB - Jim Carter
DATE STARTED: 12/11/84
DATE COMPLETED: _____
FIELD REP.: J. David Betz, II

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION See pg. 1
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						CONDITION
						WIDE		CLOSE			HORIZ.		VERT.				
						1	2	3	4	5	H	50°	V				
35																	
36	NQ	100	70	20				X			X					Soilstone, dk. grayish to light gray, moderate hardness III-IV, reddish to brown.	
37			100					X			X						
38			70						X		X						
39			0						X		X						
40			100					X			X						
41			100						X		X						
42			40						X		X						
43			70						X		X						
44			100						X		X						
44	NQ	100	0	20				X	X	X	X					level of gray ls. @ 43.3'	
45	NQ	100	80	20				X	X	X	X					Soilstone, dk. reddish to brown, moderate hardness III-IV.	
46			80					X	X		X						
47			80					X	X		X						
48			100					X	X		X						
49			85					X	X		X						
50	NQ	100	100	20				X	X		X					also crystalline ls. @ 49.3'	

COMMENTS:

BOHRING OPERATION
H - 8 1/2 HOLLOW STEM ANGLER
C - 6 1/2 CONTINUOUS FLIGHT ANGLER
GB - GEAR BIT
NX - NX ROCK CORING
NO - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

Page 5 of 10

LOCATION MAP:

See p. 1

SITE ID: 4AT - D1 LOCATION ID: 007
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: SHB - Jim Carter
DATE STARTED: 12/11/84
DATE COMPLETED: _____
FIELD REP.: J. David Betsi

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION See p. 1
SITE CONDITION _____

50
51
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63
64
65

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES						CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS		
						SPACING					ORIENTATION						
						WIDE		CLOSE		HORIZ.						VERT.	
						1	2	3	4	5	H					50°	V
NS	100	100	20				X			X			Wm SS	Sandstone, v dark red to reddish br			
		100						X	X		X			hard (III) moderate weathered, no for			
		70						X	X	X	X						
		0	20					X	X	X	X						
NS	100	0	60					X	X	X	X		Wm SS				
NS	100	10						X	X	X	X		Wm SS	2 1/2' to 1' GREEN SHALE			
	100	0	20				X		X	X	X			FOREWALL			
		100	60					X	X	X	X						
		50	50						X	X	X						
		50	50						X	X	X						
		100	50				X			X	X		SE	HZ & SCLINOSID PRING FEATURES			
		100	50				X			X	X			3' to 4' high, 1' to 2' wide, 1' to 2' deep			
		100	50				X			X	X						
		100	50			X	X			X	X		LS	TRANSITION TO SILT-CLAYSTONE VERY HARD DKRE... 500			
V	V	100	50			X	X			X	X			TRANSITION TO 65			

COMMENTS: _____

BORING OPERATION
H - 5 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
MC - MC ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 6 of 10

LOCATION MAP:

SITE ID: WATD1 LOCATION ID: 75
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: _____
DATE STARTED: 12-1-84
DATE COMPLETED: _____
FIELD REP.: JLVP

See Pg 1

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

RAIL SNOW & STORM

SITE CONDITION

12-14-84 NOON STORM, CLOUDY

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION						
						WIDE ——— CLOSE					HORIZ. ——— VERT.						
						1	2	3	4	5	H	50°	V				
65	NQ	100	100	50			X				X			NS	LS	LIMESTONE DARK GRAY CLAY 1" - 1 1/2" DIA 2" - 5" DIA / 100' - 100'	
				50			X				X					HYPED II	
				60			X				X					UN. FCA 1" - 1 1/2" DIA	
				70			X				X					LIMESTONE	
							X				X	X				✓ LIME. LIME. 2'	
70	NQ	100	100	100					X		X			WS	LS	71-2	
				0			X	X	X		X					LIME. LIME. 2'	
				75					X		X					DIPPER LIME VERIFIED III	
				80					X		X					DUSKY RED MATERIAL 10A3/4	
				0					X		X						
75	NQ	100	100	80			X				X			WS	SS	COR. 500' 500' 100'	
				100			X							WS	SL	SAL. LIME 75% N.	
				100			X									SILTY TONS - LIMESTONE	
				100			X										
				100			X										
				100			X										
				100			X										
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				100			X										

COMMENTS:

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
MX - MX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See 121

SITE ID: 4401 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: NQ WIRELINE CORE
DRILLER: BSF
DATE STARTED: 12-11-84
DATE COMPLETED: _____
FIELD REP.: SILVA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION COLD - SNOWY

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
	NQ	100	100	60		1					X				W ₂	SL	SILTSTONE - LIMESTONE REDDISH BROWN - DARK RED VERY WEAK II	
						X					X						VERT. FRACTURE PER SILTSTONE UNIFORM	
						X					X							
	↓	↓	↓	↓		X					X						GREEN-BLUE NODULES	
	1.5	100	100	90		X					X				W ₂	SL	1.5' OFF TOP OF CLAY: 1.5' SILTSTONE REDDISH BROWN PORCELAIN VENTRAL TO HARD II	
						X					X							
						Y					X							
						X	X	X	X		X							
				↓		Y					X						BLUE GRAY SAND	
				70					X		X				W ₂	SL	VERT. FRACTURE SMALL FRACTURES ON INSIDE OF FRACTURE	
			↓	60					X		X							
			100	70					Y		X							
			0	70					X		X				W	CL	CLAY - MUDSTONE @ 94' GREEN VSE ATTS	
	↓	↓	0	70					X		X						SMALL GREEN NODULES	

COMMENTS:

BORING OPERATION
M - 6 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
R2 - R2 ROCK CORING
RQ - RQ WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 8 of 10

LOCATION MAP:

See Pg 1

SITE ID: HAT01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: BEAR-SUB
DATE STARTED: 12
DATE COMPLETED: _____
FIELD REP.: SILVE

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION TODAY DATE - 12-15-84 COLD & DRY

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES										WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION								CONDITION
						WIDE		CLOSE			HORIZ.		VERT.						
						1	2	3	4	5	H	50°	V						
	NQ	100	50	30					X		X			Sm	WH	Ct	CLAYSTONE-MUDSTONE FINE GRained, silty SOFT		
			50	30			X				X						SANDSTONE - LACINE FINE GRained, silty SANDSTONE - LACINE		
			80	20			X			X	X			Sm	WM	Ss	FRAGILE, EASILY WORN, LACINE HEAVY DISCONTINUITIES		
			100	30			X				X								
			100	30			X				X								
			100	70		X					X			Sm	WA	Ss	SANDSTONE - LACINE FINE GRained, silty SANDSTONE - LACINE		
			100	80		X					X						FRAGILE, EASILY WORN, LACINE HEAVY DISCONTINUITIES		
			100	80		X					X								
			100	80		X					X								
			100	80		X					X								
			100	80		X					X								
			100	80		X					X								
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			100	80		X					X								
			100	80		X					X								
			100	80	</														

COMMENTS:

BORING OPERATION
N - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NE - NE ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE P. 1

SITE ID: HAT 01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: BFARSHB
DATE STARTED: 12-11-84
DATE COMPLETED: 12-19-84
FIELD REP.: SILVA

ARTESIAN CONDITION ENCOUNTERED @ 122'

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
12-15-84	3:00 PM	56 PM @ 5'
12-15-84	4 PM	16 PM @ 6'
12-15-84	10 PM	16 PM @ 6'
12-16-84	10:15 AM	26 PM @ 1.5'

LOCATION DESCRIPTION _____
SITE CONDITION _____

110
12TH RUN
115
120
13TH RUN
125

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
	ND	100	100	80		X					X			Snd HW Ss	SANDSTONE HIGHLY WEATHERED & FRACTURED @ 110.5			
		100	50						X		X				BELONGING SL CLAYE @ 111 CONGLOMERATE III-III.S			
	90	100							X		X			Hd HW Ls				
	100	100							X		X				BLUE-GREY LIMESTONE			
	100	100							X		X			Hd MW Ss	SMALL FISSURE CRACKS			
															H2 BEDDED VERY HARD II			
															GRADUAL COLOR CHANGE TO LT RED BROWN / BLUE STRI			
															PREDOMINANTLY SANDSTONE w/ LIMESTONE UNIFORM			

COMMENTS: TD = 125', LOST CIRCULATION @ 122'
AFTER PULLING CORE BARELL HOLE BECAME ARTESIAN @ 56 PM
RAN CLEAR @ 16 PM. AFTER PULLING CORE STEEL ON 12-16-84
ARTESIAN @ 26 PM @ 10:15 AM

BORING OPERATION
M - 5 1/2 HOLLOW STEM ANGLER
C - 4 1/2 CONTINUOUS FLIGHT ANGLER
GB - GEAR BIT
MS - MS ROCK CORING
NO - NO WHIRLPOOL ROCK CORING

JEG-AL-ENG-2A (3/84) PACKER INSTALLED @ 110' w/ 3/4" PVL THRU PACKER

BOREHOLE LOG (ROCK)Page 2 of

LOCATION MAP:

 SITE ID: HATO1 LOCATION ID: 907-
 APPROX. SITE COORDINATES (ft.):
 N E
 GROUND ELEVATION (ft. MSL):
 DRILLING METHOD:
 DRILLER:
 DATE STARTED:
 DATE COMPLETED:
 FIELD REP.:

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
12-15-84	3:00	5 gal/min @ 8'
12-15-84	4	10 PM @ 6'
12-15-84	10 PM	19 PM @ 6'
12-16-84	10:15 AM	29 AM @ 1.5' - 5 gal/min

LOCATION DESCRIPTION

SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES										WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION								CONDITION
						WIDE		CLOSE			HORIZ.		VERT.						
						1	2	3	4	5	H	50°	V						
	NQ	100	100	80		X						X			S ₁₀₀	HN	SS	SANDSTONE III	
		100	50						X			Y			LS	HN		HIGHLY WEATHERED FRACTURED VERTICAL FRACTURES III	
		90	100						X			X			HL	HN	LS	BECOMING CLAYEY III	
		100	100						Y			Y						CONGLOMERATE III - III	
	Y	100	100	↓					X			Y			HL	MW	SS	LIMESTONE BLUE GREY SMALL FISSURE CRACKS H2 BEDDED, HARD II	
	NQ	100	100	80			Y					Y						GRADUAL CHANGE TO LT RED BROWN / BLUE STREAKS PREDOMINANTLY S&LS STREAKS UNIFORM	
		100				Y						Y							
		90				Y						Y							
		90				Y						X							
		90				Y						Y							
		90	↓	↓		Y						Y							
	100	100	100				X					Y						LIMESTONE NOBLE II	
	100	100	100			1' VOID						Y						...	
		0	0	10			X					Y			VERY IMM	WS	LS	LIMESTONE GREY HARD	
		100	100	10			X					X						ARTESIAN AFTER PULLING CABLE & WATER TABLE	
		100	100	10			Y					Y						ARTESIAN 5 gal/min FROM V6 @ 122.5 - 124	

 COMMENTS: ENCOUNTERED WATER BEARING ZONE @ 122'
LOST CIRCULATION DURING DRILLING - PUMPED AQUIFER FULL
THEN BECAME ARTESIAN @ 5 gal/min - RAN CLEAR TO 16 PM @ 5:00 PM

 BORING OPERATION
 H - 8 1/2 HOLLOW STEM ANGLER
 C - 4 1/2 CONTINUOUS FLIGHT ANGLER
 GB - GEAR BIT
 RX - RX ROCK CORING
 NQ - NO WIRELINE ROCK CORING

 JEG-AL-ENG-2A (3/84) WATER STABILIZED @ 6' HEAD 1 gal/min @ 5.00 PM
 AFTER PULLING LOG STEEL - ON 12-16-84 29 AM @ 1.5'

BOREHOLE LOG (ROCK)

Page 10 of 10

LOCATION MAP:

LOG OF 4 1/2" ROTARY REAM IN 3" CORE
HOLE START AT 7'-22" ON 12-11-84
FINISH 22'-37" ON 12-17-84 2:10

SITE ID: HAT01 LOCATION ID: 907
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: _____
DATE STARTED: 12-11-84 TODAY 12-17-84
DATE COMPLETED: _____
FIELD REP.: SILVA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
12-15-84	2:30 PM	32' M
12-17-84	5:30 PM	56' M
12-18-12-1	NOON	+1.5' @ 2:59 PM

ARTESIAN CONDITIONS FROM 12-15-84 2:30 PM

LOCATION DESCRIPTION IN ARROYO

SITE CONDITION BELOW PILE IN ARROYO COLD & SNOWY

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES										CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION								
						WIDE		CLOSE	HORIZ.		VERT.								
						1	2	3	4	5	H	50°	V						
																	EXISTING 3" ROCK CORE HOLE TO 125'		
7'	NW	NA	NA	100%													LOG FOR 4 1/2" ROTARY HOLE REAMING 12-11-84		
10'	4 3/4"	TRICONE	ONE	110													START REAM 12-11-84 OUTSIDE 12" C.I. LOGGING DEEPENING TO HOLE RATE 17 MIN/FOOT		
22'																			
37'	NW																		
	2 1/8"	TRICONE	ONE	110													REAMING TO 37' WITH 4 1/2"		
	NW																		
																	BACK IN WITH 2 1/8" TRICONE DOWN TO 82'		
83'																	BEFORE (LEVEL) BIT WAS PENETRATED		
93'				120%													83'		
97'																	93' - EASY		
107'																	97' - HARDER WITH 2 1/8"		
122'																	107' - 60 PSI - 11		
125'																	122' STEEL PIPE - 119' F.P.		

COMMENTS: HOLE REAMED TO 37' IN 4 3/4" TRICONE
THEN CLEANED WITH 2 1/8" TRICONE TO 119
THEN WASHED TO 120' WITH WATER

BORING OPERATION
H - 8 1/2 HOLLOW STEM ANGLE
C - 4 1/2 CONTINUOUS FLIGHT ANGLE
GB - GEAR BIT
R2 - R2 ROCK CORING
RQ - RQ WIRELINE ROCK CORING

WELL COMPLETION RECORD

SITE ID: HAT01 LOCATION ID: 907 LOG DATE 12-11-84
APPROX. SITE COORDINATES: (FT.) N 10154.136 E 11692.355
DATE INSTALLED: 12-17-84
OPEN AREA PER LINEAL FT. (IN²/FT.) 0.440
FORMATION OF COMPLETION: SAND STONE-LIMESTONE VOID SPACE
FIELD REP.: SILVA DRILLER: SHB- BEAR

COMMENTS: ARTESIAN WELL AT TIME OF DRILLING PACKER INSTALLED 1' BELOW
MOLE @ 110' WITH 3/4" PVC FOR SAMPLING

SEC/556-1284-04/60

9.19.2.2.3

JACOB ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT 01 LOCATION ID: 907 FIELD REP: J. David Beasley
APPROX. SITE COORDINATES (FT.): N 10154.136 E 11692.355 SIVA
GROUND ELEVATION (FT. MSL): 4220.51 COMPLETION DATE: _____

BOREHOLE SUMMARY

DRILLER: SHB - Jim Carter/BEAR
RIG TYPE: CME-75

BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE
HSA	6	2	None
Caser B.t	4.5	5	Water
NO CORE	2.980		Water

CASING SUMMARY

CASING TYPE	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)
P	PROTECTIVE CASING	6"	3
B	SHUT OFF VALVE	3/4"	2
B	3/4" BLANK RISER	3/4"	110
B	PACKER BLANK	2 1/2"	110-110

* P-Protective * Screen * Blank * Open * None
* Depth from Top of Casing

WELL CONSTRUCTION

TYPE CODE	DESCRIPTION	END DEPTH (ft.)
S	CERAMIC GROUT SEAL	107
S	NEOPRENE PACKER	110
F	NO FILTER - 3/4" PREEXTENDS TO	110

* * Backfill * * Seal * * Filter Pack *
* Depth from Ground Surface

CONSTRUCTION TIME LOG

ACTIVITY

START	END
DATE	TIME

DRILLING

SEAL

BACKFILL

DEVELOPMENT

OTHER

FILTER PACK

CASING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

REMAINING

WELL DEVELOPMENT

ARTESIAN WELL - CEMENTED -
PRESSURE 60 PSI @ 110-107 ft. 3/4" RISER
PIPE AND VALVE @ GROUND SURFACE
HOLE IS GROUTED ABOVE PACKER TO
GROUND SURFACE

COMMENTS: ARTESIAN & CEMENTED

0.25 gal/min on 12-18-84

STEEL TURNED BLUE AFTER REMOVAL
IT FROM HOLE POSSIBLE COPPER SULFATES

JEG-AL-ENG-1 (8/84)

WELL 908

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

Page 1 of

LOCATION MAP:

SITE ID: HAT01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N 10000 E 9580
GROUND ELEVATION (ft. MSL): 24290
DRILLING METHOD: NQ WIRELINE
DRILLER: T CARTER
DATE STARTED: 1-8-85
DATE COMPLETED:
FIELD REP.: SILVA / MCGNRY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION NORTH OF TAILINGS AREA NEXT TO 905
SITE CONDITION IN ARROYO N.W. SIDE OF SITE

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION						
						WIDE		CLOSE	HORIZ.		VERT.						
						1	2	3	4	5	H	50°	V				
	HAB	NA	NA	DRY	-			P			P					STANDPIPE INSTALLED ON 1-2-B5 & GROUTED TAILINGS ENCOUNTERED 6' - 1'	
																OPEN HOLE THRU GROUT USING 3 1/8" GEAR BIT	
																SANDY-CLAYEY RED-DUSKY RED BROWN ALLUVIUM M	

COMMENTS:

BORING OPERATION
M - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
RX - RX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

SEE PAGE ONE

SITE ID: HATO1 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLER: CARTER ADAMS LME 75
DATE STARTED: 1-8-85
DATE COMPLETED: _____
FIELD REP.: SILVA / MEENORY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

15' 10"
2ND RUN
20'
23' 10"
23'
2ND RUN
30'
33' 10"

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						CONDITION
						WIDE		CLOSE			HORIZ.		VERT.				
						1	2	3	4	5	H	50°	V				
	NQ	100	0	100		x					x			SLT	RS	15' LAYER SOFT LAYER GRAVELLY	
		100	0			x									CL		
		100	0			x											
		100	85			x								WS	St	SILTSTONE	
		100	50			x								WS	St	GREY-RED BROWN INTERMIXED SILTSTONE WITH LIMESTONE ENCLAVES VERTICAL FRACTURES	
		100	100						x								
		100	70						x								
		100	80						x							PREDOMINANTLY CLASS III SILTSTONE RED BROWN	
	NQ	100	60	60		x											
		100	50			x								SLT	RS	24' 10" CLAY WITH ENCLAVES L3	
			0												LL	GREY & PURPLE CLAY	
			60											WS	L3	LIMESTONE LAYER	
			0												St	SILTSTONE DARK RED	
			0												St	PORE SPACES VERTICAL FRACTURES WEATHERING BLACK-BITS	
		30													St		

COMMENTS:

0
50

BORING OPERATION
H - 6 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
CR - CR ROCK CORING
NQ - NO WIRELINE ROCK CORING

Page 4 of

A
N
L

See page one

SITE ID: HAT 01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): ~ 4290
DRILLING METHOD: NO WIRELINE
DRILLER: CARTER/ADAMS
DATE STARTED: 1/8/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

DATE	TIME	DEPTH (ft.)
------	------	-------------

SITE CONDITION

[illegible]**COMMENTS:**

BONGING OPERATION
 M - 6 1/2 HOLLOW STEM ANGER
 C - 4 1/2 CONTINUOUS FLIGHT ANGER
 GS - GEAR BIT
 NX - NX ROCK CORING
 NO - NO WIRLLINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See pg. one

SITE ID: HAT 01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): ~4290
DRILLING METHOD: NO WIRELINE
DRILLER: _____
DATE STARTED: 1/8/85 TODAY'S DATE 1/9/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]**COMMENTS:**

BORING OPERATION
 M - 6 1/2 HOLLOW STEM ANGER
 C - 6 1/2 CONTINUOUS FLIGHT ANGER
 GS - GEAR BIT
 NZ - NZ ROCK CORING
 NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 6 of 6

LOCATION MAP:

see pg. one

SITE ID: HAT 01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): ~4290
DRILLING METHOD: NQ WIRELINE
DRILLER: CARTER/ADAMS
DATE STARTED: 1/8/85 TODAY: 1/9/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
65	NQ	100	100	60		X					X			Smc	WLS	St	Continuation of light reddish brown siltstone, fracturing begins at 67', becomes heavy 68'-71' both vert. + horiz. Uxing frags. Hardness Class III.	
68			30			X					X							
			0								X	X	—————	X				
			0								X	X	—————	X				
70			0								X	X	—————	X				
			100			X						Y						
73			100															
73'10"	NQ	100	100	60		X					X					SE	Thin bed of grey L. i. at 73'8"-73'10"	
			80				X					X					Continuation of light reddish brown siltstone some characteristics as the 7th core run.	
			100			X					X							
			100			X					X							
			100			X					X							

COMMENTS: _____

BORING OPERATION
M - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
RX - RX ROCK CORING
NQ - NQ WIRELINE ROCK CORING

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ANN

APPROX. SITE COORDINATES (ft.):

N _____ **M** _____

GROUND ELEVATION (ft. MSL): ~4290

DRILLING METHOD: NO WIRELINE

DRILLER: CARTER / ADAMS

DATE STARTED: 1/8/85 TODAY: 1/9/85

DATE COMPLETED: _____

FIELD REP.: M'ENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
------	------	-------------

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS: color of St when dry is light reddish brown, when wet is dusky red
color of ~~St~~ ^{L.S.} is olive when wet, grey when dry

BORING OPERATION
 M - 6 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGR
 GS - GEAR BIT
 RX - RX ROCK CORING
 NO - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

see pg one

SITE ID: HAT01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): 4290
DRILLING METHOD: NQ WIRELINE
DRILLER: CARTER/ADAMS
DATE STARTED: 1/18/85 TODAY 1/18/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
90	NQ	95	100	60		X					X			Snd	WS	St	continuation of light reddish brown siltstone, small amount of fracturing, hardness class III, slightly weathered in fractures, very homogenous unit, from 93'10"-103'10". Some inclusions of olive ^{LS} the size of rocksalt, from 97'-100' olive ^{LS} interbedded, rock integrity poor (crumbly) at ^{LS} interface btwn. St & St	
			100			X					X							
			60				X				X							
93'10"			60				X				X							
95	NQ	95	100	75		X					X			Snd	WS	St _{LS}		
			80															
			100															
			50								X							
			50								X							
100			50															
			100															
103'10"																		
105																		

COMMENTS: color of St when dry: lt. red. brn., when wet: dusky red
color of ~~st~~ when dry: grey, when wet: olive

BORING OPERATION
N - 5 1/2" HOLLOW STEM ANGER
C - 6 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SITE ID: HAT01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): ~4290
DRILLING METHOD: NO WIRELINE
DRILLER: CARTER ADAMS
DATE STARTED: 1/8/85 TODAY 1/9/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

BOREHOLE LOG (ROCK)

Page ¹⁰ of

LOCATION MAP:

AN

SITE ID: HAT01 LOCATION ID: 908

APPROX. SITE COORDINATES (ft.):

N 10000 E 9580

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLER: J.C. SHB TON 14-1-10.9

DATE STARTED: 1/8/05

DATE STARTED: 11/1/51
DATE COMPLETED: _____

DATE COMPLETED: _____
FIELD REP.: SILVA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

[COMMENTS:

BORING OPERATION
 M - 6 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGR
 GD - GEAR BIT
 BK - BK ROCK CORING
 NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE Pg 1

SITE ID: HATOI LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N 10,000 E 9580
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: NB
DRILLER: JL SHB
DATE STARTED: 1-8-85 1-10-85
DATE COMPLETED: _____
FIELD REP.: SLA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]**COMMENTS:**

BORING OPERATION
M - 6 1/2 HOLLOW STEM ANGR
C - 4 1/2 CONTINUOUS FLIGHT ANGR
GS - GEAR BIT
NX - NX ROCK CORING
NO - NO WILLING ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SITE ID: HATO1 LOCATION ID: _____

APPROX. SITE COORDINATES (ft.):

N 10,000 E 9580

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: ND

DRILLER: S4B

DATE STARTED: 1-2-85

DATE COMPLETED: _____

FIELD REP.: SILVA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS:

- BOHNING OPERATION
M - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
CB - GEAR BIT
RX - RX ROCK CORING
NQ - NQ WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See Pa 1

SITE ID: HAT01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N 10000 E 9580
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: NQ
DRILLER: J.C. SHB
DATE STARTED: 1-7-85 1-10-85
DATE COMPLETED: _____
FIELD REP.: SILVA

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS		
						SPACING					ORIENTATION					CONDITION	
						WIDE —		CLOSE	HORIZ. —		VERT.						
						1	2	3	4	5	H	50°					V
160	1VQ	100	100	80		X					X			Smo	SW	Ls	SILTSTONE MASSIVE USUALLY BEDDED DUSK RED
																SE	
170																	

COMMENTS: _____

BORING OPERATION
M - 5 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
ND - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See page one

SITE ID: HAT01 LOCATION ID: 908
APPROX. SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL): ~4290
DRILLING METHOD: NO WIRELINE
DRILLER: CARTER/ADAMS
DATE STARTED: 1/8/85 TODAY 1/11/85
DATE COMPLETED:
FIELD REP.: M CENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION							
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
NQ	180	80	100			X					X				WS	St	clayey red siltstone, massive, w/ bands + lenses of ls: 17'11" - 18'1" 18'1" - 18'2'7" dark grey ls, massive, tightly cemented, hard, no	
		50				X					X				WS	LS	18'1" - 18'2'7" dark grey ls, massive, tightly cemented, hard, no	
		0								X	X		X		WM	Ss	18'2'7" - 18'3'6" moist grey ss, friable, some small pebbles (fine grained) yellow deposits in fractures, chem. odor, like battery acid, porous texture, 1/2 size med. sand, frac. essil. water encountered	
		0								X	X		X		WM	Ss	18'3'6" - 18'4'1" moist grey ss, friable, some small pebbles (fine grained) yellow deposits in fractures, chem. odor, like battery acid, porous texture, 1/2 size med. sand, frac. essil. water encountered	
NQ	100	0	100							X	X		X		WM	Ss/LS	18'4'1" - 18'5'1" moist grey ss, friable, some small pebbles (fine grained) yellow deposits in fractures, chem. odor, like battery acid, porous texture, 1/2 size med. sand, frac. essil. water encountered	
		0								X	X				WS	LS	18'5'1" - 18'6'1" moist grey ls, closely spaced frac. pitted surface (pea size) 18'6'1" - 18'7'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		90						X			X					LS	18'7'1" - 18'8'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		90					X				X						18'8'1" - 18'9'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		90				X					X						18'9'1" - 18'10'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		0						X			X						18'10'1" - 18'11'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		100				X											18'11'1" - 18'12'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		100					X										18'12'1" - 18'13'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		50					X				X						18'13'1" - 18'14'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		100				X					X						18'14'1" - 18'15'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	
		100				X					X						18'15'1" - 18'16'1" lime green deposits on frac surface + pits + pores, strong chemical odor, hardness class II from 18'6'1" - 18'7'1"	

COMMENTS:

BORING OPERATION
M - 8 1/2" HOLLOW STEM ANGLE
C - 4 1/2" CONTINUOUS FLIGHT ANGLE
GS - GEAR BIT
NR - NR ROCK CORING
ND - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SITE ID: HAT 01 LOCATION ID: 908
 APPROX. SITE COORDINATES (ft.):
 N _____ E _____
 GROUND ELEVATION (ft. MSL): 4290
 DRILLING METHOD: NQ WIRELINE
 DRILLER: CARTER/ADAMS
 DATE STARTED: 1/8/85 TODAY 1/11/85
 DATE COMPLETED: _____
 FIELD REP.: M'ENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
------	------	-------------

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

WELL COMPLETION RECORD

SITE ID: LOCATION ID: 908 DATE INSTALLED: 3/28/85

APPROX. SITE COORDINATES: (FT.) N E

OPEN AREA PER LINEAL FT. (IN²/FT.)

FORMATION OF COMPLETION:

FIELD REP.: Roger E. Holland DRILLER: SHD13

COMMENTS: Screen From 145-160'

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT-01 LOCATION ID: 908 FIELD REP: R. Holland
APPROX. SITE COORDINATES (FT.): N _____ E _____
GROUND ELEVATION (FT. MSL): _____ COMPLETION DATE: 3/28/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>SH&B</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>CME mahew 1000</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	3/27/85		3/28/85 10:20 AM
				CASING	3/28/85	10:10 AM	10:30 AM
				FILTER PACK	3/28/85	10:30 AM	11:00 AM
				SEAL	3/28/85	11:02 AM	11:05 AM
				BACKFILL	3/28/85	3:50 PM	4:30 PM
				DEVELOPMENT	4/1/85	3:05 PM	4:05 PM
				OTHER			

CASING SUMMARY			
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)
B	PVC	2"	160
S	PVC .010	2"	141.5
B	PVC	2"	+6"

* P-Protective S-Screen B-Blank O-Open N-None
* Depth from Top of Casing

WELL CONSTRUCTION			WELL DEVELOPMENT	
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)		
F	6/160 Sand	141		
S	Bentonite pellets	139		
B	Cement Grout	Surface		

* B - Backfill S - Seal F - Filter Pack
* Depth from Ground Surface

COMMENTS: water clear
30 psi

WELL 909

BOREHOLE LOG (ROCK)

Page 1 of 1

SITE ID: HATO1 LOCATION ID: 909
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: NO WIRELINE
DRILLER: W. JEVERNICK / WILLIAMS MOBILE R.O.
DATE STARTED: 1-8-85
DATE COMPLETED: _____
FIELD REP.: SILVA

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION BETWEEN SCHOOL & ROAD - WEST SIDE OF SITE ACROSS ROAD
SITE CONDITION BELOW BLUFFS IN DRAINAGE ABOVE PONDS
COLD WTR. & GROUNDWATER 1-8-85

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION						
						WIDE		CLOSE			HORIZ.		VERT.				
						1	2	3	4	5	H	50°	V				
0	4	NT	NT	DAY										FS	SM	HOLLOW TO 3'	
	↓													HW	St	SANDSTONE LITHOLOGY START LOC 10.5'	
3	NQ			H ₂ O										HW		SILTSTONE/W GRAY LIMESTONE NODULES III FRIED HIGHLY FRACTURED	
5		30		95													
		60	0							X							
		40	0							X						NO APPARENT FILLING OF FRACTURES	
		40	0							X							
	↓	60	0	↓						X			STUCK	HW		CLAYSTONE - COARSE GRAIN FULL TO WASHING OUT PLUS 8' OF FRACTURE FRACING GREY LIMESTONE LAYER 8.10-10.5	
10	NQ	90	50	30						Y			6/16		Ls		
	NQ	100	100	50						X				MW	SE	WATER LOSS TO FRACTURE SILTSTONE AS ABOVE	
			100														
			95														
			100														
15	↓		70	↓													

COMMENTS: SWITCHED TO REVERT @ 20.5 NEXT PAGE

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

SEE Pg 1

SITE ID: HAT 01 LOCATION ID: 7-9C

APPROX. SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLER: BGR B-60

DATE STARTED: 1-8-85 TOTAL 1.07

DATE COMPLETED: _____

FIELD REP.: _____

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						
						WIDE		CLOSE			HORIZ.						VERT.
						1	2	3	4	5	H	50°					V
15	NR	100		50		X					X			NR	St	SILTSTONE DUSKY MASSIVE BEDDING NO APPARENT BEDDING HARD III-II	
		100		65													
		100															
		100															
		100									X						
		0									X						
20	70.5	0		REVERT							X			SOFT NOD	CL	SOFT CLAYSTONE GREY/CLAYSTONE & FINE SWITCHED TO REVERT	
	NO	100	100	90							X				LS	SILTSTONE - LS MIX BAI	
		90	20								X				LS	CLAYSTONE MEDIUM SOFT - CLAYSTONE FINE LS NOT MIXED BED	
		100	100					X			X				LS	SOFT CORE MASSIVE	
24.5	24.5	100	100			X								GREY HARD	St	24' LIMESTONE LAYER 1 TRANSITION UP FROM SL. TO LITHOLOGY SILTSTONE	
25	NR	100	100	80	1	X								SL. GRITTY	St	SILTSTONE VERY FINE 12 MIN/FOOT IN HARD	
															St	SMALLER CRYSTALS PREDOMINANTLY SILTSTONE LS BEDDING INTERMIXED WITH SILTSTONE III-II	

COMMENTS:

BOREHOLE OPERATION
 M - 6 1/2 HOLLOW STEM ANGER
 C - 4 1/2 CONTINUOUS FLIGHT ANGER
 GB - GEAR BIT
 NR - NR ROCK CORING
 NO - NO WHIRLLINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 3 of

LOCATION MAP:

SEE P. 1

SITE ID: HAT01 LOCATION ID: 900909
APPROX. SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
DRILLING METHOD:
DRILLER:
DATE STARTED: 1-8-85 1-9-85
DATE COMPLETED:
FIELD REP.:

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION
SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
	NQ	100	100	RECOVER 100		X					X			HARD	F	St	PREDOMINANTLY SILTSTONE WITH LIMESTONE BLUE GR. LAYERS VERY HARD	
																S		
																St		
35.5			0						X								HZ FRACTURES 35.5	
36.5											X							
											X							
											X							
											X							
40.5			0															
			100	50					X	X							SILT STONE DUNE RED	
				60							Y						HZ FRACTURES	
				70					X								VERTICAL FRACTURES	
45.5				90							X						PLUGGED OFF @ 45.5' PULP CYL	

COMMENTS:

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NQ - NX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page

LOCATION MAP:

A
N
W

SITE ID: HAT 01 LOCATION ID: 4012
APPROX. SITE COORDINATES (ft.): _____

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: NQ WIRELINE

DRILLER: JEVERNAGER WILLIAMS

DATE STARTED: 1/8/85 TODAY 1/10/85

DATE COMPLETED: _____

FIELD REP.: MENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (
------	------	---------

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS: note: st when when is dusky red, when dry
is light reddish brown

BORING OPERATION
 M - 8 1/2 HOLLOW STEM ANGER
 C - 4 1/2 CONTINUOUS FLIGHT ANGLR
 GB - GEAR BIT
 NR - NR ROCK CORING
 ND - ND WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 5 of 5

LOCATION MAP:

see pg. one

SITE ID: HAT 01 LOCATION ID: 909
APPROX. SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: NQ WIRELINE
DRILLER: JEVERNAGER WILLIAMS
DATE STARTED: 4/8/85 TODAY 1/10/85
DATE COMPLETED: _____
FIELD REP.: MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE — CLOSE					HORIZ. — VERT.							
						1	2	3	4	5	H	50°	V					
50	NO	100	100	90		X					X			WS	St	dusky red siltstone (color when wet) w/ very thin beds of ls. (dive) btwn 60.5-61' and 63'4"-63'6" and 64'6" and 64'8". Fracturing occurs primarily from 66'-68' in conjunction with surface pits (pits on both the fractured surfaces and the core surface, both fractures are Class II hard dense consistent + uniform with pits: lithology		
60.5			100															
61			100															
63.4			100															
63.6			100															
64.6			50															
64.8			50					X				X						
66			50					X				X						
68			50				X											
70			100				X											
70.5			100			X												
71			100			X												
71.5			100			X												
72			100			X												
72.5			100			X												
73			100			X												
73.5			100			X												
74			100			X												
74.5			100			X												
75			100			X												
75.5			100			X												
76			100			X												
76.5			100			X												
77			100			X												
77.5			100			X												
78			100			X												
78.5			100			X												
79			100			X												
79.5			100			X												
80			100			X												
80.5			100			X												
81			100			X												
81.5			100			X												
82			100			X												
82.5			100			X												
83			100			X												
83.5			100			X												
84			100			X												
84.5			100			X												
85			100			X												
85.5			100			X												
86			100			X												
86.5			100			X												
87			100			X												
87.5			100			X												
88			100			X												
88.5			100			X												
89			100			X												
89.5			100			X												
90			100			X												
90.5			100			X												
91			100			X												
91.5			100			X												
92			100			X												
92.5			100			X												
93			100			X												
93.5			100			X												
94			100			X												
94.5			100			X												
95			100			X												
95.5			100			X												
96			100			X												
96.5			100			X												
97			100			X												
97.5			100			X												
98			100			X												
98.5			100			X												
99			100			X												
99.5			100			X												
100			100			X												

COMMENTS: _____

BORING OPERATION
H - 5 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
N1 - N2 ROCK CORING
NQ - NQ WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 6 of

LOCATION MAP:

See page one

SITE ID: HAT 01 LOCATION ID: 909

APPROX. SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: NO WIRELINE

DRILLER: JEVERNAGER / WILLIAMS

DATE STARTED: 1/8/85 TODAY 1/10/85

DATE COMPLETED: _____

FIELD REP.: M. CENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						CONDITION
						WIDE		CLOSE			HORIZ.		VERT.				
						1	2	3	4	5	H	50°	V				
NG	100	0	90						X	X			X	Rough	US	Cg	dusty red (wet) siltstone, olive/grey
										X			X			Cg	l.s., clay clayey conglomerate
										X			X			st	poorly cemented
										X			X			Cg	dusty red siltstone, thin bands of l.s., surface
										X			X			Cg	extremely pitted grade no
													X			Cg	into l.s./siltstone consists
																	grade at 78' 6" extremely
																	fractured into sharp angular fragments

COMMENTS:

● ONING OPLHATION

H - 0 1/2 HOLLOW STEM ANGLE

C - 4 1/2 CONTINUOUS FLIGHT ANGLE

GD - GLAR BIT

93 - MI ROCK CORING

NO - NO WHIRLING ROCK CORING

WELL COMPLETION RECORD

ITE ID: HAT-01 LOCATION ID: 909 DATE INSTALLED: 3/29/85

APROX. SITE COORDINATES:(FT.) N _____ E _____

OPEN AREA PER LINEAL FT. (IN²/FT.) 37.7 in²

FORMATION OF COMPLETION: _____

ELD REP.: R. Holland DRILLER: SH+B

COMMENTS: 2 fl of bentonite pellets sent on 6-11-50 152-150

G-AL-ENG-3 (3/84)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT-01 LOCATION ID: 909 FIELD REP: Roger Holland
APPROX. SITE COORDINATES (FT.): N _____ E _____
GROUND ELEVATION (FT. MSL): _____ COMPLETION DATE: 3/29/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>CH & B</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>Maheu 1000</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	<u>3/27/85</u>		<u>2:00 pm</u> <u>3:20/85</u>
				CASING	<u>3/29/85</u>	<u>2:15 pm</u>	<u>3:35 pm</u>
				FILTER PACK	<u>3/29/85</u>	<u>3:40 pm</u>	<u>4:15 pm</u>
				SEAL	<u>3/27/85</u>	<u>4:15 pm</u>	<u>4:20 pm</u>
				BACKFILL	<u>3/27/85</u>	<u>4:25 pm</u>	
				DEVELOPMENT	<u>4/1/85</u>	<u>6:05 pm</u>	<u>6:35 pm</u>
				OTHER			

CASING SUMMARY			
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)
<u>B</u>	<u>PVC</u>	<u>2"</u>	<u>150</u>
<u>S</u>	<u>PVC .010</u>	<u>2"</u>	<u>130</u>
<u>B</u>	<u>PVC</u>	<u>2"</u>	<u>surface</u>

* P-Protective S-Screen B-Blank O-Open N-None
‡ Depth from Top of Casing

WELL CONSTRUCTION			WELL DEVELOPMENT	
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)		
<u>S</u>	<u>expanding pellets</u>	<u>153.0</u>		
<u>F</u>	<u>silica sand</u>	<u>156.0</u>		
<u>S</u>	<u>benlate pellets</u>	<u>120.0</u>		
<u>B</u>	<u>cement grout 4 1/2 inch dia</u>	<u>117.0</u>		

* B - Backfill S - Seal F - Filter Pack
● Depth from Ground Surface

COMMENTS: water clear - hole
brown marine filter sand
lost 5 min of develop.
30 psi

WELL 910

LOCATION MAP:

SITE ID: HAT 01 LOCATION ID: 910-
 APPROX. SITE COORDINATES (ft.):
 N 8,400 E 10,400
 GROUND ELEVATION (ft. MSL): 4300
 DRILLING METHOD: NQ WIRE LINE
 DRILLER: S.H.B. / CARTER & ROHNS
 DATE STARTED: 1-17-85
 DATE COMPLETED: _____
 FIELD REP.: R. Trivino / C. McEnery

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
N/A	N/A	N/A

LOCATION DESCRIPTION Approx 30' SW of SP-84-104
SITE CONDITION Flat ground, too 2% slope.

[illegible]

COMMENTS: Stopped paper at refusal in
bedrock at 4'-3"

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (ROCK)

Page 1 of

LOCATION MAP:

SITE ID: WAT01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NO WIRELINE
DRILLER: SH+B CARTER/ADAMS
DATE STARTED: 1/17/85
DATE COMPLETED:
FIELD REP.: TREVINO/MCENERY

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION
SITE CONDITION

SEE page 1 of 1
BOREHOLE LOG (SOIL)

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION							
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
																	See page 1 of 1 soil borehole log form	
			NO: 100 30	100			X				X				SMO	F	St	dusty red siltstone, fractures w/ very fine whitesand, hardness III, mineralization occurring in fractures
			0				X											
			85				X								WS			
			100				X								F			
			80				X											
			85				X								WS			
			50					X			X				F			
			100				X				X							
			100				X										St	
			75				X				X						St	
											X							
														</				

COMMENTS:

BOHING OPERATION
H - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
RX - RX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

See page one

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NO WIRE LINE
DRILLER: SHAB, CRATER / ADAMS
DATE STARTED: 1-17-85
DATE COMPLETED: _____
FIELD REP.: TREVINO / MCE Energy

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION: Approx 30' SW of SP-84-104
SITE CONDITION: Flat ground too 2% slope

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES								WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						CONDITION
						WIDE		CLOSE			HORIZ.		VERT.				
						1	2	3	4	5	H	50°	V				
	NG	100	100	100		X					X			Sd	Ws	St	dusky red siltstone, hardness class III, in filling of fractures with white very fine grained sand, fracturing increases at 20'-21' filled fine grained with sandy clay
						X					X						
						X					X						
						X					X						
						X					X						
			80			X					X			Snd			
			100			X					X			Snd			
			100			X					X			Rh			
			30						X		X			Snd			
			40					X			X						
			100			X					X				Ws	St	trace inclusions of grey ls. rock, slight decrease of in filling of fractures w/ white sand.
						X					X						
						X					X						
						X					X						
						X					X						

COMMENTS: _____

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 3 of

LOCATION MAP:

See Pg. one

SITE ID: HAT01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NO WIRELINE
DRILLER: SH + B / CARTER / ADAMS
DATE STARTED: 1/17/85
DATE COMPLETED:
FIELD REP.: MCCENERY / TREVINO

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION Approx 30' SW of SP-84-104
SITE CONDITION Flat ground top 2% slope.

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
	NQ	100	90	100		X					X		Smo	Ws	St	dusky red siltstone massive fracs at 33'-33'9", hardness class III		
			100							X								
			100							X								
			100			X				X								
			30					X		X			V	V	V			
	NQ	100	80	100			X			X			Smo	Ws	St	35'2"-35'5" crushed fragments of siltstone in a moist clay matrix siltstone - dusky red 36'4"-36'7" moist clay fill fractures siltstone w/ intermittent fractures filled with clay, dusky red		
			75										Smo					
			75										Rh					
			80										SAC					
			85				X											
			100		X													
			100		X													
			100		X													
			50			X												
			50			X				X			V	V	V			

COMMENTS:

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGLER
C - 4 1/2 CONTINUOUS FLIGHT ANGLER
GB - GEAR BIT
RX - RX ROCK CORING
NQ - NO WIRELINE ROCK CORING

Page 4 of 4

A
N
L

See page one

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NR WIRE LINE
DRILLER: SH+B & CARTER/ADAMS
DATE STARTED: 1/17/85
DATE COMPLETED: _____
FIELD REP.: MCENERY FREVINO

DATE	TIME	DEPTH (ft.)
------	------	-------------

SITE CONDITION

Approx 30' SW. of 91-84-104
flat ground too 70% slope.

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION						
						WIDE ——— CLOSE					HORIZ. ——— VERT.						
						1	2	3	4	5	H	50°					V
NR		100	100	100		X					X			Sm	Ws	St	dusky red siltstone w/ l.s. beds interbedded in very thin bands. Some clay filling the fractures. The fractures are 4-8" wide, hardness class III, small & very fine gr. s.s. cemented
		90					X										
		75					X										
		90					X										
		50				X											
		100															
		100															
		75															
		100															
		100				X					X						
		0	100					X					X				
		0						X					X				
		100				X	X				X						
		100				X	X										
		100				X	X										

Dark Red siltstone w/ l.s. interbedded in very thin bands. Some clay filling.

COMMENTS:

BONGING OPERATION
 M - 6 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGR
 GS - GEAR BIT
 NR - NR ROCK CORING
 NO - NO WILLING ROCK CORING

BOREHOLE LOG (ROCK)

Page 6 of

LOCATION MAP:

SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NR WIRELINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 1/17/85 THRU 1/18/85
DATE COMPLETED:
FIELD REP.: HOUARROT

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION 230'SW 66 SP-B4-104
SITE CONDITION FLAT TO 2% SLOPE

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION							
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
	NR	100	100	90		X					X			SMD	WS	St	DUSKY RED SILTSTONE, V. FINE GRAINED, well cemented. 68% LS nodules / occasional thin partings	
			100			X												
			100			X												
			100			X								FAH				
			0						X								DARK RED SALTSTONE, HIGHLY FRACTURED. SOME GRN-BLKS.	
			0							X								
			0							X								
			50				X							SMD		Gg	DUSKY TO DARK RED SALTSTONE / LS. Conglomerate, well cemented. F. ground	
			50				X							NO-1 SMD		Gg		
			100			X										St	DUSKY SILTSTONE - FINE GRAINED, well cemented. possibly traces of oil in rock	
			100			X												
			50				X							NO-1 SMD		St	FRACTURED reddish brown siltstone. Fractures filled in with carbonate (?)	
			100			X										St		
			100			X										LS	Reddish Brown siltstone (interbedded w/ gray to olive LS)	
			100			X												

COMMENTS: @ change @ 94' - only seen noticed on mud ppts and bad adhesion

BORING OPERATION
M - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

SEE
PAGE

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N E, 400 E 10, 400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NB WIRELINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 1/12/85 (TOTAL 1/18/85)
DATE COMPLETED:
FIELD REP.: HOLMANN

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION E 30' SW OF SP-84704
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS		
						SPACING					ORIENTATION					CONDITION	
						WIDE		CLOSE			HORIZ.						VERT.
						1	2	3	4	5	H	50°					
Nr 100			75	95				X			X			SMD	WS	St	FRactures filled in with cements
			100			X										St	
			100			X										Cg	Dusky Red siltstone - Limestone conglomerate. Tightly cemented
			100			X										Cg	Few fractures
			100			X										Cg	
			100			X										Cg	
			100			X										Cg	
			100			X										St	Brownish red siltstone - fine grained
			100			X										St	Very well cemented, uniform and
			100			X										St	
			100			X										St	
			75				X									St	Brownish red siltstone with no zonal
			50					X								St	Fracturing, calc. concretions
			50				X									St	Fill in above section

COMMENTS:

BORING OPERATION
 M - 6 1/2 HOLLOW STEM ANGR
 C - 4 1/2 CONTINUOUS FLIGHT ANGR
 GB - GEAR BIT
 NX - NX ROCK CORING
 NQ - NQ WIRELINE ROCK CORING

Page 2 of 2

SEE
PAGE

SITE ID: H401 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NO WIRELINE
DRILLER: SAB - CARTER / ADAMS
DATE STARTED: 1/12/95 (TODAY: 1/13/95)
DATE COMPLETED: _____
FIELD REP.: HOWARD GUST

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ~ 30' SW OF SP-84-104
SITE CONDITION FLAT TO 290 SLOPE

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS		
						SPACING					ORIENTATION					CONDITION	
						WIDE ——— CLOSE					HORIZ. ——— VERT.						
						1	2	3	4	5	H	50°					V
100		100	95			X					X			SMD	WS	St	Reddish brown Siltsstone. FINE GRAINED, VERTICALLY CEMENTED
		100				X										St	
		100				X										St	
		100				X										St	
		75						X						ROUGH		St	DARK RED SILTSTONE, HIGHLY FRACTURED, POORLY CEMENTED - Some clay mineral line presence
		0							X							St	
		50						X								St	
		100				X								SMD		St	DARK RED SILTSTONE - LS conglomerate thin bands of LS in places, fine grain of well cemented
		100				X										St	
		100				X										St	
						X										St	
							X							ROUGH		St	DARK RED SILTSTONE - LASS W/BL CEMENTED MEDIUM FRACTURES, FILL'D (WITH CALSINATED COC)
							X									St	
							X									St	
							X							SMD		St	DARK RED SILTSTONE - WITH THIN INTERBEDDED LS FINE GRAINED
COMMENTS:															BOHING OPERATION M - 6 1/2 HOLLOW STEM ANGER C - 4 1/2 CONTINUOUS FLIGHT ANGER GB - GEAR BIT MX - MX ROCK CORING NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: HQ WIRELINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 1/12/85 (TODAY 1/16/85)
DATE COMPLETED: _____
FIELD REP.: Holmquist

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS			
						SPACING					ORIENTATION								
						WIDE ——— CLOSE					HORIZ. ——— VERT.								
						1	2	3	4	5	H	50°					V		
119	NR	100	100	95		X					X			SM	W ₃	St	SEE PAGE 1		
120		100	100			X											C	DARK RED SILTSTONE CONGLOMERATE W/ GREY L.S.	
		100	100			X											C	FINE GRAINED, WELL CEMENTED	
		100	100			X											C		
		100	100			X											C		
		100	100			X											C		
124			100			X											St	DARK RED SANDSTONE	
129			100			X													Very Fine grained tightly cemented Traces of limestone very few fractures present
			100			X													
			100			X													
			100			X													
			100			X	X												
134			75					X											
			50						X										reddish brown siltstone with olive to gray limestone nodules. poorly cemented, slightly fractured. clay in some fractures
			0							X									
			0							X									
134 1/3																			

COMMENTS:

BORING OPERATION
H - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NX - NX ROCK CORING
NO - NO WIRELINE ROCK CORING

COMMENTS: _____

BORING OPERATION
H - 8 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE
PAGE
1

SITE ID: HAC01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8,400 E 10,400
GROUND ELEVATION (ft. MSL): 3400
DRILLING METHOD: NR 12 IRREUNE
DRILLER: SHB - CARTER/ADAMS
DATE STARTED: 1/17/85 (TRIP 1/18/85)
DATE COMPLETED: 1/21/85
FIELD REP.: Holmes

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION N. 30' SW 84-104
SITE CONDITION FLAT TO 2% SLOPE

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
NR 100		0	95					X		X			ROUGH	W. SE	SEE PAGE 9			
		0						X					SMO					
		100				X									DARK RED SILTSTONE CARBONATE IN FRAG, FINE GRAINED, TIGHTLY COMPACTED 142 TO 144' 3" HIGHLY FRAGMENTED			
		100				X												
		100				X												
		100				X												
		100				X												
		100				X												
		100				X												
		0	0					X										
		0	0					X										
140		0	0					X		X			ROUGH		DUSKY RED SILTSTONE, VERY TIGHTLY & EVENLY HIGHLY FRACTURED. NATURAL MUD FILL IN FRAG, ONE FRAG BETWEEN 141' 3" AND 145' 7" IS 3" FILL OF MUD MUD, PITTED SURFACE			
		100	0	50				X					SMO					
		0	50															
		0	50															
		0	50															

COMMENTS: LOST CEMENT AT 142E
DRILL OFF BIT @ 143'E FISHED 1/19/85
REMARKS: 100% WATER LEVEL SPALLS - 7' 8" H
BIT PULLED OFF @ 145.2" ON 1/18/85

BOHING OPERATION
H - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

JEG-AL-ENG-2A (3/84)

REVISED 1/14/85 TO 205' 11"

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE PAGE 1

SITE ID: HAT01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NQ WIRELINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 1/17/85 (TODAY 1/24/85)
DATE COMPLETED:
FIELD REP.: O. HERNANDEZ

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION N 30.5W of SR-84-104
SITE CONDITION FLAT TO 20% grade

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
149	NR	0	50						X	X			ROUGH	W3	St	}		
		50	50						X									
		50							X				SMO					
		75							X									
154		75							X							Reddish brown Siltstone, very slightly cemented, smooth core, moderately highly fractured, traces of olive limestone, laminated structure		
		75	100						X									
		75	100			X			X									
155.11"		100	90	X														
		100		X												Reddish brown Siltstone, VERY TIGHTLY CEMENTED, TRIGONS OF OLIVE LIMESTONE, LAMINATED STRUCTURE, VIBRANT VERY LITTLE FRACTURING		
159		100		X														
		100		X														
		100		X														
		50	60			X										REDDISH BROWN AND GREY SILTSTONES, WELL CEMENTED, FINE TO MEDIUM GRAINED, HIGHLY FRACTURED		
		0	60					X										
		0	60					X										
		0	60					X										

COMMENTS: BLENDED THE HOUR TO CHECK WATER LEVELS
CONTINUED DRILLING TO 161' 5"

BORING OPERATION
M - 6 1/2 HOLLOW STEM ANGLER
C - 4 1/2 CONTINUOUS FLIGHT ANGLER
GB - GEAR BIT
NR - NR ROCK CORING
WD - WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NO WIRELINE
DRILLER: SAB-CARTER/ADAMS
DATE STARTED: 1/17/85 (TODAY 1/21/85)
DATE COMPLETED: _____
FIELD REP.: O. HUMANIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION "30' SW of SP-84-104"
SITE CONDITION Flat to 2% slope

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES					CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS			
						SPACING									ORIENTATION		
						WIDE		CLOSE							HORIZ.		VERT.
						1	2	3	4	5					H	50°	V
165'11"	NR	100	50	60					X			SMO	U3	St	SEE PAGE 12		
165'11"		100	0	60				X									
169			100	90				X							Dusky red siltstone - V. tightly cemented, no fractures 165'11" to 174'0", fine grained, very competent		
171			50					X									
175'11"			0					X									
179			75					X									
179			100					X							Dusky red siltstone, very tightly cemented, (competent)		

COMMENTS: _____

BORING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

SITE ID: HAT01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10,400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: WIRELINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 11/15 (TODAY 1/21/95)
DATE COMPLETED: _____
FIELD REP.: D. HUNNIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION.

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES							CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION					
						WIDE ——— CLOSE					HORIZ. ——— VERT.					
						1	2	3	4	5	H	50°				
NR	100	100	90	X						X			SMO	W3	ST	3" BAND OF GRAY SILTSTONE @ 179' 8"
				X
				X												
				X												
																Dark red siltstone - loosely cemented, fine grained
				X
				X												
				X												
																Dark red siltstone and grey siltstone conglomerate, moderate to high fracturing, slightly cemented

																Dark red siltstone, fine grained, well cemented, few fractures

COMMENTS: _____

BOHING OPERATION
H - 6 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NX - NX ROCK CORING
ND - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See Page 1

SITE ID: HAT01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10,400
GROUND ELEVATION (ft. MSL): V300
DRILLING METHOD: NO WIRELINE
DRILLER: SHR-CARTEE / ADAMS
DATE STARTED: 1/17/85 (TADAH 1/21/85)
DATE COMPLETED:
FIELD REP.: D. Homan

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ~ 30' SW of ST-84-104
SITE CONDITION Flat to 2% slope

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE		CLOSE			HORIZ.		VERT.					
						1	2	3	4	5	H	50°	V					
154	NG	100	100	90		X					X			SMD (15)	WS	SE	CONTINUATION OF PAGE 13	
		100	100	90		X					X					SE		
			100															
199																	198' 5" TO 198' 8" OLIVE TO GRN ARGILL. SLTSTONE	
			35					X									DARK RED SLTSTONE, medium to fine grained, moderately fractured w/ clay filler, less well cemented.	
			100			X												
			100			X		X									DUSKY RED SLTSTONE, fine grained, no horz. fractures, 1/2" to 1/4" inclusions, fractures filled w/ calc. cement.	
204			75					X		X								
			50							X						LG		
205' 11"			100	80		X										SE	DUSKY RED AND GRAY SLTSTONE, coarse grained, well cemented, fine grained.	
			100														DUSKY RED SLTSTONE, fine grained, continued next page 21	
209			100															

COMMENTS:

BORING OPERATION
H - 5 1/2" HOLLOW STEM ANGER
C - 4 1/2" CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NX - NX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

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LOCATION MAP:

See Page 1

SITE ID: HAT 01 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10400
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: NR12 BBLINE
DRILLER: SHB - CARTER / ADAMS
DATE STARTED: 1/17/95 TODAY: 1/22/95
DATE COMPLETED: _____
FIELD REP.: Hummel

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ~30' SW of SP-84-104
SITE CONDITION Flat to 20% grade

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROQ)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
						SPACING					ORIENTATION							
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
209	NR	100	100	80		X					X			5-10	100	st	well cemented olive limy rock heavy rock salt to pea size	
RUN # 22			75				X											
			75				X											
			100			X												
			100			X												
214			100			X											gray siltstone & sandstone w/ petroleum odor and dark interstitial fluid	
			100			X												
			50				X											
215'11"			75			X											reddish grey (wet) siltstone w/ thin bands of limy siltstone well cemented very fine grained	
			50				X											
			75				X											
	219			50				X										
RUN # 23			75				X											
			75				X											
							X											
							X											
224							X											

COMMENTS: Run not used 145'9" to 205'11"

BORING OPERATION

M - 6 1/2 MOLLOW STEM ANGLR

C - 4 1/2 CONTINUOUS FLIGHT ANGLR

GB - GEAR BIT

NR - NO ROCK CORING

NO - NO WIRRLINE ROCK CORING

COMMENTS: Run not used 143'4" to 205'11"

BORING OPERATION
H - 8 1/2 HOLLOW STEM ANGLER
C - 4 1/2 CONTINUOUS FLIGHT ANGLER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 1 of 1

LOCATION MAP:

SEE PAGE 1

SITE ID: HATD1 LOCATION ID: 910
APPROX. SITE COORDINATES (ft.):
N 8400 E 10,420
GROUND ELEVATION (ft. MSL): 4300
DRILLING METHOD: WIRELINE
DRILLER: SHB. CARTER/ADAMS
DATE STARTED: 11/2/85 TODAY 11/2/85
DATE COMPLETED: _____
FIELD REP.: W. J. JAMES

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION N30' S120' E SP-84-104
SITE CONDITION Flat to 28° slope

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES					CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS				
						SPACING		ORIENTATION										
						WIDE — CLOSE		HORIZ. — VERT.										
						1	2	3	4	5	H	50°	V					
224'		NR	100	80		X					X			Dusty red siltstone very fine grained, interbedded w red gray fine siltstone well cemented				
225' 11"																		
229'																		
231'																		
233'																		
235' 11"																		
239'																		

COMMENTS: 11/3/85 Shut Down 7:11 PM - POSSIBLE GAS ZONE -
225' 11" - WHEN BUBBLING AND BOTTLE ROCK SAMPLE
11/24/85 - DRILLED FROM 225' 11" TO 225' 11"

BORING OPERATION
M - 5 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

SITE ID: HAT 01 LOCATION ID: 910 DATE INSTALLED: 1/24/85
APPROX. SITE COORDINATES: (FT.) N 8,400 E 10,400
OPEN AREA PER LINEAL FT. (IN²/FT.) _____
FORMATION OF COMPLETION: N/A
FIELD REP.: DATE HAT 01 C. MCENRY DRILLER: SHAB

COMMENTS: Hole grouted bottom to surface - lack of production
1 Presence of H₂S gas

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

TREMPER/MCENRY 0'-54'

SITE ID: HAT 01 LOCATION ID: 910 FIELD REP: 16mmuist - 54' - 235'11"

APPROX. SITE COORDINATES (FT.): N 8,400 E 10,400

GROUND ELEVATION (FT. MSL): - 54300 COMPLETION DATE: 1/24/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>SHB</u> RIG TYPE: <u>CMF 75</u>				ACTIVITY	START		END TIME
					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	1/17/85 TO 1/24/85		
6" HSA	6"	4'3"	N/A				
Diamond Core	3"	235'11"	H ₂ O				
				CASING	N/A		
CASING SUMMARY				FILTER PACK			
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)	SEAL			
	N/A			BACKFILL			
				DEVELOPMENT			
				OTHER	75 gal/bac grout 235'11" to SURFACE		
* P-Protective S-Screen B-Blank O-Open N-None							
* Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)		<i>NOTE: Core hole grouted then new hole drilled for well see 910A well</i>			
S	GROUT - 0' to 235'11"	235'11"					
				COMMENTS: <u>Hole grouted due to lack of productivity</u>			
* B - Backfill S - Seal F - Filter Pack							
* Depth from Ground Surface							

WELL COMPLETION RECORD

SITE ID: HAT 01 LOCATION ID: H 910-A DATE INSTALLED: 2/15/85
APPROX. SITE COORDINATES: (FT.) N ~ 8,400 E ~ 10,200
OPEN AREA PER LINEAL FT. (IN²/FT.) _____
FORMATION OF COMPLETION: RICO (?)
FIELD REP.: Hermanist DRILLER: SHB-ADAMS/PEREA

COMMENTS: Screen alternates in 5' sections between 140' and 180'
bottom of
screen section @ 180'

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT01 LOCATION ID: #910-A FIELD REP: Houmaust

APPROX. SITE COORDINATES (FT.): N 28,400 E 10,200

GROUND ELEVATION (FT. MSL): _____ COMPLETION DATE: 2/25/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>SHB - Adams/Perce</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>CME 75</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING 2/5/85 2/6/85 2/7/85 2/14/85	2/3/85		
1 5/8							
6mm bit	5 5/8	182'	AIR				
CASING SUMMARY				CASING 2/15/85	2/15/85		
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)				
P	6" Galv steel	6"	3.8'				
B	2" PVC	2"	140.8				
S	2" PVC	2"	180.8'				
B	2" PVC	2"	182.8'	SEAL 2/15/85	2/15/85		
				BACKFILL 2/15/85	2/15/85		
				DEVELOPMENT 2/18/85	2/18/85		
				OTHER			
* P-Protective B-Screen S-Blank O-Open N-None							
* Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)		attempted to develop - blew hole @ 180' - little to no recovery so development procedures terminated			
B	Grout @ 7 1/2 sack/gallon	0-187.2'					
S	Bentonite pellets	139.4					
F	120# Sand	182'					
				COMMENTS: Screened from 146' to 180' w/ 5' alternating screen/blank w/ bottom of screen @ 180'			
* B - Backfill S - Seal F - Filter Pack							
* Depth from Ground Surface							

WELL 911

BOREHOLE LOG (ROCK)

Page 1 of 1

LOCATION MAP:

SITE ID: HAT 01 LOCATION ID: 911
APPROX. SITE COORDINATES (ft.):
N 9510' E 10280'
GROUND ELEVATION (ft. MSL): Est 4290'
DRILLING METHOD: SEA NR WIRELINE
DRILLER: ADAMS/Williams - SHB
DATE STARTED: 2/19/85
DATE COMPLETED: _____
FIELD REP.: R. HOLLAND

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ON-PILE - NE CORNER LOWER PILE
SITE CONDITION DRY & DUSTY

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES									WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION							CONDITION
						WIDE ——— CLOSE					HORIZ. ——— VERT.							
						1	2	3	4	5	H	50°	V					
39	NR	75%	0	100%						X	—			SMO	WS	5'	Siltstone & reddish brown, with minor lt. gray mottling, highly calc., very hard to med hard	
40															WS			
41															WS			
42															WS			
43															WS			
44															WS			
45	NR	90%	44%	100%						X	—				WS	5'	Siltstone, reddish brown, highly calc., with angular to subround lime st. clast, lt gray. very minor alteration noted at 48'	
46															WS			
47															WS			
48															WM			
49	NR	86%	0	100%						X				R	WM	5'	Siltstone as ab only softer and becoming clayey. lost circulation at 51' soft to Hard	
50			0							X	X			R	WM	5'		
51			0	0%						X		X		R	WM	5'		
52			0	0						X	X			R	WM	5'		
53			0	0						X	X			R	WM	5'		

COMMENTS: 2 Water Hauls

BORING OPERATION
H - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
MX - MX ROCK CORING
NO - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 5 of

LOCATION MAP:

SITE ID: 99 HAT-01 LOCATION ID: 911
APPROX. SITE COORDINATES (ft.):
N E
GROUND ELEVATION (ft. MSL):
DRILLING METHOD:
DRILLER:
DATE STARTED:
DATE COMPLETED:
FIELD REP.:

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION
SITE CONDITION

Run 10

DEPTH (FT)	BORING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	DISCONTINUITIES										WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS	
						SPACING					ORIENTATION								CONDITION
						WIDE		CLOSE			HORIZ.		VERT.						
						1	2	3	4	5	H	50°	V						
99	NQ		100	0	X		X				—				Sm	F	st	at 102.9 siltstone, argillaceous, lt gray to greenish gray. highly calc. becoming reddish at 103.5	
99			55	0	X				X		—				Sm	F	st		
100			70	0	X				X		—				R	F	st- list		
101			0	0	X					X	—				R	F	st- list		
102			65	0	X				X		—				Sm	sw	st		
103			100	0	X		X				—				Sm	sw	st		
104			40	0	X					X					Sm	F	st	Hole TD @ 104.5'	
105																			
106																			
107																			
108																			
109																			
110																			
111																			
112																			
113																			

COMMENTS:

BORING OPERATION
M - 8 1/2 HOLLOW STEM ANGER
C - 4 1/2 CONTINUOUS FLIGHT ANGER
GB - GEAR BIT
NR - NR ROCK CORING
NO - NO WIRELINE ROCK CORING

JACOBS ENGINEERING GROUP INC.

ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

SITE ID: HAT-01 LOCATION ID: 911 DATE INSTALLED: 3/28/85

APPROX. SITE COORDINATES: (FT.) N _____ E _____

OPEN AREA PER LINEAL FT. (IN²/FT.) 37.7 in²

FORMATION OF COMPLETION: _____

FIELD REP.: R. Holland DRILLER: D. Pearce/Ed Adams

COMMENTS: Bottom of 2" casing @ 103'

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT-01 LOCATION ID: 911 FIELD REP: Roger Holland
APPROX. SITE COORDINATES (FT.): N E
GROUND ELEVATION (FT. MSL): COMPLETION DATE: 3/25/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>D. Proctor / Ed Adams</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>CME / Mohr 1000</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (in.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	3/26/85		
		104		CASING	3/25/85	11:46 am	12:15 pm
				FILTER PACK	3/28/85	12:15 pm	12:30 pm
						12:30 pm	12:40 pm
CASING SUMMARY				SEAL	3/25/85		
CASING TYPE*	DESCRIPTION	DIA. (in.)	END DEPTH (ft.)	104			
B	PVC	2"	103	102			
S	PVC .010	2"	93	BACKFILL	3/28/85	2:10 pm	3:09 pm
B	PVC	2"	surface	92			
P	steel 9		3	DEVELOPMENT	4/1/85	1:35 pm	2:05 pm
						2:15 pm	2:45 pm
				OTHER			
* P-Protective S-Screen B-Blank O-Open N-None							
† Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)					
F	silica sand	92	104				
S	Bentonite pellets	89	85				
B	Cement Grout	surface					
* B - Backfill S - Seal F - Filter Pack							
† Depth from Ground Surface							
COMMENTS: <u>very little water</u>							

WELL 912

SITE ID: HAT-01 LOCATION ID: 912 DATE INSTALLED: 3/28/85
APPROX. SITE COORDINATES: (FT.) N _____ E _____
OPEN AREA PER LINEAL FT. (IN²/FT.) 37.7 in²
FORMATION OF COMPLETION: _____
FIELD REP.: Roger Holland DRILLER: SH-13

COMMENT8:

Case 50-84

SITE ID: HAT-01 LOCATION ID: 912 FIELD REP: R. Holland
APPROX. SITE COORDINATES (FT.): N _____ E _____
GROUND ELEVATION (FT. MSL): _____ COMPLETION DATE: 3/28/85

JEG-AL-ENG-1 (8/84)

WELL 930

BOREHOLE LOG (SOIL)

Page 1 of 2

LOCATION MAP:

SITE ID: HAT 01 LOCATION ID: HOLE 930
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY AIR 7 7/8" TRICONE
DRILLING CONTR.: BOB BEEMAN DRILLING CO
DATE STARTED: 10-9-85
DATE COMPLETED: 10-10-85
FIELD REP.: K. DONNELSON / SH & B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
10-12-85	9:30AM	52.34 (GROUND SURF)
(HOLE NOT YET DEVELOPED)		
10-9-85	CONFINED AQUIFER	96-98 ±

LOCATION DESCRIPTION ABOUT 1.6 MILES SOUTH OF SAN JUAN RIVER & 300' W. OF H
SITE CONDITION GENTLE, SHALLOW WEATHERED SILTSTONE, SPARSE LOW VEGETATION.

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE PER 8 IN. MIN/5 FT	N VALUE	GEOL LOGS	VISUAL CLASSIFICATION
0				R				Phg	0 - 10' HALGAITO SHALE, SANDY
				O	7 7/8"			SLST	SILTSTONE: thin bedded, calcareous, moist, medium red brn. NOTE: 0-5' WEATHERED NOTE: DRY 5' - 10'
10				T					
				A		15		Phg	10 - 80' HALGAITO SHALE, SILTY SAND-
				R				Ss	STONE: thin bedded, slightly calcar-
				Y		17			eous, dry, medium red brn.
20				A					NOTE: STRONGLY CALCAREOUS 20'-7.0.
				I		5			NOTE: SOME INTERBEDDED RED
				R					ORANGE MUDSTONE 28'-31'
30						5			
						26			
40						8			
						16			NOTE: HARD DRILLING 46'-78'
50						22	52.3'		NOTE: SOME THIN INTERBEDDED GRAY
							10-12-85		LIMESTONE & RED ORANGE MUDSTONE
						26 MIN/10 FT			46' - 80
60									NOTE: VERY LITTLE MUDSTONE
									BELOW 58'

COMMENTS: INSTALLED 4" SCHED 40 PVC WITH SLOTTED SECTION
FROM 100-100' & SAND PACIC FROM 94-116'.

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 2 of 2

LOCATION MAP: SEE PAGE 1

SITE ID: _____ LOCATION ID: HOLE930

SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: ROTARY AIR 7 7/8" TRICONE

DRILLING CONTR.: BOB REEMAN DRILLING CO.

DATE STARTED: 10-9-85

DATE COMPLETED: 10-10-85

FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ABOUT 1.6 MILES SOUTH OF SAN JUAN RIVER 2300' W. OF HWY 163
SITE CONDITION GENTLE, SHALLOW WEATHERED SILTSTONE, SPARSE LOW VEGETATION.

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN/FT	N VALUE	GEOLOGICAL USGS	VISUAL CLASSIFICATION
60					7 7/8"				
						22			
						27			
70						23			
						9			
80						40		Phg SLT	80 - 84' HALGAITO SHALE, SANDY SILT- STONE: thin bedded, dry, consider- able interbedded gray limestone, medium red brown.
						44		Ph Ss	84 - 96' HALGAITO SHALE, SILTY SANDSTONE: thin bedded, some interbedded gray & tan limestone, fine-grained, dry, medium red brown.
90						42			
	10-9-85								
	10-10-85								
100								TPht LS	96 - 103' HONAKER TRAIL FORMATION LIMESTONE: light-medium gray grading to light blue green & light purple
						36			
110						17			NOTE: considerable interbedded fine-grained brown sandstone from 110 - 113'
						56 MIN/3FT		TPht Ss	113 - 116' HONAKER TRAIL FORMATION; SAND- STONE, thin bedded, silty, calcareous, some limestone, medium red brown.
118									T.D. 116', 4:58 AM, 10-10-85

COMMENTS: ROTARY AIR 0-98', ROTARY WASH 98-116'
* JACOB'S CALLS THIS THE HONAKER TRAIL, BUT CHARLES HEATON,
PROGRAM GEOLOGICAL ENGINEER FOR THE NAVAJO TRIBES DIV
NATURAL RESOURCES SAYS THAT THE HONAKER TRAIL IS 2000'

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JEG-AL-ENG-2S (4/85) DEEP. OTHERS CALL IT THE HALGAITO BUT HEATON CALLS IT
PART OF THE MOENKOPI FORMATION. MOST LIKELY IT IS
THE RICO FORMATION.

WELL COMPLETION RECORD

SITE ID: HAT 01 LOCATION ID: HOLE 930 DATE INSTALLED: 10-10-85

APPROX. SITE COORDINATES: (FT.) N _____ E _____

OPEN AREA PER LINEAL FT. (IN²/FT.) _____

FORMATION OF COMPLETION: LIMESTONE & SANDSTONE

FIELD REP.: K. DONNELSON / SH&B GEOL DRILLER: BOB BEEMAN DRILLING CO

COMMENTS: _____

WELL 931

BOREHOLE LOG (SOIL)

Page 1 of 4

LOCATION MAP:

SITE ID: HAT. 01 LOCATION ID: HOLE #931
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BOB GEEMAN DRILLING CO.
DATE STARTED: 10-10-85
DATE COMPLETED: 10-12-85
FIELD REP.: K. DONNELSON / SH & B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
	NOISE	

LOCATION DESCRIPTION ABOUT 1 MILE SOUTH OF SAN JUAN RIV. & 100' E OF OLD HWY #931
SITE CONDITION BORROW PIT FLOOR, SPARSE VEGETATION

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 0.1m MIN / 5 FT	Z VALUE	GEOL USGS	VISUAL CLASSIFICATION
0					8 3/4"	15		Phg LS	0 - 8' HALGAITO SHALE SILTY LIME- STONE: fine grained, medium brown, thin bedded. NOTE: TOP 4' WEATHERED & MOIST NOTE: SOME ORANGE SILTSTONE INTER- BEDS INCREASING W/DEPTH.
10	10-10-85			T	7 7/8"	27		Phg SST	8 - 16' HALGAITO SHALE, SILTSTONE: Sandy, calcareous, very thin bedded, medium red orange brn. NOTE: SOME INTERBEDDED LIGHT GRAY LIMESTONE 12 - 16
	10-11-85			P		18		Phg MDST	16 - 24' HALGAITO SHALE MUDSTONE: friable, thin bedded, med orange limonitic.
20				A		4		Phg SST	24 - 30' HALGAITO SHALE, SILTSTONE VERY THIN BEDDED, med orange brn CALCAREOUS.
				I		1		Phg SST	30 - 38' HALGAITO SHALE, MUDSTONE: SOFT, CALCAREOUS, MED - DK ORANGE BRN NOTE: BECOMES MORE SILTY & HARDER W/DEPTH.
30				R		26		Phg SST	38 - 48' HALGAITO SHALE, SILTSTONE: Calcareous, thin bedded, medium orange brown. NOTE: TRACE LT. GRAY LIMESTONE 46 - 48'
40						13		Phg SST	48 - 73' HALGAITO SHALE, SILTSTONE: Silty, fine cuttings, med orange brn Calcareous.
50						25		Phg SST	
						10		Phg SST	
						38		Phg SST	
60						29		Phg SST	

COMMENTS: HOLE ABANDONED AT A DEPTH OF 177 FEET &
GROUTED DUE TO ENCOUNTERING "BABY" SAND MEMBER OF
THE HONAKER TRAIL FM AT 175'. HAD STRONG PETROLEUM
ODOR & PRODUCED OIL FILM ON WATER WHEN SAMPLE WAS WASHED.

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 2 of 4

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 931
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY AIR
DRILLING CONTR.: BEEMAN DRILLING CO
DATE STARTED: 10-10-85
DATE COMPLETED: 10-12-85
FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ABOUT 1 MILE SOUTH OF SAN JUAN RIVER & 100' E OF OLD HIGHWAY 163
SITE CONDITION BORROW PIT FLOOR, SPARSE VEG - SPARSE VEGETATION.

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN / 5 FT	N VALUE	GEOL UNOS	VISUAL CLASSIFICATION
60					7 7/8"	26		GS	
						25			
70						30			NOTE: CHANGES TO BROWN w/ MORE SILTSTONE INTERBEDS BELOW 70'
						63		Phg SLST	73-100' HALGAITO SHALE, SILTSTONE: Thin bedded, fine cuttings, calcareous, light-medium brown.
80						34			
						32			
90						30			NOTE: some interbeds of light orange brown mudstone 95' - 100'
						16			
100						23		Phg SLST MPST	100-103 HALGAITO
						39			
110						28		Phg SLST MPST	110-113 HALGAITO SHALE, SILTSTONE & MUDSTONE: Thin bedded, coarse cuttings, calcareous, some orange mudstone, medium brown
						64		Phg LS	113-118 HALGAITO SHALE, LIMESTONE
120									

COMMENTS: THIS HOLE IS LOCATED AT THE SOUTH END OF THE MEXICAN OIL FIELD IN THE MEXICAN HAT SYNCLINE. THE OIL SAND IS LOCATED IN A STRATIGRAPHIC OIL TRAP RATHER THAN A STRUCTURAL TRAP. THE

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.36" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 3 of 4

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 931
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY AIR
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-10-85
DATE COMPLETED: 10-12-85
FIELD REP.: K. DONNELSON

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ABOUT 1 MILE SOUTH OF SAN JUAN RIVER & 100'
SITE CONDITION E. OF OLD HIGHWAY 163, BORROW PIT FLOOR, SPARSE VEGETATION
ROAD

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL BLOWS PER 6 IN. (24.44" MIN/5 FT)	N VALUE	GEDL #666	VISUAL CLASSIFICATION
120	10-11-85				7 7/8"	22		SLST	medium red orange brown limestone w/ trace - some light gray limestone some siltstone, fine grained
	10-12-85					35 MIN/4 FT		LS	118-124' SILTSTONE: COARSE CUTTING, calcareous, med red brown.
130						67		LS	124-129' LIMESTONE: fine grained light gray.
						58		SS	129-139' SANDY LIMESTONE: fine-grained, light-med red brown
140						26			NOTE: SOME LT GRAY LIMESTONE INTERBEDS FROM 130-139'
						23			139-150' SILTY SANDSTONE: Thinbedded, calcareous, fine-grained, med red brown.
150						37		SLST & LS	NOTE: Trace gray siltstone 145-147
						77		SS & LS	NOTE: Increased siltstone w/ depth.
160						23			150-154' SILTSTONE & LIMESTONE: fine grained interbedded, lt & med gray, gry green & gry brn.
						37			154-169' SANDSTONE & LIMESTONE: fine grained, some gry brn limestone, medium brown.
170						39		LS	NOTE: traces of gry gry limestone
						25		SS	NOTE: increasing w/ depth
									160-169'
									169-172' SILTY LIMESTONE:

COMMENTS: "BABY" SAND HAS A REPORTED THICKNESS OF 24' AND IS LOCATED ABOUT 33' BELOW THE TOP OF THE HONAKER FORMATION. THE MEXICAN HAT SYNCLINE IS ABOUT 16 MILES LONG BY 5 MILES WIDE WITH THE EAST FLANK DIPPING

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.36" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

JEG-AL-ENG-2S (4/85) PING ABOUT 24 - 48° & THE WEST FLANK DIPPING ABOUT 3-6°.

WELL 932

BOREHOLE LOG (SOIL)

Page 1 of 4

LOCATION MAP:

SITE ID: HAT 01 LOCATION ID: #932

SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: ROTARY AIR

DRILLING CONTR.: BEEMAN DRILLING CO

DATE STARTED: 10-13-85

DATE COMPLETED: _____

FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION 100' EAST OF WATER PIPELINE & 1/2 MILE SOUTH OF SAN JUAN
SITE CONDITION RIVER. AT BASE OF SMALL N-S HILL ON SLOPE, SPARSE VEG.

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 5 ft. MIN/5 FT	FORM # VALUE	GEOL USCS	VISUAL CLASSIFICATION
0				R	8 3/4"	22 + 5	H A L G A I T O S H A L E	Phg LS	0 - 6' SANDY LIMESTONE: fine grained, coarse cuttings, medium orange brown.
				T	5 1/8"	15		MDST Phg	6 - 11' MUDSTONE: some siltstone, calcareous, friable, fine cuttings, "brick" orange.
10				A		20		Phg SLST	11' - 20' SANDY SILTSTONE: thin bedded, calcareous, fine - medium cuttings, medium red orange brown.
				R		32			
20								Phg SS	20 - 50' SILTY SANDSTONE: Calcareous, coarse cuttings, fine grained medium red orange brown NOTE: SOME "BRICK" ORANGE MUDSTONE FROM 26-28'.
						30 MIN/ 15 FT			
30									
						7.5			
40						16			
						12			
50						14		Phg sist	50 - 187' SANDY SILTSTONE: calcareous coarse cuttings, fine grained, medium brown - red brown Note: some gray siltstone & limestone from 50-54
						21			
60									

COMMENTS:

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 2 of 4

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: #932
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-13-85
DATE COMPLETED: _____
FIELD REP.: K. DONNELSON / SH & B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION 100' EAST OF WATER PIPELINE & 1/2 MILE SOUTH OF SAN JUAN R.
SITE CONDITION AT BASE OF SMALL N-S RIDGE ON SLOPE, SPARSE VEGETATION.

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN/SFT	RCM # VALVE	GEOLOGICAL UNITS	VISUAL CLASSIFICATION
60				R	5 1/8"	12	H A L G A I T O S H A L E	Phg SLST	NOTE: Trace green gry siltstone from 72 - 76'
				O		11			
				T		24			
70				A		16			
				R		10.5			
						14			
80						12			
						12			
90						3.5			
						14			
100						10			
						7			
110									NOTE: Trace of light grn gry siltstone 110 - 114
120									NOTE: Considerable "brick" orange mudstone w/ trace light gry limestone 116 - 118'

COMMENTS:

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 3 of 4

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 932
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-13-85
DATE COMPLETED: _____
FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN/5 FT.	LOG VALUES	USGS GEOL.	VISUAL CLASSIFICATION
120				R	5 1/2"	14	Phg	Phg	NOTE: some mudstone 127-129'
				O		9	T	St	
				T		10	A		
				A		15	R		
130				R		12.5	Y		NOTE: some light gray limestone from 132-138'
						16			
						15			
						13.5			
140						12			NOTE: some light gray limestone from 146-162' light green
						11			
						7.5			
						11			
150									NOTE: some medium gray & trace light maroon limestone 162-166
160									NOTE: some light green limestone from 166-172
170									NOTE: TRACE medium gray limestone from 172-175
180									NOTE: TRACE dk gray limestone 178-182'

COMMENTS: NOTE: TOP OF HONAKER TRAIL FORMATION MAY BE AT 162 OR 187'. LITHOLOGY BETWEEN 50 & 187' LOOKS THE SAME. GEOPHYSICAL WELL LOG DOES NOT SHOW ANY FORMATIONAL DIFFERENCE BETWEEN 50 & 187'.

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 932
 SITE COORDINATES (N. M.):
 N
 E
 GROUND ELEVATION (ft. MSL):
 DRILLING METHOD: RETARY AIR 5/8"
 DRILLING CONTR: BEEMAN DRILLING CO.
 DATE STARTED: 10-13-85
 DATE COMPLETED: 10-13-85
 FIELD REP.: K. DONNELSON / SHAB GEOL

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
10-13-85	6:28 PM	192' (GROUND)
10-13-85	7:00 PM	153'
10-14-85	7:35 AM	151.0'

LOCATION DESCRIPTION SEE PAGE 1

SITE CONDITION SEE PAGE 1

DEPTH	TYPE	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	PERCENT BLOWS	WATER	VISUAL CLASSIFICATION
180	R	5 1/8"			4.5		NOTE: Trace med. ungray limestone
190	A				16		187-193' Limestone; fine grained light to med gray.
200	R				2.5 MIN/5 FT		T.D. 193', 10-13-85, 6:28 PM. ENCOUNTERED HYDROGEN SULFIDE FOLLOWED BY WATER (BLACK - BEANS) WITH SLIGHT PETROLEUM ODOUR AT 192'. WATER QUALITY: Salinity 2%, EC 3100 uMHO's, PH 8.08. (WATER BEANS FROM CONTAMINATED BY REMOVAL OF HOLE) GROUTED HOLE TO SURFACE ON 10-14-85

JEG-AL-ENG-2S (4/85) CLOUDY WATER (SENT BAILEY TOO DEEP?)

SAMPLE TYPE
 A - Auger cuttings
 S - 2" O.D. 1.38" I.D. drive sample
 U - 3" O.D. 2.42" I.D. tube sample
 T - 3" O.D. 1.38" I.D. thin-walled Shelby tube

COMMENTS: HOLE DRILLED WITH 5/8" TRICONE DRILLER 3 TO 4 TIMES FASTER THAN 7/8" TRICONE WATER LEVEL PROBE WAS COVERED BY 2' OF BROWN STICKY OIL. ATTEMPTED TO SAMPLE WITH BAILEY BUT GOT MOSTLY

WELL 933

Page 1 of 3

AN

SITE COORDINATES (ft.):

N _____ E

GROUND ELEVATION (ft. MSL):

DRILLING METHOD: DOWN HOLE HAMMER 5 1/4"

DRILLING CONTR.: BEEMAN DRILLING CO.

DATE STARTED: 10-17-85

DATE COMPLETED: 10-15-85

FIELD REP.: K. DONNELSON/SH & B GEOLOGIST

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)

DATE _____

TIME

DEPTH (ft.)

LOCATION DESCRIPTION ABOUT 1/4 MILE NE OF HALCHITA & 500' EAST OF SCALE HOUSE
SITE CONDITION ON SLOPE BELOW 10 TO 15' HILLS, SPARSE VEGETATION

	DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER MIN. MIN/S FT	FORM # VALUE	GEOLOGICAL USGS	VISUAL CLASSIFICATION
0		X			D	5 1/4"		H A L G A I T O S H A L E	Pkg SLST	0 - 15' SILTSTONE: Calcareous, coarse cuttings, medium brown-medium orange brown NOTE: Trace light gray siltstone 5-15'
		X			O		10			
		X			E		11			
10		X			N		14.5			
		X			H		3		Pkg MDST	15 - 32' MUDSTONE; Some interbedded siltstone, soft, medium orange-orange brown, calcareous, fine-medium cuttings.
		X			O		5			
		X			L		7.5			
20		X			A		6			
		X			M		15		Pkg SLST & MDST	32 - 52' SILTSTONE & MUDSTONE: trace some light gray limestone & siltstone calcareous, thin bedded, fine-medium cuttings, medium red brown. NOTE: MUDSTONE DECREASING BELOW 38'-50' NOTE: Trace-some chert 40-45'
		X			M		18			
		X			R		7			NOTE: Trace green slt 45-52'
30		X					14		Pkg SLST	52-65' SILTSTONE: Some chert, trace gray limestone & siltstone, calcareous med cuttings, med orange brown
		X					14		.	
40		X								
		X								
50		X								
		X								
60		X								

COMMENTS:

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. ther-waxed Shelby tube

BOREHOLE LOG (SOIL)

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 933
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: DOWN HOLE HAMMER
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-14-85
DATE COMPLETED: 10-15-85
FIELD REP.: K. DONNELSON / SH & B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION SEE PAGE 1

SITE CONDITION SEE PAGE 1

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN/5 FT	FORM & VALUE	GEOL USCS	VISUAL CLASSIFICATION
60				D	5 1/4"	13	H A T 0 1 S I D E		NOTE: limestone & gray siltstone absent 55-60 NOTE: some orange mudstone & light green gray siltstone 62-65'
				E		4		Phg Mdst	
70				H		15		Phg SLST	65-71' MUDSTONE: clayey, soft, fine cuttings, calcareous, "brick" orange
				O		15.5			
80				H		29		Phg SLST	71-80 SILTSTONE: some interbeds of orange mudstone, calcareous, medium cuttings, thin bedded, medium orange brown.
				A		12.5		Phg SLST	80-86 SILTSTONE: Cherty, calcareous med red orange brown
90				M		11.5			86-96 SILTSTONE: calcareous, some interbedded orange mudstone, med red brown.
				R		23.5		Phg SLST	NOTE: trace light gray limestone & grn gry siltstone 90-96'
100						20.5			96-169' SILTSTONE: calcareous, cherty, med red orange brn, trace gry grn siltstone to 100'. NOTE: some orange mudstone 106-108'
						14			NOTE: TRACE - SOME LT GRAY LIMESTONE, 116-120'
110						20			
						19.5			
120									

COMMENTS:

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 3 of 3

LOCATION MAP: SEE PAGE 2

SITE ID: HAT 01 LOCATION ID: 933
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: DOWN HOLE HAMMER 5 1/4"
DRILLING CONTR.: BEEHMAN DRILLING CO.
DATE STARTED: 10-14-85
DATE COMPLETED: 10-15-85
FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
10-15-85	7:40AM	125 - 145?
NO WATER OBSERVED FROM 0-145 ON 10-14-85		
WATER FORMED IN HOLE OVERNIGHT, SEEP IS		
DRILLER WAS ABLE TO BLOW DRY HOLE		

LOCATION DESCRIPTION SEE PAGE 1
SITE CONDITION SEE PAGE 1

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 IN. MIN/5 FT	FORM # VARIATION	FORM USGS GEOLOG	VISUAL CLASSIFICATION	
120					5 1/4"	22.5	H A L G A I T O S H A L E	Phy SLT	NOTE: TRACE GRAY GRN SILTSTONE 122-125'	
						17				
						20.5				
130						14				NOTE: TRACE GRAY GRN SILTSTONE 136-138'
						11				NOTE: SOME INTERBEDDED ORANGE MUD- STONE 142-144'
140						21				
						16				
						11				NOTE: SOME INTERBEDDED ORANGE MUDSTONE W/ TRACES GRAY SILTSTONE 156-159'
						29				
						14				
170						25	HOWA KER TRAIL	LS Pnt	169 - 175' LIMESTONE: Shaly at top - light gray grading to light gray brown.	
175									T.D. 175', 9:45AM, 10-15-85	

COMMENTS: \$ SO SLIGHT THAT WE ARE UNABLE TO DETERMINE FROM LITH & GEOPHYSICAL LOGS THE LOCATION OF THE AQUIFER ACQUIFER. THUS, UNABLE TO SELECT SCREEN LOCATION. ABANDONED AND GROUTED HOLE. WELL SUGGESTS THAT THE

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. ther-walled Shelby tube

JEG-AL-ENG-2S (4/85) ACQUIFER COULD BE AT 130' AMOUNT OF WATER PRESENT IS TOO SMALL TO DEVELOP.

WELL 934

BOREHOLE LOG (SOIL)

Page 1 of 3

LOCATION MAP:

SITE ID: HAT 0 LOCATION ID: 934
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-15-85
DATE COMPLETED: _____
FIELD REP.: K. DONNELSON / SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION ABOUT 300' WEST OF GYPSUM WASH & 1.5 MILES S. of Santa Fe
SITE CONDITION MESA PENINSULA, SURFACE STREWN WITH FLAT CHUNKS WEATHERED L. (LAG DEPOSITS)

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE - BLOWS PER 6 IN. MIN/5FT	PERM. VALUE	GEOLOGICAL	VISUAL CLASSIFICATION
0				R	5 1/8"	4.5	H A L G A I O S H A L E	Phg SLST	0 - 16' SILTSTONE: Cherty, calcareous, some interbedded mudstone, medium red orange brown. NOTE: SURFACE STREWN WITH CHKS of med gry rough weathered limestone, also traces of gypsum.
10				R		26/10FT			
20				R		44		Phg SLST	16 - 22' SILTSTONE: Cherty, calcareous, coarse cuttings, medium brown. NOTE: Some interbedded mudstone from 21-24'
30				R		9		Phg SLST	22 - 120' SILTSTONE: Calcareous, fine-medium cuttings, thinbedded, med brown NOTE: Considerable mudstone 29-36'
40				R		8.5			NOTE: Some mudstone w/ trace gray green siltstone 36-38'
50				R		4			NOTE: Some mudstone from 42-44'
60				R		8			
				R		5			
				R		14			NOTE: Some mudstone from 55-57'
				R		11			
				R		14.5			

COMMENTS: _____

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (SOIL)

Page 2 of 3

LOCATION MAP: SEE PAGE 1

SITE ID: HAT 01 LOCATION ID: 934
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BEEMAN DRILLING CO.
DATE STARTED: 10-15-85
DATE COMPLETED: _____
FIELD REP.: K. DONNELSON / SHB GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION SEE PAGE 1

SITE CONDITION SEE PAGE 1

DEPTH	SAMPLE INTERVAL	SAMPLE RECOVERY	SAMPLE RETAINED	TYPE	ID	DRILL RATE BLOWS PER 8 ft. MIN/SFT	FORAMEN VALVE	GEOL LOGS	VISUAL CLASSIFICATION
60				R	5 1/8"	13	H A G A I T O S H A L E	Phg SLST	NOTE: TRACE LIGHT GRAY GREEN SILTSTONE 62-64'
				O		15			NOTE: SOME MUDSTONE & LIGHT GRAY LIMESTONE INTERBEDS 66-68'
70				R		11			NOTE: SCATTERED INTERBEDS OF MUDSTONE w/ trace light gray siltstone & limestone 71-75'
				C		18			NOTE: SOME INTERBEDS OF MUDSTONE w/ trace light gray limestone 76-82'
80						14			
						21			NOTE: SOME MUDSTONE 89-91'
90						15.5			NOTE: TRACE LIGHT GRAY LIMESTONE 91-93'
						31			
100	10-15-85					14.5 MIN/3'			NOTE: TRACE GRAY LIMESTONE & SOME LIMONITIC SILTSTONE 100-104'
	10-16-85					8			NOTE: CONSIDERABLE ORANGE MUDSTONE INTERBEDS 106-109'
110						16.5			NOTE: SOME MUDSTONE 114-117'
						12.5			
120									

COMMENTS: _____

SAMPLE TYPE
A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

Page 3 of 3

ANN

SITE ID: HAT 01 LOCATION ID: 934
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: ROTARY
DRILLING CONTR.: BEEHMAN DRILLING CO.
DATE STARTED: 10-15-85
DATE COMPLETED: 10-16-85
FIELD REP.: K. DONNELSON/SH&B GEOLOGIST

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)
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LOCATION DESCRIPTION SEE PAGE 1

SITE CONDITION SEE PAGE 1

[illegible]

COMMENTS:

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. drive sample
U - 3" O.D. 2.42" I.D. tube sample
T - 3" O.D. thin-walled Shelby tube

BOREHOLE LOG (ROCK)

Page 2 of 5

LOCATION MAP:

see page 1

SITE ID: HATOL LOCATION ID: 934
SITE COORDINATES (N. E.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: Roger Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (ft.)	HOLOG OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (IRON)	% DRILLING FLUID RECOVERY	PACER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
153											
											155-175' no samples
175										514/185	2 75' siltstone to sandstone, dark red to red, very fine grained, calc., fissile, slightly micaceous with minor gray ss frags. Both are highly calc. minor aragonite coating along some fractures.
186											2 90' same as above with no st. gray to gray frags. Penetration rate very slow 20 min/5'
195											
190											2 190 as above with orange red. siltstone, slightly clayey, forms balls, micaceous, calc.
195											

COMMENTS: _____

DRILLING OPERATIONS

H - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
AC - AS ROCK CORING
NC - NO WIRELINE REEF CORING

Page 5 of 5

A
Z
W

see page 1

SITE ID: ART 01 LOCATION ID: 934
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: R. Holland

DATE	TIME	DEPTH (ft.)
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SITE CONDITION

[illegible]

COMMENTS:

BOZING OPERATIONS

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
N1 - N1 RDCY CORING
N2 - N2 WIRELINE BULK CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

SITE ID: HAT01 LOCATION ID: 934 DATE INSTALLED: 10/17/85
APPROX. SITE COORDINATES: (FT.) N NK E NK
OPEN AREA PER LINEAL FT. (IN²/FT.) 8" hole with 4.5" OD / 4.0" ID casing
FORMATION OF COMPLETION: Halqaito
FIELD-REP.: Roger Holland DRILLER: Beeman Drilling

COMMENTS: 3' of fill in hole between time of hole completion
@ 200' and setting of casing. Bottom of casing @ 197'

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS
BOREHOLE/WELL CONSTRUCTION LOG

SITE ID: HAT 01 LOCATION ID: 934 FIELD REP: R. Holland
APPROX. SITE COORDINATES (FT.): N NK E NK
GROUND ELEVATION (FT. MSL): NK COMPLETION DATE: 10/18/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>Beeman Drilling</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>Gardner Denver 1000 (Rotary)</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (In.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	10/15/85		3:46 pm
Mission Hammer	8.0"		Air/Air/Water		10/17/85		
				CASING	10/17/85	5:30 pm	6:04 pm
				FILTER PACK	10/17/85	6:37 pm	6:52 pm
				SEAL	10/17/85	7:14 pm	7:16 pm
				BACKFILL	10/18/85	8:45 Am	9:34 Am
				DEVELOPMENT			
				OTHER			
CASING SUMMARY							
CASING TYPE*	DESCRIPTION	DIA. (In.)	END DEPTH (ft.)				
B	PVC SCHED 40	4.0" ID	188				
S	PVC Slotted Screen	4.0"	198				
B	PVC SCHED 40	4.0"	200				
P	8" ID Galvanized Steel	8"	8				
* P-Protective S-Screen B-Blank O-Open N-None							
* Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION	END DEPTH (ft.)					
B	cement/Bent. Grout	172'					
S	Heavy Bentonite mud	177'					
F	silica sand	197'					
* B - Backfill S - Seal F - Filter Pack							
* Depth from Ground Surface							
COMMENTS:							

WELL 935

BOREHOLE LOG (ROCK)

Page 1 of 8

LOCATION MAP:

SITE ID: HATOI LOCATION ID: 935
SITE COORDINATES (11.):
N NK E NK
GROUND ELEVATION (11. MSL): NK
DRILLING METHOD: Rotary
DRILLING CONTR.: Beeman Drilling
DATE STARTED: 10/18/85
DATE COMPLETED: 10/19/85
FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (11.)

LOCATION DESCRIPTION East of Lower Tailings Pile
SITE CONDITION Level with sparse match brush and 4 wing salt brush

DEPTH (11.)	RODING OPERATION	% CORE RECOVERY	ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
0											
5											
10											
15											
20											

COMMENTS:

LOGGING OPERATIONS

H - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
AS - AS ROCK CORING
AC - NO WIRELINE RECY CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

see page 1

SITE ID: HAT 01 LOCATION ID: 935

SITE COORDINATES (ft.):

N _____ **E** _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.: _____

DATE STARTED: _____

DATE COMPLETED: _____

FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS:

BOEING OF 24-142

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
H1 - H1 ROCK CORING
H2 - H2 WIRELINE SLURRY CORING

BOREHOLE LOG (ROCK)

Page 3 of 8

LOCATION MAP:

see page 1

A
N
L

SITE ID: HAT01 LOCATION ID: 935

SITE COORDINATES (ft.):

2 _____ 3 _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.: _____

DATE STARTED: _____

DATE COMPLETED: _____

FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE _____

TIME

DEPTH (11.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]**COMMENTS:**

BEARING OF 26° 14' N

M - 6 1/2 HOLLOW STEM AUGER

C - 4 1/2 CONTINUOUS FLIGHT AUGER

CB - GEAR BIT

42 - 42 ROCK CORING

AC - NO WIRELINE BLOW CORING

Page 4 of 8

A
Z
W

see page 1

SITE COORDINATES (ft.):

2 _____ m _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.: _____

DATE STARTED: _____

DATE COMPLETED: _____

FIELD REP.: R. Holland

DATE	TIME	DEPTH (ft.)
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LOCATION DESCRIPTION _____

SITE CONDITION _____

80

85

90

95

COMMENTS:

BOEING DFL 40-12A

M - 6 1/2 HOLLOW STEM AUGER
 C - 4 1/2 CONTINUOUS FLIGHT AUGER
 GB - GEAR BIT
 AZ - AZ ROCK CORING
 AC - AC WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 5 of 8

LOCATION MAP:

see page 1

SITE ID: HAT01 LOCATION ID: 935
SITE COORDINATES (11.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (11.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (ft.)	DRILLING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY
100										65
101										4
102										61
103										
104										
105										
106										
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197										
198										
199										
200										

ROCK TYPE & REMARKS

COMMENTS:

DRILLING OPERATION

H - 6 1/2" HOLLOW STEM AUGER
C - 4 1/2" CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
NS - NS ROCK CORING
NC - NO WIRELINE REEF CORING

BOREHOLE LOG (ROCK)

Page 6 of 8

LOCATION MAP:

see page 1

SITE ID: HAT 01 LOCATION ID: 935

SITE COORDINATES (11.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.: _____

DATE STARTED: _____

DATE COMPLETED: _____

FIELD REP.: Roger Holland

GROUNDWATER LEVELS

DATE _____

TIME

DEPTH (11.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS:

BEARING OF 44° 12 N

M - 6 1/2 HOLLOW STEM AUGER

C - 4 1/2 CONTINUOUS FLIGHT AUGER

GB - GEAR BIT

44 - 38 8000 00000

AC - NO WIRELINE 8220 CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

see page 1

SITE ID: HAT01 LOCATION ID: 935
SITE COORDINATES (11.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: B. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (11.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH (FT.)	DRILLING OPERATION	% CORE RECOVERY	ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
155										SS ↓ silt	
160										SS/ silt ↓ LS	at 160-165 sandstone and siltstone as ab. with 50% limestone, lt to med. gray
165										LS ↓ silt	limestone as ab dec. sharply to <5%
170											sandstone and siltstone as ab. limestone as ab 0% Note: Cuttings damp @ 172' began injecting @ 174'

COMMENTS: _____

DRILLING OPERATIONS

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - BEAR BIT
N2 - N2 ROCK CORING
NC - NO WIRELINE REEF CORING

BOREHOLE LOG (ROCK)

Page 2 of 2

LOCATION MAP:

see page 1

SITE ID: HAT01 LOCATION ID: 935

SITE COORDINATES (ft.):

N _____ E _____

GROUND ELEVATION (ft. MSL): _____

DRILLING METHOD: _____

DRILLING CONTR.:

DATE STARTED: _____

DATE COMPLETED: _____

FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION

SITE CONDITION

[illegible]

COMMENTS:

ACCORDING TO [REDACTED]

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
A1 - 82 ROD CORING
A2 - 90 WIRELINE REEF CORING

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

WELL COMPLETION RECORD

SITE ID: HAT 01 LOCATION ID: 935 DATE INSTALLED: 10/20/85
APPROX. SITE COORDINATES: (FT.) N KN E KN
OPEN AREA PER LINEAL FT. (IN²/FT.) 8" bore hole with 4.5" OD / 4.0 ID casing
FORMATION OF COMPLETION: Halquita
FIELD REP.: Roger Holland DRILLER: _____

COMMENTS: _____

SITE ID: HATON LOCATION ID: 935 FIELD REP: Roger Holland
APPROX. SITE COORDINATES (FT.): N KN E KN
GROUND ELEVATION (FT. MSL): KN COMPLETION DATE: 10/20/85

BOREHOLE SUMMARY				CONSTRUCTION TIME LOG			
DRILLER: <u>Bob Beerman Drilling Co.</u>				ACTIVITY	START		END TIME
RIG TYPE: <u>Gardner Denver 1000 (Rotary)</u>					DATE	TIME	
BIT TYPE	HOLE DIA. (In.)	END DEPTH (ft.)	FLUID TYPE	DRILLING	<u>10/18/85</u>	<u>11:25 am</u>	
<u>Mission Hammer Tool</u>	<u>8.0"</u>	<u>187'</u>	<u>Air/water injection</u>		<u>10/19/85</u>	<u>6:48 am</u>	
				CASING	<u>10/20/85</u>	<u>9:15 am</u>	
				FILTER PACK	<u>10/20/85</u>	<u>10:19 am</u>	
				SEAL	<u>10/20/85</u>	<u>10:50 am</u>	
				BACKFILL	<u>10/20/85</u>	<u>11:23 am</u>	
CASING SUMMARY				DEVELOPMENT			
CASING TYPE*	DESCRIPTION		DIA. (In.)	END DEPTH (ft.)	OTHER		
<u>B</u>	<u>PVC SCHED 40</u>		<u>40±0</u>	<u>178</u>	<u>probing</u>	<u>10/19/85</u>	<u>7:12 pm</u>
<u>S</u>	<u>PVC .051" slotted</u>		<u>40"</u>	<u>188</u>			
<u>B</u>	<u>PVC SCHED 240</u>		<u>4.0"</u>	<u>190</u>			
* P-Protective G-Screen B-Blank O-Open N-None							
† Depth from Top of Casing							
WELL CONSTRUCTION				WELL DEVELOPMENT			
TYPE CODE*	DESCRIPTION		END DEPTH (ft.)				
<u>F</u>	<u>silica sand 197-166'</u>		<u>166</u>				
<u>S</u>	<u>HEAVY Bent. mud 166-160'</u>		<u>160</u>				
<u>G</u>	<u>cement/bent Grout</u>		<u>surface</u>				
• B - Backfill S - Seal F - Filter Pack				COMMENTS: <u>//</u>			
• † Depth from Ground Surface							

WELL 936

SITE ID: HAT 01 LOCATION ID: 936
SITE COORDINATES (11.):
N NK E NK
GROUND ELEVATION (11. MSL): NK
DRILLING METHOD: Rotary - Hammer Tool
DRILLING CONTR.: Beeman Drilling
DATE STARTED: 10/20/85
DATE COMPLETED: _____
FIELD REP.: Roger Holland

GROUNDWATER LEVELS		
DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION NW of the lower tailings pile and in the drainage heading under pile
SITE CONDITION Level area, sandy with some weed cover

[illegible]

COMMENTS:

BEING OF [REDACTED]

M - 5 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
AA - 42 ROCK CORING
AC - 42 WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 2 of 6

LOCATION MAP:

see page 1

SITE ID: HAT01 LOCATION ID: 936
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: Roger Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____

SITE CONDITION _____

DEPTH (ft.)	BOHNG OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY
25										slt /ss
30										
35										
40										
45										
50										

ROCK TYPE & REMARKS

COMMENTS: _____

BOHNG OPERATION

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
A1 - A2 ROCK CORING
A3 - A4 WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 3 of 6

LOCATION MAP:

see page 1

SITE ID: HATOL LOCATION ID: 936
SITE COORDINATES (11.):
N KN E KN
GROUND ELEVATION (11. MSL): KN
DRILLING METHOD: Rotary (Air Hammer)
DRILLING CONTR.: Bob Berman Drilling
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: Roger E. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (11.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (FT.)	DRILLING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
50										54 / 57	
55											
60											
65											
70											
75											

COMMENTS: _____

DRILLING OPERATIONS

H - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
AS - AS ROCK CORING
AC - NO WIRELINE ROCK CORING

BOREHOLE LOG (ROCK)

Page 4 of 4

LOCATION MAP:

see page 1

SITE ID: HAT 01 LOCATION ID: 936
SITE COORDINATES (N. E.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (ft.)	BOHING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (ROD)	% DRILLING FLUID RECOVERY	PACER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
75										514 149	
80	1 75-1			Drilling with A.I.							
85	1 75-1										
90											
95										514 149 ↓ ↓ ↓	at 95' siltstone-sandstone, maroon, purple to it green to dark red, w/fg, calc. and limestone, it gray, sandy (?)
100											

COMMENTS: _____

BOHING OPERATIONS

H - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
N1 - N2 ROD CORING
N3 - NO WIRELINE ROD CORING

BOREHOLE LOG (ROCK)

Page 2 of 4

LOCATION MAP:

SITE ID: HAT01 LOCATION ID: 936
SITE COORDINATES (ft.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (ft.)	DRILLING OPERATION	% CORE RECOVERY	% ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
125											
130											
135											
140											
145											
150											

COMMENTS:

DRILLING OPERATIONS

H - 6 1/2" HOLLOW STEM AUGER
C - 4 1/2" CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
A1 - 63" ROCK CORING
A2 - 60" WIRELINE REEL CORING

BOREHOLE LOG (ROCK)

Page 5 of 6

LOCATION MAP:

see page 1

SITE ID: HAT01 LOCATION ID: 936
SITE COORDINATES (N. E.):
N _____ E _____
GROUND ELEVATION (ft. MSL): _____
DRILLING METHOD: _____
DRILLING CONTR.: _____
DATE STARTED: _____
DATE COMPLETED: _____
FIELD REP.: R. Holland

GROUNDWATER LEVELS

DATE	TIME	DEPTH (ft.)

LOCATION DESCRIPTION _____
SITE CONDITION _____

DEPTH (ft.)	BOHNG OPERATION	% CORE RECOVERY	ROCK QUALITY DESIGNATION (RQD)	% DRILLING FLUID RECOVERY	PACKER TEST INTERVAL	SPACING	ORIENTATION	CONDITION	WEATHERING	LITHOLOGY	ROCK TYPE & REMARKS
100	Hammer Tool									SS	at 100' as ab dec to < 50% of cuttings. sandstone, white, vdfq, highly calc.
										514/155	
										↓	
105										514/155	at 105' sandstone as ab dec to < 30% of cuttings.
										↓	
110										514/155	siltstone/sandstone, chocolate brown, calc., fissile.
										↓	
											siltstone/ss as ab
115										514/155	note: cuttings damp began injecting water at 115'
										↓	
120											at 115 samples consist of siltstone to sandstone, red brown to dark red brown to chocolate brown, ss fraction vdfq, calc. to highly calc., fissile and siltstone, lt gray, calc.
125											

COMMENTS:

BOHNG OPERATIONS

M - 6 1/2 HOLLOW STEM AUGER
C - 4 1/2 CONTINUOUS FLIGHT AUGER
GB - GEAR BIT
NA - AS ROCK CORING
NC - NO WIRELINE REEL CORING

APPENDIX B

HYDROGEOLOGIC INFORMATION

HYDRAULIC CONDUCTIVITY CALCULATIONS

PACKER TESTS

CALCULATION COVER SHEET

CALC NO. HAT079H40300 DISCIPLINE Hydro NO. OF SHEETS 37

PROJECT: UMTRA

SITE: HAT01 - Mexican Hat Processing/Disposal site
SOS - Stabilization On Site

FEATURE: Packer Test Analysis - Used to determine hydraulic
conductivity of hydrostratigraphic unit (Halqueto
Shale Member) at the site

SOURCES OF DATA: Packer Test Data

HAT01 - 911
2/22/85
2/27/85
2/28/85

SOURCES OF FORMULAE & REFERENCES:

USBR, 1981 Ground Water Manual
SOP 16.1.4 - Zone 3
Computer Program in BASIC - Packer/BAS, on file w/ UMTRA
-TAC

PRELIMINARY CALC. ☒ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

		<u>R Lambert</u>	<u>7/23/91</u>	<u>Paul Good</u>	<u>8/1/91</u>	<u>KBS</u>	<u>8/7/91</u>
REV.	REVISION	CALCULATION	DATE	CHECKED	DATE	APPROVED	DATE
NO.		BY		BY		BY	

KAL
8/1/91
Cap
8/1/91

MEXICAN HAT CALCULATION HAT-07-91-14-03-00

ANALYSES OF PACKER TESTS AT MEXICAN HAT UMTRA SITE

PURPOSE

The purpose of this calculation is to estimate the change in hydraulic conductivity with depth in the Halgaito Shale in the Mexican Hat tailings pile area. This was done by conducting packer tests at different depths in borehole 911. The primary control on hydraulic conductivity in the Halgaito Shale is probably from fractures. An east-west trending fracture pattern was observed in outcrop at the site.

METHOD AND PROCEDURES

Pressure permeability tests, using packers to segregate the test section in a borehole, are used to estimate hydraulic conductivity of the interval being tested. The borehole is drilled to a given depth and a packer is seated at prescribed distances above the bottom of the borehole. Water is forced into the test section (between the packer and the bottom of the borehole) through combined applied pressure and gravity head.

The test method utilized is in conformance with the SOP from the Albuquerque Operations Manual and described in the U.S. Bureau of Reclamation Ground Water Manual (1981) (Attachment 1).

ASSUMPTIONS

Laminar flow exists within the test section.

Test water is clear and silt-free

The test water is a few degrees warmer than ground temperature. More detail on conditions specific to packer tests is given in Attachment 1.

DATA SOURCES

Field data was collected by UMTRA staff during February, 1985.

CALCULATIONS AND ANALYSES:

The packer tests were conducted on borehole 911 at the Mexican Hat site. A total of 12 tests were completed in the borehole. Input parameters for each packer test grouped according to the test interval are shown in Table 1. The field data is included in Attachment 2.

RESULTS

The input data and packer test hydraulic conductivity solutions are shown in Table 2. A summary of the resulting hydraulic

DATE

SUBJECT

BY

CHUD

SHEET NO.

JOB NO.

TABLE 1 - INPUT DATA FOR PACKER TESTS

Well ID: HAT01-911

Date: 02/22/85

Water level

Interval (ft)	Pressure (psi)	Pressure Head (ft)	Elevation Head ^a (ft)	Total Head (ft)	Flow Rate (gpm)	Interval Length A(ft)	Borehole Radius ^a r(ft)	A/c	Cond. Coeff. C _s
64.5-74.5	21.5	49.2	68.2	117.65	2.16	10	0.125	80	105
74.5-74.5	10.0	23.0	68.2	91.20	0.8	10	0.125	80	105
	15.0	34.5	68.2	102.70	1.9	10	0.125	80	105
	20.0	46.0	68.2	114.20	1.5	10	0.125	80	105
84.5-94.5	25.0	52.5	68.2	125.70	1.5	10	0.125	80	105
	30.0	59.0	68.2	137.2	0	10	0.125	80	105
94.5-104.5	20.0	46.0	68.2	114.2	1.4	10	0.125	80	105
	22.0	50.6	68.2	118.8	0.1	10	0.125	80	105
	25.0	57.5	68.2	125.7	0.02	10	0.125	80	105
	30.0	69.0	68.2	137.2	0.09	10	0.125	80	105
53.5-64.5	11.0	25.3	62.2-68.2	87.5-93.5	5.17	10	0.125	80	110
	12.0	27.6	62.2-68.2	89.8-95.8	4.86	11	0.125	88	110

a. Packer Test Data (UMTRA PDCS) File HAT 9.19.2.5, JEG/JEG-0285-914J

b. Volume removed ± elapsed time

TABLE 2 INPUT AND SOLUTIONS PACKER TESTS

KAL
8/11/91
FOR 8/1

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 911
DATE: 02/22/85
TEST INTERVAL 53.5 TO 64.5
NET TEST PRESSURE, FT OF WATER = 94.65
FLOW RATE (GPM) = 5.11 = 0.0114 cfs
A/R = 88
CONDUCTIVITY COEFFICIENT = 110
r = 0.125 ft

METHOD 1
PERMEABILITY (FT/SEC) = 8.44175E-06 = 0.73 ft/day
PERMEABILITY (CM/SEC) = 2.57305E-04

✓ KAL
7/11/91
✓ cap

METHOD 2
PERMEABILITY (FT/SEC) = 8.74873E-06 = 0.76 ft/day
PERMEABILITY (CM/SEC) = 2.66661E-04
PACKER TEST PERMEABILITY

✓ KAL
7/11/91
✓ cap

SITE: HAT01
BOREHOLE: 911
DATE: 02/22/85
TEST INTERVAL 64.5 TO 74.5
NET TEST PRESSURE, FT OF WATER = 117.65
FLOW RATE (GPM) = 2.16 = 0.005 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1
PERMEABILITY (FT/SEC) = 3.00243E-06 = 0.26 ft/day
PERMEABILITY (CM/SEC) = 9.1514E-05

✓ KAL
7/11/91
✓ cap

METHOD 2
PERMEABILITY (FT/SEC) = 3.11681E-06 = 0.27 ft/day
PERMEABILITY (CM/SEC) = 9.50002E-05
PACKER TEST PERMEABILITY

✓ KAL
7/11/91
✓ cap

TABLE 2 CONT.

KAL
8/1/91
ca
8/1/

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 911
DATE: 02/21/85
TEST INTERVAL 64.5 TO 74.5
NET TEST PRESSURE, FT OF WATER = 117.65
FLOW RATE (GPM) = 5.11
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1
PERMEABILITY (FT/SEC) = $2.10296E-06$ = 0.61 ^{FT}/day
PERMEABILITY (CM/SEC) = $2.16498E-04$

METHOD 2
PERMEABILITY (FT/SEC) = $7.37355E-06$ = 0.64 ^{FT}/day
PERMEABILITY (CM/SEC) = $2.24746E-04$
PACKER TEST PERMEABILITY

NOT VALID

SITE: HAT01
BOREHOLE: 911
DATE: 02/22/85
TEST INTERVAL 74.5 TO 84.5
NET TEST PRESSURE, FT OF WATER = 91.2
FLOW RATE (GPM) = .8 = 0.002 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1
PERMEABILITY (FT/SEC) = $1.43452E-06$ = 0.12 ^{FT}/day
PERMEABILITY (CM/SEC) = $4.37241E-05$

METHOD 2
PERMEABILITY (FT/SEC) = $1.48917E-06$ = 0.13 ^{FT}/day
PERMEABILITY (CM/SEC) = $4.53898E-05$
PACKER TEST PERMEABILITY

✓ KAL 7/11/91 ✓ cap

✓ KAL 7/11/91 ✓ cap

SITE: HAT01
BOREHOLE: 911
DATE: 02/22/85
TEST INTERVAL 74.5 TO 84.5
NET TEST PRESSURE, FT OF WATER = 102.7
FLOW RATE (GPM) = 1.9 = 0.004 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105 ✓

METHOD 1
PERMEABILITY (FT/SEC) = $3.02548E-06$ = 0.26 ^{FT}/day
PERMEABILITY (CM/SEC) = $9.22165E-05$

METHOD 2
PERMEABILITY (FT/SEC) = $3.14073E-06$ = 0.27 ^{FT}/day
PERMEABILITY (CM/SEC) = $9.57295E-05$

✓ KAL 7/11/91 ✓ cap

✓ KAL 7/11/91 ✓ cap

TABLE 2 CONT.

KAL 8/1/91 5
cap 8/1/91

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 911
DATE: 02/22
TEST INTERVAL 74.5 TO 84.5
NET TEST PRESSURE, FT OF WATER = 114.2
FLOW RATE (GPM) = 1.5 = 0.003 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $2.14801E-06$ = 0.19 FT/day
PERMEABILITY (CM/SEC) = $6.54713E-05$

✓ KAL 7/11/91 ✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $2.22984E-06$ = 0.19 FT/day
PERMEABILITY (CM/SEC) = $6.79654E-05$

✓ KAL 7/11/91 ✓ cap

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 911
DATE: 02/27/85
TEST INTERVAL 84.5 TO 94.5
NET TEST PRESSURE, FT OF WATER = 125.7
FLOW RATE (GPM) = 1.5 = 0.003 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $1.95149E-06$ = 0.17 FT/day
PERMEABILITY (CM/SEC) = $5.94815E-05$

✓ KAL 7/11/91 ✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $2.02583E-06$ = 0.18 FT/day
PERMEABILITY (CM/SEC) = $6.17474E-05$

✓ KAL 7/11/91 ✓ cap

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 911
DATE: 02/27/85
TEST INTERVAL 84.5 TO 94.5
NET TEST PRESSURE, FT OF WATER = 137.2
FLOW RATE (GPM) = 0
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

✓ KAL 7/11/91

METHOD 1

PERMEABILITY (FT/SEC) = 0
PERMEABILITY (CM/SEC) = 0

✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = 0
PERMEABILITY (CM/SEC) = 0

KAL
8/1/91 Ca
8/1

TABLE 2 - CONT

PACKER TEST PERMEABILITY

SITE: HAT01
BOREHOLE: 511
DATE: 02/28/85
TEST INTERVAL 94.5 TO 104.5
NET TEST PRESSURE, FT OF WATER = 114.2
FLOW RATE (GPM) = 1.4 = 0.003 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $2.00481E-06$ = 0.17 FT/day
PERMEABILITY (CM/SEC) = $6.11065E-05$

✓ KAL 7/11/91
✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $2.08118E-06$ = 0.18 FT/day
PERMEABILITY (CM/SEC) = $6.34344E-05$
PACKER TEST PERMEABILITY

✓ KAL 7/11/91
✓ cap

SITE: HAT01
BOREHOLE: 511
DATE: 02/28/85
TEST INTERVAL 94.5 TO 104.5
NET TEST PRESSURE, FT OF WATER = 118.8
FLOW RATE (GPM) = .1 = 0.0002 cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $1.37656E-07$ = 0.01 FT/day
PERMEABILITY (CM/SEC) = $4.19575E-06$

✓ KAL 7/11/91
✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $1.429E-07$ = 0.01 FT/day
PERMEABILITY (CM/SEC) = $4.35558E-06$
PACKER TEST PERMEABILITY

✓ KAL 7/11/91
✓ cap

SITE: HAT01
BOREHOLE: 511
DATE: 02/28/85
TEST INTERVAL 94.5 TO 104.5
NET TEST PRESSURE, FT OF WATER = 125.7
FLOW RATE (GPM) = .02 = 4.5×10^{-5} cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $2.60199E-08$ = 0.002 FT/day
PERMEABILITY (CM/SEC) = $7.93086E-07$

✓ KAL 7/11/91
✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $2.70111E-08$ = 0.002 FT/day
PERMEABILITY (CM/SEC) = $8.23299E-07$

✓ KAL 7/11/91
✓ cap

TABLE 2-CONT.

PACKER TEST PERMEABILITY

KAL
7/11/91
cc
8/1

SITE: HAT01
BOREHOLE: 911
DATE: 02/28/85
TEST INTERVAL 94.5 TO 104.5
NET TEST PRESSURE, FT OF WATER = 137.2
FLOW RATE (GPM) = .09 = 2×10^{-4} cfs
A/R = 80
CONDUCTIVITY COEFFICIENT = 105

METHOD 1

PERMEABILITY (FT/SEC) = $1.07275E-07$ = 0.01 FT/day
PERMEABILITY (CM/SEC) = $3.26975E-06$

✓ KAL
7/11/91
✓ cap

METHOD 2

PERMEABILITY (FT/SEC) = $1.11362E-07$ = 0.01 FT/day
PERMEABILITY (CM/SEC) = $3.39431E-06$

✓ KAL
7/11/91
✓ cap

KAL
8/1/91
Cay
8/1/91

conductivities by depth interval is shown in Table 3.

CONCLUSIONS

Based on analyses of packer tests conducted in monitor well 911 at different depths in the Halgaito Shale, there is a decrease in hydraulic conductivity with depth (Table 3). There is over an order of magnitude decrease in hydraulic conductivity from the shallowest section tested (53.5 - 64.5 feet) to the deepest section tested (94.5 to 104.5 feet). This provides evidence that either fracture density decreases with depth or fracture width decreases with depth due to occlusion from crystal growth or other means. Given the very low hydraulic conductivity of the lower Halgaito Shale, this zone may act as an aquitard to the underlying Honaker Trail Formation.

REFERENCES

Albuquerque Operations Manual, SOP 16.1.4

U.S. Bureau of Reclamation, 1981, Ground Water Manual, Water Resources Technical Publication, pp. 249 - 264.

Computer Program in BASIC - Packer/BAS, On file w/
UMTRA-TAC

KAL
8/6/91

TABLE 3 - Summary
Packer Test Results

✓ KAL 7/23/91 Co 8/1

7/23/91 SITE ID: HAT01-911

Date	Interval (ft)	Hydraulic Conductivity ^a (ft/day)		
		Method 1	Method 2	Average
2/22/85	53.5 - 64.5	0.73	0.76	0.745 ^a
	64.5 - 74.5	0.26	0.27	0.265 ^a
	74.5 - 84.5	0.12	0.13	0.194 ^a
		0.26	0.27	
		0.19	0.19	
2/27/85	84.5 - 94.5	0.17	0.18	0.175 ^a
		0	0	
2/28/85	94.5 - 104.5	0.17	0.18	0.014 ^b
		0.01	0.01	
		0.002	0.002	
		0.01	0.01	

GEOMETRIC MEAN FOR TOTAL
HALGATO SHALE THICKNESS: 0.16
ft/day

a: ARITHMETIC MEAN

b: GEOMETRIC MEAN

GEOMETRIC MEAN OF ALL HYDRAULIC
CONDUCTIVITIES FROM EACH INTERVAL IN
911 AND 912 (912 K from Calc. HAT01-07-91-
14-02-00):

$$= (0.6 \times 0.745 \times 0.265 \times 0.194 \times 0.175 \times 0.014)^{1/6}$$

$$= \underline{0.20}$$

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SUBJECT _____

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BY _____ CHKD. _____

JOB NO. _____

ATTACHMENT 1

PACKER TEST (PRESSURE PERMEABILITY)

METHODOLOGY

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the test section
against a total
test.

other as recom-
seriously influ-
efficiency, and
pipes, and un-
be avoided.

re applicable for
occurs depends
ctors, but a safe
laminar is about
nt of the water
area of the test
he tested mate-
ns may not be

section is com-

(1)

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(2)

area must be
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open area may
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divided into
ts, and falling
vity tests are
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section in the hole. In pressure tests, water is forced into the test section through combined applied pressure and gravity head, although the tests can be performed using gravity head only. In falling head tests, gravity head only is used. Constant head gravity tests are those in which no packers are used, and a constant water level is maintained [1].

Pressure Permeability Tests in Stable Rock.—Pressure permeability tests are run using one or two packers to isolate various zones or lengths of drill hole in stable rock. Hole diameters usually do not exceed $3\frac{1}{4}$ inches, but larger holes can also be tested if suitable equipment is available. The tests may be run in vertical, angled, or horizontal holes and analyzed if the head and zone relationships can be determined. Pressure tests are often the only practical tests to use when it is necessary to determine permeability of streambeds or lakebeds below water.

Compression packers, inflatable packers, leather cups, and similar types of packers have been used for pressure testing. Inflatable packers are usually more economical because they reduce testing time and assure a tighter seal, particularly in rough-walled or out-of-round holes. The packers are inflated through tubes extending to a cylinder of air or nitrogen at the surface. If a pressure sensing instrument is included, pressure in the test section is sensed by the instrument and is transmitted to the surface by an electrical circuit where it is either read from a register at the surface or is recorded on a chart. Although this arrangement permits an accurate determination of test pressures, other observations outlined in this section should still be made to permit an estimate of permeability should the pressure sensor fail. This double packer arrangement permits successive tests at different depths in a completed hole without having to remove the packer between each test. The pressure sensor can also be adapted where a single packer is used.

(a) *Methods of Testing.*—The most common testing practice by the Bureau is the drilling of about 10 feet of hole and pressure testing the newly drilled section. In rock that tends to ravel or bridge the hole and which must be cemented to permit continuation of drilling, this is the only practical method of testing. In such rock, long lengths of open hole are impractical and the test sections must be kept short because the tests must be made before the hole is cemented if good test data are to be obtained.

Where the rock is stable and does not require cementing, the following method of testing may offer distinct advantages. The hole

* Numbers in brackets refer to items in the bibliography, section 10-5.

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is drilled to the total depth without testing. Two inflatable packers 5 to 10 feet apart are mounted near the bottom of the rod or pipe used for making the test. The bottom of the rod or pipe is sealed, and the section between the packers is perforated. The perforations should be at least one quarter of an inch in diameter, and the total area of all perforations should be greater than two times the inside cross-sectional area of the pipe or rod. Tests are made beginning at the bottom of the hole. After each test, the packers are raised the length of the test section and another test made. This procedure is followed until the entire length of the hole has been tested.

(b) *Cleaning Test Sections Before Testing.*—Before each test, the test section should be surged with clear water and bailed out to clean cuttings and drilling fluid from the face of the hole. If the test section is above the water table and will not hold water, water should be poured into the hole during the surging, then bailed out as rapidly as possible. When a completed hole is tested using two packers, the entire hole can be cleaned in one operation. Cleaning the hole is frequently omitted from testing procedures; however, this omission may result in a permeable rock appearing to be impermeable because the hole face is sealed by cuttings or drilling fluid. In such cases, the computed permeability will be lower than the true permeability.

Alternative methods to surging and bailing a drill hole in consolidated formations before pressure testing include the use of a rotating, stiffly bristled brush while washing and jetting with water. An average jet velocity of 150 feet per second is desirable. This is approximated by a rate of pumping equal to 1.4 gallons per minute per $\frac{1}{8}$ -inch-diameter hole in the rod. On completion of jetting, the hole should be blown or bailed out to the bottom, if possible.

(c) *Length of Test Section.*—The length of the test section is governed by the character of the rock, but generally a length of 10 feet is desirable. At times, a good seal cannot be obtained for the packer at the planned elevation because of bridging, raveling, or the presence of fractures. Under these circumstances, the test section length should be increased or decreased or test sections overlapped to assure that the test is made with well-seated packers. On some tests, a 10-foot section will take more water than the pump can deliver; hence, no back pressure can be developed. When this occurs, the length of the test section should be shortened until back pressure can be developed, or the falling head test (sec. 10-4) might be tried.

The test sections should never be shortened to where the ratio $\frac{A}{D}$ is less than 5, where D is the diameter of the hole and A is the length of the test section. Under no circumstances should a packer be set inside

the casing when making the hole. Except in sections greater than sections may not pack and may complicate

(d) *Size of Rod or* used as intake pipe and NW rods can be the reliability of the exceed 12 to 15 gallon test section does not larger pipe is more head losses per 10-foot different sizes of drill piled from experience. pipe, particularly when is obvious from stuck pipe must be turned use in AX holes.

(e) *Pumping Equipment* pump for pumping the cylinder type with pumps have a maximum and, if not in good condition 18 gallons per minute analyze because such back pressure in the the tests are general developed." This results of the material tested pressures of multiple used, are often difficult readings must be average pressure, a difficulty such pumps occasionally causes which may fracture

Permeability tests using centrifugal pump pressure. A pump is against a total head Head and discharge engine speed or with

(f) *Swivels for Use* selected for minimum

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the casing when making a test unless the casing has been grouted in the hole. Except under the most adverse conditions, the use of test sections greater than 20 feet in length is inadvisable. Longer test sections may not permit sufficient localization of permeable zones and may complicate computations.

(d) *Size of Rod or Pipe to Use in Tests.*—Drill rods are commonly used as intake pipes to make pressure and permeability tests. NX and NW rods can be used for this purpose without seriously affecting the reliability of the test data, if the intake of the test section does not exceed 12 to 15 gallons per minute and the depth to the top of the test section does not exceed 50 feet. For general use, 1½-inch or larger pipe is more satisfactory. Figures 10-1 through 10-4 show head losses per 10-foot section at various deliveries of water for different sizes of drill rod and 1½-inch pipe. These figures were compiled from experimental tests. The desirability of using the 1½-inch pipe, particularly where holes 50 feet or more in depth are to be tested, is obvious from study of the graphs. The couplings on the 1½-inch pipe must be turned down to an outside diameter of 1.8 inches for use in AX holes.

(e) *Pumping Equipment.*—Tests are commonly run using a mud pump for pumping the water. Such pumps are generally of the multiple cylinder type with a uniform fluctuation in pressure. Many of these pumps have a maximum capacity of about 25 gallons per minute and, if not in good condition, the capacities may be as small as 17 to 18 gallons per minute. Tests are often difficult, if not impossible, to analyze because such pumps do not have sufficient capacity to develop back pressure in the length of hole being tested. When this happens, the tests are generally reported: "took capacity of pump, no pressure developed." This result does not permit determination of permeability of the material tested other than it is probably high. The fluctuating pressures of multiple cylinder pumps, even when an air chamber is used, are often difficult to read accurately because the high and low readings must be averaged to determine the approximate true effective pressure, a difficulty which may be a source of error. In addition, such pumps occasionally develop instantaneous excessively high pressures which may fracture the rock or blow out a packer.

Permeability tests made in drill holes ideally should be performed using centrifugal pumps having sufficient capacity to develop back pressure. A pump with a capacity of up to 250 gallons per minute against a total head of 160 feet would be adequate for most testing. Head and discharge of such pumps are easily controlled by changing engine speed or with a control valve on the discharge.

(f) *Swivels for Use in Tests.*—Swivels used for testing should be selected for minimum head losses.

(g) *Location of Pressure Gage in Tests.*—The ideal location for a pressure gage is near the well head, preferably between the packer and the swivel.

(h) *Recommended Watermeters.*—Required water deliveries in pressure tests may range from less than 1 gallon per minute to as much as 400 gallons per minute. No one meter is sufficiently accurate at all ranges to be reliably used. Therefore, two meters are recommended: (1) a 4-inch propeller or impeller-type meter to measure flows between 50 and 350 gallons per minute; and (2) a 1-inch disk-type meter for flows between 1 and 50 gallons per minute. Ideally, each meter should be equipped with an instantaneous flow indicator as well as a totalizer. Watermeters should be tested frequently to assure reliability.

Inlet pipe adapters should be available for each meter to minimize turbulent inflow. The adapters should be at least 10 times as long as the diameter of the rated size of the meter.

(i) *Length of Time for Tests.*—The minimum length of time to run a test depends upon the nature of the material tested. Tests should be run until stabilization occurs; that is, until three or more readings of water intake and pressure taken at 5-minute intervals are essentially equal. In tests above the water table, water should be pumped into the test section at the desired pressure for about 10 minutes in coarse materials or 20 minutes in fine-grained materials before making measurements.

Stability is obtained more rapidly in tests below the water table than in unsaturated material. When multiple pressure tests are made, each pressure theoretically should be maintained until stabilization occurs. This is not practicable in some cases, however, but good practice requires that each pressure stop be maintained for at least 20 minutes with intake and pressure readings made at 5-minute intervals as the pressure is increased and for 5 minutes as pressure is decreased.

(j) *Pressures to be Used in Testing.*—Where subsurface conditions for proposed reservoirs or other water-impounding or storage facilities are being investigated, the theoretical minimum pressure used in the test section should equal the head imposed by the maximum reservoir level. However, when tests are made in locations where the ground surface is below the proposed maximum pool level, the use of such test pressures may be impractical because of the danger of blowouts or fracturing the hole face. Under these conditions, a safe pressure in consolidated rock is 0.5 pound per square inch, or 1.15 feet of water per foot of depth from the ground surface to the top of the test section. In all other locations, the same criterion is a good rule-of-thumb guide. Tables 10-1 and 10-2 are provided for converting pounds per square inch to feet of water and vice versa, respectively.

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PERMEABILITY TEST

TABLE 10-1.—Conversion of pressures in pounds

Weight of Water

HEAD IN FEET	0	1	2	3
0	—	0.43	0.87	1.3
10	4.33	4.77	5.20	5.6
20	8.67	9.10	9.54	9.9
30	13.00	13.44	13.87	14.3
40	17.34	17.77	18.21	18.6
50	21.67	22.11	22.54	22.9
60	26.01	26.44	26.88	27.3
70	30.34	30.78	31.21	31.6
80	34.68	35.11	35.55	35.9
90	39.01	39.45	39.88	40.3
100	43.35	43.78	44.22	44.6
110	47.68	48.12	48.55	48.9
120	52.02	52.45	52.89	53.3
130	56.36	56.79	57.22	57.6
140	60.69	61.12	61.56	61.9
150	65.02	65.46	65.89	66.3
160	69.36	69.79	70.23	70.6
170	73.69	74.13	74.56	75.0
180	78.03	78.46	78.90	79.3
190	82.36	82.80	83.23	83.6
200	86.70	87.13	87.57	88.0

(k) *Arrangement of Equipment*—test equipment starting at the

Source of water, suction storage tank or basin, watermeter adapter (if required), pipe, plug valve, water rod to packer. All connections as possible with a minimum hose, pipe, etc.

All joints, connections, and packer or casing should be tight meter and the test section.

(l) *Pressure Permeability*—The following two methods are

PERMEABILITY TESTS IN INDIVIDUAL DRILL HOLES

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TABLE 10-1.—Conversion of heads of water in feet to hydrostatic pressures in pounds per square inch. 103-D-1486.

Weight of Water - 62.4 pounds per cubic foot

HEAD IN FEET	ADDITIONAL UNITS									
	0	1	2	3	4	5	6	7	8	9
0	—	0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.47	3.90
10	4.33	4.77	5.20	5.64	6.07	6.50	6.94	7.37	7.80	8.24
20	8.67	9.10	9.54	9.97	10.40	10.84	11.27	11.70	12.14	12.57
30	13.00	13.44	13.87	14.31	14.74	15.17	15.61	16.04	16.47	16.91
40	17.34	17.77	18.21	18.64	19.07	19.51	19.94	20.37	20.81	21.24
50	21.67	22.11	22.54	22.98	23.41	23.84	24.28	24.71	25.14	25.58
60	26.01	26.44	26.88	27.31	27.74	28.18	28.61	29.04	29.48	29.91
70	30.34	30.78	31.21	31.65	32.08	32.51	32.95	33.38	33.81	34.25
80	34.68	35.11	35.55	35.98	36.41	36.85	37.28	37.71	38.15	38.58
90	39.01	39.45	39.88	40.32	40.75	41.18	41.62	42.05	42.48	42.92
100	43.35	43.78	44.22	44.65	45.08	45.52	45.95	46.38	46.82	47.25
110	47.68	48.12	48.55	48.99	49.42	49.85	50.29	50.72	51.15	51.59
120	52.02	52.45	52.89	53.32	53.75	54.19	54.62	55.05	55.49	55.92
130	56.36	56.79	57.22	57.66	58.09	58.52	58.96	59.39	59.82	60.26
140	60.69	61.12	61.56	61.99	62.42	62.86	63.29	63.72	64.16	64.59
150	65.02	65.46	65.89	66.33	66.76	67.19	67.63	68.06	68.49	68.93
160	69.36	69.79	70.23	70.66	71.09	71.53	71.96	72.39	72.83	73.26
170	73.69	74.13	74.56	75.00	75.43	75.86	76.30	76.73	77.16	77.60
180	78.03	78.46	78.90	79.33	79.76	80.20	80.63	81.06	81.50	81.93
190	82.36	82.80	83.23	83.67	84.10	84.53	84.97	85.40	85.83	86.27
200	86.70	87.13	87.57	88.00	88.43	88.87	89.30	89.73	90.17	90.60

(k) *Arrangement of Equipment.*—Recommended arrangement of test equipment starting at the source of water is as follows:

Source of water, suction line, pump, waterline to settling and storage tank or basin, suction line, centrifugal test pump, line to watermeter adapter (if required) or to watermeter, short length of pipe, plug valve, waterline to swivel, sub for gage, and pipe or rod to packer. All connections should be kept as short and straight as possible with a minimum number of changes in diameter of hose, pipe, etc.

All joints, connections, and hose between the watermeter and the packer or casing should be tight so no water loss occurs between the meter and the test section.

(l) *Pressure Permeability Test Methods.*—A schematic drawing of the following two methods is shown on figure 10-5.

TABLE 10-2.—Conversion of hydrostatic pressures in pounds per square inch to heads of water in feet. 103-D-1487.

POUNDS PER SQ. INCH	ADDITIONAL UNITS									
	0	1	2	3	4	5	6	7	8	9
0	—	2.31	4.62	6.93	9.24	11.55	13.86	16.17	18.48	20.79
10	23.10	25.41	27.72	30.03	32.34	34.65	36.96	39.27	41.58	43.89
20	46.20	48.51	50.82	53.13	55.44	57.75	60.06	62.37	64.68	66.99
30	69.30	71.61	73.92	76.23	78.54	80.85	83.16	85.47	87.78	90.09
40	92.40	94.71	97.02	99.33	101.64	103.95	106.26	108.57	110.88	113.19
50	115.50	117.81	120.12	122.43	124.74	127.05	129.36	131.67	133.98	136.29
60	138.60	140.91	143.22	145.53	147.84	150.15	152.46	154.77	157.08	159.39
70	161.70	164.01	166.32	168.63	170.94	173.25	175.56	177.87	180.18	182.49
80	184.80	187.11	189.42	191.73	194.04	196.35	198.66	200.97	203.28	205.59
90	207.90	210.21	212.52	214.83	217.14	219.45	221.76	224.07	226.38	228.69
100	231.00	233.31	235.62	237.93	240.24	242.55	244.86	247.17	249.48	251.79
110	254.10	256.41	258.72	261.03	263.34	265.65	267.96	270.27	272.58	274.89
120	277.20	279.51	281.82	284.13	286.44	288.75	291.06	293.37	295.68	297.99
130	300.30	302.61	304.92	307.23	309.54	311.85	314.16	316.47	318.78	321.09
140	323.40	325.71	328.02	330.33	332.64	334.95	337.26	339.57	341.88	344.19
150	346.50	348.81	351.12	353.43	355.74	358.05	360.36	362.67	364.98	367.29
160	369.60	371.91	374.22	376.53	378.84	381.15	383.46	385.77	388.08	390.39
170	392.70	395.01	397.32	399.63	401.94	404.25	406.56	408.87	411.18	413.49
180	415.80	418.11	420.42	422.73	425.04	427.35	429.66	431.97	434.28	436.59
190	438.90	441.21	443.52	445.83	448.14	450.45	452.76	455.07	457.38	459.69
200	462.00	464.31	466.62	468.93	471.24	473.55	475.86	478.17	480.48	482.79

Method 1: This method is primarily applicable to testing in consolidated rock which requires casing as the hole is drilled, although it may be used in stable material if desired. The hole is drilled, the tools removed, a packer seated a given distance above the bottom of the hole, water under pressure is pumped into the test section, and the readings recorded. The packer is then removed, the hole drilled deeper, the packer is inserted so as to leave the full length of the newly drilled hole within the test section, and the test repeated.

Method 2: This method is applicable in consolidated rock which is stable and does not require cementing. The hole is drilled to the final depth, cleaned, and blown out or bailed. Two packers, spaced on pipe or drill stem to isolate the desired test section, are used. Tests should be started at the bottom of the hole. After each test, the pipe is lifted a distance equal to the *A* dimension shown on figure 10-5 and the test repeated until the entire hole is tested.

K = coefficient of permeability, feet per second under a unit gradient
Q = steady flow into well, ft³/s
H = $h_1 + h_2 - L$ = effective head, ft
h (above water table) = distance between Bourdon gage and bottom of hole for method 1 or distance between gage and upper surface of lower packer for method 2, ft
h (below water table) = distance between gage and water table, ft
*h*₂ = applied pressure at gage, 1 lb/in² = 2.307 ft of water
L = head loss in pipe due to friction, ft; ignore head loss for *Q* < 4 gal/min in 1.5 - inch pipe; use length of pipe between gage and top of test

K = coefficient of permeability, feet per second under a unit gradient
 Q = steady flow into well, ft^3/s
 $H = h_1 + h_2 - L$ = effective head, ft
 h_1 (above water table) = distance between Bourdon gage and bottom of hole for method 1 or distance between gage and upper surface of lower packer for method 2, ft
 h_2 (below water table) = distance between gage and water table, ft
 h_3 = applied pressure at gage, 1 $\text{lb}/\text{in}^2 = 2.307$ ft of water
 L = head loss in pipe due to friction, ft; ignore head loss for $Q < 4$ gpm/mm in $1\frac{1}{2}$ -inch pipe; use length of pipe between gage and top of test section for computations
 $X = \frac{U}{U+H} (100)$ = percent of unsaturated stratum
 A = length of test section, ft
 r = radius of test hole, ft
 C_u = conductivity coefficient for unsaturated materials with partially penetrating cylindrical test wells
 C_s = conductivity coefficient for semi-spherical flow in saturated materials through partially penetrating cylindrical test wells
 U = thickness of unsaturated material, ft
 S = thickness of saturated material, ft
 $T_u = U - D + H$ = distance from water surface in well to water table, ft
 D = distance from ground surface to bottom of test section, ft
 a = surface area of test section, ft^2 ; area of wall plus area of bottom for method 1; area of wall for method 2
 Limitations:
 $Q/a \leq 0.10$, $S \geq 5A$, $A \geq 10r$, thickness of each packer must be $\geq 10r$ in method 2

FIGURE 10-5.—Permeability test for use in saturated or unsaturated consolidated rock [4]. 103-D-1474.

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Data required for computing the permeability may not be available until the hole has encountered the water table or a relatively impermeable bed. The required data for each test include:

1. Radius r of the hole, in feet.
2. Length of test section A , the distance between the packer and the bottom of the hole, method 1, or between the packers, method 2, in feet.
3. Depth h_1 from pressure gage to bottom of the hole, method 1, or from gage to upper surface of lower packer in method 2, in feet. If a pressure sensor is used, substitute the pressure recorded in test section prior to pumping for the h_1 value.
4. Applied pressure h_2 at the gage, in feet, or the pressure recorded during pumping in test section if a sensor is used.
5. Steady flow Q into well at 5-minute intervals, in ft^3/s .
6. Nominal diameter in inches and length of intake pipe in feet between the gage and upper packer.
7. Thickness U of unsaturated material above water table, in feet.
8. Thickness S of saturated material above a relatively impermeable bed, in feet.
9. Distance D from the ground surface to the bottom of the test section, in feet.
10. The time that the test is started and time measurements are made.
11. If tests are made in streambeds or lakebeds below water, the effective head is the difference in feet between the elevation of the free water surface in the pipe and the elevation of the gage plus the applied pressure.
12. If a pressure sensor is used, the effective head in the test section is the difference in pressure before water is pumped into the test section and the pressure readings made during the test.

The following examples show some typical calculations using methods 1 and 2 in the different zones shown on figure 10-5. Figure 10-6 shows the location of the zone 1 lower boundary for use in unsaturated materials.

PRESSURE PERMEABILITY TESTS EXAMPLES OF METHODS 1 AND 2

Example 1:

Zone 1—Method 1

Given: $U=75$ ft, $D=25$ ft, $A=10$ ft, $r=0.5$ ft,
 $h_1=32$ ft, $h_2=25$ lb/in²=57.8 ft, and
 $Q=20$ gal/min=0.045 ft^3/s .

PERMEABILITY TEST

FIGURE 10-6.—Location of zone 1 lower boundary [4].

From figure 10-4: Head loss = 0.76 foot per 10-foot section. the bottom of the pipe is 22

$$H = h_1 + h_2 - L = 32 + 57.8 - 1.076 = 88.724$$

$$T_s = U - D + H = 75 - 25 + 88.724 = 138.724$$

$$X = \frac{H}{T_s} (100) = \frac{88.724}{138.724} (100) = 63.96$$

$$\frac{T_s}{A}$$

The values for X and $\frac{T_s}{A}$ lie in the zone 1 lower boundary conductivity coefficient C_s from figure 10-5.

$$\frac{H}{r}$$

$$\frac{A}{H} = \frac{10}{88.724}$$

Then,

$$K = \frac{Q}{C_s H} = \frac{0.045}{0.1116 \times 88.724} = 0.0045$$

JACOBS ENGINEERING

DATE _____

SUBJECT _____

BY _____ CHKD. _____

SHEET NO. 8/1/91

JOB NO. 8/1/91

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ATTACHMENT 2

PACKER TEST FIELD DATA

KHL 2C
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8/1/91

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Page 1 of 2

PACKER (DRILL STEM) TEST

SITE ID: HAT-01 LOCATION ID: 911 LOG DATE: 2-21-85
LOGGING COMPANY: Jacobs/SH13 FIELD REP.: R. Holland
TESTED INTERVAL:
BEGINNING DEPTH 64.5 END DEPTH 74.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL Siltstone 64.5-74.5
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 74.5 DIA. (IN.) 3.0
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) NA
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) NA
(AT START OF FIRST TEST)

Note Soil Reading on meter 2361.0

TIME INTERVAL (MIN)	VOLUME REMOVED (GAL) ft^3	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
0.5	1.15		200
1.0	1.3	22 21.5	
1.5	1.4		
2.0	1.5		
2.5	1.55		
3.0	1.7	22 21.5	
3.5	1.8		
4.0	1.9		
4.5	2.02		
5.0	2.15		
5.5	2.26		
6.0	2.37		
6.5	2.50		
7.0	2.62	22 21.5	
7.5	2.73		
8.0	2.84		
8.5	2.95		

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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Page 8 of 8

PACKER (DRILL STEM) TEST

SITE ID: HAT-01 LOCATION ID: 911 LOG DATE: 2/21/85

LOGGING COMPANY: Jacobs/SHB FIELD REP.: R. Holland

TESTED INTERVAL:

BEGINNING DEPTH 64.5 END DEPTH 74.5 (FT. BELOW DATUM)

SOIL/ROCK INTERVAL _____

BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) _____ DIA. (IN.) _____

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) _____

STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) _____

(AT START OF FIRST TEST)

TIME INTERVAL (MIN)	VOLUME REMOVED (GAL) ft^3	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
9.0	3.06	21.5	200
9.5	3.16		
10.0	3.27		
10.5	3.39		
11.0	3.50		
11.5	3.61		
12.0	3.72		
12.5	3.82		
13.0	3.92		
13.5	4.02		
14.0	4.12	20	
14.5	4.23		
15.0	4.34		

EQUIPMENT DESCRIPTION: Air wire line Packer

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TOP PACKER: DEPTH (FT. BELOW DATUM) 64.5 LENGTH (FT.) 7'

PACKER TYPE: (S)INGLE (D)OUBLE 2 TEST INTERVAL LENGTH (FT.) 10'

COMMENTS: End of Packer Test at 3:00 pm.

NOTE: DATUM = GROUND SURFACE

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ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

SITE ID: HAT 01 LOCATION ID: 911 LOG DATE: 850221
LOGGING COMPANY: JEG FIELD REP.: R. Holland
TESTED INTERVAL:
BEGINNING DEPTH 64.5 END DEPTH 74.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL ST-3
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 74.5 DIA. (IN.) 3.0
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2
(AT START OF FIRST TEST) 4292.0

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
0.5	8.60	21.5	200
1.0	1.12		
1.5	0.75		
2	0.75		
2.5	0.37		
3	1.12		
3.5	0.75		
4	0.75		
4.5	0.90		
5	0.97		
5.5	0.82		
6	0.82		
6.5	0.97		
7	0.90		
7.5	0.83		
8	0.82		
8.5	0.82		

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (9/84)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

SITE ID: HKT01 LOCATION ID: 911 LOG DATE: 850221

LOGGING COMPANY: JEG FIELD REP.: R. Holland

TESTED INTERVAL:

BEGINNING DEPTH 64.5 END DEPTH 74.5 (FT. BELOW DATUM)

SOIL/ROCK INTERVAL ST-3

BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 74.5 DIA. (IN.) _____

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3

STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2

(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
9.0	0.82	21.5	20.0
9.5	0.75		
10	0.82		
10.5	0.90		
11	0.82		
11.5	0.82		
12	0.82		
12.5	0.75		
13	0.75		
13.5	0.75		
14	0.75		
14.5	0.82		
15	0.82		

EQUIPMENT DESCRIPTION:

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (8/84)

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TESTED INTERVAL:

SOIL/ROCK INTERVAL ST - 3

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3

(AT START OF FIRST TEST)

Meas. Ref. Pt. 4292.0

[illegible]

EQUIPMENT DESCRIPTION: _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENT8: _____

NOTE: DATUM = GROUND SURFACE

REG-AL-ENG-8 (8/84)

JUN 28 1985

JACOBS ENGINEERING GROUP INC.
 ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

 SITE ID: HAT01 LOCATION ID: 911 LOG DATE: 850222

 LOGGING COMPANY: JEG FIELD REP.: _____

TESTED INTERVAL: _____

 BEGINNING DEPTH 74.5 END DEPTH 84.5 (FT. BELOW DATUM)

 SOIL/ROCK INTERVAL ST-3

 BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 84.5 DIA. (IN.) 3.0

 HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3.0

 STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2

(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
0 2.5	0	15	200
0.5 3.5	1.12		
1 3.5	2.02 ϕ 9 ϕ		
1.5 4	2.99 ϕ 9 ϕ		
2 4.5	3.89 ϕ 9		
2.5 5	4.79 ϕ 9		
3 5.5	5.76 ϕ 9.7		
3.5 6	6.58 ϕ 8.2		
4 6.5	7.48 ϕ 9		
4.5 7	8.38 ϕ 8.2		
5 7.5	9.28 ϕ 9		
5.5 8	10.32 1.12		
6 8.5	11.07 ϕ 7.5		
6.5 9	11.89 ϕ 8.2		
7 9.5	12.79 ϕ 9		
7.5 10	13.64 ϕ 8.2		
10.5			

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (8/84)

JUN 28 1985

 JACOBS ENGINEERING GROUP INC.
 ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PACKER (DRILL STEM) TEST

SITE ID: WAT61 LOCATION ID: 911 LOG DATE: 850222
 LOGGING COMPANY: JE FIELD REP.: B. HOLLAND
 TESTED INTERVAL:
 BEGINNING DEPTH 74.5 END DEPTH 84.5 (FT. BELOW DATUM)
 SOIL/ROCK INTERVAL ST-3
 BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 84.5 DIA. (IN.) 3.0
 HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3.0
 STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2
 (AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
0 11	0	20	200
0.5 10.5	0.6		200
1 12.5	1.72 1.12		200
1.5 11.5	2.47 0.75		200
2 13.5	3.22 0.75		200
2.5 13.0	4.11 0.89		400
3 14.5	4.86 0.75		400
3.5 13.5	5.61 0.75		200
4 13.5	6.43 0.82		
4.5 14.5	7.14 0.68		
5 14.5	7.63 0.52		
5.5 13.5	8.20 0.67		
6 15.5	9.05 0.75		
6.5 14.5	9.65 0.6		
7.0 18.5	10.25 0.6		
7.5 12.5	10.55 0.3		

EQUIPMENT DESCRIPTION:

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (8/84)

BOREHOLE 911 Packer Test 1-3

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JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

Pg 1 of 2

PACKER (DRILL STEM) TEST

SITE ID: HM-01 LOCATION ID: 911 LOG DATE: 2/22/85
LOGGING COMPANY: JACOBS/SHB FIELD REP.: B. H. H. H.
TESTED INTERVAL:
BEGINNING DEPTH 74.5 END DEPTH 84.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL Rock 74.5-84.5 From 39 feet
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 84.5 DIA. (IN.) 3.5
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 3'
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 55.43 Too high 68.2'
(AT START OF FIRST TEST)

TIME INTERVAL (MIN)			VOLUME REMOVED (GAL) CH FT			WATER PRESSURE (PSI)			AIR PRESSURE (PSI)		
10psi	15psi	20psi	10psi	15psi	20psi	10psi	15psi	20psi	10psi	15psi	20psi
0	0	0	72.1	82.5	1.8				200	200	200
0.5	0.5	0.5	73	84.0	2.0						
1	1	1	73.5	85.2	2.5						
1.5	1.5	1.5	73.5	86.5	2.5						
2	2	2	73.5	87.1	2.5						
2.5	2.5	2.5	Test	88.9	2.7						400
3	3	3	STOPPED	90.2	2.9						
3.5	3.5	3.5	FOR AIR	91.3	2.7						200
4	4	4	REVERSE	92.5	2.7						
4.5	4.5	4.5		92.6	2.8						
5	5	5		91.8	2.9						
5.5	5.5	5.5		90.5	3.0						
6	6	6		97.3	3.3						
6.5	6.5	6.5		98.1	3.2						
7	7	7		99.0	3.2						
7.5	7.5	7.5		100.2	3.2						

EQUIPMENT DESCRIPTION: WIRING PAKED

TOP PACKER: DEPTH (FT. BELOW DATUM) 74.5-30" LENGTH (FT.) 7'

PACKER TYPE: (S)INGLE/(D)OUBLE D TEST INTERVAL LENGTH (FT.) 10'

COMMENTS: Test run @ 10, 15, 20 psi

NOTE: DATUM = GROUND SURFACE

BOREHOLE 911

Packer Test # 3

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8/1/1 JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

SITE ID: HA 01 LOCATION ID: 911 LOG DATE: 2/22/95

LOGGING COMPANY: _____ FIELD REP.: _____

TESTED INTERVAL: _____

BEGINNING DEPTH _____ END DEPTH _____ (FT. BELOW DATUM)

SOIL/ROCK INTERVAL _____

BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) _____ DIA. (IN.) _____

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) _____

STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) _____

(AT START OF FIRST TEST)

TIME INTERVAL (MIN)		VOLUME REMOVED (GAL)		WATER PRESSURE (PSI)		AIR PRESSURE (PSI)	
15 PSI	20 PSI	15 PSI	20 PSI	15 PSI	20 PSI	75 PSI	20 PSI
8	8	10 ¹⁷	30 350			200	200
8 ⁵	8 ⁵	10 ²⁷	353				
9	9	10 ³⁸	TEST				
9 ⁵	9 ⁵	10 ⁵⁰	STOPPED				
10	10	10 ⁶¹	@				
10 ⁵	10 ⁵	10 ⁷²	8.5 min				
11	11	10 ⁸²					
11 ⁵	11 ⁵	10 ⁹⁰					
12	12	11 ⁰					
12 ⁵	12 ⁵	11 ¹²					
13	13	11 ²⁰					
13 ⁵	13 ⁵	11 ²⁹					
14	14	11 ³⁹					
14 ⁵	14 ⁵	11 ⁴⁹					
15	15	11 ⁵⁹					

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEO-AL-ENG-8 (8/84)

JUN 25 1985

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONSKAC
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PACKER (DRILL STEM) TEST

SITE ID: HATCH LOCATION ID: 911 LOG DATE: 050227LOGGING COMPANY: JEH FIELD REP.: R. Holland

TESTED INTERVAL:

BEGINNING DEPTH 84.5 END DEPTH 94.5 (FT. BELOW DATUM)SOIL/ROCK INTERVAL ST - 3BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 94.5 DIA. (IN.) 3.0HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4.0STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2

(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
.5	1.5	25	200
1.0	0	25	200
1.5	0		
2.0			
2.5			
3.0			
3.5			
4.0			
4.5			
5.0			
5.5			
6.0			
6.5			
7.0			
7.5			
8.0			
8.5			

EQUIPMENT DESCRIPTION:

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (3/84)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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JUN 28 1985

PACKER (DRILL STEM) TEST

SITE ID: HA761 LOCATION ID: 711 LOG DATE: 850227

LOGGING COMPANY: JE6 FIELD REP.: _____

TESTED INTERVAL:

BEGINNING DEPTH 84.5 END DEPTH 94.5 (FT. BELOW DATUM)

SOIL/ROCK INTERVAL ST-3

BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 94.5 DIA. (IN.) 3.0

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4.0

STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2

(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
9.3	0	30	200
9.5	0	30	
10.5			
10.5			
11.5			
11.5			
12.5			
12.5			
13			
13.5			
14			
14.5			
15			
15.5		20	
16		30	
16.5		30	
17		30	

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (8784)

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Packer Test No. 4
Page 1 of 1

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PACKER (DRILL STEM) TEST

SITE ID: HAT-01 LOCATION ID: 911 LOG DATE: 2/27/85
LOGGING COMPANY: JACOBS/SHR FIELD REP.: R. Holland
TESTED INTERVAL:
BEGINNING DEPTH 84.5 END DEPTH 94.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL 84.5 - 94.5 From 39 ft.
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 94.5 DIA. (IN.) 3"
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4.0'
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) _____
(AT START OF FIRST TEST) Initial meter reading 2378

TIME INTERVAL (MIN)			VOLUME REMOVED (GAL) F ³			WATER PRESSURE (PSI)			AIR PRESSURE (PSI)		
0.5	0.5		0.2	0		25	30		200	200	200
1.0	1.0		Refused	0							
1.5	1.5		0	0			30				
2.0	2.0		0	0		25					
2.5	2.5		0	0							
3.0	3.0		0	0							
3.5	3.5		0	0							
4.0	4.0		0	0							
4.5	4.5		0	0							
5.0	5.0		0	0							
5.5	5.5		0	0							
6.0	6.0		0	0		25					
6.5	6.5		0	0							
7.0	7.0		0	0			28				
7.5	7.5		0	0			30				
8.0	8.0		0	0			30				
8.5	8.5		0	0		25	30				

EQUIPMENT DESCRIPTION: wire line double packer

TOP PACKER: DEPTH (FT. BELOW DATUM) 84.5' LENGTH (FT.) 7.0'
PACKER TYPE: (S)INGLE/(D)OUBLE SP TEST INTERVAL LENGTH (FT.) 10.0'

COMMENTS: Formation refused water at 25 and 30 PSI. No higher test was attempted because of fear of frac. of formation

NOTE: DATUM = GROUND SURFACE

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JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

SITE ID: HATCH LOCATION ID: 911 LOG DATE: 850228
LOGGING COMPANY: JEG FIELD REP.: R. Holland
TESTED INTERVAL:
BEGINNING DEPTH 94.5 END DEPTH 104.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL ST-3
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 104.5 DIA. (IN.) 3.0
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4.0
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 60.2
(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
.5	1.87	20	20
1.0	2.24 0.37	20	
1.5	2.42 0.38	20	
2	2.77 0.15	20	
2.5	2.77 0	22	
3	2.77 0	22	
3.5	2.92 0.15	22	
4	2.92 0	22	
4.5	2.95 0.03	22	
5	2.99 0.04	25	
5.5	2.99 0	25	
6	2.99 0	25	
6.5	2.99 0	25	
7	2.99 0	25	
7.5	3.03 0.04	25	
8	3.03 0	25	
8.5	3.03 0	25	

EQUIPMENT DESCRIPTION: _____

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (8/84)

JUN 28 1985

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

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PACKER (DRILL STEM) TEST

SITE ID: DAT 01 LOCATION ID: 911 LOG DATE: 05/02/88

LOGGING COMPANY: JEG FIELD REP.: R. Holland

TESTED INTERVAL:

BEGINNING DEPTH 94.5 END DEPTH 104.5 (FT. BELOW DATUM)

SOIL/ROCK INTERVAL ST-3

BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 104.5 DIA. (IN.) 3.0

HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4.0

STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2

(AT START OF FIRST TEST)

ELAPSE TIME (MIN)	VOLUME REMOVED (GAL)	WATER PRESSURE (PSI)	AIR PRESSURE (PSI)
9.0	0.64	30	200
9.5	0		
10.0	0		
10.5	0		
11.0	0		
11.5	0.07		
12.0	0.14		
12.5			
13.0			
13.5			
14.0			
14.5			
15.0			
15.5			
16.0			
16.5			
17.0			

EQUIPMENT DESCRIPTION:

TOP PACKER: DEPTH (FT. BELOW DATUM) _____ LENGTH (FT.) _____

PACKER TYPE: (S)INGLE/(D)OUBLE _____ TEST INTERVAL LENGTH (FT.) _____

COMMENTS: _____

NOTE: DATUM = GROUND SURFACE

JEG-AL-ENG-8 (3/84)

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

PACKER (DRILL STEM) TEST

WELL ID: HAT-01 LOCATION ID: 911 LOG DATE: 2/28/85
TESTING COMPANY: Jacobs/SNA FIELD REP.: R. Holland
TESTED INTERVAL:
BEGINNING DEPTH 94.5 END DEPTH 104.5 (FT. BELOW DATUM)
SOIL/ROCK INTERVAL 94.5 - 104.5 Rock From 39.0 ft
BOREHOLE: DEPTH AT TEST (FT. BELOW DATUM) 104.5 DIA. (IN.) 3.0
HEIGHT OF WATER SWIVEL (FT. ABOVE DATUM) 4
STATIC GROUNDWATER DEPTH (FT. BELOW DATUM) 68.2
(AT START OF FIRST TEST) 68.2 Initial meter reading 6394.85

TIME INTERVAL (MIN)		VOLUME REMOVED (GAL) ft^3		WATER PRESSURE (PSI)		AIR PRESSURE (PSI)	
20	10	95.1	95.34	20	30	200	
1.0	1.0	95.15	95.34		30		
1.5	1.5	95.2	95.34				
2.0	2.0	95.23	95.34				
2.5	2.5	95.22	95.34	20			
3.0	3.0	95.22	95.35				
3.5	3.5	95.24	95.35				
4.0	4.0	95.24	95.35				
4.5	4.5	95.245	95.35				
5.0	5.0	95.25	95.35	25	30		
5.5	5.5	95.25	95.35	25			
6.0	6.0	95.25	95.35				
6.5	6.5	95.25	95.35				
7.0	7.0	95.25	95.35				
7.5	7.5	95.255	95.35				
8.0	8.0	95.255	95.35				
8.5	8.5	95.255	95.35				

EQUIPMENT DESCRIPTION: wire line packer (Double)

TOP PACKER: DEPTH (FT. BELOW DATUM) 94.5 LENGTH (FT.) 7.0
PACKER TYPE: (S)INGLE (D)OUBLE TEST INTERVAL LENGTH (FT.) 10
COMMENTS: Formation refused water at 20-30 psi

NOTE: DATUM = GROUND SURFACE

THE

TEST INTERVAL

LOW
RATE

64.51-74.51

74.5' - 84.5'

[illegible]

PACKER TEST DATA (PAC)										H2216					
(TEST INTERVAL)															
(-BOREHOLE--)															
SITE	LOC	LOG	DEB	OP	END	OP	S	DEPTH	DIAM	HOT	LEVEL	ELAPSED	TIME	REMOVE	PRESS
CODE	ID	DATE	(FTSD)	(FTSD)	WIR/RC	0	(FTSD)	(IN)	FTAD	(FTSD)	(MIN)	(HIN)	(DAL)	(PSI)	
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	1.00	0.37	20.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	1.50	0.38	20.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	2.00	0.15	20.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	2.50	0.00	22.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	3.00	0.00	22.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	3.50	0.15	22.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	4.00	0.00	22.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	4.50	0.03	22.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	5.00	0.04	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	5.50	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	6.00	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	6.50	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	7.00	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	7.50	0.04	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	8.00	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	8.50	0.00	25.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	9.00	0.64	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	9.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	10.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	10.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	11.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	11.50	0.07	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	12.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	12.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	13.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	13.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	14.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	14.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	15.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	15.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	16.00	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	16.50	0.00	30.0		
HAT01	911	850228	94.50	104.50	BT	3	104.50	3.000	4.00	68.20	17.00	0.00	30.0		

..... END REPORT

1.4 gpm

0.1 gpm

0.02 gpm

94.5' - 104.5'

0.09 gpm

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HYDRAULIC CONDUCTIVITY CALCULATIONS

SLUG TESTS

8-7-91

JACOBS ENGINEERING GROUP INC. •
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALC NO. HAT-0791402-00 DISCIPLINE Hydro NO. OF SHEETS 92

PROJECT: U M T R A

SITE: HAT 01 - Mexican HAT Processing Site / Disposal Site (SOS)
- Stabilization On Site

FEATURE: Slug Test Analysis - Used to determine hydraulic conductivity of hydrostratigraphic units at the site

SOURCES OF DATA: Slug Test Data collected on the following monitor wells along with dates the test were conducted.

<u>HAT01</u>	<u>Dates</u>	<u>HAT01</u>	<u>Dates</u>	<u>HAT01</u>	<u>Dates</u>
908	4/11/85	912	8/14/85	934	11/1/85
	7/31/85				
909	4/10/85	930	10/30/85	935	11/1/85
	8/14/85				

SOURCES OF FORMULAE & REFERENCES:

SOURCES OF FORMULAE & REFERENCES:
USGS Water Supply Paper 1536-I, Methods of Determining Permeability, Transmissibility and Drawdown 1963, 341pp compiled by Bentall

Bouwer, H. Groundwater Hydrology 1978.

Bouwer, H. Groundwater Hydrology 1978.
Computer Program in BASIC - Slug/BAS, On file w/ UMTRA-TAC

USGS Professional Paper 708, Groundwater Hydraulics, 1972,
by S. W. Lohman.

Hvorslev, M^J 1951, Bulletin No-36, US Corp Engineers, U.S. Army
Vicksburg, Miss

PRELIMINARY CALC. ☒ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

		K. Zamboni	7/19/91	Clark G. 522	7/31/91	KTB	8/17/91
REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE

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MEXICAN HAT CALCULATION HAT-07-91-14-02-00

SLUG TEST ANALYSES FOR MONITOR WELLS: MEXICAN HAT
PROCESSING/DISPOSAL SITE

PURPOSE:

The purpose of this calculation is to estimate the hydraulic conductivity of the hydrostratigraphic units at the Mexican Hat site. The results of these calculations will be used in groundwater velocity calculations for the Mexican Hat site.

METHOD AND PROCEDURES:

Slug test data were collected from monitor wells 908, 909, 912, 930, 934, and 935 in 1985. Slug test data were evaluated using the following methods:

Unconfined System

Bouwer-Rice and Hvorslev

Confined System

Cooper-Bredehoeft-Papadopoulos, Ferris-Knowles, and Skibitske

For further information refer to Technical Memo No. 1 (May 15, 1985; Attachment 1) and Technical Memo No. 5 (June 10, 1985; Attachment 2) on slug test analysis.

ASSUMPTIONS:

Refer to Technical Memo No. 1 and No. 5 for specifics to each slug test method.

DATA SOURCES:

All slug test data was collected by UMTRA Technical Assistance Contractor (TAC) staff in April, July, August, October, and November 1985. Slug test field data forms, graphical plots, and computed solutions are included in Attachment 3.

CALCULATIONS AND ANALYSES:

BOUWER-RICE METHOD

A detailed description of the Bouwer-Rice method of slug test analysis is presented in Bouwer and Rice, 1976. The equation used to calculate the hydraulic conductivity is:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L(t)} \ln\left(\frac{y_0}{y_t}\right) \quad (1)$$

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where y_0 is y-intercept at time zero, y_t is y-intercept at time t , and all other parameters are indicated in Tech Memo No. 5.

The dimensionless ratio $\ln(R_e/r_w)$ is fitted using two equations, one for the case where $L_w < H$, and one for the case where $L_w = H$. These equations are, respectively,

$$\ln \frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{A+B \ln[(H-L_w)/r_w]}{(L_e/r_w)} \right]^{1/2} \quad (1)$$

$$\ln \frac{R_e}{r_w} = \left[\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{(L_e/r_w)} \right]^{1/2} \quad (2)$$

where A , B , and C are dimensionless numbers, plotted a function of L_e/r_w (see Tech Memo No. 5).

The parameter $[\ln(y_0/y_t)]/t$ is determined by plotting the residual drawdown versus time on semilog paper, fitting a straight line to the curve, then estimating y_0 (y at time zero), and then selecting a point on the line and determining y_t at time t .

Occasionally, the water table is located below the top of the gravel pack. In this case, the thickness and porosity of the gravel pack should be taken into account when calculating the equivalent value of r_c , the casing radius. The equation used to calculate the equivalent value of r_c for this situation is:

$$r_c = [(1-n)r_c^2 + nr_w^2]^{.5}$$

Note also that slug injection tests should be considered invalid for this particular case, as these tests will overestimate the hydraulic conductivity due to the influence of the gravel pack.

HVORSLEV METHOD

A detailed description of the Hvorslev method of slug test analysis is presented in Hvorslev, 1951. The equation used to calculate the hydraulic conductivity is:

$$K = \frac{r^2 \ln(L/R)}{2 L T_0} \quad (4)$$

where T_0 is the time it takes for the water level to rise or fall to 37 percent of the initial change. All other parameters are indicated in Tech Memo No. 5.

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Cooper-Bredehoeft-Papadopoulos Method

A detailed description of the Cooper-Bredehoeft-Papadopoulos method of slug test analysis is presented in Lohman, 1972. The equation used to calculate the hydraulic conductivity is:

$$K = \frac{r_c^2}{t L} \quad (5)$$

where t is obtained from matching the data points of residual drawdown/ initial residual drawdown versus log of time to a type curve found in Lohman, 1972.

Ferris-Knowles Method

A detailed description of the Ferris-Knowles method of slug test analysis is presented in the USGS Water-Supply paper 1536-I, 1963. The equation used to calculate the hydraulic conductivity is:

$$K = \frac{q \left(\frac{1}{t} \right)}{4 \pi s L} \quad (6)$$

The values of $1/t$ and s are obtained from a straight line fit through the data points. The method is valid for large values of t and the straight line fit passing through the origin.

Skibitske Method

A detailed description of the Skibitske method of slug test analysis is presented in the USGS Water-Supply paper 1536-I, 1963. The equation used to calculate the hydraulic conductivity is:

$$K = \frac{q}{4 \pi S L t} \quad (7)$$

The method is used in wells completed in confined units with low permeability. The residual drawdown should be at the last measurement before complete recovery.

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RESULTS:

Table 1 shows the input data for the slug test calculations for each monitor well tested and for each applicable analysis technique. Table 2 shows the hydraulic conductivities for each slug test method for the respective monitor wells tested.

CONCLUSIONS:

Based on analyses of slug tests conducted in monitor wells at the Mexican Hat site, the average hydraulic conductivity in the Halgaito Shale unconfined hydrostratigraphic unit is approximately 0.6 ft/day. The average hydraulic conductivity in the Honaker Trail confined hydrostratigraphic unit is approximately 0.07 ft/day.

Slug tests yield only a rough approximation of the hydraulic conductivity of an aquifer, and these values should be considered to be an order-of-magnitude estimate of the hydraulic conductivity. Furthermore, the area of influence of a slug test extends only a short distance from the borehole. Therefore, results from slug tests should not be inferred to be valid at a significant distance away from the area of influence.

Because pumping tests are usually more accurate than slug tests for estimating hydraulic conductivity, any critical engineering design should be based primarily on the results of pumping tests, rather than slug tests.

REFERENCES: *Computer Program in BASIC - Slug/BAS, On file w/ UMTRA TAC*

Bouwer, H., 1978, Groundwater Hydrology, McGraw-Hill Company, N.Y., N.Y., pp. 114-118. *KAL 8/6/91*

Bouwer, H. and R. C. Rice, 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells, Water Resources Research, 12:423-428.

Hvorslev, M. J., 1951, Time Lag and Soil Permeability in Ground Water Observations, Bulletin 36, 50pp., U.S. Army Corps of Engineers Waterways Experimentation Station, Vicksburg, Miss.

Lohman, S.W., 1972, Groundwater Hydraulics, USGS Professional Paper 708, pp. 27-30.

U.S. Geological Survey, 1963, Methods of Determining Permeability, Transmissibility, and Drawdown, USGS Water-Supply Paper 1536-I, pp. 299-304

ATTACHMENTS

Attachment 1 - Technical Memo No. 1: Borehole Hydraulic Testing for Aquifer Characterization.

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Attachment 2 - Slug Test Calculations

Attachment 3 - Slug Test Field Data Forms, Data Plots, and Computed Solutions.

TABLE 1 - SLUG TEST ANALYSES INPUT PARAMETERS

WELL ID	DATE	MEMO	L ² (ft)	g ² (ft)	r _e (ft)	R ₁ (ft)	SPRINT			BOUSER-RICE			H ₀ (ft)	T ₀	1/2 (min)	C-R-D
							t ₀ (min)	S (ft)	Y ₀	t ₀ (ft)	Y _e	L _w (ft)				
HATH-908	04/11/85	F-K C-B-P	15	0.05	0.083	0.2344	20	0.02	N/A	N/A	N/A	N/A	N/A	N/A	0.4	1.5
HATH-909	04/11/85	F-K C-B-P	20	0.05	0.083	0.2344	1860	0.09	N/A	N/A	N/A	N/A	N/A	N/A	0.2	0.6
HATH-908	04/11/85	F-K C-B-P	15	0.05	0.083	0.2344	20	0.04	—	—	—	—	—	—	0.4	1.6
HATH-909	04/11/85	F-K C-B-P	20	0.05	0.083	0.2344	36	0.01	—	—	—	—	—	—	0.4	0.5
HATH-912	08/11/85	B-R H	8.0	0.05	0.083	0.2344	—	—	0.47	360	0.042	8.0	8.0	1.4	—	—
							—	—	0.47	1440	0.02	8.0	8.0	—	—	—
a		Well completion														
b		Slug Test Data														
HATH-930	10/14/85	F-K C-B-P	10	0.217	0.167	0.3291	90	0.41	N/A	N/A	N/A	N/A	N/A	N/A	0.1	1.3
HATH-934	11/1/85	F-K C-B-P	10	0.217	0.167	0.3291	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01	1.5
HATH-935	11/1/85	F-K C-B-P	10	0.217	0.167	0.3291	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.01	2.0

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L₂ = contributing internal length
 q₂ = volume discharged
 r₂ = well radius
 R₂ = borehole radius
 C-B-P = COOPER-BREDBENT- PAPADOPOLUS
 * SCREEN IS 20 FT., HOWEVER ONLY 8 FT. IS SATURATED

TABLE 2 - Hydraulic Conductivities from Slug Test Analysis (ft/day)

Well ID - Date	Skibitska	Ferris-Knowles	C-B-P	Bower-Rice	Hvorslev	Average	HYDRO-STRATIGRAPHIC UNIT
<u>908</u> 4/11/85	0.96	0.10	0.41	—	—	0.4 ^a	HONAKER TRAIL
7/31/85	0.48	0.10	0.40	—	—		
<u>909</u> 4/10/85	0.002	0.10	0.12	—	—	0.03 ^b	HONAKER TRAIL
8/14/85	0.80	0.23	0.51	—	—		
<u>912</u> 8/14/85	—	—	—	0.67	1.56	0.6 ^b	HALGAITO SHALE
<u>930</u> 10/30/85	6.7 x 10 ⁻²	1.9 x 10 ⁻¹	—	—	—	0.1 ^b	HONAKER TRAIL
<u>934</u> 11/1/85	7.6 x 10 ⁻³	1.7 x 10 ⁻²	—	—	—	0.04 ^b	HONAKER TRAIL
5.9 x 10 ⁻¹	—	—	—	—	—		
<u>935</u> 11/1/85	1.0 x 10 ⁻²	1.2 x 10 ⁻²	—	—	—	0.04 ^b	HONAKER TRAIL
5.9 x 10 ⁻¹	—	—	—	—	—		
Average ^b Honaker Trail Cont'd = 0.07 ft/day Halgaito Shale Unconfined = 0.61 ft/day							

a: Arithmetic Mean
b: Geometric Mean

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FORM 91-008-1 (4/81)

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SUBJECT _____

BY _____ CHKD. _____

SHEET NO. _____

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ATTACHMENT 1

BOREHOLE HYDRAULIC TESTING FOR
AQUIFER CHARACTERIZATION

Hal O'Byrne
KAL
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS *7/30/*

To: Hydrological Services Group
From: John Thackston *JT*
Date: May 15, 1985
Subject: Bore Hole Hydraulic Testing for Aquifer Characterization
Technical Memorandum No. 1

Slug & Pump Tests

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7/31/9.

The purpose of the attached technical memo is to provide guidelines for conducting hydraulic tests in boreholes or wells in order to characterize the hydraulic properties of aquifers for the UMTRA Project.

Guidelines provided herein are intended to be supplementary to the standard operating procedures (SOP) for these activities currently in effect for the UMTRA Project. In the event there is overlap or conflicts in direction regarding procedures or methodology between this technical memo and the project SOP documents, please advise me. In all such cases, assume that the SOP directives take precedence.

JT:mas
Attachment

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TECHNICAL MEMORANDUM NO. 1
BORE HOLE HYDRAULIC TESTING FOR
AQUIFER CHARACTERIZATION

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1.0 INTRODUCTION

This technical memorandum provides guidelines and procedures for determining the hydraulic parameters of aquifers using slug tests and pumping tests. The hydraulic conductivity (K) of an aquifer is a measure of the aquifer's ability to conduct water. The greater the value of hydraulic conductivity, the more readily the aquifer conducts water. Figure 1 illustrates the typical range of hydraulic conductivity values associated with a variety of earth materials. The transmissivity (T) of an aquifer is defined as the ability of the aquifer to transmit water through its entire thickness and is equal to the hydraulic conductivity (K) times the saturated thickness of the aquifer (b); this can be stated as $T = Kb$, for cases in which K is constant with depth. Otherwise, transmissivity is equal to the integration of hydraulic conductivity over depth, $T = \int K(z) dz$.

Specific yield of an aquifer is the ratio of the volume of water drained by gravity from a unit volume of aquifer material. The storage coefficient of an aquifer is the volume of water in storage released from a column of aquifer with unit cross section under a unit decline of head.

1.1 SLUG TEST

1.1.1 PURPOSE

The purpose of this section is to outline procedures for the conduction and evaluation of slug tests which are a quick and inexpensive method of estimating the hydraulic conductivity or transmissivity of many aquifer systems.

A slug test will generally work in aquifers where K is less than or equal to 10^{-2} cm/sec. In aquifers of greater hydraulic conductivity the water level may return to static level before a sufficient number of water level readings can be made. In aquifers of low K (10^{-4} to 10^{-7} cm/sec), slug tests are generally a reliable field method of determining hydraulic conductivity or transmissivity near the screened zone of the well.

The advantages of using slug tests to estimate hydraulic conductivities are:

1. Estimates can be made in situ and errors incurred in laboratory testing of disturbed samples are avoided.

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2. Tests can be performed quickly at relatively low cost because a pumping well and observation wells are not required.
3. The hydraulic conductivity of small discrete portions of an aquifer can be made, for example, such as sand layers in a clay.

There are disadvantages in using slug tests which must be evaluated before the test is conducted. These include:

1. Only the hydraulic conductivity of the area immediately surrounding the well is estimated. These results may not be representative of the average hydraulic conductivity of the area.
2. Often only a range of hydraulic conductivity values rather than an average value can be deduced from test results.
3. Certain assumptions are made in the analysis process. If the assumptions made are inappropriate for the geologic conditions at the site, the results may be erroneous.
4. The storage coefficient, S , usually cannot be determined.
5. Data sufficient for analysis may not be collected if the hydraulic conductivity is relatively high.

This technical memorandum explains procedures and equipment commonly used in conducting most slug tests and a list of analysis techniques used under different geologic conditions and for different bore hole or well systems. Also included are example calculations of typical slug tests (Appendices 1-1 and 1-2).

1.1.2 DESIGN, DRILLING AND CONSTRUCTION OF SLUG TEST WELL

Several factors enter into the design of a well for the performance of slug testing. These include depth and diameter of the test well, length of screened interval and size of screen openings. Some of these factors can be chosen as drilling proceeds or be predetermined from previous borings. Well design is generally determined from a combination of drill cuttings, corings, and geophysical logging.

The depth and screened interval of the hole are determined by the location of the zone of interest. The diameter of the hole and casing to be inserted in the hole should be large enough in order that the volume of the slug does not overflow the top of casing. This may be a problem when the water level in the bore hole is relatively close to the ground surface. The screened interval should consist of screen with a percentage of open intervals large enough so as not to excessively restrict water flowing from the bore hole to the subsurface materials tested. Wells with screened intervals which require a gravel pack should be packed with material of a grain size distribution that would result in approximately an order of magnitude of higher hydraulic conductivity than the subsurface materials being tested.

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A variety of drilling techniques can be used in completing the test well. These may include mud-rotary, air-rotary, coring and auger techniques. The type of drilling method used depends on the behavior of the material being drilled and the specific objectives of the project. Drilling without drilling fluids is preferred because this prevents further contamination of the subsurface. Mud-rotary techniques are sometimes required in order to lubricate the bit and hold up the bore hole walls when relatively thick, coarse, unconsolidated materials are encountered. Augering is normally performed without the use of drilling fluids and used in the drilling of relatively shallow holes with relatively cohesive materials.

The construction of the test well is relatively simple and involves the assembly of the appropriate diameter casing (usually PVC because of lower cost) for insertion into the bore hole. A pre-slotted screened section is prepared and attached to the casing string, normally with a cap on the bottom (to prevent material from entering the bottom of the screen), and the whole assembly is lowered into the hole. If a gravel pack is necessary as a filter due to the aquifer containing very fine unconsolidated sand, then it should be placed opposite the screened interval using a tremie pipe. The annulus is then grouted from the top of the gravel pack up to the ground surface in order to allow hydraulic connection only between the test well and the zone to be tested. The hole should be flushed or bailed before grouting if drilling fluid remains in the hole. If the ground water in the hole is highly contaminated, special safety precautions should be taken to control the discharge water before test well development.

1.1.3 EQUIPMENT

Equipment necessary to conduct a slug test include:

- o Well or bore hole
- o Water level measuring device
- o Known solid volume of particular shape (slug) that will easily fit into the well or bore hole or container to add or remove a known volume of water
- o Watch with second hand
- o Semi-log graph paper
- o Indelible pen or pencil and paper

A number of water level measuring devices can be used for measuring the depth to water in a well. An excellent device for measuring the depth to water during a slug test is the pressure transducer. An example strip chart data record is shown in Appendix 1-2. Accurate readings may also be obtained with electric water level indicators or weighted tapes with ploppers. Water level measurement by the wetted-tape method should be avoided as it may be difficult to obtain a sufficient number of readings for analysis of the test if the water level recovers quickly in a short amount of time.

1.1.4 PROCEDURE

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Before beginning the slug test, the following information should be recorded:

- o Site ID and well or bore hole location
- o Location and elevation of reference point from which water depth measurements are made
- o Elevation of ground water with respect to the reference point
- o Date and time of test
- o Well depth, screen length, riser pipe radius, well screen radius, and radius of the gravel pack plus the well screen or bore hole depth and radius
- o Aquifer or ground water zone being tested
- o Volume of water added or withdrawn or volume of solid cylinder (slug)
- o Type of measuring device used
- o Names of personnel conducting test

The following procedures will apply to most slug tests. The field procedures required for a particular slug test may be slightly different, however, and the procedures should be modified to that test as necessary.

- o Determine the static water level in the well by measuring the depth to water periodically for several minutes and taking the average of the readings.
- o "Instantaneously" introduce or remove a known volume of water to the well. Another method is to introduce a solid cylinder of known volume to displace and raise the water level, allow the water level to restabilize and remove the cylinder. It is important to remove or add the volumes as quickly as possible because the analysis assumes an "instantaneous" change in volume is created in the well.
- o With the moment of volume addition or removal assigned time zero, measure and record the depth to water and the time at each reading. Depths should be measured to the nearest 0.01 foot. The number of depth-time measurements necessary to complete the test are variable. It is critical to make as many measurements as possible in the early part of the test.
- o Continue measuring and recording depth-time measurements until the water level returns to equilibrium conditions or a sufficient number of readings have been made to clearly show a trend on a semi-log plot of time versus depth.

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The time required for a slug test to be completed is a function of the volume of the "slug", the hydraulic conductivity of the formation and the type of well completion. The slug volume should be large enough that a sufficient number of water level measurements can be made before the water level returns to equilibrium conditions. The length of the test may range from less than a minute to several hours.

If the well is to be used as a monitoring well, precautions should be taken that the wells are not contaminated by material introduced into the well. If water is added to the monitoring well, it should be from an uncontaminated source and transported in a clean container. Bailers or measuring devices should be cleaned prior to the test. If tests are performed on more than one monitoring well, care must be taken to avoid cross contamination of the wells.

1.1.5 DATA ANALYSIS

The analysis of slug test data is based on the modification of well-known ground water flow equations (either the Theim equation, the Theis equation, or subsequent modification). Several authors have presented analytical solutions for the analysis of slug test data. Most solutions require a semi-logarithmic plot of the data collected: dimensionless head (logarithmic scale) or residual head (logarithmic scale) versus time (arithmetic scale).

Hvorslev (1951) was one of the first researchers to publish techniques of analysis of either constant or slug (falling head) tests in near-surface saturated soils. His analysis for slug tests involves a semi-logarithmic plot of the falling head (or water level) divided by the initial head against time. Basic algebraic equations are presented for different configurations of the soil relative to the test hole. In general, the permeability is proportional to a "shape factor" and inversely proportional to a "time lag". The "shape factor" is determined from the test well characteristics or dimensions. "Time lag" is determined from the semi-logarithmic plot.

Cooper et al (1967) and Papadopoulos et al (1973) developed a set of type curves for analyzing slug test data, particularly for tests run in materials which are confined (under artesian pressure). The field data are plotted as dimensionless head (arithmetic scale) versus time (logarithmic scale) and matched to a set of type curves. The match point values are substituted into simple algebraic formulated to obtain a value for K (Appendix 1-1).

Bower and Rice (1976) and Bower (1978) developed a technique for analyzing slug test data collected from completely or partially penetrating wells in unconfined aquifers. Their analysis involves a plot of residual head (logarithmic scale) versus time (arithmetic scale). A straight line is applied to the early-time data and used to calculate a value for K. An example of the use of this technique is presented in Appendix 1-2. A plot of the data and calculations are included.

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Pressurized slug test methods have been developed for testing extremely low conductivity (10^{-8} cm/sec or lower) materials (Bredehoeft and Papadopoulos, 1980). Basically, the pressurized slug technique is a modification of the conventional slug test discussed previously. The advantage of the pressurized slug technique is the reduction of time required to perform a test in tight formations. This method involves creating an instantaneous pressure surcharge on drawdown in the test zone, then closing a valve to shut in the well. Based on the rate of decay of the pressure slug and the geometry of the test zone, the transmissivity, hydraulic conductivity, and storativity may be calculated.

1.2 ~~AQUIFER PUMPING TEST~~

1.2.1 PURPOSE

The purpose of this section is to briefly describe the use of aquifer pumping tests to evaluate aquifer characteristics. Aquifer pumping tests, commonly referred to as pump tests, are used to determine hydraulic characteristics and properties of water-bearing zones. Pumping tests provide results that are often more representative of the aquifer's characteristics than do slug tests.

Aquifer characteristics which may be obtained from pumping tests include hydraulic conductivity (K), transmissivity (T), and specific yield (S_y) for unconfined aquifers and storage coefficient (S) for confined aquifers.

Equipment, personnel and time commitments needed to conduct pumping tests are greater than those required for slug tests. Briefly, a pumping test consists of pumping one well and recording the drawdown in the pumping well and in other nearby observation wells.

There are advantages and disadvantages of pumping tests. Some of these are listed below.

Advantages of pumping test:

- o A greater portion of the aquifer is tested and the results obtained may be more reliable and representative of the aquifer characteristics.
- o Coefficient of storage and specific yield values can be determined.

Disadvantages of pumping test:

- o In low permeability aquifers long-term pumping may be required to complete the test and obtain reliable aquifer characteristics.
- o Disposal of discharged water may require special provisions if the ground water is contaminated.

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ATTACHMENT 2

SLUG TEST CALCULATIONS

18
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

TO: Hydrology Staff
FROM: JBrinkman *J.B.*
DATE: June 10, 1985
SUBJECT: Technical Memo #5
Slug Test Calculations

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This memo is a rerelease of a memo entitled "Slug Tests" released on May 20, 1985. It has been reformatted and some information has been added to make it consistent with "Final Technical Position on Documentation of Computer codes for High-Level Waste Management", NUREG 0856

JB/11

JACOBS WESTON TEAM

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A. FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

1. Summary date			52. Summary prepared by Name and Phone		53. Summary action	
Yr.	Mo.	Day	Jim Brinkman (505) 846-1250		New ☒ Replacement ☐ Deletion ☐	
815	06	013	54. Software name		Previous Internal Software ID ☐	
54. Software name			SLUG/BAS		57. Software Software ID	
Yr.	Mo.	Day				
815	06	013				

55. Software type		56. Processing mode		58. Application area	
☐ Automated Data System ☒ Computer Program ☐ Subroutine Module		☒ Interactive ☐ Batch ☐ Combination		General ☐ Computer Systems Support/Utility ☒ Scientific Engineering ☐ Bibliographic Tables Specific ☐ Management Business ☐ Process Control ☐ Other	
Program to solve 5 Slug test calculations.					

51. Submitting organization and address		52. Technical contact name and phone	
Technical Assistance Contractor UMTRA Project 5301 Central Avenue NE, Suite 1400 Albuquerque, New Mexico 87108		Jim Brinkman or John Thackston (505) 846-1250	

59. Narrative

This program solves 4 very simple slug test methods and one rather involved method. For four methods, a value or values obtained from a graphical representation of the test data is required input. The program is user-friendly and interactive. All input and the calculated value of hydraulic conductivity are printed.

60. Keywords

Slug Test

61. Computer model and name	62. Computer operating system	63. Programming language(s)	64. Number of source program statements
TRS-80	TRSDOS	BASIC	97
65. Computer memory requirements	66. Tape drives	67. Disk drive units	68. Terminals
	None	None	One

69. Other operational requirements

Printer

70. Software availability		71. Documentation availability	
Available ☒	Limited ☐	Available ☒	Insufficient ☐
Source only ☐		Source only ☐	

72. FOR SUBMITTING ORGANIZATION USE

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B. Mathematical Models and Numerical Methods

SLUG/BAS is a user-friendly BASIC program to analysis slug test data. This program can be used directly on the TRS microprocessors linked with a printer. Five slug test methods can be solved.

o Skibitske

Reference: Methods of Determining Permeability, Transmissibility and Drawdown 1963, USGS Water-Supply paper 1536-1, pp-293-298.

o Bower-Rice

Reference: Groundwater Hydrology, 1978, Herman Bower, p-114-118.

o Hvorslev

Reference: Time Lag and Soil Permeability in Ground-Water Observations, 1951, M. Joul Hvorslev, Bulletin No-36, Waterways Experiment Station, Corps of Engineers, U.S. Army, Vicksburg, Mississippi.

o Ferris-Knowles

Reference: Methods of Determining Permeability, Transmissibility and Drawdown, 1963, USGS Water-Supply paper 1536-1, pp-299-304.

o Cooper-Bredehoeft-Papadopoulos

Reference: Ground-water Hydraulics, 1972, S.W. Lohman, USGS Professional Paper 708, p-27-30 and Plate 2.

For all the methods except Bower-Rice, very simple equations are solved. The Bower-Rice method is much more complicated and empirical than the other methods and the solution by hand is rather time consuming. The primary benefit to using this program is that all input data are printed in a uniform format and documentation and certification, i.e., calculation checking, is very easy and quick. For all methods consistent units must be used.

The following Section satisfies all applicable requirements of parts, 2, 3, 4, and 5 of Section B and also serves as a User's Manual.

To run:

1. Insert diskette into TRS microprocessor.
Be sure printer is attached and on-line.
2. After initializing microprocessor, i.e., entering date and time, enter BASIC by typing BASIC return.
3. Wait until micro response, then load program by typing LOAD "SLUG/BAS" return.

For all five methods, first input:

4. After program is loaded, then run program by typing RUN return.

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1. Well Identification - it is recommended that a nine space identifier be used.

Example:

LKV02-508

a b c

a Is three letter site designation

b Is two number designation for processing site or a specific alternate disposal or borrow site.

c Is three number well designation.

2. The day the field test was initiated.

3. Length of contributing, i.e., screened, packed, etc., interval (L).

4. Which one of the five methods will be applied.

A description of the use of the five methods follow:

o Skibitzke Method

- Used for well completed in confined units with low permeability; residual drawdown should be at last measurement before complete recovery.

- Input data are:

1. Volume discharged or added (q).

2. Time from test initiation until residual drawdown measurement (t).

3. Residual drawdown measurement at time, t (s).

- The equation solved is:

$$K = \frac{qL}{47SL^2}$$

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o Bower-Rice Method

- Used for wells completed in unconfined units.

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- Input data are:

1. Well radius (r_w)
2. Borehole radius (r_b)
3. Residual drawdown at the initiation of test (y_0)
4. Time to residual drawdown measurement (t)
5. From straight line fit of log (residual drawdown) vs. time, residual drawdown at time, t (y_t).
6. Distance from the watertable to the bottom of the contributing interval (L_w).
7. Distance from the watertable to an impermeable boundary (H).

- The equation solved is:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L(t)} \ln \frac{y_0}{y_t} \text{ where}$$

R_e is effective radius.

The term, $\ln(R_e/r_w)$ is determined with one of two empirical relationships.

$$\text{For partially penetrating wells, } \ln \frac{R_e}{r_w} = \frac{1}{\frac{1.1}{\ln(L_w/r_w)} + \frac{A + B \ln[(H-L_w)/r_w]}{(L_e/r_w)}}$$

$$\text{for fully penetrating wells, } \ln \frac{R_e}{r_w} = \frac{1}{\frac{1.1}{\ln(L_w/r_w)} + \frac{C}{(L_e/r_w)}}$$

A, B and C are empirical coefficients derived from curves based on the value of L_e/r_w (Figures 1, 2 and 3)

Each of the three curves was matched numerically with two parabolas fit to the curve. The points used for the parabolic numerical fits and the resulting parabolas follow:

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FIGURE 1

COMPARISON OF PUBLISHED AND NUMERICALLY PRODUCED COEFFICIENT RELATIONSHIPS (A,A')

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Curve A

L_e/r_w	$X = \ln(L_e/r_w)$	A	
4	1.386	1.8	Parabola 1
32	3.466	2.5	
120	4.787	5.15	
120	4.787	5.15	Parabola 2
450	6.109	8.0	
1600	7.378	9.6	

Parabola 1: $A = 0.491x^2 - 2.045x + 3.691$

Parabola 2: $A = 0.3455x^2 + 5.9206x - 15.2747$

Curve B

L_e/r_w	$X = \ln(L_e/r_w)$	B	
4	1.386	0.25	Parabola 1
27	3.296	0.43	
190	5.247	1.1	
190	5.247	1.1	Parabola 2
525	6.263	2.3	
1650	7.409	3.3	

Parabola 1: $B = 0.0659x^2 - 0.217x + 0.4241$

Parabola 2: $B = 0.12x^2 + 2.5128x - 8.7825$

Curve C

L_e/r_w	$X = \ln(L_e/r_w)$	C	
3.8	1.335	0.8	Parabola 1
32	3.466	2.0	
150	5.011	6.0	
150	5.011	6.0	Parabola 2
970	5.914	9.7	
1650	7.409	13.0	

Parabola 1: $C = 0.5511x^2 - 2.0829x + 2.5992$

Parabola 2: $C = -0.7882x^2 + 12.7088x - 37.8922$

Figures 1, 2 and 3 show a comparison of the published curves and the curves developed with the numerical approximations.

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FIGURE 2

COMPARISON OF PUBLISHED AND NUMERICALLY PRODUCED COEFFICIENT RELATIONSHIPS (B, B')

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FIGURE 3

COMPARISON OF PUBLISHED AND NUMERICALLY PRODUCED COEFFICIENT RELATIONSHIPS (C, C')

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The greatest relative error due to matching of the curves occurs when the published value of $C=1.05$ and the numerical value = 0.72. For test cases with L ranging from 10 to 200, L ranging from 2 to 10 and R ranging from 0.083 to 0.25, the maximum relative error was approximately 16 percent with $L=200$, $L=2$ and $R=0.25$. For most cases, the relative should be much less than 5 percent.

o Hvorslev Method

- Used for unconfined units. This method is valid only if a reasonably fit straight line through the data curve of $\log$ (residual drawdown/initial residual drawdown) vs. time passes through the point (1,0).

- Input data are:

1. Well radius (r)
2. Borehole radius (R)
3. Time lag (T), T is the time when (residual drawdown/initial residual drawdown) = $10^{-10.4343}$

The equation solved is:

$$K = \frac{r^2 \ln(L/R)}{2 L T_0}$$

o Ferris - Knowles Method

- Used for confined units with $K < 0.5$ cm/sec

- Input data are:

1. Volume discharge (q)
2. Reciprocal of time ($1/t$)
3. Residual drawdown at time, t (s)

The values of $1/t$ and s are taken from a straight line fit through the data points. To be valid, this straight line fit must pass through the origin.

- The equation solved is:

$$K = \frac{q (1/t)}{4\pi s L}$$

$$\frac{0.05 \text{ m}^3 \text{ (1)}^{1/2}}{4\pi (1) (1)} = \frac{2.149 \text{ m}^3 \text{ (1)}^{1/2}}{4\pi (1) (1)} = 6.19 \text{ m}^3 \text{ (1)}^{1/2} = 4.2 \text{ m}^3 \text{ (1)}^{1/2}$$

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o Cooper-Bredhehoeft-Papadopoulos Method

- Used for confined unit with $K < 0.5$ cm/sec.

- Input data are:

1. Radius of well (r)
2. Time representing point on matched type curve (t).

t is obtained from matching the data points of residual drawdown/initial residual drawdown vs. log of time to a type curve found in the referenced report.

- The equation solved is:

$$K = \frac{r_c^2}{tL}$$

C. User's Manual

SLUG/BAS is very easy to use. All input is prompted by explicit commands. The information supplied in Part B is a User's Manual.

D. Code Assessment and Support

To assess and verify the computer code, examples of each method with hand calculation checks are supplied (Attachment 1). Given the simplicity of the calculations, these checks are sufficient verification. The present version of SLUG/BAS is the only presently available version.

E. Continuing Documentation and Code Listings

The code listing is supplied as Attachment 2.

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ATTACHMENT 1

BOUWER-RICE SLUG TEST ANALYSIS

SITE:LKV01

LOCATION:501

DATE:08/26/84

$$Y_0 = 2.5 \text{ ft.}$$

$$t_c = 3.72 \times 10^{-3} \text{ days}$$

$$Y_c = 5.729 \times 10^{-2} \text{ ft.}$$

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ATTACHMENT 1 - Continued

LKV01 SLUG TEST - WELL 505

$$\frac{(H-H(T))}{(H-H_0)}$$

Hvorslev Method
Invaded

10/10

LKV01 SLUG TEST- WELL 503

$T_0 = 5 \text{ mins} = 342 \times 10^{-3} \text{ days}$

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ATTACHMENT 1 - Continued

FERRIS-KNOWLES SLUG TEST ANALYSIS
SITE: RVT01 LOCATION: 704

DATE: 01/16/85

For $\frac{1}{E} = 0.21 \times 10^{-1} = 5.7 \times 10^{-1}$
 $S = 0.5 \%$

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ATTACHMENT 1 - Continued

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
SITE: RVT01 LOCATION: 704 DATE: 01/16/65

WELL TEST SOLUTIONS

WELL IDENTIFICATION- LW01-501
DATE OF FIELD TEST- 8/26/1984
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
SKIN EFFECT METHOD
FOR DISCHARGE (Q)= .054
RESIDUAL DRAWDOWN (S)= .02
TIME TO RESIDUAL DRAWDOWN (t)= 4.3E-03
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= 9.5493
WELL IDENTIFICATION- LW01-501
DATE OF FIELD TEST- 8/26/1984
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
BOJER-RICE METHOD
FOR WELL RADIUS (R)= .083
BOREHOLE RADIUS (R)= .25
HEAD AT 10 (Y0)= 2.5
HEAD AT 10 (Y0)= 2.5
TIME TO HEAD MEASUREMENT (t)= 3.47E-03
HEAD AT TIME (Yt)= .0573
DISTANCE FROM WATERABLE TO BOTTOM OF OPEN OR SCREENED INTERVAL (L)= 16.75
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= 1.59556
WELL IDENTIFICATION- LW01-501
DATE OF FIELD TEST- 8/26/1984
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
BOJER-RICE METHOD
FOR WELL RADIUS (R)= .083
BOREHOLE RADIUS (R)= .25
HEAD AT 10 (Y0)= 2.5
HEAD AT 10 (Y0)= 2.5
TIME TO HEAD MEASUREMENT (t)= 3.47E-03
HEAD AT TIME (Yt)= .0573
DISTANCE FROM WATERABLE TO IMPERMEABLE BOUNDARY (M)= 2000
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= 1.59556
WELL IDENTIFICATION- LW01-501
DATE OF FIELD TEST- 8/26/1984
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
BOJER-RICE METHOD
FOR WELL RADIUS (R)= .083
BOREHOLE RADIUS (R)= .25
HEAD AT 10 (Y0)= 2.5
HEAD AT 10 (Y0)= 2.5
TIME TO HEAD MEASUREMENT (t)= 3.47E-03
HEAD AT TIME (Yt)= .0573
DISTANCE FROM WATERABLE TO IMPERMEABLE BOUNDARY (M)= 2000
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= 2.25225
WELL IDENTIFICATION- LW01-503
DATE OF FIELD TEST- 9/5/1984
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
Hvorslev METHOD
FOR WELL RADIUS (R)= .083
BOREHOLE RADIUS (R)= .25
AND TIME LAG (t0)= 3.47E-03
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= .594744
WELL IDENTIFICATION- LW01-704
DATE OF FIELD TEST- 1/16/1985
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
BOJER-RICE METHOD
FOR DISCHARGE (Q)= .054
RESIDUAL DRAWDOWN (S)= .02
TIME TO RESIDUAL DRAWDOWN (t)= 4.3E-03
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= .0992071
WELL IDENTIFICATION- LW01-704
DATE OF FIELD TEST- 1/16/1985
LENGTH OF CONTRIBUTING INTERVAL (L)= 5
BOJER-RICE METHOD
FOR DISCHARGE (Q)= .054
RESIDUAL DRAWDOWN (S)= .02
TIME TO RESIDUAL DRAWDOWN (t)= 4.3E-03
THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= .335549

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DATE _____

SUBJECT Verification of
Slug Test Results

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Test cases are on previous page

1. Skibitske:

$$K = \frac{q}{4\pi s L} = \frac{0.054}{4\pi(0.02)(4.5 \times 10^{-3})5} = 9.5493$$

2a. Gower-like with impermeable boundary deeper than bottom of well screen:

$$\ln[(H-L_w)/r_w] = \ln[(2000-16.75)/0.25] = 8.93$$

Substitute 6.0 for 8.93, see Gower, 1978, p.115 last sentence

$$\text{For } L_e/r_w = 5/0.25 = 20,$$

$$A = 2.2, B = 0.3 \text{ see Gower, 1978, p.116 fig 5.11}$$

$$\text{Equa 5.42, p.115: } \ln \frac{R_e}{r_w} = \left\{ \frac{L_e}{\ln(L_e/r_w)} + \frac{A+B \ln[(H-L_w)/r_w]}{(L_e/r_w)} \right\}^{-1}$$

$$\left[\frac{L_e}{\ln(L_e/r_w)} + \frac{2.2+0.3(6)}{(5/0.25)} \right]^{-1} = 2.165$$

$$\text{Equa 5.41, p.115: } K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \frac{1}{r_c} \ln\left(\frac{y_0}{y_c}\right) =$$

$$\frac{(0.083)^2 (2.165)}{2(5)} \frac{1}{347 \times 10^{-3}} \ln\left(\frac{2.5}{0.0522}\right) = 1.623$$

$$\text{Ratio of computed to long-term } K = \frac{1.57556}{1.623} = 0.983$$

ATTACHMENT 2

```

10 '*****
20 '*****SLUG/BA5*****
30 '*****
40 '
50 ' THIS PROGRAM SOLVES FIVE SLUG TEST METHODS: SKIBITSKE,BOWLER-RICE,
60 ' HVORSLEV,FERRIS-KNOWLES AND COPPER-BREDEHOEFT-PAPADOPULOS.
70 ' IT WAS WRITTEN BY JIM SPINKMAN OF SH&B
90 LPRINT "SLUG TEST SOLUTIONS"
100 LPRINT " "
105 LPRINT "*****"
110 INPUT "WELL IDENTIFICATION- "IN$
120 LPRINT "WELL IDENTIFICATION- "IN$
130 INPUT " DATE OF TEST RUN- "ID$
140 LPRINT "DATE OF FIELD TEST- "I D$
144 INPUT "LENGTH OF CONTRIBUTING INTERVAL,(L)"IL
146 LPRINT "LENGTH OF CONTRIBUTING INTERVAL,(L)= "IL
150 INPUT "CHOOSE METHOD OF ANALYSIS,SKIBITSKE(1),BOWLER(2),HVORSLEV(3),FERRIS-KNOWLES(4) OR COPPER-BREDEHOEFT-PAPADOPULOS(5)"MA
160 IF MA<1 OR MA>5 THEN 150
170 ON MA GOTO 190,290,440,520,740
190 PRINT "SKIBITSKE METHOD"
205 LPRINT "SKIBITSKE METHOD"
210 INPUT "INPUT VOLUME DISCHARGE(Q)"Q
220 INPUT "INPUT RESIDUAL DRAWDOWN(s)"IS
230 INPUT "INPUT TIME OF RESIDUAL DRAWDOWN MEASUREMENT(t)"IT
250 K=Q/T/S/12.566371/L
255 LPRINT "FOR DISCHARGE(Q)= "Q
258 LPRINT "RESIDUAL DRAWDOWN(s)= "IS
260 LPRINT "TIME TO RESIDUAL DRAWDOWN(t)= "IT
280 GOTO 755
290 PRINT "BOWLER-RICE METHOD"
300 LPRINT "BOWLER-RICE METHOD"
310 INPUT "WELL RADIUS(Rc)"IRC
320 INPUT "BOREHOLE RADIUS (Rw)"IRW
340 INPUT "HEAD AT To(Yo)"IYO
350 INPUT "TIME TO HEAD MEASUREMENT(t)"IT
360 INPUT "HEAD AT TIME t(Yt)"IYT
370 INPUT "DISTANCE FROM WATERTABLE TO BOTTOM OF OPEN OR SCREENED INTERVAL(Lw)"ILW
380 INPUT "DISTANCE FROM WATERTABLE TO IMPERMEABLE BOUNDARY(H)"IH
390 IF H=LU THEN 480
400 D=LOG((H-LU)/RW)
410 IF D>4. THEN D=4.
420 X=LOG(L/RW)
430 IF X>4.7875 THEN A=-.3455*X*X+5.9206*X-15.2747 ELSE A=-.491*X*X-2.045*X+3.691
440 IF X>5.247 THEN B=-.12*X*X+2.5128*X-8.7825 ELSE B=-.0459*X*X-.217*X+.4241
450 LRR=1./((1.1/LOG(LW/RW))+(A+B*D)*RW/L)
470 GOTO 520
480 X=LOG(L/RW)
490 IF X>5.0104 THEN C=-.7887*X*X+12.7088*X-37.8922 ELSE C=-.5511*X*X-2.0829*X+2.5992
500 LRP=1./((1.1/LOG(LW/RW))+C*RW/L)
520 K=RC*RC*LRR/2./L/T*LOG(YO/YT)
540 LPRINT "FOR WELL RADIUS(Rc)= "IRC
560 LPRINT "BOREHOLE RADIUS(Rw)= "IRW
580 LPRINT "HEAD AT To(Yo)= "IYO
590 LPRINT "TIME TO HEAD MEASUREMENT(t)= "IT
600 LPRINT "HEAD AT TIME t(Yt)= "IYT
610 LPRINT "DISTANCE FROM WATERTABLE TO BOTTOM OF OPEN OR SCREENED INTERVAL(Lw)= "ILW
620 LPRINT "DISTANCE FROM WATERTABLE TO IMPERMEABLE BOUNDARY(H)= "IH
640 GOTO 755
640 PRINT "HVORSLEV METHOD"
650 LPRINT "HVORSLEV METHOD"

```

640 INPUT "WELL RADIUS(R)=";RW
 680 INPUT "BUNEHOLE RADIUS(R)=";RB
 690 INPUT "TIME LAG- TIME AT WHICH (H-h)/(H-Ho)=1DE-.4343(To)";TO
 700 K=RW*RW*LOG(L/PB)/2./L/TO
 710 LPRINT "FOR WELL RADIUS(R)= ";RW
 740 LPRINT "BUNEHOLE RADIUS(R)= ";RW
 750 LPRINT "AND TIME LAG(To)= ";TO
 755 LPRINT "*****"
 760 LPRINT "THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= ";K
 765 PRINT "THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= ";K
 770 INPUT "DO YOU WANT ANOTHER RUN(YES OR NO)";AS
 772 LPRINT "*****"
 773 LPRINT ""
 775 LPRINT ""
 777 LPRINT ""
 780 IF AS="YES" THEN 100
 790 IF AS<>"NO" THEN 770
 810 END
 820 PRINT "FERRIS-KNOWLES METHOD"
 830 LPRINT "FERRIS-KNOWLES METHOD"
 840 INPUT "VOLUME DISCHARGED(Q)=";Q
 850 INPUT "RECIPROCAL OF TIME(1/t)=";IRT
 860 INPUT "DRAWDOWN AT 1/t (s)=";IS
 880 K=Q*IRT/6/L/12.566371
 890 LPRINT "FOR DISCHARGE(Q)= ";Q
 900 LPRINT "RECIPROCAL TIME(1/t)= ";IRT
 910 LPRINT "DRAWDOWN (s)= ";IS
 930 GOTO 755
 940 PRINT "COOPER-BREDEHOEFT-PAPADOPOULOS METHOD"
 950 LPRINT "COOPER-BREDEHOEFT-PAPADOPOULOS METHOD"
 960 INPUT "RADIUS OF WELL CASING(Rc)=";IRC
 970 INPUT "TIME FOR POINT ON MATCHED TYPE CURVE(t)=";IT
 990 K=IRC*IRC/IT/L
 1000 LPRINT "FOR WELL RADIUS (Rc)= ";IRC
 1010 LPRINT "TIME(t)= ";IT
 1030 GOTO 755

KHL
7/30/91

DATE _____

SUBJECT _____

SHEET NO. _____

BY _____

CHKD. _____

JOB NO. _____

Cap
7/31/91

ATTACHMENT 3

SLUG TEST FIELD DATA FORMS

DATA PLOTS

COMPUTED SOLUTIONS

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

KH
7/30/91
Cap 7/30/91
NOV 26 1995

SLUG TEST DATA

SITE ID: HAT-01 LOCATION ID: 930

STATIC WATER LEVEL:
DATE: 85/10/31 TIME: 3:00 p

SLUG VOLUME (ft.³): • 2.17

DEPTH (ft.): 56.80

INITIAL WATER LEVEL (AT t_0):

OPEN INTERVAL (ft.) 105.53 to 115.1

DATE: 85/10/30

TOTAL DEPTH OF WELL (ft.): 117.53

TIME: 6:00 p

WELL DIAM. (ft.): Ø333

DEPTH (ft FROM TOC): 54.49

FIELD REP: E. Mignardot

ELAPSED TIME (MIN. from to)	GROUNDWATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/t _m	H/H ₀ or $\frac{H}{H_0}$
:0	56.80	—	—	
1:00	59.39 2.59	2.59	1	
:50	59.27	2.47	0.67	
2:00	59.14	2.34	0.50	
:50	59.02	2.22	0.40	
3:00	58.93	2.13	0.33	
:50	58.74	1.94	0.29	
4:00	58.67	1.87	0.25	
:50	58.59	1.79	0.22	
5:00	58.52	1.72	0.20	
7:00	58.28	1.48	0.14	
10:00	58.09	1.29	0.10	
15:00	57.89	1.09	0.07	
30:00	57.62	0.82	0.03	
45:00	57.49	0.69	0.02	
60:00	57.38	0.58	0.016	
75:00	57.30	0.50	0.013	
90:00	57.21	0.41	0.011	
	56.80			

COMMENTS: Dropped slug @ 6:00 p, 85/10/30

Pulled slug @ 3:00 p, 85/10/31

CHECK STAGE @ 12:00 a, 85/11/4 = 54.81 ft

KAL
7/30/91
Cap
7/21/91

PLUG TEST DATA

SITE: HA001 MEXICAN HAT
LOCATION: 930
DATE: 10/31/85

---- ELAPSED TIME ----			GROUND WATER	RESIDUAL	HCTJ/HO
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	56.80✓	.00	.0000
4.00	4.00000	60	59.39✓	-2.59	-4.0416
4.50	.66667	90	59.27✓	-2.47	-.9933
2.00	.50000	120	59.14✓	-2.34	-.9410
2.50	.40000	150	59.02✓	-2.22	-.8928
3.00	.33333	180	58.93✓	-2.13	-.8566
3.50	.28571	210	58.74✓	-1.94	-.7802
4.00	.25000	240	58.67✓	-1.87	-.7520
4.50	.22222	270	58.59✓	-1.79	-.7198
5.00	.20000	300	58.52✓	-1.72	-.6947
7.00	.14286	420	58.28✓	-1.48	-.5952
10.00	.10000	600	58.09✓	-1.29	-.5108
15.00	.06667	900	57.89✓	-1.09	-.4383
30.00	.03333	1800	57.62✓	-.82	-.3298
45.00	.02222	2700	57.49✓	-.69	-.2775
60.00	.01667	3600	57.38✓	-.58	-.2332
75.00	.01333	4500	57.30✓	-.50	-.2014
90.00	.01111	5400	57.21✓	-.41	-.1649

[FERRIS-KNOWLES
[Hvorslev
[Bowler-Rice
[COOPER, BREDHOEFT, PAPADOPULOS
[WGNOPR

UMTRA*EZPLOTJ000
UMTRA*EZPLOTJ001
UMTRA*EZPLOTJ002
UMTRA*EZPLOTJ003

CFJOHN F-K
CFJOHN CBP

90/13/01:ITV

A 10x10 grid of 100 small, square, black and white images. Each square contains a different pattern of noise or texture, ranging from solid black to white with scattered black pixels. The patterns are arranged in a regular grid, with each square separated by a thin black line. The overall effect is a dense, textured surface composed of many small, distinct units.

(重刊) 重刊

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
SITE: HAT01 LOCATION: 930 DATE: 11/02/86

(11/02/86)

NOV 26 1985

KAL
7/30/91

Cap

SLUG TEST DATA

SITE ID: HAT-01 LOCATION ID: 934 STATIC WATER LEVEL:
DATE: 85/11/2 TIME: 1:30p
SLUG VOLUME (H₂O): 2.217 DEPTH (ft.): 194.16
INITIAL WATER LEVEL (AT t₀): OPEN INTERVAL (ft.) 142.52 to 196.52
DATE: 85/11/1 TOTAL DEPTH OF WELL (ft.): 198.52
TIME: 5:17p WELL DIAM. (ft.): 0.333
DEPTH (ft FROM TOC): 194.04 FIELD REP: E. Mignardot / W. Cordery

ELAPSED TIME (MIN. from to)	GROUNDWATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or $\frac{H-h}{H-H_0}$
10:00	194.16			
:50	195.40			
1:00	195.39			
:50	195.38			
2:00	195.38			
:50	195.37			
3:00	195.37			
:50	195.36			
4:00	195.36			
:50	195.36			
5:00	195.36			
7:00	195.36			
10:00	195.36			
15:00	195.36			
30:00	195.36			
45:00	195.36			
60:00	195.36			
120:00	195.34			
180:00	195.32			
240:00	195.20			

COMMENTS: Dropped slug @ 5:17p, 85/11/1
Pulled slug @ 1:30p, 85/11/4

KAL 4
7/30/91
Cap
7/31/91

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
LOCATION: 934
DATE: 11/02/85

ELAPSED TIME			GROUND WATER	RESIDUAL	HIT1/H0
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	194.16	.00	.0000
.50	2.00000	30	195.40	-1.24	-.4987
1.00	1.00000	60	195.39	-1.23	-.4946
1.50	.66667	90	195.38	-1.22	-.4906
2.00	.50000	120	195.38	-1.22	-.4906
2.50	.40000	150	195.37	-1.21	-.4866
3.00	.33333	180	195.37	-1.21	-.4866
3.50	.28571	210	195.36	-1.20	-.4826
4.00	.25000	240	195.36	-1.20	-.4826
4.50	.22222	270	195.36	-1.20	-.4826
5.00	.20000	300	195.36	-1.20	-.4826
7.00	.14286	420	195.36	-1.20	-.4826
10.00	.10000	600	195.36	-1.20	-.4826
15.00	.06667	900	195.36	-1.20	-.4826
30.00	.03333	1800	195.36	-1.20	-.4826
45.00	.02222	2700	195.36	-1.20	-.4826
60.00	.01667	3600	195.36	-1.20	-.4826
120.00	.00833	7200	195.34	-1.18	-.4745
180.00	.00556	10800	195.32	-1.16	-.4665
240.00	.00417	14400	195.20	-1.04	-.4182

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHOEFT, PAPADOPOULOS
QQNOPR

UMTRA*EZPLOTJ004
UMTRA*EZPLOTJ005
UMTRA*EZPLOTJ006
UMTRA*EZPLOTJ007

FERRIS-KNOWLES SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:934

DATE:11/02/88

RESIDUAL DRAWDOWN (FE)

Handwritten notes:
 11/11/88
 Cdf
 11/11/88

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
SITE: HAT01 LOCATION: 934 DATE: 11/26/86

2 10 TIME (SEC)

(11/11) 02/(11)

46
130/11
11/26/86

NOV 26 1985

KAL
7/30/91

Cap 7/3

SLUG TEST DATA

SITE ID: HAT LOCATION ID: 935 STATIC WATER LEVEL: 240P
DATE: 85/11/2 TIME: 240P
SLUG VOLUME (ft.³): 217 DEPTH (ft.): 173.35
INITIAL WATER LEVEL (AT t₀): 170.0 to 187.04
DATE: 85/11/1 TOTAL DEPTH OF WELL (ft.): 189.04
TIME: 1:10P WELL DIAM. (ft.): 0.333
DEPTH (ft FROM TOC): 179.96 FIELD REP: Ed Mignardot / W. Cordor

ELAPSED TIME (MIN. from t ₀)	GROUNDWATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or $\frac{H-h}{H-H_0}$
0:00	173.35			
1:00	175.48			
1:50	175.47			
2:00	175.46			
2:50	175.46			
3:00	175.46			
3:50	175.46			
4:00	175.46			
4:50	175.46			
5:00	175.46			
7:00	175.46			
10:00	175.46			
15:00	175.46			
30:00	175.44			
45:00	175.44			
60:00	175.43			
120:00	175.32			
180:00	175.18			
	173.35			
	1.83			

COMMENTS: Dropped slug @ 1:10P, 85/11/1
Pulled slug @ 2:40P, 85/11/4

KAL 4
7/30/91
Cap 7/87/9

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
LOCATION: 935
DATE: 11/02/85

ELAPSED TIME			GROUND WATER	RESIDUAL	HCT1/H0
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	173.35	.00	.0000
4.00	1.00000	60	175.48	-2.13	-.8566
4.50	.66667	90	175.47	-2.12	-.8526
2.00	.50000	120	175.46	-2.11	-.8485
2.50	.40000	150	175.46	-2.11	-.8485
3.00	.33333	180	175.46	-2.11	-.8485
3.50	.28571	210	175.46	-2.11	-.8485
4.00	.25000	240	175.46	-2.11	-.8485
4.50	.22222	270	175.46	-2.11	-.8485
5.00	.20000	300	175.46	-2.11	-.8485
7.00	.14286	420	175.46	-2.11	-.8485
10.00	.10000	600	175.46	-2.11	-.8485
15.00	.06667	900	175.46	-2.11	-.8485
30.00	.03333	1800	175.44	-2.09	-.8405
45.00	.02222	2700	175.44	-2.09	-.8405
60.00	.01667	3600	175.43	-2.08	-.8365
120.00	.00833	7200	175.32	-1.97	-.7922
180.00	.00556	10800	175.18	-1.83	-.7359

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHOEFT, PAPADOPULOS
@@NDPR

UMTRA*EZPLOTJ008
UMTRA*EZPLOTJ009
UMTRA*EZPLOTJ010
UMTRA*EZPLOTJ011

c / 10 /

FERRIS-KNOWLES SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:935

DATE:11/05/88

RESIDUAL HEAD (FT)

TIME (1/MIN)

High
Cap
HAT01

COOPER, BREDEHOEFT, PAPADOPOULOS SLUG TEST ANALYSIS

SITE: HAT01 LOCATION: 935

5
7/2/71
07
7/2/71

H(T)/H0 (IN/IN)

BLUG TEST SOLUTIONS

WELL IDENTIFICATION- MAT01-730
DATE OF FIELD TEST- 10/30/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10 ✓
SKIBITZKE METHOD
FOR DISCHARGE(Q)= .217 ✓
RESIDUAL DRAWDOWN(s')= .41 ✓
TIME TO RESIDUAL DRAWDOWN(t)= 90.

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $4.67976E-05 \text{ }^{\text{ft}}/\text{min} = 6.7 \times 10^{-5} \text{ }^{\text{ft}}/\text{day}$ ✓

KAL 5.
7/31/91
Cap
7/31/91

✓ Cap
6/24/91

WELL IDENTIFICATION- MAT01-730
DATE OF FIELD TEST- 10/30/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10 ✓
FERRIS-KNOWLES METHOD
FOR DISCHARGE(Q)= .217 ✓
RECIPROCAL TIME(1/t)= .1 ✓
DRAWDOWN (s)= 1.3 ✓

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $1.32833E-04 \text{ }^{\text{ft}}/\text{min} = 1.9 \times 10^{-4} \text{ }^{\text{ft}}/\text{day}$ ✓

✓ Cap
6/24/91

WELL IDENTIFICATION- MAT01-730
DATE OF FIELD TEST- 10/30/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
COOPER-BREDEHOEFT-PAPADOPULOS METHOD
FOR WELL RADIUS (Rc)= .167
TIME(t)= 20

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $3.39445E-04 \text{ }^{\text{ft}}/\text{min} = 12.5 \text{ }^{\text{ft}}/\text{day}$

WELL IDENTIFICATION- MAT01-734
DATE OF FIELD TEST- 11/01/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
SKIBITZKE METHOD
FOR DISCHARGE(Q)= .217
RESIDUAL DRAWDOWN(s')= 1.83
TIME TO RESIDUAL DRAWDOWN(t)= 180

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $5.24235E-06 \text{ }^{\text{ft}}/\text{min} = 7.6 \times 10^{-6} \text{ }^{\text{ft}}/\text{day}$

late-time data

✓ Cap
6/24/91

WELL IDENTIFICATION- HAT01-934
DATE OF FIELD TEST- 11/01/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
KIBITKE METHOD
FOR DISCHARGE(Q)= .217
RESIDUAL DRAWDOWN(s')= 2.11
TIME TO RESIDUAL DRAWDOWN(t)= 2

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $0.09202E-04 \text{ ft/min} = 5.9 \times 10^{-1} \text{ ft/day}$

KHL 52
7/30/91
Cap
7/31/91

early-time data

✓ Cap
6/24/91

WELL IDENTIFICATION- HAT01-934
DATE OF FIELD TEST- 11/01/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
FERRIS-KNOWLES METHOD
FOR DISCHARGE(Q)= .217
RECIPROCAL TIME(1/t)= .01
DRAWDOWN (s)= 1.5

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $1.15122E-05 \text{ ft/min} = 1.7 \times 10^{-2} \text{ ft/day}$

✓ Cap
6/24/91

WELL IDENTIFICATION- HAT01-934
DATE OF FIELD TEST- 11/01/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
COOPER-BREDEHOEFT-PAPADOPULOS METHOD
FOR WELL RADIUS (Rc)= .167
TIME(t)= 30

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $9.29633E-05 \text{ ft/sec} = 8.0 \text{ ft/day}$

probably invalid

WELL IDENTIFICATION- HAT01-935
DATE OF FIELD TEST- 11/01/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 10
KIBITKE METHOD
FOR DISCHARGE(Q)= .217
RESIDUAL DRAWDOWN(s')= 2.04
TIME TO RESIDUAL DRAWDOWN(t)= 240

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $6.9184E-06 \text{ ft/min} = 1.0 \times 10^{-2} \text{ ft/day}$

late-time data

✓
Cap
6/24/91

WELL IDENTIFICATION- HAT01-35

DATE OF FIELD TEST- 11/01/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 10

SKIBITSKE METHOD

FOR DISCHARGE(Q)= .217

RESIDUAL DRAWDOWN(s')= 1.2

TIME TO RESIDUAL DRAWDOWN(t)= 3.5

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= { 4.1115E-04 ^{FT}/min = 5.9 x 10⁻¹ ^{FT}/day

WELL IDENTIFICATION- HAT01-35

DATE OF FIELD TEST- 11/01/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 10

FERRIS-KNOWLES METHOD

FOR DISCHARGE(Q)= .217

RECIPROCAL TIME(1/t)= .01

DRAWDOWN (s)= 2

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= { 8.63416E-06 ^{FT}/min = 1.2 x 10⁻² ^{FT}/day

MAY 30 1985

MAY 29 1985

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

SLUG TEST DATA

SITE ID: HAT-01 LOCATION ID: 908 DATE: 85/4/17 TIME: 12:07 P.M.
SLUG VOLUME (IL³): 0.05 H³ DEPTH (II): 50.80
INITIAL WATER LEVEL: (161 FT) OPEN INTERVAL NOT KNOWN TO NOT KNOWN
DATE: 85/4/11 TOTAL DEPTH OF WELL (II): 164.30
TIME: 11:00 A.M. WELL DIAM. (II): .167
DEPTH (II FROM TOC): 51.15 OBSERVERS: R. BANSBERG

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (II.)	1/I _m	H/H ₀ or $\frac{H-h}{H-H_0}$
0:00	50.80	0		
:30	52.70	1.90		
1:00	52.60	1.80		
:30	52.49	1.69		
2:00	52.37	1.54		
:30	52.21	1.41		
3:00	52.10	1.30		
:30	51.98	1.18		
4:00	51.86	1.06		
:30	51.76	0.96		
5:00	51.68	0.88		
:30	51.59	0.79		
6:00	51.52	0.72		
:30	51.46	0.66		
7:00	51.39	0.59		
:30	51.33	0.53		
8:00	51.27	0.47		
:30	51.23	0.43		
9:00	51.20	0.40		
:30	51.14	0.34		

COMMENTS: DROPPED SLUG 85/4/12 @ 9:00 A.M.

5.
KAL
7/30/91
cap
7/31/91

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

SLUG TEST DATA

SITE ID: HAT-01 LOCATION ID: 908 STATIC WATER LEVEL: _____
DATE: _____ TIME: _____
SLUG VOLUME (ft.³): CONTINUED DEPTH (ft.): _____
INITIAL WATER LEVEL: _____ OPEN INTERVAL _____ to _____
DATE: _____ TOTAL DEPTH OF WELL (ft.): _____
TIME: _____ WELL DIAM. (ft.): _____
DEPTH (ft. FROM TOC): _____ OBSERVERS: _____

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/h _m	H/H ₀ or $\frac{H-h}{H-H_0}$
10:00	51.10	0.30		
11:00	51.05	0.25		
12:00	50.99	0.19		
13:00	50.95	0.15		
14:00	50.92	0.12		
15:00	50.89	0.09		
16:00	50.87	0.07		
17:00	50.85	0.05		
18:00	50.83	0.03		
19:00	50.83	0.03		
20:00	50.82	0.02		
25:00	50.80	0.00		
30:00	50.80	0.00		
1 HOUR 60	50.76	+0.04		
2 HOUR 120	50.72	+0.08		
31 HOURS 1860	50.73	+0.07		

COMMENTS: _____

KAL S.
7/30/91.
Cap
7/31/91

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

KPL
7/30/91
Cap
7/31/91

SLUG TEST DATA

SITE ID: Hat01 LOCATION ID: 908 STATIC WATER LEVEL:
DATE: 85/7/31 TIME: 9:07 A.M.
SLUG VOLUME (ft.³): 0.05 DEPTH (ft.): 50.94
INITIAL WATER LEVEL: 146 FT to 161 FT
DATE: 85/7/28 TOTAL DEPTH OF WELL (ft.): 164.20
TIME: 11:30 A WELL DIAM. (in): .167
DEPTH (ft FROM TOC): 50.95 OBSERVERS: Fritts / Scorsato

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or H-h H-H ₀
Initial	50.94			
.5	53.12			
1:00	52.92			
.5	52.88			
2:00	52.56			
.5	52.42			
3:00	52.30			
.5	52.18			
4:00	52.09			
.5	51.95			
5:00	51.86			
6:00	51.70			
7:00	51.59			
8:00	51.49			
9:00	51.38			
10:00	51.30			
12:00	51.16			
14:00	51.07			
16:00	51.03			
18:00	50.98			

COMMENTS: dropped slug 8/1/88 85/7/29
pulled slug 85/7/30, 9:07 A.M.
Page 1 of 2

5
KAL
7/30/91
cap
7/31/91

SITE ID: Hat 01 LOCATION ID: 908 STATIC WATER LEVEL: _____
DATE: 8/7/31 TIME: _____

SLUG VOLUME (11.3): _____ DEPTH (11): _____

INITIAL WATER LEVEL: _____ OPEN INTERVAL _____ to _____

DATE: _____ TOTAL DEPTH OF WELL (ft): _____

TIME: _____ WELL DIAM. (ft): _____

DEPTH (ft FROM TOC): _____ **OBSERVERS:** _____

[illegible]

COMMENTS: _____

page 2 of 2

KAL 5
7/30/91
Cap
7/31/91

1/SLUG TEST SOLUTIONS

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 07/31/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15

SKIBITSKE METHOD

FOR DISCHARGE (Q)= .05

RESIDUAL DRAWDOWN (s')= .04 ft.

TIME TO RESIDUAL DRAWDOWN (t)= 20 min.

THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= $3.31573E-04$ ft/min = 0.48 ft/day

$$K = \frac{t}{4\pi s L t}$$

✓ KAL
7/10/91
✓ Cap

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 07/31/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15

FERRIS-KNOWLES METHOD

FOR: DISCHARGE (Q)= .05

RECIPROCAL TIME (1/t)= .4 1/min

DRAWDOWN (s)= 1.6 ft

THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= $6.63146E-05$ ft/min = 0.10 ft/day

✓ KAL
7/10/91
✓ Cap

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 07/31/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15

COOPER-BREDEHOEFT-PAPADOPULOS METHOD

FOR: WELL RADIUS (Rc)= .083 ft

TIME (t)= 100 sec

THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= $4.59267E-06$ ft/sec = 0.40 ft/day

✓ KAL
7/10/91
✓ Cap

SLUG TEST DATA

SITE: HAT04 MEXICAN HAT
LOCATION: 908
DATE: 07/31/85

KAL 3
7/30/91
caf
7/31/91

ELAPSED TIME			GROUND WATER	RESIDUAL	
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	HIT/HO [FT./FT.]
.00	.00000	0	50.94	.00	.0000
.50	2.00000	30	53.42	-2.48	-.9542
1.00	1.00000	60	52.92	-1.98	-.8639
1.50	.66667	90	52.88	-1.94	-.8465
2.00	.50000	120	52.56	-1.62	-.7069
2.50	.40000	150	52.42	-1.48	-.6458
3.00	.33333	180	52.30	-1.36	-.5934
3.50	.28571	210	52.18	-1.24	-.5411
4.00	.25000	240	52.09	-1.15	-.5018
4.50	.22222	270	51.95	-1.01	-.4407
5.00	.20000	300	51.86	-.92	-.4014
6.00	.16667	360	51.70	-.76	-.3316
7.00	.14286	420	51.59	-.65	-.2836
8.00	.12500	480	51.49	-.55	-.2400
9.00	.11111	540	51.38	-.44	-.1920
10.00	.10000	600	51.30	-.36	-.1571
12.00	.08333	720	51.16	-.22	-.0960
14.00	.07143	840	51.07	-.13	-.0567
16.00	.06250	960	51.03	-.09	-.0393
18.00	.05556	1080	50.98	-.04	-.0175
20.00	.05000	1200	50.98	-.04	-.0175
22.00	.04545	1320	50.94	.00	.0000
24.00	.04167	1440	50.94	.00	.0000
26.00	.03846	1560	50.94	.00	.0000

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHOEFT, PAPADOPULOS
@@NOPR

UMTRA*EZPLOTJD01
UMTRA*EZPLOTJD02
UMTRA*EZPLOTJD03
UMTRA*EZPLOTJD04

COOPER, BREDEHOEFT, PAPADOPOULOS SLUG TEST ANALYSIS

DATE: 07/31/85

LOCATION: 908

SITE: HAT01

(14/14) OH/(1)M

7/31/91
 Cef
 #30/91
 KHL

6
KMC
7/30/91
Cap
7/31/91

FERRIS-KNOWLES SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:908

DATE:07/31/85

RESIDUAL DRAWDOWN (FT)

SLUG TEST SOLUTIONS

KAL 6
7/30/91
Cap
7/31/91

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 04/11/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15 ft.

SKIBITSKE METHOD

FOR DISCHARGE(Q)= .05

RESIDUAL DRAWDOWN(s')= .02 ft.

TIME TO RESIDUAL DRAWDOWN(t)= 20 min

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 6.63146E-04 $\text{ft/min} = 0.96 \text{ ft/d}$

$$K = \frac{Q}{4\pi SLt}$$

✓ KAL
7/10/91
✓ Cap

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 04/11/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15

FERRIS-KNOWLES METHOD

FOR: DISCHARGE(Q)= .05

RECIPROCAL TIME(1/t)= .4 ft. /min

DRAWDOWN (s)= 1.5 ft.

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 7.07355E-05 $\text{ft/min} = 0.1 \text{ ft/d}$

✓ KAL
7/10/91
✓ Cap

WELL IDENTIFICATION- HAT01-908

DATE OF FIELD TEST- 04/11/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 15

COOPER-BREDEHOEFT-PAPADOPULOS METHOD

FOR: WELL RADIUS (Rc)= .084 ft.

TIME(t)= 100 sec.

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 4.704E-06 $\text{ft/sec} = 0.41 \text{ ft/d}$

✓ KAL
7/10/91
✓ Cap

John Dupew

KAL
7/30/91
Cap 7/31/91

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
LOCATION: 908
DATE: 04/11/85

checked by Sclarville
8/1/85

---- ELAPSED TIME ----			GROUND WATER	RESIDUAL	HITJ/HO
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	50.80	.00	.0000
.50	2.00000	30	52.70	-1.90	-.8290
1.00	1.00000	60	52.60	-1.80	-.7854
1.50	.66667	90	52.49	-1.69	-.7374
2.00	.50000	120	52.34	-1.54	-.6720
2.50	.40000	150	52.21	-1.41	-.6152
3.00	.33333	180	52.10	-1.30	-.5672
3.50	.28571	210	51.98	-1.18	-.5149
4.00	.25000	240	51.86	-1.06	-.4625
4.50	.22222	270	51.76	-.96	-.4189
5.00	.20000	300	51.68	-.88	-.3840
5.50	.18182	330	51.59	-.79	-.3447
6.00	.16667	360	51.52	-.72	-.3142
6.50	.15385	390	51.46	-.66	-.2880
7.00	.14286	420	51.39	-.59	-.2574
7.50	.13333	450	51.33	-.53	-.2313
8.00	.12500	480	51.27	-.47	-.2051
8.50	.11765	510	51.23	-.43	-.1876
9.00	.11111	540	51.20	-.40	-.1745
9.50	.10526	570	51.14	-.34	-.1484
10.00	.10000	600	51.10	-.30	-.1309
11.00	.09091	660	51.05	-.25	-.1091
12.00	.08333	720	50.99	-.19	-.0829
13.00	.07692	780	50.95	-.15	-.0654
14.00	.07143	840	50.92	-.12	-.0524
15.00	.06667	900	50.89	-.09	-.0393
16.00	.06250	960	50.87	-.07	-.0305
17.00	.05882	1020	50.85	-.05	-.0218
18.00	.05556	1080	50.83	-.03	-.0131
19.00	.05263	1140	50.83	-.03	-.0131
20.00	.05000	1200	50.82	-.02	-.0087
25.00	.04000	1500	50.80	.00	.0000
30.00	.03333	1800	50.80	.00	.0000
60.00	.01667	3600	50.76	.04	.0175
120.00	.00833	7200	50.72	.08	.0349
1860.00	.00054	111600	50.73	.07	.0305

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHOEFT, PAPADOPULOS
@@PRNT

PLOT FILE=
PLOT FILE=
PLOT FILE=
PLOT FILE=

UMTRA*EZPLOTH100 .
UMTRA*EZPLOTH101 .
UMTRA*EZPLOTH102 .
UMTRA*EZPLOTH103 .

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS

SITE: HAT01

LOCATION: 908

DATE: 04/11/85

checked by SColarullo
8/6/85

KAL
2/30/91
Caf
7/31/91

FERRIS-KNOWLES SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:908

DATE:04/11/85

checked by JColarullo
8/6/85

KAC
7/30/91
CQP
7/31/91

CONFIRMED

HVORSLEV SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:908

DATE:04/11/85

KAL 6
7/30/91
Cap
7/31/91

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
 SITE: HAT01 LOCATION: 908 DATE: 04/11/85

H(t)/H0 (ft/ft)

>

KAC 6
 7/30/91
 Cef
 7/31/91

HVORSLEV SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:908

DATE:04/11/85

KHL
7/30/91
Cap
7/31/91

BOUWER-RICE SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:908

DATE:04/11/85

RESIDUAL DRAWDOWN (FT)

KHL
7/30/91
Cef
7/31/91

30 1985

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

KAL
7/30/91
Cap
7/31/91

SLUG TEST DATA

SITE ID: HAT-01 LOCATION ID: 909 STATIC WATER LEVEL: _____
DATE: 85/4/17 TIME: 10:50 AM
SLUG VOLUME (ft.³): .05 DEPTH (ft.): 37.94 ^{36.94}
INITIAL WATER LEVEL: _____ OPEN INTERVAL NOT KNOWN TO NOT KNOWN
DATE: 85/4/10 TOTAL DEPTH OF WELL (ft.): 142.35
TIME: 3:22 P.M. WELL DIAM. (ft.): .167
DEPTH (ft. FROM TOC): 39.58 OBSERVERS: R. BANSBERG

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or $\frac{H-h}{H-H_0}$
0:00	<u>37.94</u> ^{36.94}			
:30				
1:00	<u>38.46</u>			
:30	<u>38.19</u>			
2:00	<u>38.07</u>			
:30	<u>37.94</u>			
3:00	<u>37.80</u>			
:30	<u>37.71</u>			
4:00	<u>37.65</u>			
:30	<u>37.57</u>			
5:00	<u>37.57</u>			
:30	<u>37.51</u>			
6:00	<u>37.48</u>			
:30	<u>37.43</u>			
7:00	<u>37.41</u>			
:30	<u>37.40</u>			
8:00	<u>37.40</u>			
:30	<u>37.38</u>			
9:00	<u>37.38</u>			
:38	<u>37.36</u>			

COMMENTS: DROPPED SLUG 85/4/11 ~ 9:00 A.M.

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

SLUG TEST DATA

7/31/91
KAL
7/30/91
Cap

WELL ID: HAT-01 LOCATION ID: 909 STATIC WATER LEVEL: _____
SLUG VOLUME (ft.³): CONTINUED DATE: _____ TIME: _____
INITIAL WATER LEVEL: _____ DEPTH (ft): _____
DATE: _____ OPEN INTERVAL _____ to _____
TIME: _____ TOTAL DEPTH OF WELL (ft): _____
DEPTH (ft FROM TOC): _____ WELL DIAM. (ft): _____
OBSERVERS: _____

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/t _m	H/H ₀ or $\frac{H-h}{H-H_0}$
11:00	37.31			
12:00	37.30			
13:00	37.29			
14:00	37.29			
15:00	37.28			
20:00	37.27			
25:00	37.27			
30:00	37.24			
35:00	—			
40:00	—			
45:00	—			
50:00	—			
55:00	—			
1 HOUR 00	37.19			
2 HOUR 120	37.16			
3 HOUR 180	37.10			
31 HOUR 1860	37.03			

COMMENTS: _____

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

SLUG TEST DATA

SITE ID: Hat01 LOCATION ID: 909

STATIC WATER LEVEL:

DATE: 85/8/14 TIME: 2:30 P

SLUG VOLUME (II.3): 1.05 FT³

DEPTH (II): 35.96

INITIAL WATER LEVEL:

OPEN INTERVAL 132.0 FT to 152.0 FT

DATE: 85/7/27

TOTAL DEPTH OF WELL (II): 142.35

TIME: 6:15 P

WELL DIAM. (II): 0.167

DEPTH (II FROM TOC): 36.37

OBSERVERS: Fritts

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or $\frac{H-h}{H-H_0}$
:00	35.96			
.5	32.21			
1:00	36.93			
.5	36.75			
2:00	36.59			
.5	36.48			
3:00	36.40			
.5	36.34			
4:00	36.27			
.5	36.24			
5:00	36.20			
6:00	36.14			
7:00	36.11			
8:00	36.09			
9:00	36.08			
10:00	36.05			
12:00	36.03			
14:00	36.03			
16:00	36.01			
20:00	35.99			

COMMENTS: dropped slug 85/7/27 6:00 P

pulled slug 85/8/14 2:30 P

note: Water samplers not in Field 85/8/2 - 8/15.

page 1 of 2

KAL
7/30/91
Cap
7/31/91

SLUG TEST DATA

SITE ID: H401 LOCATION ID: 909 STATIC WATER LEVEL: _____
DATE: 8/8/14 TIME: _____

SLUG VOLUME (ft.³): _____ **DEPTH (ft):** _____

INITIAL WATER LEVEL (AT t_0): OPEN INTERVAL (ft.) _____ to _____

DATE: _____ **TOTAL DEPTH OF WELL (ft):** _____

TIME: _____ WELL DIAM. (ft): _____

DEPTH (ft FROM TOC): _____ FIELD REP: _____

[illegible]

COMMENTS: page 2 of 2

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 04/10/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
SKIBITSKE METHOD

FOR DISCHARGE(Q)= .05
RESIDUAL DRAWDOWN(s')= .09 ft
TIME TO RESIDUAL DRAWDOWN(t)= 1860 min

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $1.18843E-06 \text{ }^{ft}/\text{min} = 0.002 \text{ }^{ft}/\text{day}$

KAL
7/30/91
Cap
7/31/91
 $K = \frac{Q}{4\pi S L t}$

✓ KAL
7/10/91
✓ Cap

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 04/10/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
FERRIS-KNOWLES METHOD
FOR: DISCHARGE(Q)= .05
RECIPROCAL TIME(1/t)= .2 min
DRAWDOWN (s)= .6 ft

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $6.63146E-05 \text{ }^{ft}/\text{min} = 0.10 \text{ }^{ft}/\text{day}$

✓ KAL
7/10/91

✓ Cap

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 04/10/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
COOPER-BREDEHDEFT-PAPADOPULOS METHOD
FOR: WELL RADIUS (Rc)= .084 ft.
TIME(t)= 250 sec.

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $1.4112E-06 \text{ }^{ft}/\text{sec} = 0.12 \text{ }^{ft}/\text{day}$

✓ Cap ✓ KAL
7/10/91

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
 LOCATION: 909
 DATE: 04/10/85

KAL
 7/30/85
 cap
 7/31/85
 checked by S&L
 8/6/85

ELAPSED TIME			GROUND WATER	RESIDUAL	HET]/H0
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	36.94	.00	.0000
1.00	1.00000	60	38.46	-1.52	-.6632
1.50	.66667	90	38.19	-1.25	-.5454
2.00	.50000	120	38.07	-1.13	-.4931
2.50	.40000	150	37.94	-1.00	-.4363
3.00	.33333	180	37.80	-.86	-.3752
3.50	.28571	210	37.74	-.77	-.3360
4.00	.25000	240	37.65	-.74	-.3098
4.50	.22222	270	37.57	-.63	-.2749
5.00	.20000	300	37.57	-.63	-.2749
5.50	.18182	330	37.51	-.57	-.2487
6.00	.16667	360	37.48	-.54	-.2356
6.50	.15385	390	37.43	-.49	-.2138
7.00	.14286	420	37.41	-.47	-.2051
7.50	.13333	450	37.40	-.46	-.2007
8.00	.12500	480	37.40	-.46	-.2007
8.50	.11765	510	37.38	-.44	-.1920
9.00	.11111	540	37.38	-.44	-.1920
9.50	.10526	570	37.36	-.42	-.1833
11.00	.09091	660	37.31	-.37	-.1614
12.00	.08333	720	37.30	-.36	-.1571
13.00	.07692	780	37.29	-.35	-.1527
14.00	.07143	840	37.29	-.35	-.1527
15.00	.06667	900	37.28	-.34	-.1484
20.00	.05000	1200	37.27	-.33	-.1440
25.00	.04000	1500	37.27	-.33	-.1440
30.00	.03333	1800	37.24	-.30	-.1309
60.00	.01667	3600	37.19	-.25	-.1091
120.00	.00833	7200	37.16	-.22	-.0960
180.00	.00556	10800	37.10	-.16	-.0698
1860.00	.00054	111600	37.03	-.09	-.0393

DATA FILE

NAME

FERRIS-KNOWLES
 HVORSLEV
 BOWLER-RICE
 COOPER, BREDHOEFT, PAPADOPULOS
 @NOPR

UMTRA*EZPLOTH004 - CFJON1
 UMTRA*EZPLOTH005
 UMTRA*EZPLOTH006
 UMTRA*EZPLOTH007 - CFJON1

FERRIS-KNOWLES SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:909

DATE:04/11/85

checked by S Colarullo
8/6/85

7/6 KAC
7/31/91
7/31/91

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
 SITE: HAT01 LOCATION: 909 DATE: 04/10/85

checked by J. Colarullo
 8/6/85

77 KAL
 7/30/91
 CCF
 7/31/91

KAL
7/30/91
caf
7/31/91

SLUG TEST SOLUTIONS

WELL IDENTIFICATION- HAT01-909

DATE OF FIELD TEST- 08/14/85

LENGTH OF CONTRIBUTING INTERVAL, (L)= 20

$$K = \frac{q}{4\pi s L t}$$

SKIBITSKE METHOD

FOR DISCHARGE (Q)= .05

RESIDUAL DRAWDOWN (s')= .01 ft

TIME TO RESIDUAL DRAWDOWN (t)= 36 min

THE CALCULATED HYDRAULIC CONDUCTIVITY (K)= , 5.52621E-04 ^{FT}/min = 0.80 ^{FT}/day ✓

✓caf
KAL
7/10/91

SLUG TEST SOLUTIONS

KAL
7/30/91
cap
7/31/91

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
SKIBITSKE METHOD
FOR DISCHARGE(Q)= .05
RESIDUAL DRAWDOWN(s')= .01 ft
TIME TO RESIDUAL DRAWDOWN(t)= 20 min *INVALID*

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $9.94719E-04$ $\frac{ft}{min} = 1.4 \frac{ft}{day}$

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
FERRIS-KNOWLES METHOD
FOR: DISCHARGE(Q)= .05
RECIPROCAL TIME(1/t)= .4 $\frac{1}{min}$
DRAWDOWN (s)= .5 ft

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $1.59155E-04$ $\frac{ft}{min} = 0.23 \frac{ft}{day}$

✓cap ✓KAL
7/10/91

WELL IDENTIFICATION- HAT01-909
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 20
COOPER-BREDEHOEFT-PAPADOPULOS METHOD
FOR: WELL RADIUS (R_w)= .083
TIME(t)= 95 min sec

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= $3.62579E-06$ $\frac{ft}{min \ sec} = 0.31 \frac{ft}{day}$

✓cap ✓KAL
7/10/91

KAL
7/30/91
CAF
7/31/91

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
LOCATION: 909
DATE: 08/14/85

----- ELAPSED TIME -----			GROUND WATER	RESIDUAL	HIT1/H0
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	35.96	.00	.0000
.50	2.00000	30	37.21	-1.25	-.5454
1.00	1.00000	60	36.93	-.97	-.4232
1.50	.66667	90	36.75	-.79	-.3447
2.00	.50000	120	36.59	-.63	-.2749
2.50	.40000	150	36.48	-.52	-.2269
3.00	.33333	180	36.40	-.44	-.1920
3.50	.28571	210	36.34	-.38	-.1658
4.00	.25000	240	36.27	-.31	-.1353
4.50	.22222	270	36.24	-.28	-.1222
5.00	.20000	300	36.20	-.24	-.1047
6.00	.16667	360	36.14	-.18	-.0785
7.00	.14286	420	36.11	-.15	-.0654
8.00	.12500	480	36.09	-.13	-.0567
9.00	.11111	540	36.08	-.12	-.0524
10.00	.10000	600	36.05	-.09	-.0393
12.00	.08333	720	36.03	-.07	-.0305
14.00	.07143	840	36.03	-.07	-.0305
16.00	.06250	960	36.01	-.05	-.0218
20.00	.05000	1200	35.99	-.03	-.0131
24.00	.04167	1440	35.99	-.03	-.0131
28.00	.03571	1680	35.99	-.03	-.0131
32.00	.03125	1920	35.98	-.02	-.0087
36.00	.02778	2160	35.97	-.01	-.0044
40.00	.02500	2400	35.97	-.01	-.0044
44.00	.02273	2640	35.97	-.01	-.0044

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHDEFT, PAPADOPULOS
@@NPR

UMTRA*EZPLOTJD05
UMTRA*EZPLOTJD06
UMTRA*EZPLOTJD07
UMTRA*EZPLOTJD08

COOPER, BREDEHOEFT, PAPADOPULOS SLUG TEST ANALYSIS
 SITE: HAT01 LOCATION: 909 DATE: 08/14/85

H(t)/H0 (10⁻¹)

KAL
 7/30/91
 Caf
 7/31/91

FERRIS-KNOWLES SLUG TEST ANALYSIS
SITE:HAT01 LOCATION:909

DATE:08/14/85

KAL
7/30/91
Cef
7/31/91

SUBJECT

DATE

BY

CHKD.

SHEET NO.

JOB NO.

KAL
7/30/91
Ced

Slog Test Summary - HAT01

Hydraulic Conductivity (ft/day)

Well ID

Sibilities

Ferns-Knuckles

Cooper-Bredheft-Appapoulos

Average

Standard Deviation

908

0.955

0.102

0.397

0.485

0.433

909

0.002

0.095

0.119

0.072

0.062

DATE _____

SUBJECT _____

SHEET NO. _____

BY _____ CHKD. _____

JOB NO. _____

KAL
7/30/91

cap

7/31/91

Skibitz MethodHATØ1-908 :

$$K = \frac{9}{4\pi SLE}$$

$$= \frac{0.05 \text{ ft}^3}{4\pi (0.02 \text{ ft}) (15 \text{ ft}) (20 \text{ min})}$$

$$= 6.63146 \times 10^{-4} \frac{\text{ft}}{\text{min}} \left(\frac{1440 \text{ min}}{1 \text{ day}} \right)$$

$$= 0.96 \frac{\text{ft}}{\text{day}} \quad \checkmark \text{ KAL } 7/10/91 \quad \checkmark \text{ cap}$$

HATØ1-909 :

$$K = \frac{9}{4\pi SLE}$$

$$= \frac{0.05 \text{ ft}^3}{4\pi (0.09 \text{ ft}) (20 \text{ ft}) (1860 \text{ min})}$$

$$= 1.18843 \times 10^{-6} \frac{\text{ft}}{\text{min}} \left(\frac{1440 \text{ min}}{1 \text{ day}} \right)$$

$$= 0.002 \frac{\text{ft}}{\text{day}} \quad \checkmark \text{ KAL } 7/10/91 \quad \checkmark \text{ cap}$$

DATE _____

SUBJECT _____

BY _____ CHKD. _____

SHEET NO. _____

JOB NO. _____

KAL
7/30/91
Cap

7/31/91

Ferris-Knowles Method

HATQ1-908:

$$K = \frac{9(1/L)}{4\pi SL}$$

$$= \frac{0.05 \text{ ft}^2 (0.4 \text{ min}^{-1})}{4\pi (1.5 \text{ ft})(15 \text{ ft})}$$

$$= 2.07355 \times 10^{-5} \frac{\text{ft}}{\text{min}} \left(\frac{1440 \text{ min}}{1 \text{ day}} \right)$$

$$= 0.1 \frac{\text{ft}}{\text{day}} \quad \checkmark \text{ KAL } 7/10/91 \quad \checkmark \text{ Cap}$$

HATQ1-909:

$$K = \frac{9(1/L)}{4\pi SL}$$

$$= \frac{(0.05 \text{ ft}^2)(0.2 \text{ min}^{-1})}{4\pi (0.6 \text{ ft})(20 \text{ ft})}$$

$$= 6.63146 \times 10^{-5} \frac{\text{ft}}{\text{min}} \left(\frac{1440 \text{ min}}{1 \text{ day}} \right)$$

$$= 0.1 \text{ ft/day} \quad \checkmark \text{ KAL } 7/10/91 \quad \checkmark \text{ Cap}$$

DATE _____

SUBJECT _____

SHEET NO. _____

BY _____ CHKD. _____

JOB NO. _____

cap

7/31/91

Cooper - Brechhoff - Papadopoulos Method

HATØ1-9Ø8 :

$$K = \frac{r_c^2}{tL}$$

$$= \frac{(0.083 \text{ ft})^2}{(100 \text{ sec})(15 \text{ ft})}$$

$$= 4.59267 \times 10^{-6} \frac{\text{ft}}{\text{sec}} \left(\frac{86400}{1 \text{ day}} \right)$$

$$= 0.40 \text{ ft/day} \quad \checkmark \text{ KAL} \quad 7/18/91 \quad \checkmark \text{ cap}$$

HATØ1-9Ø9 :

$$K = \frac{r_c^2}{tL}$$

$$= \frac{(0.083 \text{ ft})^2}{(250 \text{ sec})(20 \text{ ft})}$$

$$= 1.3778 \times 10^{-6} \frac{\text{ft}}{\text{sec}} \left(\frac{86400 \text{ sec}}{1 \text{ day}} \right)$$

$$= 0.12 \text{ ft/day} \quad \checkmark \text{ KAL} \quad 7/18/91 \quad \checkmark \text{ cap}$$

SLUG TEST DATA

SITE ID: Hot 01 LOCATION ID: 912 STATIC WATER LEVEL: _____
DATE: 85/8/14 TIME: 3:40p
SLUG VOLUME (ft.³): 0.05 DEPTH (ft.): 74.13
INITIAL WATER LEVEL: _____ OPEN INTERVAL 62.0 FT to 82.0 FT
DATE: 85/07/28 TOTAL DEPTH OF WELL (ft.): 81.50
TIME: 7:30 P WELL DIAM. (ft.): .167
DEPTH (ft FROM TOC): 74.48 OBSERVERS: Fritts

ELAPSED TIME (MIN, SEC from t ₀)	DEPTH TO WATER (ft. from TOC)	RESIDUAL DDN (ft.)	1/m	H/H ₀ or $\frac{H-h}{H-H_0}$
:00	74.13			
.5	74.60			
1.00	74.49			
.5	74.39			
2.00	74.33			
.5	74.32			
3.00	74.27			
.5	74.24			
4.00	74.23			
.5	74.20			
5.00	74.20			
6.00	74.18			
7.00	74.18			
8.00	74.18			
10.00	74.18			
12.00	74.16			
14.00	74.16			
18.00 19.00	74.16			
24.00	74.15			
29.00	74.15			

COMMENTS: dropped slug 85/7/29 5:30pm
pulled slug 85/8/14 3:40p

Page 1 of 2

Note: Water samplers not working 85/8/2 - 8/13

KAL
7/30/9
Jep
7/31/9

Case
7/3

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

SLUG TEST DATA

SITE ID: H-401 LOCATION ID: 912 STATIC WATER LEVEL:
DATE: 8/5/14 TIME: _____
SLUG VOLUME (ft.³): _____ DEPTH (ft.): _____
INITIAL WATER LEVEL (AT t_0): _____ OPEN INTERVAL (ft.) _____ to _____
DATE: _____ TOTAL DEPTH OF WELL (ft.): _____
TIME: _____ WELL DIAM. (ft.): _____
DEPTH (ft FROM $\uparrow$ OC): _____ FIELD REP: _____

[illegible]

COMMENTS: page 2 of 2

SLUG TEST SOLUTIONS

KAL 8
7/30/91
cap
7/31/91

WELL IDENTIFICATION- HATD1-912 EARLY TIME DATA
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 8
BOUWER-RICE METHOD
FOR WELL RADIUS(Rc)= .083
BOREHOLE RADIUS(Rw)= .2344
HEAD AT To(Yo)= .47
TIME TO HEAD MEASUREMENT(t)= 360 sec
HEAD AT TIME t(Yt)= .042
DISTANCE FROM WATERTABLE TO BOTTOM OF OPEN OR SCREENED INTERVAL(Lw)= 8
DISTANCE FROM WATERTABLE TO IMPERMEABLE BOUNDARY(H)= 8

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 7.73255E-06 ^{FT}/sec = 0.67 ^{FT}/day

$$\frac{Le}{rw} = 34.13$$

$$C = 2.2$$

$$\ln \frac{Re}{rw} = 2.66$$

$$\ln \left(\frac{Yo}{Yt} \right) = 2.415$$

KAL
7/12/91
✓cap

WELL IDENTIFICATION- HATD1-912 LATE TIME DATA
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 8
BOUWER-RICE METHOD
FOR WELL RADIUS(Rc)= .083
BOREHOLE RADIUS(Rw)= .2344
HEAD AT To(Yo)= .47
TIME TO HEAD MEASUREMENT(t)= 1440 sec
HEAD AT TIME t(Yt)= .02
DISTANCE FROM WATERTABLE TO BOTTOM OF OPEN OR SCREENED INTERVAL(Lw)= 8
DISTANCE FROM WATERTABLE TO IMPERMEABLE BOUNDARY(H)= 8

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 12.52702E-06 ^{FT}/sec = 0.22 ^{FT}/day

$$\frac{Le}{rw} = 34.13$$

$$C = 2.2$$

$$\ln \frac{Re}{rw} = 2.66$$

$$\ln \left(\frac{Yo}{Yt} \right) = 3.16$$

✓cap KAL
7/12/91

WELL IDENTIFICATION- HATD1-912
DATE OF FIELD TEST- 08/14/85
LENGTH OF CONTRIBUTING INTERVAL, (L)= 8
Hvorslev METHOD
FOR WELL RADIUS(r)= .083
BOREHOLE RADIUS(R)= .2344
AND TIME LAG(To)= 1.4 min

THE CALCULATED HYDRAULIC CONDUCTIVITY(K)= 1.08568E-03 ^{FT}/min = 1.56 ^{FT}/day

✓cap KAL
7/12/91

SLUG TEST DATA

SITE: HAT01 MEXICAN HAT
LOCATION: 912
DATE: 08/14/85

KAL
7/30/91
cap
7/31/91

----- ELAPSED TIME -----			GROUND WATER	RESIDUAL	HITJ/HO
[MIN]	[1/MIN]	[SEC]	DEPTH [FT.]	DRAWDOWN [FT.]	[FT./FT.]
.00	.00000	0	74.13	.00	.0000
.50	2.00000	30	74.60	-.47	-.2051
1.00	1.00000	60	74.49	-.36	-.1571
1.50	.66667	90	74.39	-.26	-.1134
2.00	.50000	120	74.33	-.20	-.0873
2.50	.40000	150	74.32	-.19	-.0829
3.00	.33333	180	74.27	-.14	-.0611
3.50	.28571	210	74.24	-.11	-.0480
4.00	.25000	240	74.23	-.10	-.0436
4.50	.22222	270	74.20	-.07	-.0305
5.00	.20000	300	74.20	-.07	-.0305
6.00	.16667	360	74.18	-.05	-.0218
7.00	.14286	420	74.18	-.05	-.0218
8.00	.12500	480	74.18	-.05	-.0218
10.00	.10000	600	74.18	-.05	-.0218
12.00	.08333	720	74.16	-.03	-.0131
14.00	.07143	840	74.16	-.03	-.0131
19.00	.05263	1140	74.16	-.03	-.0131
24.00	.04167	1440	74.15	-.02	-.0087
29.00	.03448	1740	74.15	-.02	-.0087
35.00	.02857	2100	74.16	-.03	-.0131
40.00	.02500	2400	74.16	-.03	-.0131

FERRIS-KNOWLES
HVORSLEV
BOWLER-RICE
COOPER, BREDHOEFT, PAPADOPULOS
@@NOPR

UMTRA*EZPLOTJD09
UMTRA*EZPLOTJD10✓
UMTRA*EZPLOTJD11✓
UMTRA*EZPLOTJD12

@1

KAL
 7/30/91
 Cap
 7/31/91

HVORSLEV SLUG TEST ANALYSIS

SITE:HAT01

LOCATION:912

DATE:08/14/86

KHE
 7/30/91
 7/31/91
 912

WATER LEVEL RECORDS

STATIC GROUNDWATER LEVELS
SITE: HAT01 MEXICAN HAT
REPORT DATE: 09/23/94

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0905	10006.3	9544.2	HM	O	4295.63	4294.13	04/22/85	12:00	DRY	DRY	-
							06/03/85	13:25	DRY	DRY	-
							07/28/85	07:25	DRY	DRY	-
0906	10137.5	11703.1	HM	O	4223.04	4220.83	04/22/85	16:48	9.79	7.58	4213.25
							06/03/85	13:25	9.78	7.57	4213.26
							07/28/85	15:30	DRY	DRY	-
0907	10154.1	11692.4	RI	N	4221.66	4220.51	04/11/85	11:54	+0.05	-1.10	4221.61
							04/22/85	16:39	+0.05	-1.10	4221.61
							06/03/85	13:45	0.90	-0.25	4220.76
							07/26/85	09:10	+0.90	-0.25	4220.76
							08/27/88	09:50	FLOWING	FLOWING	-
0908	10019.3	9538.7	RI	N	4292.63	4294.60	04/12/85	08:25	51.15	53.12	4241.48
							04/22/85	16:12	51.13	53.10	4241.50
							06/03/85	13:30	50.86	52.83	4241.77
							07/28/85	07:35	51.32	53.29	4241.31
							08/28/88	17:00	49.86	51.83	4242.77
0909	7925.5	7134.4	RI	N	4335.30	4349.77	04/10/85	15:21	39.58	54.05	4295.72
							04/22/85	18:20	37.94	52.41	4297.36
							06/03/85	15:05	36.91	51.38	4298.39
							07/27/85	15:00	36.07	50.54	4299.23
							08/28/88	14:45	34.16	48.63	4301.14
							11/17/88	12:00	34.10	48.57	4301.20
							04/25/91	09:20	36.71	51.18	4298.59
							08/23/91	07:25	36.48	50.95	4298.82
							12/13/91	08:15	37.71	52.18	4297.59
							08/08/92	14:21	37.40	51.87	4297.90
							11/19/92	15:08	36.53	51.00	4298.77
							06/23/93	09:40	24.54	39.01	4310.76
							04/26/94	10:04	26.65	41.12	4308.65
0910	8336.5	10067.7	HM	D	4371.60	4353.22	04/10/85	12:30	167.68	149.30	4203.92
							04/22/85	18:02	168.65	150.27	4202.95
							06/03/85	14:45	167.97	149.59	4203.63
							07/30/85	09:30	167.99	149.61	4203.61
							10/09/85	15:40	168.91	150.53	4202.69
							08/28/88	08:10	164.65	146.27	4206.95
0911	9508.4	11114.0	HM	O	4292.53	4294.35	04/13/85	10:09	93.43	95.25	4199.10

FORMATION OF COMPLETION CODE:

HM - HALGAITO MEMBER

RI - HONAKER TRAIL

FLOW RELATIONSHIP CODE:

O - ON-SITE

N - UNKNOWN

D - DOWN GRADIENT

STATIC GROUNDWATER LEVELS
SITE: HATO1 MEXICAN HAT
REPORT DATE: 09/23/94

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0911	9508.4	11114.0	HM	O	4292.53	4294.35	04/22/85	18:30	100.77	102.59	4191.76
							06/03/85	14:10	DRY	DRY	-
							07/29/85	13:40	DRY	DRY	-
							10/09/85	16:00	DRY	DRY	-
							08/28/88	12:00	DRY	DRY	-
							11/03/88	12:00	DRY	DRY	-
0912	9527.0	11133.4	HM	O	4292.20	4294.43	04/13/85	11:55	74.03	76.26	4218.17
							04/22/85	18:35	74.60	76.83	4217.60
							06/03/85	14:15	75.00	77.23	4217.20
							07/29/85	13:50	74.28	76.51	4217.92
							10/09/85	16:20	74.06	76.29	4218.14
							05/18/88	12:00	70.98	73.21	4221.22
							08/27/88	08:30	72.00	74.23	4220.20
							11/03/88	12:00	72.40	74.63	4219.80
0920	9865.0	10715.0	NR	N	-	4290.00	06/03/85	14:20	51.37	-	-
0921	9730.0	11140.0	AL	N	-	4292.00	06/03/85	14:00	2.50	-	-
0930	10550.3	7733.0	RI	N	4314.03	4311.65	10/29/85	09:04	54.49	52.11	4259.54
							05/18/88	12:00	54.18	51.80	4259.85
							08/28/88	09:30	54.10	51.72	4259.93
							11/16/88	12:00	55.01	52.63	4259.02
0932	13167.7	12636.3	NR	N	4228.49	4225.13	10/14/85	07:35	151.00	147.64	4077.49
0934	9221.3	11989.9	HM	D	4291.74	4289.27	11/01/85	15:30	194.04	191.57	4097.70
							08/27/88	10:50	179.12	176.65	4112.62
							11/17/88	12:00	193.68	191.21	4098.06
							06/02/89	08:50	196.50	194.03	4095.24
							11/30/89	13:30	197.77	195.30	4093.97
							06/20/90	10:00	192.17	189.70	4099.57
							10/04/90	12:00	191.5	189.03	4100.24
							08/21/91	14:32	192.48	190.01	4099.26
							12/12/91	10:49	192.58	190.11	4099.16
							08/12/92	09:43	191.55	189.08	4100.19
							11/19/92	08:15	190.80	188.33	4100.94
							06/22/93	16:09	191.20	188.73	4100.54
0935	10023.8	12468.3	RI	D	4233.06	4230.62	11/01/85	10:18	179.96	177.52	4053.10

FORMATION OF COMPLETION CODE:

HM - HALGAITO MEMBER
NR - NO RECOVERY OF DATA FOR CLASSIFYING
AL - ALLUVIUM
RI - HONAKER TRAIL

FLOW RELATIONSHIP CODE:

O - ON-SITE
N - UNKNOWN
D - DOWN GRADIENT

STATIC GROUNDWATER LEVELS
SITE: HAT01 MEXICAN HAT
REPORT DATE: 09/23/94

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	GROUND ELEVATION (FT MSL)	LOG DATE	LOG TIME	DEPTH FROM TOP OF CASING (FT)	DEPTH FROM GROUND (FT)	GROUNDWATER ELEVATION (FT MSL)
0935	10023.8	12468.3	RI	D	4233.06	4230.62	08/27/88	13:45	76.42	73.98	4156.64
0936	11391.7	10912.3	NR	N	4184.98	4182.90	10/22/85	08:45	103.00	100.92	4081.98

FORMATION OF COMPLETION CODE:

RI - HONAKER TRAIL

NR - NO RECOVERY OF DATA FOR CLASSIFYING

FLOW RELATIONSHIP CODE:

D - DOWN GRADIENT

N - UNKNOWN

DATA FILE: \DART\HAT01\GWL10002.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

APPENDIX C

RISK CALCULATIONS FOR HUMANS, LIVESTOCK, AND WILDLIFE

APPENDIX C - DEFINITION OF TERMS

BAF	Bioaccumulation factor
Bv	Soil-plant partition coefficient
EC20	Effective concentration that affects 20 percent of the test organisms.
Ff	Ingestion-to-tissue transfer coefficient
Fm	Ingestion-to-milk transfer coefficient
HI	Hazard index
HQ	Hazard quotient
Kd	Distribution coefficient
kg	Kilograms
L/day	Liters per day
L/kg	Liters per kilogram
mg/kg	Milligrams per kilogram
mg/kg-day	Milligrams per kilogram per day
mg/L	Milligrams per liter
NAWQC	National Ambient Water Quality Criteria
pCi/kg	Picocuries per kilogram
pCi/L	Picocuries per liter
RfD	Reference dose

Table C.1

Human Health Risk Calculations: Non-carcinogens

Site													North Arroyo
Body weight (kg)				7.00E+01				Forage Ingestion rate of sheep (kg dry weight/day)			2.30E+00		
Exposure Duration (years)				3.00E+01				Forage Ingestion rate beef cattle (kg dry weight/day)			8.00E+00		
Exposure Frequency (days)				3.50E+02				Forage Ingestion rate dairy cattle (kg dry weight/day)			1.60E+01		
Water Ingestion Rate (L/day)				2.00E+00				Water Ingestion Rate of sheep (L/day)			1.45E+01		
Ingestion rate lamb				5.00E-03				Water Ingestion Rate of beef (L/day)			2.38E+01		
Ingestion rate beef				8.96E-02				Water Ingestion Rate of dairy cattle (L/day)			6.00E+01		
Ingestion rate of milk (L/day)				1.61E-01				Averaging Time (days)			1.10E+04		
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	BAFsheep (L/kg wet sheep)	BAFbeef (L/kg wet beef)	BAFmilk (L/kg milk)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Ff beef (day/kg wet meat)	Ff sheep (day/kg wet meat)	Fm (days/kg milk)	Oral RfD (mg/kg-day)	
Ammonium	33.2	33.2	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00					
Antimony	0.06	2.7	2.25E+00	7.87E-04	1.67E-03	9.60E-03	4.50E+01	5.00E-02	4.00E-05	4.00E-05	1.00E-04	4.00E-04	
Bromide	1.1	16.5	2.25E+01	1.66E+00	5.10E+00	8.40E+00	1.50E+01	1.50E+00	2.50E-02	2.50E-02	2.00E-02		
Cadmium	0.005	0.37	4.07E+01	3.78E-02	1.22E-01	7.11E-01	7.40E+01	5.50E-01	3.50E-04	3.50E-04	1.00E-03		
Chloride	440	110	1.75E+01	9.31E-01	2.78E+00	5.10E+00	2.50E-01	7.00E+01	1.70E-02	1.70E-02	1.50E-02		
Manganese	2.27	111.23	1.47E+02	1.06E-02	6.00E-01	8.44E-01	4.90E+01	3.00E+00	5.00E-04	3.00E-05	3.50E-04	5.00E-03	
Molybdenum	0.45	3.33	2.96E+00	2.13E-02	4.75E-02	1.61E-01	7.40E+00	4.00E-01	1.00E-03	1.00E-03	1.50E-03	5.00E-03	
Nitrate	676	676	1.00E+00	6.72E-02	1.27E-01	0.00E+00	1.00E+00	1.00E+00	4.00E-03	4.00E-03		1.60E+00	
Silica	37	1221	1.16E+01	0.00E+00	0.00E+00	4.90E-01	3.30E+01	3.50E-01			2.00E-03		
Sulfate	3470	3470	1.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E+00	1.00E+00					
Sulfide	28.4	0	0.00E+00	4.93E-03	8.09E-03	9.00E-01			3.40E-04	3.40E-04	1.50E-02		
Uranium	0.806	26.598	3.30E-01	3.05E-03	5.29E-03	3.92E-02	3.30E+01	1.00E-02	2.00E-04	2.00E-04	6.00E-04	3.00E-03	
Chemical		HI (Beef)	HI (Lamb)	HI (Milk)									TOTAL
Ammonium													
Antimony		3.08E-04	8.09E-06	3.18E-03									
Bromide													
Cadmium													
Chloride													
Manganese		3.34E-01	3.29E-04	8.47E-01									
Molybdenum		5.24E-03	1.31E-04	3.20E-02									
Nitrate		6.60E-02	1.94E-03	0.00E+00									
Silica													
Sulfate													
Sulfide													
Uranium		1.74E-03	5.62E-05	2.33E-02									
Total		4.08E-01	2.47E-03	9.06E-01									

Modified From Duncan et al., 1994

Table C.2

Gypsum Creek

Modified from Duncan et al., 1994

Table C.3

Human Health Risk Calculations: Radionuclides

Site		North Arroyo										
Exposure Duration (years)	3.00E+01	Forage Ingestion Rate of Sheep (kg dry weight/day)	2.30E+00									
Exposure Frequency (days/year)	3.50E+02	Forage Ingestion Rate Beef Cattle (kg dry weight/day)	8.00E+00									
Water Ingestion Rate (L/day)	2.00E+00	Forage Ingestion Rate Dairy Cattle (kg dry weight/day)	1.60E+01									
Ingestion Rate Lamb (kg/day)	5.00E-03	Water Ingestion Rate of Sheep (L/day)	1.45E+01									
Ingestion Rate Beef (kg/day)	8.96E-02	Water Ingestion Rate of Beef (L/day)	2.38E+01									
Ingestion Rate of Milk (L/day)	1.61E-01	Water Ingestion Rate of Dairy Cattle (L/day)	6.00E+01									
Chemical	Water Concentration (pCi/L)	Soil Concentration (pCi/kg)	BAF _{plant} (L/kg dry plant)	BAF _{sheep} (L/kg wet sheep)	BAF _{beef} (L/kg wet beef)	BAF _{milk} (L/kg milk)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	FI _{sheep} (day/kg wet meat)	FI _{beef} (day/kg wet meat)	F _m (days/kg milk)	Cancer Slope (risk/pCi)
LEAD-210	1.20E+00	3.24E+02	2.43E+01	2.82E-02	8.73E-02	1.35E-01	2.70E+02	9.00E-02	4.00E-04	4.00E-04	3.00E-04	6.60E-10
RADIUM-226	6.00E-01	2.94E+02	9.80E+01	2.16E-01	7.27E-01	9.77E-01	4.90E+02	2.00E-01	9.00E-04	9.00E-04	6.00E-04	1.20E-10
RADIUM-228	1.50E+00	7.35E+02	9.80E+01	2.16E-01	7.27E-01	9.77E-01	4.90E+02	2.00E-01	9.00E-04	9.00E-04	6.00E-04	1.00E-10
THORIUM-230	2.00E-01	3.00E-06	1.50E-08	1.45E-03	2.38E-03	3.00E-04	1.50E-05	1.00E-03	1.00E-04	1.00E-04	5.00E-06	1.30E-11
URANIUM-238 + D	5.41E+02	1.79E+04	3.30E-01	5.19E-03	8.99E-03	3.92E-02	3.30E+01	1.00E-02	3.40E-04	3.40E-04	6.00E-04	2.80E-11
Chemical				Risk (Beef)	Risk (Lamb)	Risk (Milk)						
LEAD-210				6.50E-08	1.17E-09	1.81E-07						
RADIUM-226				4.92E-08	8.16E-10	1.19E-07						
RADIUM-228				1.03E-07	1.70E-09	2.48E-07						
THORIUM-230				5.82E-12	1.98E-13	1.32E-12						
URANIUM-238 + D				1.28E-07	4.13E-09	1.01E-06						
TOTAL				3.45E-07	7.81E-09	1.55E-06						

Modified From Duican et al, 1994

Table C.4

Human Health Risk Calculations: Radionuclides

Gypsum Creek												
Site												
Exposure Duration (years)		3.00E+01		Forage Ingestion Rate of Sheep (kg dry weight/day)		2.30E+00						
Exposure Frequency (days/year)		3.50E+02		Forage Ingestion Rate Beef Cattle (kg dry weight/day)		8.00E+00						
Water Ingestion Rate (L/day)		2.00E+00		Forage Ingestion Rate Dairy Cattle (kg dry weight/day)		1.60E+01						
Ingestion Rate Lamb (kg/day)		5.00E-03		Water Ingestion Rate of Sheep (L/day)		1.45E+01						
Ingestion Rate Beef (kg/day)		8.96E-02		Water Ingestion Rate of Beef (L/day)		2.38E+01						
Ingestion Rate of Milk (L/day)		1.61E-01		Water Ingestion Rate of Dairy Cattle (L/day)		6.00E+01						
Chemical	Water Concentration (pCi/L)	Soil Concentration (pCi/kg)	BAFplant (L/kg dry plant)	BAFsheep (L/kg wet sheep)	BAFbeef (L/kg wet beef)	BAFmilk (L/kg milk)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Ff sheep (day/kg wet meat)	Ff beef (day/kg wet meat)	Fm (days/kg milk)	Cancer Slope (risk/pCi)
LEAD-210	9.00E-01	2.43E+02	2.43E+01	2.82E-02	8.73E-02	1.35E-01	2.70E+02	9.00E-02	4.00E-04	4.00E-04	3.00E-04	6.60E-10
RADIUM-226	3.00E-01	1.47E+02	9.80E+01	2.16E-01	7.27E-01	9.77E-01	4.90E+02	2.00E-01	9.00E-04	9.00E-04	6.00E-04	1.20E-10
RADIUM-228	7.80E+00	3.82E+03	9.80E+01	2.16E-01	7.27E-01	9.77E-01	4.90E+02	2.00E-01	9.00E-04	9.00E-04	6.00E-04	1.00E-10
THORIUM-230	4.00E-01	6.00E-06	1.50E-08	1.45E-03	2.38E-03	3.00E-04	1.50E-05	1.00E-03	1.00E-04	1.00E-04	5.00E-06	1.30E-11
URANIUM-238 + D	5.26E+02	1.74E+04	3.30E-01	5.19E-03	8.99E-03	3.92E-02	3.30E+01	1.00E-02	3.40E-04	3.40E-04	6.00E-04	2.80E-11
Chemical	Risk (Beef)			Risk (Lamb)			Risk (Milk)					
LEAD-210	4.88E-08			8.78E-10			1.36E-07					
RADIUM-226	2.46E-08			4.08E-10			5.96E-08					
RADIUM-228	5.34E-07			8.84E-09			1.29E-06					
THORIUM-230	1.16E-11			3.96E-13			2.64E-12					
URANIUM-238 + D	1.25E-07			4.01E-09			9.78E-07					
TOTAL	7.31E-07			1.41E-08			2.46E-06					

Modified From Duncan et al, 1994

Table C.5

Site	North Arroyo				Ecological Risk Calculations				
Species	Domestic Sheep								
Body Weight (kg)	6.80E+01		Days per week exposed	1					
Exposure Duration (unitless)	1.43E-01		Home Range (acres)	600					
Site Foraging Frequency (unitless)	4.17E-03		Contaminated Acreage	2.5					
Water Ingestion Rate (L/day)	1.45E+01								
Food Ingestion Rate (kg dry weight/day)	2.32E+00	Wet Weight	2.32E+00						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	1.23E-01	2.06E-04	1.98E-04	4.05E-04
Ammonium	33.2	33.2	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	7.42E-02	1.03E-04	7.39E-06	1.10E-04
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	8.96E-02	2.83E-04	2.72E-05	3.11E-04
Beryllium	0.01	2.4	2.40E+00	2.40E+02	1.00E-02	9.49E-02	1.34E-05	5.14E-06	1.85E-05
Boron	0.9	2.7	1.20E+01	3.00E+00	4.00E+00	8.79E-04	1.30E-01	2.50E-01	3.79E-01
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	1.48E-02	4.29E-05	2.79E-04	3.22E-04
Chloride	440	110	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	4.22E-01	3.01E-06	3.22E-07	3.33E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	8.79E-02	7.22E-05	2.08E-05	9.30E-05
Copper	0.02	0.7	1.40E+01	3.50E+01	4.00E-01	1.33E-02	1.91E-04	4.28E-04	6.18E-04
Cyanide	0.01	NA	NA	NA	NA	1.90E+00	6.68E-07		6.68E-07
Fluoride	1.1	165	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.16	35.2	2.20E-01	2.20E+02	1.00E-03	1.06E+00	1.92E-05	6.74E-07	1.98E-05
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	1.37E-01	1.39E-05	6.00E-06	1.99E-05
Magnesium	515	2317.5	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	2.27	111.23	1.96E+01	4.90E+01	4.00E-01	4.62E+00	6.24E-05	1.96E-04	2.58E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	1.12E-02	2.27E-06	1.09E-06	3.35E-06
Molybdenum	0.45	3.33	7.40E-01	7.40E+00	1.00E-01	3.09E-01	1.85E-04	2.19E-05	2.07E-04
Nickel	0.13	52	2.00E+01	4.00E+02	5.00E-02	4.24E+00	3.89E-06	1.25E-05	1.63E-05
Nitrate	676	676	1.00E+00	1.00E+00	1.00E+00	1.62E+00	5.30E-02	8.47E-03	6.14E-02
Potassium	25	137.5	1.65E+00	5.50E+00	3.00E-01	1.79E+01	1.77E-04	4.68E-05	2.24E-04
Selenium	0.015	2.25	1.50E+01	1.50E+02	1.00E-01	4.45E-03	4.28E-04	1.03E-03	1.45E-03
Silica	37	1221	1.16E+01	3.30E+01	3.50E-01	6.85E-01	6.86E-03	1.27E-02	1.95E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	1.41E-02	9.00E-05	2.59E-04	3.49E-04
Sodium	520	52000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	1.30E+01	3.00E-01	4.62E+01	4.01E-05	2.50E-05	6.51E-05
Sulfate	3470	3470	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	28.4	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	1.30E+02	3.00E-01	8.79E-03	9.53E-04	5.95E-03	6.90E-03
Uranium	0.806	26.598	6.60E-02	3.30E+01	2.00E-03	1.08E-01	9.47E-04	1.00E-05	9.57E-04
Vanadium	0.05	50	5.50E+00	1.00E+03	5.50E-03	7.42E-02	8.55E-05	7.53E-05	1.61E-04
Zinc	0.02	4	8.00E+01	2.00E+02	4.00E-01	1.70E+00	1.49E-06	1.91E-05	2.06E-05
Total							1.94E-01	2.79E-01	4.73E-01

Table C.6

Site	North Arroyo				Ecological Risk Calculations				
Species	Domestic Beef Cattle								
Body Weight (kg)	5.00E+02		Days per week exposed	1					
Exposure Duration (unitless)	1.43E-01		Home Range (acres)	600					
Site Foraging Frequency (unitless)	4.17E-03		Contaminated Acreage	2.5					
Water Ingestion Rate (L/day)	2.38E+01								
Food Ingestion Rate (kg dry weight/day)	8.00E+00	Wet Weight	8.00E+01						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	6.37E-02	8.90E-05	1.79E-04	2.68E-04
Ammonium	33.2	33.2	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.84E-02	4.43E-05	6.70E-06	5.10E-05
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	4.64E-02	1.22E-04	2.46E-05	1.47E-04
Beryllium	0.01	2.4	2.40E+00	2.40E+02	1.00E-02	4.91E-02	5.77E-06	4.66E-06	1.04E-05
Boron	0.9	2.7	1.20E+01	3.00E+00	4.00E+00	4.55E-04	5.60E-02	2.26E-01	2.82E-01
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	7.68E-03	1.84E-05	2.52E-04	2.71E-04
Chloride	440	110	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	2.18E-01	1.30E-06	2.93E-07	1.59E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	4.55E-02	3.11E-05	1.88E-05	5.00E-05
Copper	0.02	0.7	1.40E+01	3.50E+01	4.00E-01	6.87E-03	8.25E-05	3.88E-04	4.71E-04
Cyanide	0.01	NA	NA	NA	NA	9.82E-01	2.89E-07		2.89E-07
Fluoride	1.1	165	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.16	35.2	2.20E-01	2.20E+02	1.00E-03	5.50E-01	8.24E-06	6.10E-07	8.85E-06
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	7.10E-02	5.99E-06	5.43E-06	1.14E-05
Magnesium	515	2317.5	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	2.27	111.23	1.96E+01	4.90E+01	4.00E-01	2.39E+00	2.69E-05	1.77E-04	2.04E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	5.82E-03	9.74E-07	9.82E-07	1.96E-06
Molybdenum	0.45	3.33	7.40E-01	7.40E+00	1.00E-01	1.60E-01	7.97E-05	1.98E-05	9.95E-05
Nickel	0.13	52	2.00E+01	4.00E+02	5.00E-02	2.20E+00	1.67E-06	1.13E-05	1.29E-05
Nitrate	676	676	1.00E+00	1.00E+00	1.00E+00	8.36E-01	2.29E-02	7.70E-03	3.06E-02
Potassium	25	137.5	1.65E+00	5.50E+00	3.00E-01	9.28E+00	7.63E-05	4.23E-05	1.19E-04
Selenium	0.015	2.25	1.50E+01	1.50E+02	1.00E-01	2.30E-03	1.85E-04	9.32E-04	1.12E-03
Silica	37	1221	1.16E+01	3.30E+01	3.50E-01	3.55E-01	2.95E-03	1.15E-02	1.44E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	7.28E-03	3.89E-05	2.35E-04	2.74E-04
Sodium	520	52000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	1.30E+01	3.00E-01	2.39E+01	1.73E-05	2.27E-05	4.00E-05
Sulfate	3470	3470	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	28.4	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	1.30E+02	3.00E-01	4.55E-03	4.11E-04	5.39E-03	5.80E-03
Uranium	0.806	26.598	6.60E-02	3.30E+01	2.00E-03	5.60E-02	4.08E-04	9.05E-06	4.17E-04
Vanadium	0.05	50	5.50E+00	1.00E+03	5.50E-03	3.84E-02	3.69E-05	6.82E-05	1.05E-04
Zinc	0.02	4	8.00E+01	2.00E+02	4.00E-01	8.82E-01	6.42E-07	1.73E-05	1.79E-05
Total							8.36E-02	2.53E-01	3.37E-01

Table C.7

Site	North Arroyo				Ecological Risk Calculations				
Species	Domestic Dairy Cattle								
Body Weight (kg)	6.00E+02				Days per week exposed	1			
Exposure Duration (unitless)	1.43E-01				Home Range (acres)	600			
Site Foraging Frequency (unitless)	4.17E-03				Contaminated Acreage	2.5			
Water Ingestion Rate (L/day)	6.00E+01								
Food Ingestion Rate (kg dry weight/day)	1.60E+01	Wet Weight	8.00E+02						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	6.00E-02	1.98E-04	3.17E-04	5.16E-04
Ammonium	33.2	33.2	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.62E-02	9.87E-05	1.18E-05	1.10E-04
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	4.37E-02	2.72E-04	4.36E-05	3.16E-04
Beryllium	0.01	2.4	2.40E+00	2.40E+02	1.00E-02	4.63E-02	1.29E-05	8.23E-06	2.11E-05
Boron	0.9	2.7	1.20E+01	3.00E+00	4.00E+00	4.28E-04	1.25E-01	4.01E-01	5.26E-01
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	7.23E-03	4.12E-05	4.47E-04	4.88E-04
Chloride	440	110	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	2.06E-01	2.89E-06	5.16E-07	3.41E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	4.28E-02	6.95E-05	3.34E-05	1.03E-04
Copper	0.02	0.7	1.40E+01	3.50E+01	4.00E-01	6.47E-03	1.84E-04	6.87E-04	8.71E-04
Cyanide	0.01	NA	NA	NA	NA	9.25E-01	6.44E-07		6.44E-07
Fluoride	1.1	165	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.16	35.2	2.20E-01	2.20E+02	1.00E-03	5.17E-01	1.84E-05	1.08E-06	1.95E-05
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	6.68E-02	1.34E-05	9.62E-06	2.30E-05
Magnesium	515	2317.5	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	2.27	111.23	1.96E+01	4.90E+01	4.00E-01	2.25E+00	6.01E-05	3.14E-04	3.74E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	5.48E-03	2.17E-06	1.74E-06	3.91E-06
Molybdenum	0.45	3.33	7.40E-01	7.40E+00	1.00E-01	1.51E-01	1.77E-04	3.50E-05	2.12E-04
Nickel	0.13	52	2.00E+01	4.00E+02	5.00E-02	2.07E+00	3.74E-06	1.99E-05	2.37E-05
Nitrate	676	676	1.00E+00	1.00E+00	1.00E+00	7.87E-01	5.11E-02	1.36E-02	6.48E-02
Potassium	25	137.5	1.65E+00	5.50E+00	3.00E-01	8.74E+00	1.70E-04	7.49E-05	2.45E-04
Selenium	0.015	2.25	1.50E+01	1.50E+02	1.00E-01	2.17E-03	4.11E-04	1.65E-03	2.06E-03
Silica	37	1221	1.16E+01	3.30E+01	3.50E-01	3.34E-01	6.59E-03	2.03E-02	2.69E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	6.85E-03	8.69E-05	4.17E-04	5.04E-04
Sodium	520	52000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	1.30E+01	3.00E-01	2.25E+01	3.86E-05	4.02E-05	7.88E-05
Sulfate	3470	3470	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	28.4	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	1.30E+02	3.00E-01	4.28E-03	9.18E-04	9.55E-03	1.05E-02
Uranium	0.806	26.598	6.60E-02	3.30E+01	2.00E-03	5.27E-02	9.10E-04	1.60E-05	9.26E-04
Vanadium	0.05	50	5.50E+00	1.00E+03	5.50E-03	3.62E-02	8.22E-05	1.21E-04	2.03E-04
Zinc	0.02	4	8.00E+01	2.00E+02	4.00E-01	8.31E-01	1.43E-06	3.06E-05	3.20E-05
Total							1.87E-01	4.48E-01	6.35E-01

Table C.8

Site	Gypsum Creek				Ecological Risk Calculations				
Species	Domestic Sheep								
Body Weight (kg)	6.80E+01		Days per week exposed		1				
Exposure Duration (unitless)	1.43E-01		Home Range (acres)		600				
Site Foraging Frequency (unitless)	8.33E-03		Contaminated Acreage		5				
Water Ingestion Rate (L/day)	1.45E+01								
Food Ingestion Rate (kg dry weight/day)	2.32E+00	Wet Weight	2.32E+00						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	1.23E-01	4.13E-04	3.96E-04	8.09E-04
Ammonium	3.44	3.44	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	7.42E-02	2.05E-04	1.48E-05	2.20E-04
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	8.96E-02	5.67E-04	5.44E-05	6.21E-04
Beryllium	0.005	1.2	2.40E+00	2.40E+02	1.00E-02	9.49E-02	1.34E-05	5.14E-06	1.85E-05
Boron	1.27	3.81	1.20E+01	3.00E+00	4.00E+00	8.79E-04	3.67E-01	7.04E-01	1.07E+00
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	1.48E-02	8.58E-05	5.58E-04	6.44E-04
Chloride	246	61.5	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	4.22E-01	6.02E-06	6.45E-07	6.66E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	8.79E-02	1.44E-04	4.16E-05	1.86E-04
Copper	0.033	1.155	1.40E+01	3.50E+01	4.00E-01	1.33E-02	6.30E-04	1.41E-03	2.04E-03
Cyanide	0.01	NA	NA	NA	NA	1.90E+00	1.34E-06		1.34E-06
Fluoride	0.8	120	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.1	22	2.20E-01	2.20E+02	1.00E-03	1.06E+00	2.39E-05	8.43E-07	2.48E-05
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	1.37E-01	2.78E-05	1.20E-05	3.98E-05
Magnesium	880	3960	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	1.59	77.91	1.96E+01	4.90E+01	4.00E-01	4.62E+00	8.74E-05	2.74E-04	3.61E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	1.12E-02	4.53E-06	2.18E-06	6.71E-06
Molybdenum	0.2	1.48	7.40E-01	7.40E+00	1.00E-01	3.09E-01	1.64E-04	1.95E-05	1.84E-04
Nickel	0.29	116	2.00E+01	4.00E+02	5.00E-02	4.24E+00	1.74E-05	5.56E-05	7.29E-05
Nitrate	994	994	1.00E+00	1.00E+00	1.00E+00	1.62E+00	1.56E-01	2.49E-02	1.81E-01
Potassium	28	154	1.65E+00	5.50E+00	3.00E-01	1.79E+01	3.97E-04	1.05E-04	5.02E-04
Selenium	0.31	46.5	1.50E+01	1.50E+02	1.00E-01	4.45E-03	1.77E-02	4.24E-02	6.01E-02
Silica	49.6	1636.8	1.16E+01	3.30E+01	3.50E-01	6.85E-01	1.84E-02	3.40E-02	5.23E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	1.41E-02	1.80E-04	5.19E-04	6.99E-04
Sodium	1520	152000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	15.1	196.3	3.90E+00	1.30E+01	3.00E-01	4.62E+01	8.30E-05	5.18E-05	1.35E-04
Sulfate	4840	4840	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	26.9	NA	NA	NA	NA	NA			
Tin	0.25	32.5	3.90E+01	1.30E+02	3.00E-01	8.79E-03	7.22E-03	4.51E-02	5.23E-02
Uranium	0.784	25.872	6.60E-02	3.30E+01	2.00E-03	1.08E-01	1.84E-03	1.95E-05	1.86E-03
Vanadium	0.08	80	5.50E+00	1.00E+03	5.50E-03	7.42E-02	2.74E-04	2.41E-04	5.15E-04
Zinc	0.051	10.2	8.00E+01	2.00E+02	4.00E-01	1.70E+00	7.62E-06	9.75E-05	1.05E-04
Total							5.71E-01	8.54E-01	1.43E+00

Table C.9

Site	Gypsum Creek				Ecological Risk Calculations				
Species	Domestic Beef Cattle								
Body Weight (kg)	5.00E+02		Days per week exposed		1				
Exposure Duration (unitless)	1.43E-01		Home Range (acres)		600				
Site Foraging Frequency (unitless)	8.33E-03		Contaminated Acreage		5				
Water Ingestion Rate (L/day)	2.38E+01								
Food Ingestion Rate (kg dry weight/day)	8.00E+00	Wet Weight	8.00E+01						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	6.37E-02	1.78E-04	3.59E-04	5.37E-04
Ammonium	3.44	3.44	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.84E-02	8.85E-05	1.34E-05	1.02E-04
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	4.64E-02	2.44E-04	4.93E-05	2.94E-04
Beryllium	0.005	1.2	2.40E+00	2.40E+02	1.00E-02	4.91E-02	5.77E-06	4.66E-06	1.04E-05
Boron	1.27	3.81	1.20E+01	3.00E+00	4.00E+00	4.55E-04	1.58E-01	6.38E-01	7.96E-01
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	7.68E-03	3.69E-05	5.05E-04	5.42E-04
Chloride	246	61.5	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	2.18E-01	2.60E-06	5.85E-07	3.18E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	4.55E-02	6.23E-05	3.77E-05	9.99E-05
Copper	0.033	1.155	1.40E+01	3.50E+01	4.00E-01	6.87E-03	2.72E-04	1.28E-03	1.55E-03
Cyanide	0.01	NA	NA	NA	NA	9.82E-01	5.77E-07		5.77E-07
Fluoride	0.8	120	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.1	22	2.20E-01	2.20E+02	1.00E-03	5.50E-01	1.03E-05	7.62E-07	1.11E-05
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	7.10E-02	1.20E-05	1.09E-05	2.28E-05
Magnesium	880	3960	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	1.59	77.91	1.96E+01	4.90E+01	4.00E-01	2.39E+00	3.77E-05	2.48E-04	2.86E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	5.82E-03	1.95E-06	1.96E-06	3.91E-06
Molybdenum	0.2	1.48	7.40E-01	7.40E+00	1.00E-01	1.60E-01	7.08E-05	1.76E-05	8.85E-05
Nickel	0.29	116	2.00E+01	4.00E+02	5.00E-02	2.20E+00	7.47E-06	5.02E-05	5.77E-05
Nitrate	994	994	1.00E+00	1.00E+00	1.00E+00	8.36E-01	6.74E-02	2.26E-02	9.00E-02
Potassium	28	154	1.65E+00	5.50E+00	3.00E-01	9.28E+00	1.71E-04	9.48E-05	2.66E-04
Selenium	0.31	46.5	1.50E+01	1.50E+02	1.00E-01	2.30E-03	7.64E-03	3.85E-02	4.61E-02
Silica	49.6	1636.8	1.16E+01	3.30E+01	3.50E-01	3.55E-01	7.92E-03	3.07E-02	3.87E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	7.28E-03	7.78E-05	4.71E-04	5.49E-04
Sodium	1520	152000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	15.1	196.3	3.90E+00	1.30E+01	3.00E-01	2.39E+01	3.58E-05	4.69E-05	8.27E-05
Sulfate	4840	4840	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	26.9	NA	NA	NA	NA	NA			
Tin	0.25	32.5	3.90E+01	1.30E+02	3.00E-01	4.55E-03	3.11E-03	4.08E-02	4.39E-02
Uranium	0.784	25.872	6.60E-02	3.30E+01	2.00E-03	5.60E-02	7.93E-04	1.76E-05	8.11E-04
Vanadium	0.08	80	5.50E+00	1.00E+03	5.50E-03	3.84E-02	1.18E-04	2.18E-04	3.36E-04
Zinc	0.051	10.2	8.00E+01	2.00E+02	4.00E-01	8.82E-01	3.28E-06	8.81E-05	9.14E-05
Total							2.46E-01	7.74E-01	1.02E+00

Table C.10

Site	Gypsum Creek				Ecological Risk Calculations				
Species	Domestic Dairy Cattle								
Body Weight (kg)	6.00E+02		Days per week exposed		1				
Exposure Duration (unitless)	1.43E-01		Home Range (acres)		600				
Site Foraging Frequency (unitless)	8.33E-03		Contaminated Acreage		5				
Water Ingestion Rate (L/day)	6.00E+01								
Food Ingestion Rate (kg dry weight/day)	1.60E+01	Wet Weight	8.00E+02						
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF plant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	6.00E-02	3.97E-04	6.35E-04	1.03E-03
Ammonium	3.44	3.44	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.62E-02	1.97E-04	2.37E-05	2.21E-04
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	4.37E-02	5.45E-04	8.72E-05	6.32E-04
Beryllium	0.005	1.2	2.40E+00	2.40E+02	1.00E-02	4.63E-02	1.29E-05	8.23E-06	2.11E-05
Boron	1.27	3.81	1.20E+01	3.00E+00	4.00E+00	4.28E-04	3.53E-01	1.13E+00	1.48E+00
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	7.23E-03	8.23E-05	8.94E-04	9.76E-04
Chloride	246	61.5	1.75E+03	2.50E+01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	2.06E-01	5.78E-06	1.03E-06	6.81E-06
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	4.28E-02	1.39E-04	6.68E-05	2.06E-04
Copper	0.033	1.155	1.40E+01	3.50E+01	4.00E-01	6.47E-03	6.07E-04	2.27E-03	2.87E-03
Cyanide	0.01	NA	NA	NA	NA	9.25E-01	1.29E-06		1.29E-06
Fluoride	0.8	120	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.1	22	2.20E-01	2.20E+02	1.00E-03	5.17E-01	2.30E-05	1.35E-06	2.44E-05
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	6.68E-02	2.67E-05	1.92E-05	4.60E-05
Magnesium	880	3960	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	1.59	77.91	1.96E+01	4.90E+01	4.00E-01	2.25E+00	8.41E-05	4.40E-04	5.24E-04
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	5.48E-03	4.34E-06	3.48E-06	7.82E-06
Molybdenum	0.2	1.48	7.40E-01	7.40E+00	1.00E-01	1.51E-01	1.58E-04	3.11E-05	1.89E-04
Nickel	0.29	116	2.00E+01	4.00E+02	5.00E-02	2.07E+00	1.67E-05	8.90E-05	1.06E-04
Nitrate	994	994	1.00E+00	1.00E+00	1.00E+00	7.87E-01	1.50E-01	4.01E-02	1.90E-01
Potassium	28	154	1.65E+00	5.50E+00	3.00E-01	8.74E+00	3.81E-04	1.68E-04	5.49E-04
Selenium	0.31	46.5	1.50E+01	1.50E+02	1.00E-01	2.17E-03	1.70E-02	6.80E-02	8.50E-02
Silica	49.6	1636.8	1.16E+01	3.30E+01	3.50E-01	3.34E-01	1.77E-02	5.45E-02	7.21E-02
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	6.85E-03	1.74E-04	8.34E-04	1.01E-03
Sodium	1520	152000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	15.1	196.3	3.90E+00	1.30E+01	3.00E-01	2.25E+01	7.99E-05	8.31E-05	1.63E-04
Sulfate	4840	4840	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	26.9	NA	NA	NA	NA	NA			
Tin	0.25	32.5	3.90E+01	1.30E+02	3.00E-01	4.28E-03	6.95E-03	7.23E-02	7.93E-02
Uranium	0.784	25.872	6.60E-02	3.30E+01	2.00E-03	5.27E-02	1.77E-03	3.12E-05	1.80E-03
Vanadium	0.08	80	5.50E+00	1.00E+03	5.50E-03	3.62E-02	2.63E-04	3.86E-04	6.49E-04
Zinc	0.051	10.2	8.00E+01	2.00E+02	4.00E-01	8.31E-01	7.31E-06	1.56E-04	1.63E-04
Total							5.50E-01	1.37E+00	1.92E+00

Table C.11 Comparison of Contaminants of Concern for North Arroyo to Aquatic Benchmarks. Values listed are derived from dividing the maximum concentration by the aquatic benchmark. Shaded areas correspond to benchmarks that were exceeded by the detected concentration.

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
ALUMINUM	0.2000	0.2667	2.2989	0.1053	0.0345	0.3704	0.0426	2.6667
AMMONIUM	33.2000	.	.	.	.	.	.	.
ANTIMONY	0.0600	.	.	0.0111	0.0375	0.0316	0.0260	.
ARSENIC (As-III)	0.0250	0.0117	0.0694	.	0.0274	0.0084	0.0395	0.1316
ARSENIC (As-V)	0.0250	.	.	0.0556	0.0280	0.0268	0.0167	.
BARIUM	0.2000	.	.	0.0098	.	.	.	.
BERYLLIUM	0.0100	.	.	1.8868	.1754	2.6416	.0676	.
BORON	0.9000	.	.	96.7742	.	128.5714	.	.
BROMIDE	1.1000	.	.	.	.	.	.	.
CADMIUM	0.0050	1.2821	4.5435	33.3333	2.9412	6.6667	2.7778	394.6154
CALCIUM	625.0000	.	.	.	.	.	.	.
CHLORIDE	440.0000	.	0.5116	.	.	.	.	1.9130
CHROMIUM (Cr-III)	0.0100	0.1124	0.0059	.	0.2273	0.1453	.	0.0476
CHROMIUM (Cr-VI)	0.0100	0.1961	0.6250	.	1.6303	0.1366	20.0000	0.9091
COBALT	0.0500	.	.	9.8039	0.1724	11.3636	0.0617	.
COPPER	0.0200	1.1111	1.6667	86.9565	5.1640	97.5610	4.0000	76.9231
CYANIDE	0.0100	0.4545	1.9231	.	1.2821	.	1.8868	4.5470
FLUORIDE	1.1000	.	.	.	.	.	.	.

Table C.11 (continued)

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
IRON	0.1600	.	0.1600	1.0127	.	10.0000	.	.
LEAD	0.0150	0.1829	4.6875	1.2235	0.7945	.	0.6818	42.8571
MAGNESIUM	515.0000	.	.	.	.	.	.	.
MANGANESE	2.2700	.	.	2.0636	1.2825	2.0636	1.7874	.
MERCURY (Hg)	.0002	0.0833	.	0.2083	0.8696	0.2299	0.2299	1.1111
MERCURY (MeHg)	.0002	.	.	5.0000	0.3846	0.2299	6.6667	.
MOLYBDENUM	0.4500	.	.	0.5114	.	1.2500	.	.
NICKEL	0.1300	0.0929	0.8125	26.0000	3.7143	2.8889	2.0909	11.8182
NITRATE	676.0000	.	.	.	.	.	.	.
PHOSPHATE	0.1000	.	.	.	.	.	.	.
POTASSIUM	25.0000	.	.	.	.	.	.	.
SELENIUM	0.0150	0.7500	3.0000	0.1637	0.1698	0.6000	0.3750	5.7692
SILICA	37.0000	.	.	.	.	.	.	.
SILVER	0.0100	2.4390	.	3.8462	83.3333	17.8571	30.0000	71.4286
SODIUM	520.0000	.	.	6.1141	.	.	.	.
STRONTIUM	14.6000	.	.	.	.	.	.	.
SULFATE	3470.0000	.	.	.	.	.	.	.
SULFIDE	28.4000	.	.	.	.	.	.	.

Table C.11 (Continued)

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
THALLIUM	0.0100	.	.	0.0741	0.2500	0.1563	0.1235	.
TIN	0.0660	.	.	.	.	.	.	.
URANIUM	0.8060	.	.	.	1.6761	.	1.7714	.
VANADIUM	0.0500	.	.	0.0532	0.6250	0.1163	1.2195	.
ZINC	0.0200	0.1667	0.1818	0.4280	0.5493	.	0.4255	0.9524

From Duncan et al., 1994

Table C.12 Comparison of Contaminants of Concern for Gypsum Creek to Aquatic Benchmarks. Values listed are derived from dividing the maximum concentration by the aquatic benchmark. Shaded areas correspond to benchmarks that were exceeded by the detected concentration.

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
ALUMINUM	0.2000	0.2667	2.2989	0.1053	0.0345	0.3704	0.0426	2.6667
AMMONIUM	3.4400	.	.	.	.	.	.	.
ANTIMONY	0.0600	.	.	0.0111	0.0375	0.0316	0.0260	.
ARSENIC (As-III)	0.0250	0.0694	0.1316	0.0274	0.0084	0.0395	0.0117	0.4545
ARSENIC (As-V)	0.0250	.	.	0.0556	0.0280	0.0268	0.0167	.
BARIUM	0.2000	.	.	0.0098	.	.	.	.
BERYLLIUM	0.0050	.	.	.9434	.0877	1.3158	.0338	.
BORON	1.2700	.	.	136.5591	.	181.4286	.	.
BROMIDE	1.1000	.	.	.	.	.	.	.
CADMIUM	0.0050	1.2821	4.5455	33.3333	2.9412	6.6667	2.7778	384.6154
CALCIUM	656.0000	.	.	.	.	.	.	.
CHLORIDE	246.0000	0.2860	1.0696	.	.	.	.	.
CHROMIUM (Cr-III)	0.0100	0.0059	0.0476	0.2273	0.1453	.	0.1124	1.1848
CHROMIUM (Cr-VI)	0.0100	0.6250	0.9091	1.6308	0.1366	20.0800	0.1961	37.5940
COBALT	0.0500	.	.	9.8039	0.1724	11.3636	0.0617	.

Table C.12 (Continued)

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
COPPER	0.0330	1.8333	2.7500	143.4783	8.5205	160.9756	6.6000	126.9231
CYANIDE	0.0100	0.4545	1.9231	.	1.2821	.	1.8868	8.5470
FLUORIDE	0.8000	.	.	.	.	.	.	.
IRON	0.1000	.	0.1000	0.6329	.	6.2500	.	.
LEAD	0.0150	0.1829	4.6875	1.2235	0.7945	.	0.6818	42.3571
MAGNESIUM	880.0000	.	.	.	.	.	.	.
MANGANESE	1.5900	.	.	1.4455	0.8983	1.4455	1.2520	.
MERCURY (Hg)	0.0002	0.0833	.	0.2083	0.8696	0.2299	0.2299	1.1111
MERCURY (MeHg)	0.0002	.	.	5.0000	0.3846	0.2299	6.6667	.
MOLYBDENUM	0.2000	.	.	0.2273	.	0.5556	.	.
NICKEL	0.2900	0.2071	1.8125	58.0000	8.2857	6.4444	4.6774	26.3636
NITRATE	994.0000	.	.	.	.	.	.	.
PHOSPHATE	0.1000	.	.	.	.	.	.	.
POTASSIUM	28.0000	.	.	.	.	.	.	.
SELENIUM	0.3100	15.5000	62.0000	3.3824	3.5100	12.4000	7.7500	119.2308
SILICA	49.6000	.	.	.	.	.	.	.
SILVER	0.0100	2.4390	.	3.8462	83.3333	17.3571	50.0000	71.4286

Table C.12 (continued)

		AQUATIC BENCHMARKS						
		NAWQC		LOWEST CHRONIC VALUE		LOWEST TEST VALUE		SENSITIVE SPECIES
CONTAMINANT	MAX CONC (mg/l)	ACUTE	CHRONIC	DAPHNIDS	FISH	DAPHNIDS	FISH	EC20
SODIUM	1520.0000	.	.	17.8721	.	.	.	.
STRONTIUM	15.1000	.	.	.	.	.	.	.
SULFATE	4840.0000	.	.	.	.	.	.	.
SULFIDE	26.9000	.	.	.	.	.	.	.
THALLIUM	0.0100	.	.	0.0741	0.2500	0.1563	0.1235	.
TIN	0.0250	.	.	.	.	.	.	.
URANIUM	0.7840	.	.	.	5.5211	.	1.7231	.
VANADIUM	0.0800	.	.	0.0851	1.0000	0.1860	1.9512	.
ZINC	0.0510	0.4250	0.4636	1.0914	1.4007	.	1.0851	2.4286

From Duncan et al., 1994

C.13

Table Ecological Risk Calculations

Site	North Arroyo
Species	Coyote
Body weight (kg)	2.04E+01
Exposure Duration (unitless)	1.00E+00
Site Foraging Frequency (unitless)	1.00E+00
Water Ingestion Rate (L/day)	1.50E+00
Food Ingestion Rate (kg dry weight/day)	6.00E-02 Wet weight 6.00E-01
Fraction diet soils	0.00E+00
Fraction diet plants	2.50E-01
Fraction diet meat	7.50E-01
Food Ingestion Rate of Prey (kg dry weight/day)	8.15E-02
Water Ingestion Rate of Prey (L/day)	9.07E-02

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF _{plant} (L/kg dry plant)	BAF _{prey} (L/kg wet prey)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	F _i (day/kg wet meat)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	8.70E-04	1.50E+03	4.00E-03	1.50E-03	1.83E-01	8.04E-02	4.84E-03	8.52E-02
Ammonium	33.2	33.2	1.00E+00	NA	1.00E+00	1.00E+00	NA	NA			
Antimony	0.06	2.7	4.50E-01	5.10E-06	4.50E+01	1.00E-02	4.00E-05	1.10E-01	4.00E-02	1.80E-04	4.02E-02
Barium	0.2	12	6.00E-01	3.21E-05	6.00E+01	1.00E-02	2.30E-04	1.33E-01	1.10E-01	6.63E-04	1.11E-01
Beryllium	0.01	2.4	2.40E+00	2.86E-04	2.40E+02	1.00E-02	1.00E-03	1.41E-01	5.21E-03	1.26E-04	5.34E-03
Boron	0.9	2.7	1.20E+01	8.55E-04	3.00E+00	4.00E+00	8.00E-04	1.31E-03	5.07E+01	6.09E+00	5.67E+01
Bromide	1.1	16.5	2.25E+01	4.81E-02	1.50E+01	1.50E+00	2.50E-02	NA			
Cadmium	0.005	0.37	4.07E+01	1.36E-03	7.40E+01	5.50E-01	4.00E-04	2.21E-02	1.67E-02	6.79E-03	2.34E-02
Chloride	440	110	1.75E+01	2.58E-02	2.50E-01	7.00E+01	1.70E-02	NA			
Chromium	0.01	0.67	6.70E-01	1.31E-03	6.70E+01	1.00E-02	9.00E-03	6.27E-01	1.17E-03	8.32E-06	1.18E-03
Cobalt	0.05	3	1.80E+00	4.75E-03	6.00E+01	3.00E-02	2.00E-02	1.31E-01	2.81E-02	5.47E-04	2.87E-02
Copper	0.02	0.7	1.40E+01	1.11E-02	3.50E+01	4.00E-01	9.00E-03	1.97E-02	7.45E-02	1.07E-02	8.51E-02
Cyanide	0.01	0	NA	NA	NA	NA	NA	2.82E+00	2.61E-04	0.00E+00	2.61E-04
Fluoride	1.1	165	9.00E+00	1.24E-01	1.50E+02	6.00E-02	1.50E-01	NA			
Iron	0.16	35.2	2.20E-01	2.17E-03	2.20E+02	1.00E-03	2.00E-02	1.58E+00	7.45E-03	2.13E-05	7.47E-03
Lead	0.015	4.05	2.70E+00	1.24E-04	2.70E+02	1.00E-02	4.00E-04	2.04E-01	5.41E-03	1.46E-04	5.56E-03
Magnesium	515	2317.5	4.50E+00	9.15E-03	4.50E+00	1.00E+00	2.00E-02	NA			
Manganese	2.27	111.23	1.96E+01	8.44E-04	4.90E+01	4.00E-01	5.00E-04	6.87E+00	2.43E-02	4.77E-03	2.91E-02
Mercury (Hg)	0.0002	0.002	3.00E+00	8.38E-02	1.00E+01	3.00E-01	2.50E-01	1.67E-02	8.79E-04	4.85E-05	9.28E-04
Molybdenum	0.45	3.33	7.40E-01	1.51E-04	7.40E+00	1.00E-01	1.00E-03	2.21E-02	1.50E+00	1.12E-02	1.51E+00
Nickel	0.13	52	2.00E+01	8.95E-03	4.00E+02	5.00E-02	5.20E-03	6.31E+00	1.51E-03	3.07E-04	1.82E-03
Nitrate	676	676	1.00E+00	NA	1.00E+00	1.00E+00	NA	2.40E+00	2.07E+01	2.07E-01	2.09E+01
Potassium	25	137.5	1.65E+00	4.05E-03	5.50E+00	3.00E-01	1.80E-02	2.67E+01	6.90E-02	1.22E-03	7.02E-02
Selenium	0.015	2.25	1.50E+01	1.97E-02	1.50E+02	1.00E-01	1.50E-02	6.62E-03	1.67E-01	2.60E-02	1.93E-01
Silica	37	1221	1.16E+01	4.13E-03	3.30E+01	3.50E-01	4.00E-03	1.02E+00	2.67E+00	3.12E-01	2.98E+00
Silver	0.01	0.9	1.80E+01	4.67E-03	9.00E+01	2.00E-01	3.00E-03	2.09E-02	3.52E-02	6.38E-03	4.15E-02

c,13
Table continued

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF _{plant} (L/kg dry plant)	BAF _{prey} (L/kg wet prey)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	F _f (day/kg wet meat)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Sodium	520	52000	5.00E+00	3.99E-02	1.00E+02	5.00E-02	8.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	3.27E-03	1.30E+01	3.00E-01	8.00E-03	6.88E+01	1.56E-02	6.24E-04	1.62E-02
Sulfate	3470	3470	1.00E+00	NA	1.00E+00	1.00E+00	NA	NA			
Sulfide	28.4	0	NA	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	2.62E-01	1.30E+02	3.00E-01	8.00E-02	1.31E-02	3.71E-01	1.74E-01	5.45E-01
Uranium	0.806	26.598	6.60E-02	3.27E-05	3.30E+01	2.00E-03	3.40E-04	1.61E-01	3.69E-01	2.47E-04	3.69E-01
Vanadium	0.05	50	5.50E+00	1.35E-03	1.00E+03	5.50E-03	2.50E-03	1.10E-01	3.33E-02	1.85E-03	3.52E-02
Zinc	0.02	4	8.00E+01	6.61E-01	2.00E+02	4.00E-01	1.00E-01	2.53E+00	5.80E-04	5.79E-04	1.16E-03
Total									7.70E+01	6.86E+00	8.38E+01

From Duncan et al., 1994

C.14

Table 1

Ecological Risk Calculations

Site Species	North Arroyo Spotted Bat					
Body weight (kg)	2.00E-02					
Exposure Duration (unitless)	7.50E-01					
Site Foraging Frequency (unitless)	1.00E+00					
Water Ingestion Rate (L/day)	2.93E-03					
Food Ingestion Rate (kg dry weight/day)	2.75E-04	Wet weight	2.75E-03			
Fraction diet soils	0.00E+00					
Fraction diet plants	0.00E+00					
Fraction diet aquatic insects	1.00E+00					
Food Ingestion Rate of Prey (kg dry weight/day)	NA					
Water Ingestion Rate of Prey (L/day)	NA					
Chemical	Water Concentration (mg/L)	BAFaquatic (L/kg aq prey)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	10*	1.80E+00	1.22E-02	1.15E-01	1.27E-01
Ammonium	33.2	NA				
Antimony	0.06	1	1.09E+00	6.07E-03	5.70E-03	1.18E-02
Barium	0.2	4	1.31E+00	1.68E-02	6.29E-02	7.97E-02
Beryllium	0.01	2	1.39E+00	7.91E-04	1.49E-03	2.28E-03
Boron	0.9	NA	1.29E-02	7.69E+00		7.69E+00
Bromide	1.1	NA				
Cadmium	0.005	50	2.17E-01	2.53E-03	1.19E-01	1.21E-01
Chloride	440	50				
Chromium	0.01	200	6.17E+00	1.78E-04	3.34E-02	3.36E-02
Cobalt	0.05	300	1.29E+00	4.27E-03	1.20E+00	1.21E+00
Copper	0.02	210	1.94E-01	1.13E-02	2.23E+00	2.24E+00
Cyanide	0.01	9.43*	2.78E+01	3.96E-05	3.50E-04	3.90E-04
Fluoride	1.1	NA				
Iron	0.16	100	1.55E+01	1.13E-03	1.06E-01	1.07E-01
Lead	0.015	300	2.01E+00	8.22E-04	2.31E-01	2.32E-01
Magnesium	515	50*				
Manganese	2.27	400	6.76E+01	3.69E-03	1.39E+00	1.39E+00
Mercury (Hg)	0.0002	63,000	1.65E-01	1.34E-02	7.89E+00	7.90E+00
Molybdenum	0.45	NA	2.17E-01	2.28E-01		2.28E-01
Nickel	0.13	100	6.21E+01	2.30E-04	2.16E-02	2.18E-02
Nitrate	676	NA	2.36E+01	3.14E+00		3.14E+00
Potassium	25	NA	2.62E+02	1.05E-02		1.05E-02
Selenium	0.015	8	6.52E-02	2.53E-02	1.90E-01	2.15E-01
Silica	37	NA	1.00E+01	4.05E-01		4.05E-01
Silver	0.01	2	2.06E-01	5.34E-03	1.00E-02	1.54E-02
Sodium	520	100				
Strontium	14.6	60	6.77E+02	2.37E-03	1.34E-01	1.36E-01
Sulfate	3470	NA				
Sulfide	28.4	NA				
Tin	0.066	NA	1.29E-01	5.64E-02		5.64E-02
Uranium	0.806	NA	1.58E+00	5.60E-02		5.60E-02
Vanadium	0.05	0.01	1.09E+00	5.06E-03	4.75E-05	5.11E-03
Zinc	0.02	1,000	2.49E+01	8.81E-05	8.27E-02	8.28E-02
*ASG 1994			Total	1.17E+01	1.38E+01	2.55E+01

From Duncan et al., 1994

Table

C.15

Ecological Risk Calculations

Site	North Arroyo					
Species	Southwestern Willow Flycatcher					
Body weight (kg)	1.64E-02					
Exposure Duration (unitless)	1.00E+00					
Site Foraging Frequency (unitless)	1.00E+00					
Water Ingestion Rate (L/day)	3.76E-03					
Food Ingestion Rate (kg dry weight/day)	4.46E-05	Wet weight	4.46E-04			
Fraction diet soils	0.00E+00					
Fraction diet plants	0.00E+00					
Fraction diet aquatic insects	1.00E+00					
Food Ingestion Rate of Prey (kg dry weight/day)	NA					
Water Ingestion Rate of Prey (L/day)	NA					
Chemical	Water Concentration (mg/L)	BAFaquatic (L/kg aq prey)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	10	1.15E+00	3.98E-02	4.72E-02	8.71E-02
Ammonium	33.2	NA				
Antimony	0.06	1				
Barium	0.2	4				
Beryllium	0.01	2				
Boron	0.9	NA	6.77E-02	3.05E+00		3.05E+00
Bromide	1.1	NA	5.76E+01	4.38E-03		4.38E-03
Cadmium	0.005	50	7.73E-01	1.48E-03	8.80E-03	1.03E-02
Chloride	440	50				
Chromium	0.01	200	1.13E+01	2.03E-04	4.82E-03	5.02E-03
Cobalt	0.05	300	1.09E-01	1.05E-01	3.75E+00	3.86E+00
Copper	0.02	210	9.08E+01	5.05E-05	1.26E-03	1.31E-03
Cyanide	0.01	9.43	2.11E-01	1.09E-02	1.22E-02	2.30E-02
Fluoride	1.1	NA	2.30E+00	1.10E-01		1.10E-01
Iron	0.16	100	9.16E+00	4.01E-03	4.75E-02	5.15E-02
Lead	0.015	300	1.17E+01	2.94E-04	1.05E-02	1.08E-02
Magnesium	515	50	9.21E+01	1.28E+00	7.60E+00	8.88E+00
Manganese	2.27	400	2.30E+02	2.26E-03	1.07E-01	1.10E-01
Mercury (Hg)	0.0002	63,000	7.47E-01	6.14E-05	4.59E-01	4.59E-01
Molybdenum	0.45	NA	1.12E+00	9.25E-02		9.25E-02
Nickel	0.13	100	6.85E+00	4.35E-03	5.17E-02	5.60E-02
Nitrate	676	NA				
Potassium	25	NA				
Selenium	0.015	8	3.88E-01	8.86E-03	8.41E-03	1.73E-02
Silica	37	NA				
Silver	0.01	2	2.30E+00	9.95E-04	2.36E-04	1.23E-03
Sodium	520	100				
Strontium	14.6	60	6.91E+01	4.84E-02	3.45E-01	3.93E-01
Sulfate	3470	NA				
Sulfide	28.4	NA				
Tin	0.066	NA	9.52E-01	1.59E-02		1.59E-02
Uranium	0.806	NA	3.59E+01	5.14E-03		5.14E-03
Vanadium	0.05	0.01	4.23E+00	2.71E-03	3.22E-06	2.71E-03
Zinc	0.02	1,000	6.77E+00	6.77E-04	8.04E-02	8.10E-02
*ASG 1994			Total	4.05E-02	1.28E-01	5.14E-03

From Duncan et al., 1994

Table 16

Ecological Risk Calculations

Site	North Arroyo
Species	Desert Bighorn

Body weight (kg)	9.10E+01		
Exposure Duration (unitless)	1.00E+00		
Site Foraging Frequency (unitless)	1.00E+00		
Water Ingestion Rate (L/day)	1.82E+01		
Food Ingestion Rate (kg dry weight/day)	2.32E+00	Wet weight	2.32E+01
Fraction diet soils	0.00E+00		
Fraction diet plants	1.00E+00		
Fraction diet meat	0.00E+00		
Food Ingestion Rate of Prey (kg dry weight/day)	NA		
Water Ingestion Rate of Prey (L/day)	NA		

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	1.12E-01	3.58E-01	2.74E-01	6.32E-01
Ammonium	33.2	33.2	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	6.74E-02	1.78E-01	1.02E-02	1.88E-01
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	8.14E-02	4.91E-01	3.77E-02	5.29E-01
Beryllium	0.01	2.4	2.40E+00	2.40E+02	1.00E-02	8.62E-02	2.32E-02	7.11E-03	3.03E-02
Boron	0.9	2.7	1.20E+01	3.00E+00	4.00E+00	7.98E-04	2.26E+02	3.46E+02	5.71E+02
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	1.35E-02	7.42E-02	3.86E-01	4.60E-01
Chloride	440	110	1.75E+01	2.50E-01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	3.83E-01	5.22E-03	4.47E-04	5.67E-03
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	7.98E-02	1.25E-01	2.88E-02	1.54E-01
Copper	0.02	0.7	1.40E+01	3.50E+01	4.00E-01	1.21E-02	3.32E-01	5.93E-01	9.25E-01
Cyanide	0.01	NA	NA	NA	NA	1.72E+00	1.16E-03		1.16E-03
Fluoride	1.1	165	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.16	35.2	2.20E-01	2.20E+02	1.00E-03	9.64E-01	3.32E-02	9.33E-04	3.41E-02
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	1.24E-01	2.41E-02	8.31E-03	3.24E-02
Magnesium	515	2317.5	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	2.27	111.23	1.96E+01	4.90E+01	4.00E-01	4.19E+00	1.08E-01	2.71E-01	3.79E-01
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	1.02E-02	3.92E-03	1.50E-03	5.42E-03
Molybdenum	0.45	3.33	7.40E-01	7.40E+00	1.00E-01	2.81E-01	3.21E-01	3.03E-02	3.51E-01
Nickel	0.13	52	2.00E+01	4.00E+02	5.00E-02	3.85E+00	6.75E-03	1.72E-02	2.40E-02
Nitrate	676	676	1.00E+00	1.00E+00	1.00E+00	1.47E+00	9.21E+01	1.18E+01	1.04E+02
Potassium	25	137.5	1.65E+00	5.50E+00	3.00E-01	1.63E+01	3.07E-01	6.47E-02	3.72E-01
Selenium	0.015	2.25	1.50E+01	1.50E+02	1.00E-01	4.04E-03	7.42E-01	1.42E+00	2.16E+00
Silica	37	1221	1.16E+01	3.30E+01	3.50E-01	6.22E-01	1.19E+01	1.75E+01	2.94E+01

From Duncan et al., 1994

Table

0.16
Continued

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	1.28E-02	1.57E-01	3.60E-01	5.17E-01
Sodium	520	52000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	1.30E+01	3.00E-01	4.20E+01	6.95E-02	3.46E-02	1.04E-01
Sulfate	3470	3470	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	28.4	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	1.30E+02	3.00E-01	7.98E-03	1.65E+00	8.24E+00	9.89E+00
Uranium	0.806	26.598	6.60E-02	3.30E+01	2.00E-03	9.82E-02	1.64E+00	1.38E-02	1.66E+00
Vanadium	0.05	50	5.50E+00	1.00E+03	5.50E-03	6.74E-02	1.48E-01	1.04E-01	2.53E-01
Zinc	0.02	4	8.00E+01	2.00E+02	4.00E-01	1.55E+00	2.58E-03	2.64E-02	2.90E-02
Total							3.36E+02	3.87E+02	7.23E+02

From Duncan et al., 1994

Table C. 17

Ecological Risk Calculations

Site Species	North Arroyo Desert Cottontail								
Body weight (kg)	9.08E-01								
Exposure Duration (unitless)	1.00E+00								
Site Foraging Frequency (unitless)	1.00E+00								
Water Ingestion Rate (L/day)	9.07E-02								
Food Ingestion Rate (kg dry weight/day)	8.15E-02	Wet weight		8.15E-01					
Fraction diet soils	0.00E+00								
Fraction diet plants	1.00E+00								
Fraction diet meat	0.00E+00								
Food Ingestion Rate of Prey (kg dry weight/day)	NA								
Water Ingestion Rate of Prey (L/day)	NA								
Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	5.11E-01	3.91E-02	2.11E-01	2.50E-01
Ammonium	33.2	33.2	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.08E-01	1.94E-02	7.86E-03	2.73E-02
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	3.72E-01	5.36E-02	2.89E-02	8.26E-02
Beryllium	0.01	2.4	2.40E+00	2.40E+02	1.00E-02	3.94E-01	2.53E-03	5.46E-03	8.00E-03
Boron	0.9	2.7	1.20E+01	3.00E+00	4.00E+00	3.65E-03	2.46E+01	2.66E+02	2.90E+02
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	6.17E-02	8.10E-03	2.96E-01	3.04E-01
Chloride	440	110	1.75E+01	2.50E-01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	1.75E+00	5.70E-04	3.43E-04	9.13E-04
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	3.65E-01	1.37E-02	2.21E-02	3.58E-02
Copper	0.02	0.7	1.40E+01	3.50E+01	4.00E-01	5.52E-02	3.62E-02	4.55E-01	4.92E-01
Cyanide	0.01	NA	NA	NA	NA	7.89E+00	1.27E-04		1.27E-04
Fluoride	1.1	165	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.16	35.2	2.20E-01	2.20E+02	1.00E-03	4.41E+00	3.62E-03	7.16E-04	4.34E-03
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	5.70E-01	2.63E-03	6.38E-03	9.01E-03
Magnesium	515	2317.5	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	2.27	111.23	1.96E+01	4.90E+01	4.00E-01	1.92E+01	1.18E-02	2.08E-01	2.20E-01
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	4.67E-02	4.27E-04	1.15E-03	1.58E-03
Molybdenum	0.45	3.33	7.40E-01	7.40E+00	1.00E-01	6.17E-02	7.29E-01	4.85E-01	1.21E+00
Nickel	0.13	52	2.00E+01	4.00E+02	5.00E-02	1.76E+01	7.36E-04	1.32E-02	1.40E-02
Nitrate	676	676	1.00E+00	1.00E+00	1.00E+00	6.71E+00	1.01E+01	9.04E+00	1.91E+01
Potassium	25	137.5	1.65E+00	5.50E+00	3.00E-01	7.45E+01	3.35E-02	4.97E-02	8.32E-02
Selenium	0.015	2.25	1.50E+01	1.50E+02	1.00E-01	1.85E-02	8.10E-02	1.09E+00	1.17E+00
Silica	37	1221	1.16E+01	3.30E+01	3.50E-01	2.85E+00	1.30E+00	1.35E+01	1.48E+01

Table C.17 *Continued*

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF _{plant} (L/kg dry plant)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	5.84E-02	1.71E-02	2.77E-01	2.94E-01
Sodium	520	52000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	14.6	189.8	3.90E+00	1.30E+01	3.00E-01	1.92E+02	7.59E-03	2.66E-02	3.42E-02
Sulfate	3470	3470	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	28.4	NA	NA	NA	NA	NA			
Tin	0.066	8.58	3.90E+01	1.30E+02	3.00E-01	3.65E-02	1.81E-01	6.33E+00	6.51E+00
Uranium	0.806	26.598	6.60E-02	3.30E+01	2.00E-03	4.49E-01	1.79E-01	1.06E-02	1.90E-01
Vanadium	0.05	50	5.50E+00	1.00E+03	5.50E-03	3.08E-01	1.62E-02	8.00E-02	9.62E-02
Zinc	0.02	4	8.00E+01	2.00E+02	4.00E-01	7.08E+00	2.82E-04	2.03E-02	2.06E-02
Total							3.74E+01	2.98E+02	3.35E+02

From Duncan et al., 1994

Table C. 18

Ecological Risk Calculations

Site	Gypsum Creek
Species	Coyote

Body weight (kg)	2.04E+01		
Exposure Duration (unitless)	1.00E+00		
Site Foraging Frequency (unitless)	1.00E+00		
Water Ingestion Rate (L/day)	1.50E+00		
Food Ingestion Rate (kg dry weight/day)	6.00E-02	Wet weight	6.00E-01
Fraction diet soils	0.00E+00		
Fraction diet plants	2.50E-01		
Fraction diet meat	7.50E-01		
Food Ingestion Rate of Prey (kg dry weight/day)	8.15E-02		
Water Ingestion Rate of Prey (L/day)	9.07E-02		

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	BAFprey (L/kg wet prey)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Ff (day/kg wet meat)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	8.70E-04	1.50E+03	4.00E-03	1.50E-03	1.83E-01	8.04E-02	4.84E-03	8.52E-02
Ammonium	3.44	3.44	1.00E+00	0.00E+00	1.00E+00	1.00E+00	NA	NA			
Antimony	0.06	2.7	4.50E-01	5.10E-06	4.50E+01	1.00E-02	4.00E-05	1.10E-01	4.00E-02	1.80E-04	4.02E-02
Barium	0.2	12	6.00E-01	3.21E-05	6.00E+01	1.00E-02	2.30E-04	1.33E-01	1.10E-01	6.63E-04	1.11E-01
Beryllium	0.005	1.2	2.40E+00	2.86E-04	2.40E+02	1.00E-02	1.00E-03	1.41E-01	2.61E-03	6.28E-05	2.67E-03
Boron	1.27	3.81	1.20E+01	8.55E-04	3.00E+00	4.00E+00	8.00E-04	1.31E-03	7.15E+01	8.60E+00	8.01E+01
Bromide	1.1	16.5	2.25E+01	4.81E-02	1.50E+01	1.50E+00	2.50E-02	NA			
Cadmium	0.005	0.37	4.07E+01	1.36E-03	7.40E+01	5.50E-01	4.00E-04	2.21E-02	1.67E-02	6.79E-03	2.34E-02
Chloride	246	61.5	1.75E+01	2.58E-02	2.50E-01	7.00E+01	1.70E-02	NA			
Chromium	0.01	0.67	6.70E-01	1.31E-03	6.70E+01	1.00E-02	9.00E-03	6.27E-01	1.17E-03	8.32E-06	1.18E-03
Cobalt	0.05	3	1.80E+00	4.75E-03	6.00E+01	3.00E-02	2.00E-02	1.31E-01	2.81E-02	5.47E-04	2.87E-02
Copper	0.033	1.155	1.40E+01	1.11E-02	3.50E+01	4.00E-01	9.00E-03	1.97E-02	1.23E-01	1.76E-02	1.40E-01
Cyanide	0.01	NA	NA	NA	NA	NA	NA	2.82E+00	2.61E-04		2.61E-04
Fluoride	0.8	120	9.00E+00	1.24E-01	1.50E+02	6.00E-02	1.50E-01	NA			
Iron	0.1	22	2.20E-01	2.17E-03	2.20E+02	1.00E-03	2.00E-02	1.58E+00	4.66E-03	1.33E-05	4.67E-03
Lead	0.015	4.05	2.70E+00	1.24E-04	2.70E+02	1.00E-02	4.00E-04	2.04E-01	5.41E-03	1.46E-04	5.56E-03
Magnesium	880	3960	4.50E+00	9.15E-03	4.50E+00	1.00E+00	2.00E-02	NA			
Manganese	1.59	77.91	1.96E+01	8.44E-04	4.90E+01	4.00E-01	5.00E-04	6.87E+00	1.70E-02	3.34E-03	2.04E-02
Mercury (Hg)	0.0002	0.002	3.00E+00	8.38E-02	1.00E+01	3.00E-01	2.50E-01	1.67E-03	8.79E-03	4.85E-04	9.28E-03
Molybdenum	0.2	1.48	7.40E-01	1.51E-04	7.40E+00	1.00E-01	1.00E-03	2.21E-02	6.66E-01	4.96E-03	6.71E-01
Nickel	0.29	116	2.00E+01	8.95E-03	4.00E+02	5.00E-02	5.20E-03	6.31E+00	3.38E-03	6.85E-04	4.06E-03
Nitrate	994	994	1.00E+00	0.00E+00	1.00E+00	1.00E+00	NA	2.40E+00	3.04E+01	3.04E-01	3.07E+01
Potassium	28	154	1.65E+00	4.05E-03	5.50E+00	3.00E-01	1.80E-02	2.67E+01	7.72E-02	1.37E-03	7.86E-02
Selenium	0.31	46.5	1.50E+01	1.97E-02	1.50E+02	1.00E-01	1.50E-02	6.62E-03	3.44E+00	5.37E-01	3.98E+00
Silica	49.6	1636.8	1.16E+01	4.13E-03	3.30E+01	3.50E-01	4.00E-03	1.02E+00	3.58E+00	4.18E-01	4.00E+00
Silver	0.01	0.9	1.80E+01	4.67E-03	9.00E+01	2.00E-01	3.00E-03	2.09E-02	3.52E-02	6.38E-03	4.15E-02

Table C.18 continued

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF _{plant} (L/kg dry plant)	BAF _{prey} (L/kg wet prey)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	F _f (day/kg wet meat)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Sodium	1520	152000	5.00E+00	3.99E-02	1.00E+02	5.00E-02	8.00E-02	NA			
Strontium	15.1	196.3	3.90E+00	3.27E-03	1.30E+01	3.00E-01	8.00E-03	6.88E+01	1.61E-02	6.46E-04	1.68E-02
Sulfate	4840	4840	1.00E+00	0.00E+00	1.00E+00	1.00E+00	NA	NA			
Sulfide	26.9	NA	NA	NA	NA	NA	NA	NA			
Tin	0.25	32.5	3.90E+01	2.62E-01	1.30E+02	3.00E-01	8.00E-02	1.31E-02	1.41E+00	6.59E-01	2.07E+00
Uranium	0.784	25.872	6.60E-02	3.27E-05	3.30E+01	2.00E-03	3.40E-04	1.61E-01	3.59E-01	2.40E-04	3.59E-01
Vanadium	0.08	80	5.50E+00	1.35E-03	1.00E+03	5.50E-03	2.50E-03	1.10E-01	5.33E-02	2.95E-03	5.63E-02
Zinc	0.051	10.2	8.00E+01	6.61E-01	2.00E+02	4.00E-01	1.00E-01	2.53E+00	1.48E-03	1.48E-03	2.96E-03
Total									1.12E+02	1.06E+01	1.23E+02

From Duncan et al, 1994

Table 6.19.

Ecological Risk Calculations

Site Species		Gypsum Creek Spotted Bat				
Body weight (kg)				2.00E-02		
Exposure Duration (unitless)				7.50E-01		
Site Foraging Frequency (unitless)				1.00E+00		
Water Ingestion Rate (L/day)				2.93E-03		
Food Ingestion Rate (kg dry weight/day)				2.75E-04	Wet weight	2.75E-03
Fraction diet soils				0.00E+00		
Fraction diet plants				0.00E+00		
Fraction diet aquatic insects				1.00E+00		
Food Ingestion Rate of Prey (kg dry weight/day)				NA		
Water Ingestion Rate of Prey (L/day)				NA		
Chemical	Water Concentration (mg/L)	BAFaquatic (L/kg aq prey)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	10	1.80E+00	1.22E-02		1.22E-02
Ammonium	3.44	NA				
Antimony	0.06	1	1.09E+00	6.07E-03	5.70E-03	1.18E-02
Barium	0.2	4	1.31E+00	1.68E-02	6.29E-02	7.97E-02
Beryllium	0.005	2	1.39E+00	3.96E-04	7.43E-04	1.14E-03
Boron	1.27	NA	1.29E-02	1.09E+01		1.09E+01
Bromide	1.1	NA				
Cadmium	0.005	50	2.17E-01	2.53E-03	1.19E-01	1.21E-01
Chloride	246	50				
Chromium	0.01	200	6.17E+00	1.78E-04	3.34E-02	3.36E-02
Cobalt	0.05	300	1.29E+00	4.27E-03	1.20E+00	1.21E+00
Copper	0.033	210	1.94E-01	1.87E-02	3.68E+00	3.70E+00
Cyanide	0.01	9.43	2.78E+01	3.96E-05		3.96E-05
Fluoride	0.8	NA				
Iron	0.1	100	1.55E+01	7.07E-04	6.64E-02	6.71E-02
Lead	0.015	300	2.01E+00	8.22E-04	2.31E-01	2.32E-01
Magnesium	880	50				
Manganese	1.59	400	6.76E+01	2.59E-03	9.71E-01	9.73E-01
Mercury (Hg)	0.0002	63,000	1.65E-01	1.34E-02	7.89E+00	7.90E+00
Molybdenum	0.2	NA	2.17E-01	1.01E-01		1.01E-01
Nickel	0.29	100	6.21E+01	5.13E-04	4.82E-02	4.87E-02
Nitrate	994	NA	2.36E+01	4.62E+00		4.62E+00
Potassium	28	NA	2.62E+02	1.17E-02		1.17E-02
Selenium	0.31	8	6.52E-02	5.23E-01	3.92E+00	4.45E+00
Silica	49.6	NA	1.00E+01	5.43E-01		5.43E-01
Silver	0.01	2	2.06E-01	5.34E-03	1.00E-02	1.54E-02
Sodium	1520	100				
Strontium	15.1	60	6.77E+02	2.45E-03	1.38E-01	1.41E-01
Sulfate	4840	NA				
Sulfide	26.9	NA				
Tin	0.25	NA	1.29E-01	2.14E-01		2.14E-01
Uranium	0.784	NA	1.58E+00	5.45E-02		5.45E-02
Vanadium	0.08	0.01	1.09E+00	8.09E-03	7.60E-05	8.17E-03
Zinc	0.051	1,000	2.49E+01	2.25E-04	2.11E-01	2.11E-01
*ASG 1994			Total	1.70E+01	1.86E+01	3.56E+01

From Duncan et al., 1994

Table 2.2

Ecological Risk Calculations

Site	Gypsum Creek					
Species	Southwestern Willow Flycatcher					
Body weight (kg)				2.00E-02		
Exposure Duration (unitless)				7.50E-01		
Site Foraging Frequency (unitless)				1.00E+00		
Water Ingestion Rate (L/day)				2.93E-03		
Food Ingestion Rate (kg dry weight/day)				2.75E-04	Wet weight	2.75E-03
Fraction diet soils				0.00E+00		
Fraction diet plants				0.00E+00		
Fraction diet aquatic insects				1.00E+00		
Food Ingestion Rate of Prey (kg dry weight/day)				NA		
Water Ingestion Rate of Prey (L/day)				NA		
Chemical	Water Concentration (mg/L)	BAFaquatic (L/kg aq prey)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	10	1.15E+00	1.22E-02		1.22E-02
Ammonium	3.44	NA				
Antimony	0.06	1				
Barium	0.2	4				
Beryllium	0.005	2				
Boron	1.27	NA	6.77E-02	1.09E+01		1.09E+01
Bromide	1.1	NA	5.76E+01			
Cadmium	0.005	50	7.73E-01	2.53E-03	1.19E-01	1.21E-01
Chloride	246	50				
Chromium	0.01	200	1.13E-01	1.78E-04	3.34E-02	3.36E-02
Cobalt	0.05	300	1.09E-01	4.27E-03	1.20E+00	1.21E+00
Copper	0.033	210	9.08E+01	1.87E-02	3.68E+00	3.70E+00
Cyanide	0.01	9.43	2.11E-01	3.96E-05		3.96E-05
Fluoride	0.8	NA	2.30E+00			
Iron	0.1	100	9.16E+00	7.07E-04	6.64E-02	6.71E-02
Lead	0.015	300	1.17E+01	8.22E-04	2.31E-01	2.32E-01
Magnesium	880	50	9.21E+01			
Manganese	1.59	400	2.30E+02	2.59E-03	9.71E-01	9.73E-01
Mercury (Hg)	0.0002	63,000	7.47E-01	1.34E-03	7.89E+01	7.90E+01
Molybdenum	0.2	NA	1.12E+00			
Nickel	0.29	100	6.85E+00	5.13E-04	4.82E-02	4.87E-02
Nitrate	994	NA				
Potassium	28	NA				
Selenium	0.31	8	3.88E-01	5.23E-01	3.92E+00	4.45E+00
Silica	49.6	NA				
Silver	0.01	2	2.30E+00	5.34E-03	1.00E-02	1.54E-02
Sodium	1520	100				
Strontium	15.1	60	6.91E+01	2.45E-03	1.38E-01	1.41E-01
Sulfate	4840	NA				
Sulfide	26.9	NA				
Tin	0.25	NA	9.52E-01	2.14E-01		2.14E-01
Uranium	0.784	NA	3.59E+01	5.45E-02		5.45E-02
Vanadium	0.08	0.01	4.23E+00	8.09E-03	7.60E-05	8.17E-03
Zinc	0.051	1,000	6.77E+00	2.25E-04	2.11E-01	2.11E-01
*ASG 1994	Total			1.24E-02	2.11E-01	2.23E-01

From Duncan et al, 1994

Table

21

Ecological Risk Calculations

Site	Gypsum Creek
Species	Desert Bighorn Sheep

Body weight (kg)	9.10E+01		
Exposure Duration (unitless)	1.00E+00		
Site Foraging Frequency (unitless)	1.00E+00		
Water Ingestion Rate (L/day)	1.82E+01		
Food Ingestion Rate (kg dry weight/day)	2.32E+00	Wet weight	2.32E+01
Fraction diet soils	0.00E+00		
Fraction diet plants	1.00E+00		
Fraction diet meat	0.00E+00		
Food Ingestion Rate of Prey (kg dry weight/day)	NA		
Water Ingestion Rate of Prey (L/day)	NA		

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	1.12E-01	3.58E-01	2.74E-01	6.32E-01
Ammonium	3.44	3.44	1.00E+00	1.00E+00	1.00E+00				
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	6.74E-02	1.78E-01	1.02E-02	1.88E-01
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	8.14E-02	4.91E-01	3.76E-02	5.29E-01
Beryllium	0.005	1.2	2.40E+00	2.40E+02	1.00E-02	8.62E-02	1.16E-02	3.55E-03	1.52E-02
Boron	1.27	3.81	1.20E+01	3.00E+00	4.00E+00	7.98E-04	3.18E+02	4.87E+02	8.05E+02
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00				
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	1.35E-02	7.42E-02	3.85E-01	4.59E-01
Chloride	246	61.5	1.75E+01	2.50E-01	7.00E+01				
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	3.83E-01	5.22E-03	4.46E-04	5.67E-03
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	7.98E-02	1.25E-01	2.88E-02	1.54E-01
Copper	0.033	1.155	1.40E+01	3.50E+01	4.00E-01	1.21E-02	5.47E-01	9.77E-01	1.52E+00
Cyanide	0.01	NA	NA	NA	NA	1.72E+00	1.16E-03		1.16E-03
Fluoride	0.8	120	9.00E+00	1.50E+02	6.00E-02				
Iron	0.1	22	2.20E-01	2.20E+02	1.00E-03	9.64E-01	2.07E-02	5.82E-04	2.13E-02
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	1.24E-01	2.41E-02	8.29E-03	3.24E-02
Magnesium	880	3960	4.50E+00	4.50E+00	1.00E+00				
Manganese	1.59	77.91	1.96E+01	4.90E+01	4.00E-01	4.19E+00	7.58E-02	1.89E-01	2.65E-01
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	1.02E-03	3.92E-02	1.50E-02	5.41E-02
Molybdenum	0.2	1.48	7.40E-01	7.40E+00	1.00E-01	2.81E-01	1.42E-01	1.34E-02	1.56E-01
Nickel	0.29	116	2.00E+01	4.00E+02	5.00E-02	3.85E+00	1.50E-02	3.84E-02	5.34E-02
Nitrate	994	994	1.00E+00	1.00E+00	1.00E+00	1.47E+00	1.35E+02	1.73E+01	1.53E+02
Potassium	28	154	1.65E+00	5.50E+00	3.00E-01	1.63E+01	3.44E-01	7.23E-02	4.16E-01
Selenium	0.31	46.5	1.50E+01	1.50E+02	1.00E-01	4.04E-03	1.53E+01	2.93E+01	4.46E+01

Table C.11 Continued

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Silica	49.6	1636.8	1.16E+01	3.30E+01	3.50E-01	6.22E-01	1.59E+01	2.35E+01	3.94E+01
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	1.28E-02	1.57E-01	3.59E-01	5.16E-01
Sodium	1520	152000	5.00E+00	1.00E+02	5.00E-02				
Strontium	15.1	196.3	3.90E+00	1.30E+01	3.00E-01	4.20E+01	7.19E-02	3.58E-02	1.08E-01
Sulfate	4840	4840	1.00E+00	1.00E+00	1.00E+00				
Sulfide	26.9	NA	NA	NA	NA				
Tin	0.25	32.5	3.90E+01	1.30E+02	3.00E-01	7.98E-03	6.27E+00	3.11E+01	3.74E+01
Uranium	0.784	25.872	6.60E-02	3.30E+01	2.00E-03	9.82E-02	1.60E+00	1.34E-02	1.61E+00
Vanadium	0.08	80	5.50E+00	1.00E+03	5.50E-03	6.74E-02	2.37E-01	1.66E-01	4.04E-01
Zinc	0.051	10.2	8.00E+01	2.00E+02	4.00E-01	1.55E+00	6.59E-03	6.72E-02	7.38E-02
Total							4.96E+02	5.91E+02	1.09E+03

From Duncan et al., 1994

Table 12.22

Ecological Risk Calculations

Site Species	Gypsum Creek Desert Cottontail		
Body weight (kg)	9.08E-01		
Exposure Duration (unitless)	1.00E+00		
Site Foraging Frequency (unitless)	1.00E+00		
Water Ingestion Rate (L/day)	9.07E-02		
Food Ingestion Rate (kg dry weight/day)	8.15E-02	Wet weight	8.15E-01
Fraction diet soils	0.00E+00		
Fraction diet plants	1.00E+00		
Fraction diet meat	0.00E+00		
Food Ingestion Rate of Prey (kg dry weight/day)	NA		
Water Ingestion Rate of Prey (L/day)	NA		

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAFplant (L/kg dry plant)	Kd (L/kg dry soil)	Bv (kg dry soil/kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Aluminum	0.2	300	6.00E+00	1.50E+03	4.00E-03	5.11E-01	3.91E-02	2.11E-01	2.50E-01
Ammonium	3.44	3.44	1.00E+00	1.00E+00	1.00E+00	NA			
Antimony	0.06	2.7	4.50E-01	4.50E+01	1.00E-02	3.08E-01	1.94E-02	7.86E-03	2.73E-02
Barium	0.2	12	6.00E-01	6.00E+01	1.00E-02	3.72E-01	5.36E-02	2.89E-02	8.26E-02
Beryllium	0.005	1.2	2.40E+00	2.40E+02	1.00E-02	3.94E-01	1.27E-03	2.73E-03	4.00E-03
Boron	1.27	3.81	1.20E+01	3.00E+00	4.00E+00	3.65E-03	3.47E+01	3.75E+02	4.09E+02
Bromide	1.1	16.5	2.25E+01	1.50E+01	1.50E+00	NA			
Cadmium	0.005	0.37	4.07E+01	7.40E+01	5.50E-01	6.17E-02	8.10E-03	2.96E-01	3.04E-01
Chloride	246	61.5	1.75E+01	2.50E-01	7.00E+01	NA			
Chromium	0.01	0.67	6.70E-01	6.70E+01	1.00E-02	1.75E+00	5.70E-04	3.43E-04	9.13E-04
Cobalt	0.05	3	1.80E+00	6.00E+01	3.00E-02	3.65E-01	1.37E-02	2.21E-02	3.58E-02
Copper	0.033	1.155	1.40E+01	3.50E+01	4.00E-01	5.52E-02	5.97E-02	7.51E-01	8.11E-01
Cyanide	0.01	NA	NA	NA	NA	7.89E+00	1.27E-04		1.27E-04
Fluoride	0.8	120	9.00E+00	1.50E+02	6.00E-02	NA			
Iron	0.1	22	2.20E-01	2.20E+02	1.00E-03	4.41E+00	2.26E-03	4.48E-04	2.71E-03
Lead	0.015	4.05	2.70E+00	2.70E+02	1.00E-02	5.70E-01	2.63E-03	6.38E-03	9.01E-03
Magnesium	880	3960	4.50E+00	4.50E+00	1.00E+00	NA			
Manganese	1.59	77.91	1.96E+01	4.90E+01	4.00E-01	1.92E+01	8.28E-03	1.46E-01	1.54E-01
Mercury (Hg)	0.0002	0.002	3.00E+00	1.00E+01	3.00E-01	4.67E-02	4.27E-04	1.15E-03	1.58E-03
Molybdenum	0.2	1.48	7.40E-01	7.40E+00	1.00E-01	6.17E-02	3.24E-01	2.15E-01	5.39E-01
Nickel	0.29	116	2.00E+01	4.00E+02	5.00E-02	1.76E+01	1.64E-03	2.95E-02	3.12E-02
Nitrate	994	994	1.00E+00	1.00E+00	1.00E+00	6.71E+00	1.48E+01	1.33E+01	2.81E+01
Potassium	28	154	1.65E+00	5.50E+00	3.00E-01	7.45E+01	3.75E-02	5.57E-02	9.32E-02
Selenium	0.31	46.5	1.50E+01	1.50E+02	1.00E-01	1.85E-02	1.67E+00	2.26E+01	2.42E+01
Silica	49.6	1636.8	1.16E+01	3.30E+01	3.50E-01	2.85E+00	1.74E+00	1.81E+01	1.98E+01

Table C.22 continued

Chemical	Water Concentration (mg/L)	Soil Concentration (mg/kg)	BAF _{plant} (L/kg dry plant)	K _d (L/kg dry soil)	B _v (kg dry soil/ kg dry plant)	Oral Benchmark (mg/kg-day)	HQ (Water)	HQ (Food)	HQ (Total)
Silver	0.01	0.9	1.80E+01	9.00E+01	2.00E-01	5.84E-02	1.71E-02	2.77E-01	2.94E-01
Sodium	1520	152000	5.00E+00	1.00E+02	5.00E-02	NA			
Strontium	15.1	196.3	3.90E+00	1.30E+01	3.00E-01	1.92E+02	7.85E-03	2.75E-02	3.54E-02
Sulfate	4840	4840	1.00E+00	1.00E+00	1.00E+00	NA			
Sulfide	26.9	NA	NA	NA	NA	NA			
Tin	0.25	32.5	3.90E+01	1.30E+02	3.00E-01	3.65E-02	6.84E-01	2.40E+01	2.47E+01
Uranium	0.784	25.872	6.60E-02	3.30E+01	2.00E-03	4.49E-01	1.74E-01	1.03E-02	1.85E-01
Vanadium	0.08	80	5.50E+00	1.00E+03	5.50E-03	3.08E-01	2.59E-02	1.28E-01	1.54E-01
Zinc	0.051	10.2	8.00E+01	2.00E+02	4.00E-01	7.08E+00	7.19E-04	5.17E-02	5.24E-02
Total							5.44E+01	4.55E+02	5.09E+02

From Dunean et al., 1994