Nevada
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DOE/NV--1166

# Well Completion Report for Corrective Action Unit 447, Project Shoal Area Churchill County, Nevada

Revision No.: 0

September 2006

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# WELL COMPLETION REPORT FOR CORRECTIVE ACTION UNIT 447, PROJECT SHOAL AREA CHURCHILL COUNTY, NEVADA

U.S. Department of Energy, National Nuclear Security Administration
Nevada Site Office
Las Vegas, Nevada

Revision No.: 0

September 2006

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**WELL COMPLETION REPORT FOR**
**CORRECTIVE ACTION UNIT 447,**
**PROJECT SHOAL AREA**
**CHURCHILL COUNTY, NEVADA**

Approved by:_____ Date:_____

John B. Jones
Offsites Federal Sub-Project Director
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Approved by: _____ Date: _____

Janet Appenzeller-Wing
Federal Sub-Project Director
Environmental Restoration Project

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## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| gal | Gallon |
| gpm | Gallons per minute |
| HASL | Health and Safety Laboratory |
| HASP | Health and Safety Plan |
| HC | Hydrologic characterization |
| HP | Horsepower |
| HSU | Hydrostratigraphic unit |
| id | Inside diameter |
| in. | Inch |
| LiBr | Lithium bromide |
| m | Meter |
| mg/L | Milligrams per liter |
| mi | Mile |
| mm | Millimeter |
| MV | Monitoring/validation |
| NA | Not analyzed |
| N/A | Not applicable |
| NAD | North American Datum |
| NAIL | Nuclear Annulus Investigation Log |
| NAVD | North American Vertical Datum |
| NDEP | Nevada Division of Environmental Protection |
| NDWS | Nevada Drinking Water Standards |
| NNSA/NSO | U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office |
| od | Outside diameter |
| PSA | Project Shoal Area |
| pCi/L | Picocuries per liter |
| PVC | Polyvinyl chloride |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| SBMS | Standards-Based Management System |
| SGZ | Surface ground zero |
| SNJV | Stoller-Navarro Joint Venture |
| SP | Spontaneous potential |
| SS | Stainless steel |
| SSHASP | Site Specific Health and Safety Plan |
| SU | Standard Unit |
| TD | Total depth |
| TFC | Technical field change |
| TSB | Tailgate safety briefing |
| UGTA | Underground Test Area |
| USGS | U.S. Geological Survey |
| UTM | Universal Transverse Mercator |
| WD | Well Development |
| µS/cm | Microsiemens per centimeter |

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# 1.0 Introduction

This Well Completion Report is being provided as part of the implementation of the Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP) for Corrective Action Unit (CAU) 447 (NNSA/NSO, 2006a). The CADD/CAP is part of an ongoing U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) funded project for the investigation of CAU 447 at the Project Shoal Area (PSA). All work performed on this project was conducted in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996), and all applicable Nevada Division of Environmental Protection (NDEP) policies and regulations. Investigation activities included the drilling, construction, and development of three monitoring/validation (MV) wells at the PSA. This report summarizes the field activities and data collected during the investigation.

## 1.1 Site Location and Background

The PSA is located approximately 30 miles (mi) southeast of Fallon in Churchill County, Nevada. The site is situated within the north-central portion of the Sand Springs Range at an elevation of approximately 5,200 feet (ft) above mean sea level (amsl). The project area is located on withdrawn federal lands depicted within Sections 33 and 34, Township 16 North, Range 32 East and unsurveyed portions of Township 15 North, Range 32 East of the United States Geologic Survey (USGS) Chukar Canyon, Nevada, 7.5 minute topographic quadrangle map. Refer to Figure 1-1 for a map showing the location of the PSA.

The PSA was part of the Vela Uniform Program, which was conducted to improve the United States' ability to detect, identify, and locate underground nuclear detonations. The underground test consisted of detonating a 12-kiloton nuclear device in granitic rock approximately 1,204 ft below ground surface (bgs). The test was conducted to determine whether seismic waves produced from an underground nuclear test could be differentiated from seismic waves produced from naturally occurring earthquakes. The Vela Uniform Program was a joint effort conducted by the U.S. Atomic Energy Commission and the U.S. Department of Defense in October 1963 (AEC, 1964).

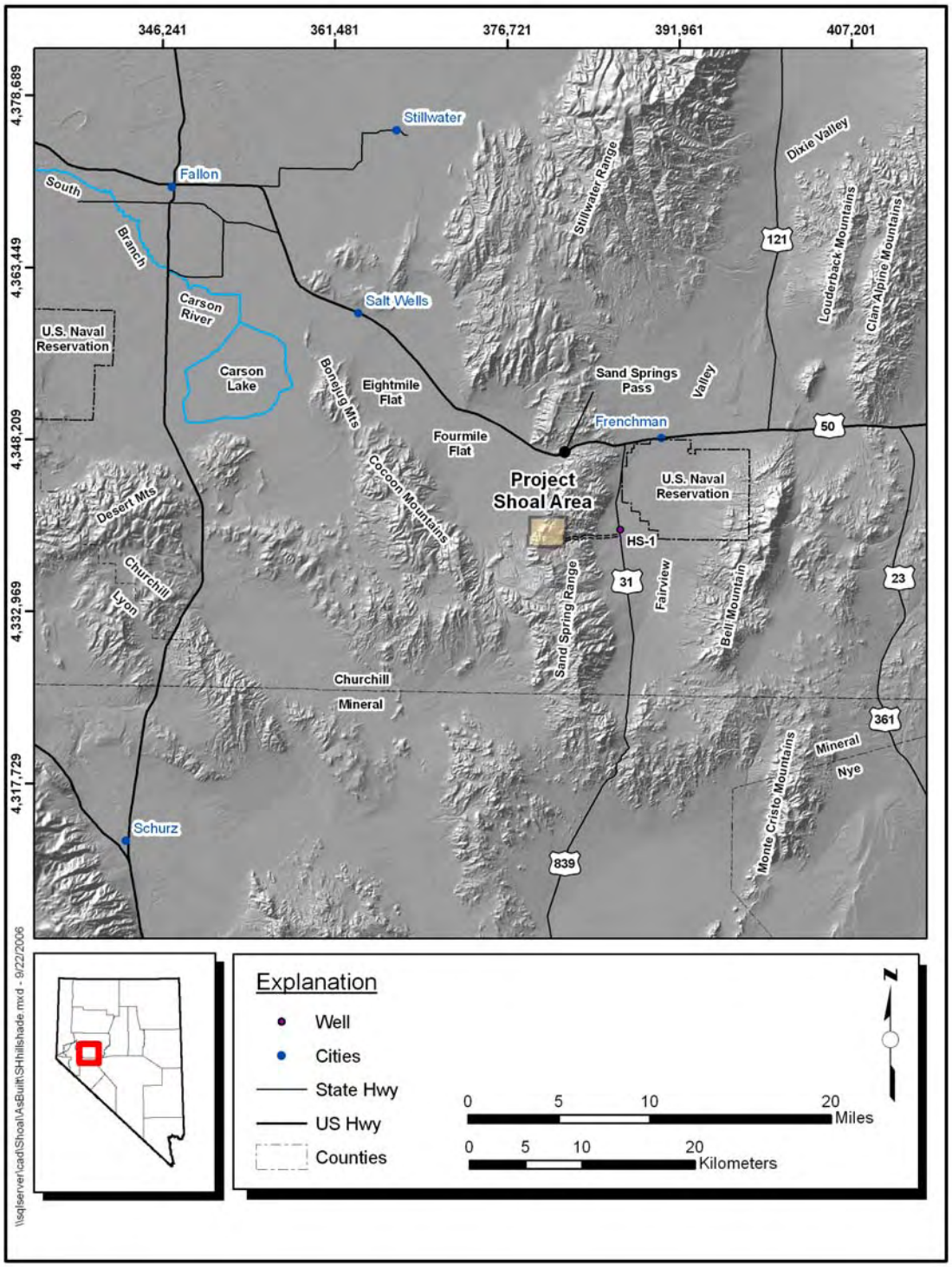



**Figure 1-1**
**Project Shoal Area Site Location Map**

The subsurface source of contamination at the PSA is the test cavity and includes radioactive fission products, uranium, plutonium, and tritium (NNSA/NSO, 2004b). Corrective action investigations (CAIs) associated with CAU 447 and the underground test cavity can be broadly grouped into two phases performed under two Corrective Action Investigation Plans (CAIPs) dated 1996 and 1998. The first phase included the drilling of four hydrologic characterization (HC) wells (HC-1 through HC-4), data analysis, and data collection for development of the groundwater flow model by Desert Research Institute (DRI). This CAI was completed in 1998. The second phase included the drilling of four additional HC wells (HC-5 through HC-8), a long-term tracer test, data analysis, and data collection for further development of the groundwater flow model. The CAIP developed for this investigation called for a Data Decision Analysis (DDA) (Pohll et al., 1999) to determine which investigation and data collection methods would minimize model uncertainty. Specific objectives for the investigation, as determined from the DDA, can be found in the Addendum to the 1998 CAIP (DOE/NV, 1999). The updated and refined groundwater model depicting flow and contaminant transport developed by DRI was approved by NDEP in February 2004. Refer to Figure 1-2 for a map showing well locations.

The groundwater model and data obtained from the two CAIs were evaluated to develop and recommend a corrective action alternative for CAU 447. Based on this evaluation, it was determined that the preferred corrective action alternative would be Proof-of-Concept and Monitoring with Institutional Controls. This corrective action alternative meets the requirements for the technical components evaluated and was intended to control inadvertent exposure to contaminated groundwater at CAU 447. The corrective action alternative was submitted in the *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 447: Project Shoal Area, Subsurface, Nevada* (NNSA/NSO, 2006a).

## 1.2 Purpose

In support of the Proof-of-Concept and Monitoring decision by the NNSA/NSO, Environmental Management Program, the Offsites Project drilled and constructed three MV wells at PSA. The purpose of this report is to summarize field activities and data collected during the installation of the three MV wells, MV-1, MV-2, and MV-3.

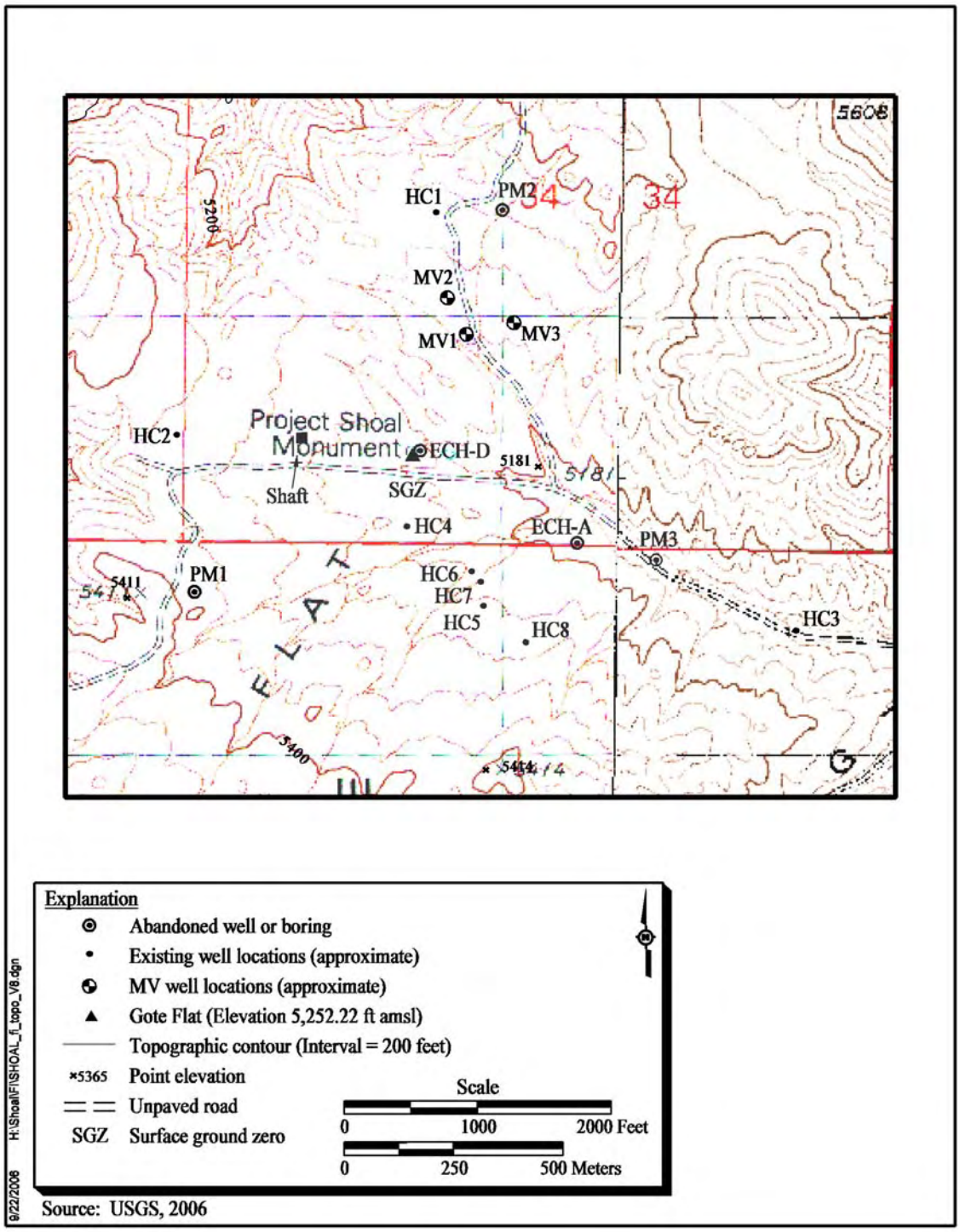



**Figure 1-2**
**Project Shoal Area Site Map**

## *1.3 Scope of Work and Technical Objectives*

The scope of work was designed to meet the technical objectives as defined in the *Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 447: Project Shoal Area, Subsurface, Nevada* (NNSA/NSO, 2006a). This included the drilling and construction of the three MV wells, MV-1, MV-2, and MV-3. These wells were installed to collect geologic, geophysical, hydrologic, and geochemical data as specified in the CADD/CAP (NNSA/NSO, 2006a).

The scope of work for the investigation included:

- Constructing drill pads and fluid storage sumps
- Advancing three boreholes to the required depths
- Installing piezometers to monitor the upper portion of the aquifer
- Monitoring drilling effluent for radionuclides
- Collecting downhole geophysical data
- Constructing three MV wells
- Installing dedicated submersible pumps in each MV well
- Developing MV wells
- Monitoring well development effluent for radionuclides
- Documenting well development parameters

The technical objectives of the MV wells included:

- Collecting data to validate DRI's groundwater flow and contaminant transport models
- Installing wells and piezometers for compliance monitoring
- Providing detailed hydrogeologic information in the vicinity of each well in terms of hydrostratigraphic unit (HSU), geologic structures, and hydraulic properties of the HSU
- Installing dedicated submersible pumps in completed wells suitable for aquifer testing to determine hydraulic properties for the HSU
- Measuring hydraulic head in the HSU both laterally and vertically to better understand hydraulic gradients and preferential flow paths
- Obtaining representative groundwater samples and analyze for radionuclides
- Obtaining borehole formation samples for detailed lithologic description

- Providing potential long-term monitoring point(s) for the evaluation of temporal changes in hydraulic head (water levels) to evaluate possible contaminant transport flow paths and groundwater chemistry

The scope of work was accomplished by a team consisting of Stoller-Navarro Joint Venture (SNJV); DRI; Lang Exploratory Drilling, a division of Boart Longyear Company (Lang); and Colog, Inc. (COLOG).

### *1.4 Drill Site and Sump Construction*

Three drill pads with fluid storage sumps and an area designated for office trailers were constructed for the installation of the MV wells. Construction of the drill pads and sumps began in late August 2005 and were completed in mid-September 2005. The drill pads were constructed to accommodate the necessary drilling equipment and materials. Sumps were generally constructed to be nominally five times the estimated volume of material to be displaced from the borehole. The drill pads each measured approximately 250 by 250 ft. The drill pads for MV-1 and MV-3 were constructed with one unlined sump both measuring approximately 60 by 120 by 12 ft. The drill pad at MV-2 was constructed with two unlined sumps each measuring approximately 60 by 90 by 15 ft.

### *1.5 Sampling of Source Water for Drilling*

Stoller-Navarro Joint Venture arranged for the U.S. Environmental Protection Agency (EPA) to collect groundwater samples from the HS-1 well during a routine groundwater sampling event conducted at the PSA. The water from the HS-1 well was used for makeup water during the drilling and development of the MV wells. The EPA collected the samples on March 13, 2006, which were relinquished to SNJV on March 15, 2006. The samples were submitted to Paragon Analytical to be analyzed for radionuclides by gamma spectroscopy in accordance with Health and Safety Laboratory (HASL)-300 and priority pollutant metals in accordance with EPA Method 6010/7470. A portion of these samples were also analyzed for tritium by SNJV personnel using a Packer Tri-Corb Liquid Scintillation Unit. The analytical data provided from the laboratory received a Tier I quality assurance review. The analytical results obtained from this sampling event are for informational use only and not intended for decision making. A summary of the analytical results is provided in Table A.1-1 of Appendix A.

## *1.6 Summary of Drilling Methods*

Wells MV-1, MV-2, and MV-3 were drilled by Lang utilizing an LM 140 rotary drill rig with top head drive. The boreholes were advanced by conventional rotary and dual-tube reverse circulation drilling methods using both tricone and downhole hammer drilling bits. The initial boreholes for the three wells were drilled for the surface conductor casing using conventional mud rotary with a 31-inch (in.) tricone roller bit. These boreholes were advanced to depths ranging from 97 to 100 ft bgs.

The drilling method for the main boreholes was initially intended to be primarily dual-tube flooded reverse circulation with a tricone roller bit. This drilling method was changed to downhole hammer during the advancement of the first borehole (MV-3). The change was formalized in a contract modification with Lang and implemented during the advancement of MV-3 at a depth of 1,225.80 ft bgs. The change in drilling method was based on the encountered drilling conditions and included changes to the originally proposed well construction and borehole diameters. A summary of the drilling methods used during the advancement of the boreholes is provided in the order they were drilled in the following paragraphs.

Well MV-3 was the first drilled during this drilling program. This borehole was advanced from 97 ft bgs to 1,225.80 ft bgs using a 22-in. diameter tricone bit. The drilling method switched from conventional rotary drilling to dual-tube flooded reverse circulation at a depth of 180 ft bgs. The drilling fluid consisted of the polymer additive Drispac™ with water. The remaining borehole was advanced from 1,225.80 ft bgs to the total depth of 1,668.84 ft bgs using dual-tube reverse circulation with a 12.45-in. downhole hammer. The fluid for this method consisted of air and foam. A summary of the drilling operations for well MV-3 is provided in Section 3.0.

Wells MV-1 and MV-2 were advanced from approximately 100 ft bgs to the total depths of 1,788.20 ft and 2,018.00 ft bgs, respectively. These boreholes were advanced to the total depths using the downhole hammer drilling method with air foam and a 12.45-in. bit. Upon reaching the total depths in each borehole it was necessary to return to the dual-tube flood reverse circulation drilling method to clean out and stabilize the borehole. Initially the drilling fluid for well MV-1 consisted of the polymer additive Drispac™ with water. The final drilling fluids for both MV-1 and MV-2 included the use of bentonite to further stabilize and clean out the boreholes. A summary of the drilling operations for wells MV-1 and MV-2 is provided in Sections 4.0 and 5.0, respectively.

A total of 78 days were spent drilling, constructing, and developing the wells. Operations were conducted 24 hours per day, 7 days a week for the duration of the project.

### *1.7 Well Locations*

The well locations were determined based on the groundwater flow and contaminant transport model developed by DRI. The wells MV-1, MV-2, and MV-3 are located to the north-northeast of surface ground zero (SGZ). Stoller-Navarro Joint Venture contracted Lumos & Associates (Lumos), a Nevada Registered Land Survey, to survey new and existing well locations upon completion of the drilling program. The well locations were surveyed on June 22 and 23, 2006. The survey included providing northings and eastings with top of casing elevations for the existing wells HC-1 through HC-8. The survey of the MV wells also included northings and eastings for the north corner of the concrete pad within the well box, north top of the water access tube casing, and the north top of piezometer casing. All survey data were documented in the Universal Transverse Mercator (UTM) Zone 11 coordinate system with horizontal data based on the North American Datum (NAD) 1927 and vertical data based on the North American Vertical Datum (NAVD) 1929. Refer to Figure 1-2 for a map showing the well locations. A summary of the survey data is provided in Table A.1-2 of Appendix A.

# 2.0 Project Shoal Area Geology

This section of the report provides a description of the regional and local geologic settings of the PSA. Information was obtained from various sources that included surface/subsurface geologic features, geophysical data, USGS literature, and previous investigation reports. Summaries of the regional and local geologic settings are provided in the following sections.

## 2.1 Regional Geologic Setting

The PSA is located in the northern portion of the Sand Springs Range in west-central Nevada's Churchill County. The Sand Springs Range is the southern extension of the Stillwater Range, a north-northeast/south-southwest trending fault block range that traverses Churchill County north to south (Figure 1-1). The Sand Springs and Stillwater Ranges are composed of late Mesozoic granitic batholiths and stocks intruded into older Mesozoic sedimentary and volcanic rocks overlain locally by Tertiary volcanic rocks. These rocks record the late Mesozoic plutonism that followed the middle Mesozoic compressional tectonics associated with the Luning-Fencemaker thrust fault. Marine sediments deposited in an early Mesozoic back-arc basin during this orogenic event were folded, metamorphosed, thrust eastward, and then intruded (Stewart, 1980). Younger volcanic rocks were deposited on the older Mesozoic rocks in a southwest-northeast trending volcanic belt that cuts across the northern Sand Springs Range and the southern Stillwater Range. This belt of Tertiary volcanism continues to the southwest of the PSA through the Cocoon Mountains, Sehoo Mountains, Bunejug Mountains, and Sand Mountains (Willden and Speed, 1974).

The Sand Springs and Stillwater Ranges form the eastern boundary of the Carson Sink. The Carson sink is the largest geographic feature in Churchill County. The Stillwater Range separates the Carson Sink from Dixie Valley, which is the second largest valley in Churchill County. The Sand Springs Range forms a miniature version of the same type of geography, separating Fourmile Flat and its playa from Fairview Valley (Figure 1-1).

## 2.2 Local Geological Setting

The Sand Springs Range rises to an elevation of 6,751 ft amsl, and is flanked by Fourmile Flat to the west and Fairview Valley to the east (Figure 1-1). The PSA is located in Gote Flat at an elevation of

approximately 5,252 ft amsl and is surrounded by granite peaks with the highest being Aplite Ridge to the south at an elevation of 6,342 ft amsl (Figure 1-2). The PSA is located within the Cretaceous-age Sand Springs granitic batholith that comprises the northern half of the Sand Springs Range. The Sand Springs Range south of the PSA is comprised of older Paleozoic and Mesozoic age sedimentary rocks that were recrystalized during Mesozoic age regional metamorphism (Greene et al., 1991). The metamorphic rocks contain several west-dipping thrust faults as well as high-angle normal faults. The southern portion of these metamorphic rocks is intruded by smaller stocks of Triassic- and Jurassic-age granite porphyries, and by isolated cupolas of the Cretaceous-aged Sand Springs granite (Satterfield, 2002).

Younger Tertiary volcanic rocks overly the granitic intrusions and metamorphic rocks in the very northern and southern parts of the range. These volcanic rocks include rhyolitic tuffs and andesitic lava flows. Although many of these Tertiary volcanic rocks exhibit depositional contacts with the underlying metamorphic and intrusive rocks, locally brecciated contact zones suggest the existence of low-angle normal detachment faults (Satterfield, 2002). Hydrothermal alteration and mineralization has localized gold- and silver-bearing quartz veins in a shear zone in the northern part of the Sand Springs Range. Based on cross-cutting relations, this mineralization is Tertiary in age and post-dates some of the Tertiary volcanic rocks (Beal et al., 1964).

Internal deformation of the Sand Springs granite is largely by high-angle normal faults that strike northeast and northwest, joints that parallel the northwest-trending faults, and fracture cleavage that generally parallel the northeast-trending faults. These faults, joints, and fractures are distributed between two dominant structural trends that generally strike N 50$^{o}$ W and N 30$^{o}$ E and are vertical to steeply dipping. Several dikes of varying composition predominantly follow the same two orientations and intrude along these lines of pre-existing weakness. These orthogonal-type sets of faults and fractures appeared early in the history of the Sand Springs granite and affected much of the subsequent structural and chemical evolution of this large intrusion (Beal et al., 1964). There is no fracture cleavage associated with Tertiary-age faulting.

Cross-cutting relations indicate that the northeast-striking faults formed during the same time interval as the northwest-striking faults, and likely resulted from the same stress regime. Fracture cleavage data suggest that most of the offset on the northeast-trending faults occurred early, after emplacement

of the granite, granodiorite, and aplite/pegmatite dikes, and that only modest amounts of offset occurred at a later time (Beal et al., 1964).

The Sand Springs batholith is composed of granodiorite and granite, aplite and pegmatite dikes, andesite dikes, rhyolite dikes, and rhyolitic intrusive breccia. Alteration and mineralization is widespread but not pervasive in the Sand Springs Range. Alteration is localized along faults, fractures, and partings, with unfaulted and unfractured granite exhibiting no alteration. The most common forms of alteration are hydrothermal bleaching, propylitic alteration, argillic alteration, iron oxide staining, and disseminated pyrite. Propylitically altered rock typically contains calcite, chlorite, epidote, and quartz. Argillic alteration is the forming of secondary clay minerals from the chemical breakdown of feldspar minerals; clay gouge is also associated with structural lineations that exhibit small amounts of offset. Alteration products are generally exhibited within and adjacent to faults, fractures, and joints. Additionally, rhyolite and andesite dikes commonly exhibit propylitic alteration (Beal et al., 1964).

### *2.2.1 Surface Geology*

The Sand Springs granite underlies SGZ and outcrops through out the PSA. A broad band of aplite/pegmatite dikes are identified several thousand feet west of SGZ, although very few crop out near SGZ. This broad band of north-northeast trending aplite/pegmatite dikes arc around SGZ for several miles north and south. These dikes range in length from 1,500 to 3,000 ft. Most of the dikes in this band and near the PSA site strike N $50^0$W to N$60^0$ W and are vertical to steeply dipping in the northeast or southwest directions. The width of this band diminishes south of the PSA, and the number of dikes within it decreases (Beal et al., 1964).

Detailed geologic mapping conducted before the underground test at the PSA identified several important northeast-striking normal faults. Five of these faults, identified as faults “A” through “E,” were mapped in detail (Beal et al., 1964). Fault “A,” a shear zone several hundred feet wide, is one of the principal northeast-striking faults within the Sand Springs Range. This dominant structure is used as the eastern boundary of the groundwater flow model developed by DRI (Pohlmann, et al., 2004). The northern end of this fault zone is characterized by a single mapped fault that offsets the northwest trending range front fault in a right-lateral sense. Fault “A” widens southward into a fault zone with numerous fault planes over 328 ft wide as it approaches the site, and the strike of the fault zone rotates

from N 45° E to N 62° E. South of SGZ the strain manifested in fault "A" becomes distributed between three to four different mapped fault splays before the main fault splay abruptly terminates against a west-striking fault (Beal et al., 1964).

Field observations of bedrock outcrops adjacent to the MV-1, MV-2, and MV-3 drill pads were documented during this drilling program. Bedrock exposures of porphyritic granite were observed to the north of the MV-3 drill pad to contain irregular selvages of pegmatite. These selvages do not form discrete dikes, but instead appear as very coarsely crystalline leucosomes composed predominantly of microcline with subordinate amounts of quartz. A pegmatite dike observed to the east of MV-3 drill pad strikes N 50° W and projects onto the drill pad. This pegmatite dike was encountered in the MV-3 borehole at a depth of 270 ft bgs. A small shear zone located east of the MV-3 drill pad strikes N 25° W and comprises several fractures that offset mineral grains. This shear zone does not exhibit any alteration or iron oxide staining. However, a similar shear zone with the same strike lies approximately 328 ft to the north and exhibits propylitic alteration, argillic alteration, and iron oxide staining. Bedrock exposures south of the MV-1 drill pad, north of the MV-3 drill pad, and northwest of the MV-2 drill pad manifest well-developed fracture cleavage that strike N 20° E. Northwest of the MV-2 drill pad pegmatite/aplite dikes strike N 65° W and are composed of individual dike segments oriented en echelon to one another.

### *2.2.2 Subsurface Geology*

Subsurface investigations of the PSA have included the drilling of numerous boreholes during several phases of investigations conducted before and after the underground nuclear test. The exploratory core hole (ECH) boreholes, ECH-D and ECH-A, were drilled to characterize the subsurface geology before conducting the nuclear test (Figure 1-2). Borehole ECH-D was a vertical borehole drilled to a depth of 2,017 ft bgs, and borehole ECH-A was a slant borehole drilled to a depth of 1,898 ft bgs. The ECH-D borehole encountered granite as the primary lithologic unit; however, two thin aplite/pegmatite dikes were also encountered. A fault zone was also encountered from depths ranging from 1,440 to 1,675 ft bgs. This fault zone was characterized by breccia within a zone of bleached and propylitically altered granite. Evidence for the northeast-striking fracture cleavage and northwest-striking joints were present throughout the drilled interval with all exhibiting bleaching, propylitic alteration, and/or iron staining (Beal et al., 1964).

The slant borehole ECH-A was advanced at a 45-degree angle in a westerly direction. This borehole was drilled near the eastern boundary of the shear zone and may have cut across and been sub-parallel to the shear zone (Beal et al., 1964). The ECH-A borehole encountered granite throughout the drilled interval. Two major fault zones were encountered at depths ranging from 120 to 450 ft bgs and 600 to 890 ft bgs. These faults contained fault breccia and clay fault gouge enveloped within a zone of bleached and propylitized granite (Beal et al., 1964). Numerous thin gouge seams were also detected and evidence for the northeast-striking cleavage fracture and northwest-striking joints observed throughout the drilled interval.

The HC boreholes were advanced during CAIs conducted in 1996 and 1999. The boreholes, HC-1 through HC-8, were completed to depths ranging from 1,060 to 3,565 ft bgs. These boreholes encountered porphyritic granite throughout the drilled intervals; however, dikes of varying composition were encountered in the HC-1, HC-2, HC-4, HC-5, HC-7, and HC-8 boreholes. Faults were encountered in the HC-4, HC-5, HC-6, HC-8, and HC-1 boreholes. Fracture zones, propylitic alteration, and iron oxide staining was observed in all of these boreholes and sericitic alteration was observed in the HC-5, HC-6, and HC-8 boreholes (DOE/NV, 1998, and IT, 2000). Borehole radar reflection logging was conducted in the HC boreholes to characterize the network of fractures (Lane et al., 2001). Two orientation trends dominated the data, northeast-striking fractures, and west- to north-northwest-striking fractures. These trends are approximately parallel to the N 30$^{o}$ E striking faults and subparallel to the N 50$^{o}$ W to N 60$^{o}$ W striking faults observed in the surface mapping.

The MV boreholes, drilled as part of this investigation, were advanced to depths ranging from 1,668.84 to 2,018.00 ft bgs. These boreholes generally encountered porphyritic granite throughout the drilled intervals. The MV-3 borehole encountered three pegmatite dikes of varying compositions. The dikes were encountered at depths ranging from approximately 270 to 280 ft bgs, 310 to 320 ft bgs, and 535 to 548 ft bgs. The MV-1 borehole encountered two fault zones at depths ranging from approximately 1,352 to 1,372 ft bgs and 1,424 to 1,436 ft bgs. The MV-2 borehole encountered three fault zones at depths ranging from approximately 418 to 442 ft bgs, 521 to 551 ft bgs, and 655 to 684 ft bgs. The fault zones encountered in the MV-1 and MV-2 boreholes were characterized by clay gouge, propylitic alteration, and fault breccia. No pegmatite dikes were encountered in the MV-1 and MV-2 boreholes. Detailed lithologic logs for the MV-3, MV-1, and MV-2 boreholes are provided in Appendices B, C, and D, respectively.

# 3.0 Summary of Well MV-3 Field Activities

Monitoring/validation well MV-3 was the first well constructed at CAU 447. This well is located approximately 1,224 feet northeast of SGZ (Figure 1-2). Drilling of the well began on April 3, 2006, with the advancement of a 31-in. diameter borehole for the surface conductor casing. The surface conductor casing was set and drilling resumed on April 6, 2006. Geophysical logging of the borehole was conducted in two phases during the advancement of this borehole. The first phase of geophysical logging was conducted from the drilled depth of 1,225.80 ft bgs and began on April 24, 2006. The second phase of geophysical logging was conducted from the completion depth of 1,668.84 ft bgs and began on May 2, 2006. The final well construction was completed on May 4, 2006, and included a piezometer and main well completed to depths of 1,210.03 ft and 1,657.59 ft bgs, respectively. The airlift development of the main well was completed on May 6, 2006. The installation of the dedicated pump and final well development was performed May 31 through June 4, 2006. Summaries of the well construction, geophysical logging, sampling, and pump installation/final well development activities are provided in the following sections. Refer to Table B.1-1 in Appendix B for a chronology of the drilling operations at MV-3.

## 3.1 Well Construction

The construction of well MV-3 included the installation of two casing sets. The first casing was a 24-in. diameter carbon-steel (CS) casing with fully welded joints installed as a surface seal and wellhead control apparatus. This casing was set to a depth of 97 ft bgs and cemented in place using approximately 214.2 cubic feet ($ft^3$) of Portland Type II cement. The second casing was a 13.375-in. CS casing threaded and coupled installed in a 22-in. diameter borehole to a depth of 1,224.61 ft bgs. A piezometer was constructed in the annular space between the 13.375-in. casing and 22-in. diameter borehole. The 13.375-in. casing was cemented at the base of the casing and borehole using approximately 32 $ft^3$ of Portland Type II cement with 2 percent calcium chloride (CaCl). The cement sealed the bottom 21 ft (approximately) of the casing and borehole. The piezometer was constructed with 2.375-in. outside diameter (od) CS casing with approximately 60 ft of slotted screen installed from 1,140.42 to 1,200.45 ft bgs. The piezometer was completed to a total depth of 1,210.03 ft bgs and included approximately 10 ft of blank casing below the well screen for a sump. A graded filter pack was installed around the slotted interval of the piezometer.

The final borehole was advanced from 1,225.80 ft using the downhole hammer drilling method with a 12.45-in. bit. This portion of the borehole was completed to a depth of 1,668.84 ft bgs. The main well was constructed within this borehole and consisted of 5.5-in od internally epoxy-coated CS casing. The well was screened from 1,463.59 to 1,634.75 ft bgs with 3-by-0.08-in. slotted openings on 6-in. centers staggered at 10 degrees with 18 slots per row. The main well was completed to a total depth of 1,657.59 ft bgs and included approximately 23 ft of blank casing below the well screen for a sump. Four centralizers were placed around the main well casing at approximate 80-ft intervals starting at approximately 1,635 ft bgs to ensure proper spacing of stemming materials between the well casing and borehole annulus. Refer to Figure 3-1 for a diagram showing well construction details.

Filter pack materials for MV-3 include $^{1}/_{8}$-by-$^{1}/_{4}$-in. clean gravel, 6x12 clean silica sand, and 20/40 silica sand. The gravel filter pack was placed around the well and piezometer screen intervals. The 6x12 silica sand was placed above the gravel, and 20/40 silica sand completed the filter pack as a transition sand. Gravel and sand stemming materials were placed using a sand pump with a clean water flush into the borehole annulus through an NQ tremie pipe. Portland Type II cement was used to seal the annulus above the filter pack. Cement was also pumped down the NQ tremie followed by a clean water rinse. The NQ tremie was raised in stages during the placement of the stemming materials and cement to help ensure proper placement without plugging or bridging. Placement of stemming materials were monitored in real time to ensure correct tagging depths using a Nuclear Annulus Investigation Log (NAIL), conducted by COLOG. Well construction materials and volumes used to complete MV-3 are provided in Table B.1-2 of Appendix B.

## *3.2 Geophysical Surveys*

Borehole geophysical survey data were acquired from the MV-3 borehole in three separate phases by the geophysical subcontractor COLOG. The first phase of logging was performed within the 22-in. diameter borehole from below the surface casing to a depth of approximately 1,225.80 ft bgs. This phase of logging was completed on April 25, 2006. The second phase of logging was performed in the 12.45-in. borehole to the completion depth of approximately 1,668.84 ft bgs. This phase of logging was completed on May 3, 2006. The geophysical logging of the borehole included temperature, sonic velocity, resistivity (single point, 16-in., and 64-in.), spontaneous potential (SP),

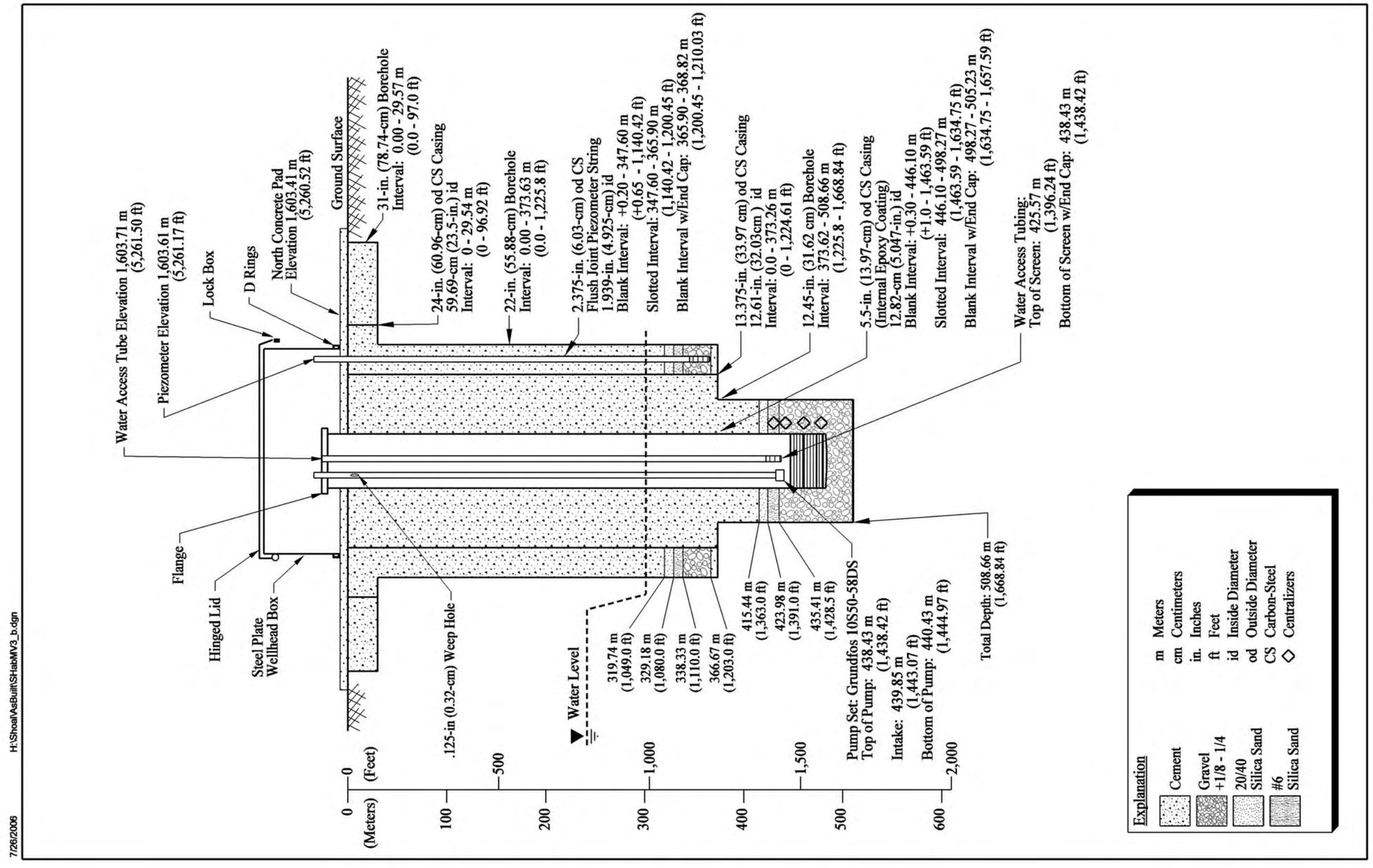
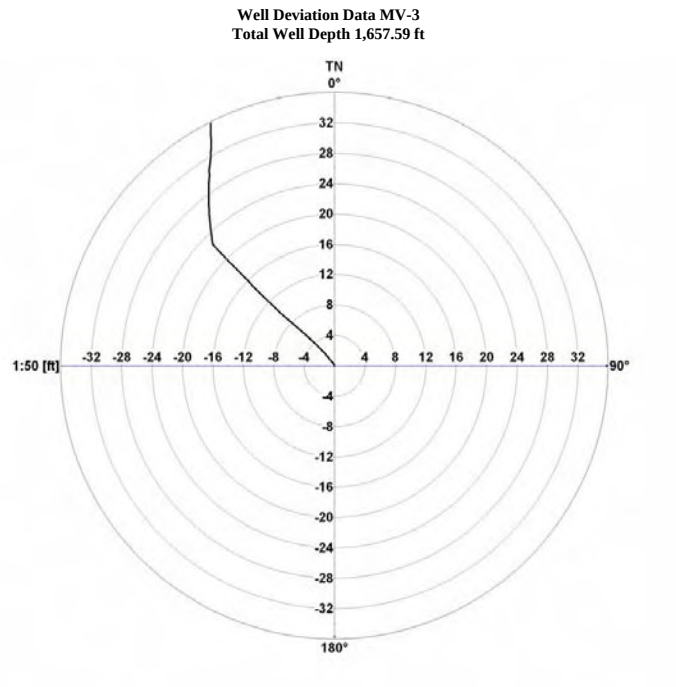



**Figure 3-1**
**As-Built Drawing for Project Shoal Area Well MV-3**

natural gamma, epithermal neutron (short and long spaced), caliper, spectral gamma, density, optical televiewer, and acoustic televiewer logs.

The final phase of geophysical logging consisted of a final deviation survey and NAIL. This phase of geophysical logging was completed on May 4, 2006. The NAIL log was used for real-time tagging of stemming materials during the final well construction. The final deviation survey was performed within the main well to determine the extent of deviation of the well from vertical. The deviation survey indicated the bottom of the well had deviated approximately 1.2 degrees from vertical. The well deviation survey placed the bottom of the well approximately 36 ft from the collar and resulted in a true vertical depth of 1,657.20 ft bgs. Refer to Figure 3-2 for a deviation plot of the MV-3 well. Refer to Appendix B for a condensed version (one page) of the geophysical signatures for MV-3. A summary of the geophysical logs obtained from the MV-3 borehole is provided in Table B.1-3 of Appendix B.




Note: Northing and Easting computed from open-hole azimuth data and cased-hole tilt data.
All directions are with respect to True North. All distances are in units of feet.

**Figure 3-2**
**Deviation Plot for MV-3**

## 3.3 Sampling

Lithologic and water quality samples were collected during the advancement of the borehole, construction of the well, and development of the MV-3 well. Samples included rock cuttings for lithologic description and drilling fluid/groundwater for water quality analysis. Samples were collected as directed in the Fluid Management Plan (FMP) (NNSA/NSO, 2006b) and Field Instruction (FI) (SNJV, 2006a). Summaries of the sampling activities performed are provided in the following sections.

### 3.3.1 Geologic Material Sampling

Samples of the drill cuttings were collected during the advancement of the MV-3 borehole. These samples were collected from the drill rig shaker screen. The samples were washed and composited for each 10-ft interval. A portion of the washed cuttings were placed in a chip tray for lithologic description upon collection. These samples were later used for a more detailed description using an optical light microscope and the geophysical logs obtained during the drilling. The lithologic descriptions included grain size, mineralogy, alteration, color, fracturing, and other notable geologic characteristics. The lithologic descriptions were documented following the guidance of Standards-Based Management System (SBMS) Underground Test Area (UGTA) procedure "Geologic Description of Cuttings and Core." A complete lithologic log of the samples collected from MV-3 is provided in Appendix B.

### 3.3.2 Radiological Sampling and Monitoring

Samples of drilling fluid, makeup/source water, and groundwater from discharge during well development were collected following the guidance of SBMS UGTA procedure "Fluid Sample Collection, Field Filtration, and Processing." Samples obtained during the drilling operation were collected at approximate 20-ft intervals and/or every two hours from below the cyclone as the fluid entered the mud tank. Samples obtained during well development were collected approximately every four hours from the discharge line. Samples were also collected from the water trucks and frac tanks on site.

Samples collected for radiological monitoring were analyzed in the field for tritium using a Beta Scout field instrument. The analytical results obtained from groundwater samples collected from

HS-1 before initiating drilling activities were used as a baseline to establish the background for the area. The EPA and Nevada Drinking Water Standards (NDWS) radiological action level for tritium in groundwater is 20,000 picocuries per liter (pCi/L). The action level used on site was 10,000 pCi/L. Samples collected and analyzed for tritium during field operations were within the background range throughout the duration of the MV-3 drilling and development activities. The tritium results obtained from samples collected during drilling, airlift development, and pump development of MV-3 are provided in Table B.1-4 of Appendix B.

### *3.3.3 Bromide Sampling*

Samples were collected of drilling fluid, makeup/source water, and groundwater from discharge during well development to monitor bromide ($Br^-$) concentrations obtained from the lithium bromide (LiBr) tracer that was added to the makeup/source water used during the drilling operations. The LiBr tracer was added to each tanker truck of water obtain from the source well HS-1 located in Fairview Valley. The makeup water with tracer was used during the drilling, well construction, and development. Bromide concentrations in the makeup/source water were generally maintained between 20 and 40 milligrams per liter (mg/L). The purpose of the tracer used during drilling and development operations was to:

- Assist in detection of perched water zones
- Assist in detection of groundwater table
- Provide a monitoring parameter to establish effectiveness of well development

Samples obtained during drilling operations were collected at approximate 20-ft intervals and/or every two hours from below the cyclone as the fluid entered the mud tank. Samples obtained during development were collected approximately every four hours from the discharge line. Samples were analyzed using an Orion 290A ion-specific meter. Concentrations of $Br^-$ in the drilling fluid ranged from 67.10 to 5.06 mg/L during drilling operations, 28.40 to 2.24 mg/L during airlift development, and 26.20 to 1.13 mg/L during pump development activities. A summary of the well development activities is provided in Section 3.4. Refer to Figure 3-3 for a graph of the results obtained during drilling, airlift development, and pump development. A summary of the analytical results is provided in Table B.1-5 of Appendix B.

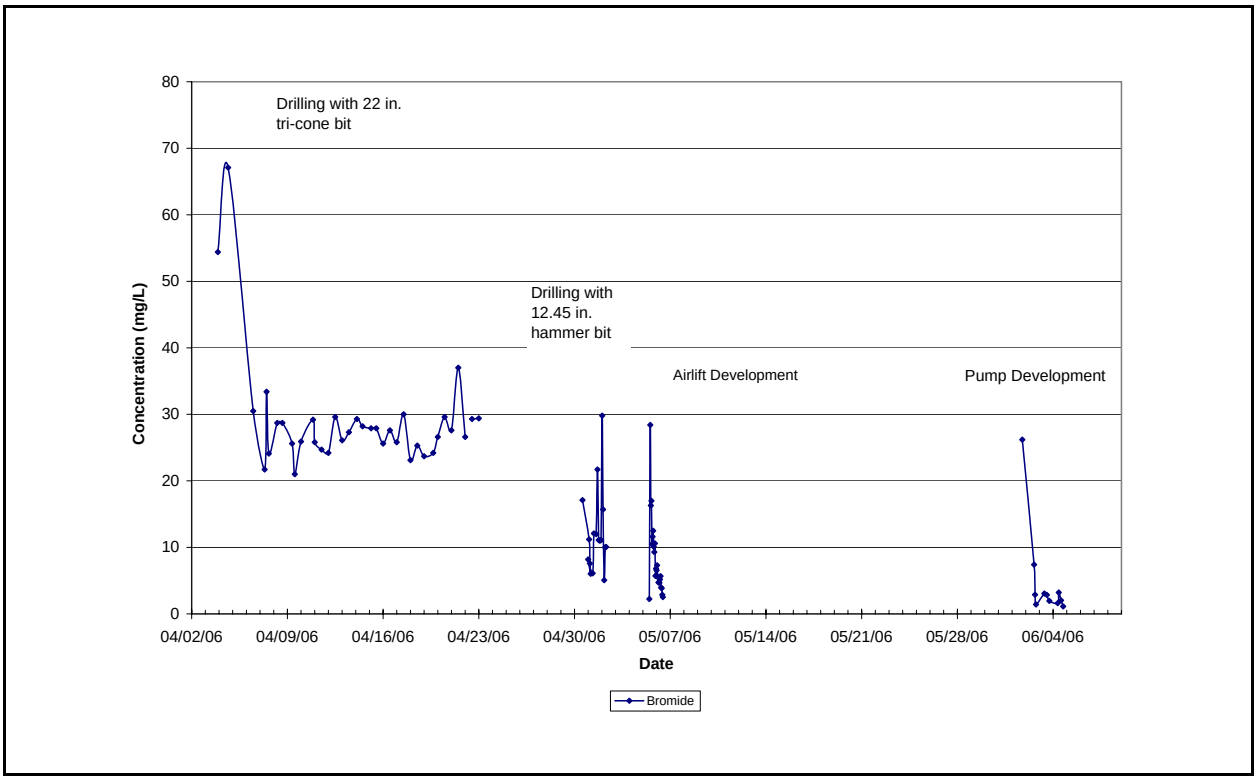



**Figure 3-3**
**Bromide Data from MV-3 Drilling, Airlift, and Pump Development**

### *3.3.4 Water Quality Parameter Sampling*

Samples were collected of drilling fluid, makeup/source water, and groundwater from discharge during well development to monitor the water quality parameters pH, specific conductance, and temperature. The samples were collected following the guidance of SBMS UGTA procedure "Water Quality Monitoring." Samples were collected every two hours and/or at approximate 20-ft depth intervals from the cyclone as the fluid entered the mud tank. Samples collected during well development were obtained approximately every four hours from the discharge line. Samples were analyzed in the field for pH, temperature, and specific conductance using a YSI-63 water quality meter. The pH values ranged from 9.83 to 6.22 and temperatures ranged from 32.3 to 16.3 degrees Celsius (ºC) during drilling, airlift development, and pump development operations. Specific conductance ranged from 3,249 to 110.10 microsiemens per centimeter (µS/cm) during drilling operations, 934 to 716 µS/cm during airlift development, and 2,614 to 376.60 µS/cm during the final pump development. Refer to Figure 3-4 for a graph showing water quality parameter results obtained

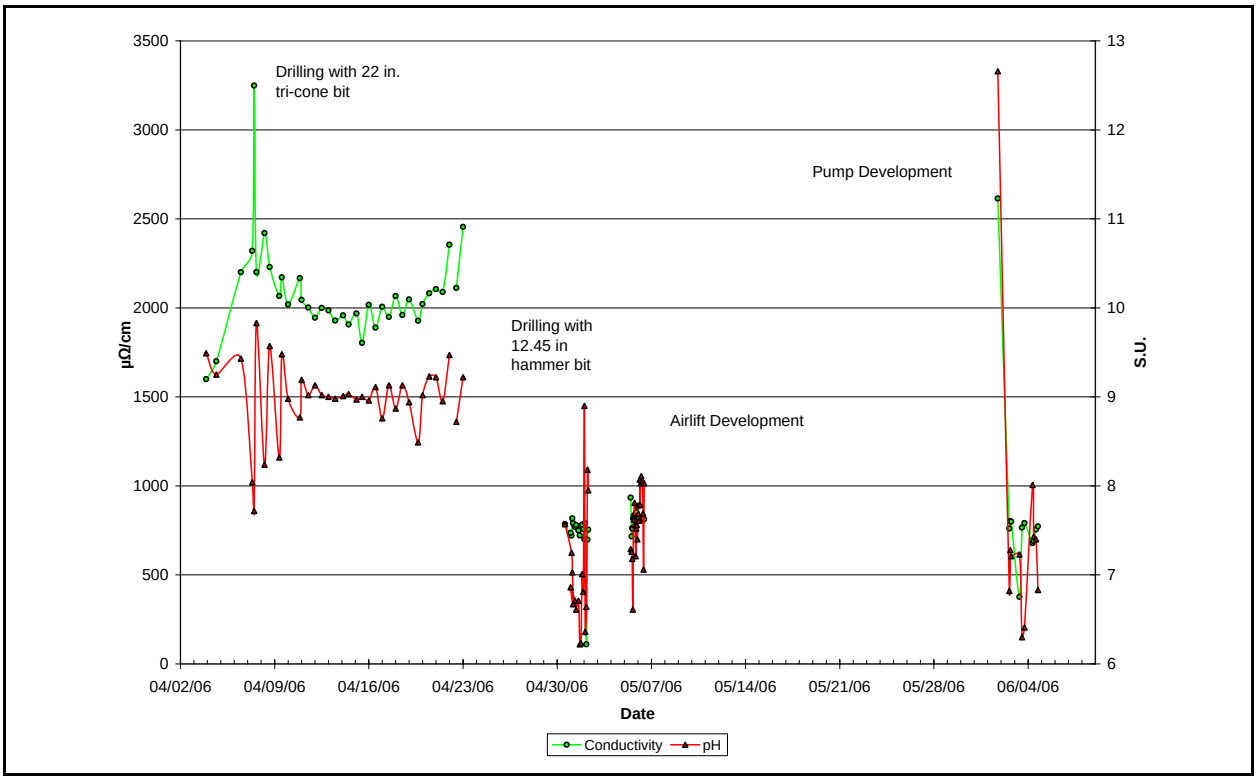



**Figure 3-4**
**Water Quality Parameters from MV-3 Drilling, Airlift, and Pump Development**

during drilling, airlift development, and pump development. A summary of the water quality parameter results is provided in Table B.1-5 of Appendix B.

### *3.4 Well Development and Testing*

The initial development of the MV-3 well began on May 5, 2006. This development consisted of airlifting and was performed with the LM 140 drill rig using a 1,100 cubic feet per minute (CFM) air compressor plumbed to an AQ airline with HQ eductor (Figure 3-5). The initial development was conducted for 24 hours and included approximately 19.1 hours of airlifting and surging. Samples were collected and analyzed on site for water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. Fluid discharge rates averaged approximately 13.5 gallons per minute (gpm) during the airlift development period. The fluid discharge rates decreased to approximately 9.4 gpm at the completion of the airlift development. Concentrations of $Br^-$ obtained from samples analyzed during the airlift development ranged from 28.4 mg/L at startup to 2.24 mg/L at completion. A total of 13,699.72 gallons (gal) of fluid were purged during the airlift development of MV-3.

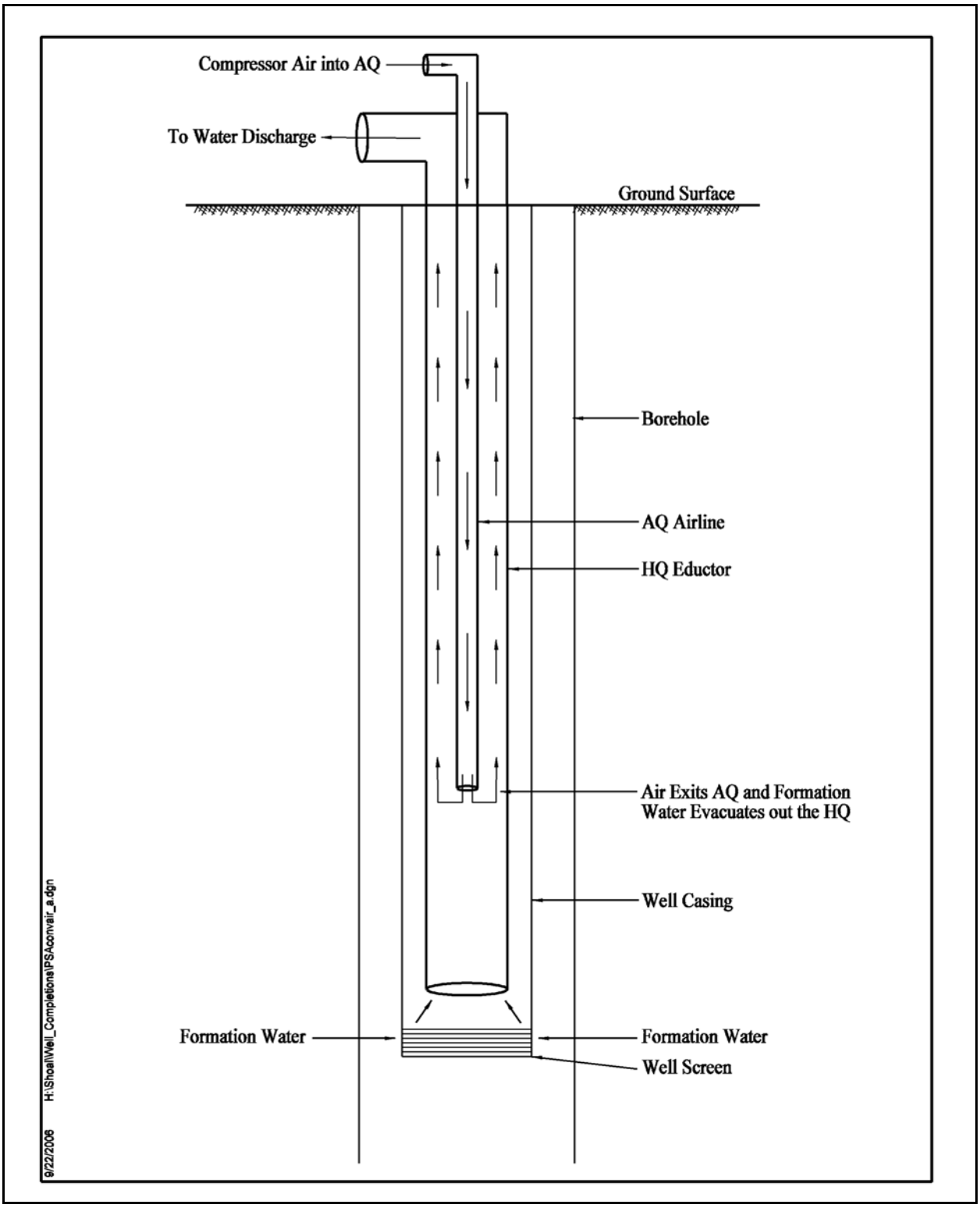



**Figure 3-5**
**A Schematic of Dual-Tube Airlifting**

Development of the MV-3 piezometer began on June 1, 2006. This development consisted of bailing and was performed with the LX29 pump rig and a wireline bailer. A total of 4 gal were removed on June 1, 2006. Airlift development was performed using the LX29 pump rig with 1,100 CFM air compressor and 0.5-in. airline began on June 6, 2006. Fluid discharge rates from the piezometer ranged from 0.37 to 1.0 gpm. Development of the piezometer ended on June 8, 2006. A total of approximately 506 gal of fluid were removed from the piezometer during the development. As a result of low discharge rates and slow recharge from the formation, the piezometer could not be fully developed.

The MV-3 well was completed with a 4-in. stainless-steel (SS) submersible Grundfos® pump, model 10S50-58DS, with a 5-HP Grundfos® motor. Installation of the dedicated pump began on May 31, 2006. The pump was installed using the LX29 pump rig and included the setting of the pump, riser pipe, and water access tube. Installation of the pump was completed on June 1, 2006. The top of the pump was set at 1,438.42 ft bgs, the bottom of the pump motor was set at 1,444.97 ft bgs, and the intake was at 1,443.07 ft bgs. The pump is powered by an MS 4000, 5-horsepower (HP), 480-volt, three-phase Grundfos® motor. Power is supplied to the pump using 8 American Wire Gauge (AWG) 600-volt heavy-duty flat submersible cable, banded and clamped to the 1¼-in. inside diameter (id) CS American Petroleum Institute (API) tubing with external upset ends (EUE). The water access tube is also banded and clamped to the discharge pipe. The water access tube is constructed with 1¼-in. od schedule 80 polyvinyl chloride (PVC) pipe with flush joints. The water access tube is completed with 40 ft of 0.02-in. screen that is set just above the top of the pump. The discharge pipe has a $^{1}/_{8}$-in. weep hole approximately 15 ft below the wellhead and a brass check valve just above the pump that is in addition to the pump's internal check valve. A functional test of the pump was performed on June 2, 2006, and removed approximately 165 gal of fluid from the well.

The final development of the MV-3 well was performed using the dedicated pump and began on June 2, 2006. Samples were collected during the development and analyzed on site for water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. Pump development was performed during day time operations and was completed on June 4, 2006. Concentrations of $Br^-$ obtained from samples analyzed during development ranged from 7.41 mg/L at startup to 1.13 mg/L at completion. A total of approximately 14,150 gal of fluid were removed during the pump development at MV-3.

Refer to Figure 3-6 for a graph showing $Br^-$ concentrations versus gallons removed during development of the MV-3 well.

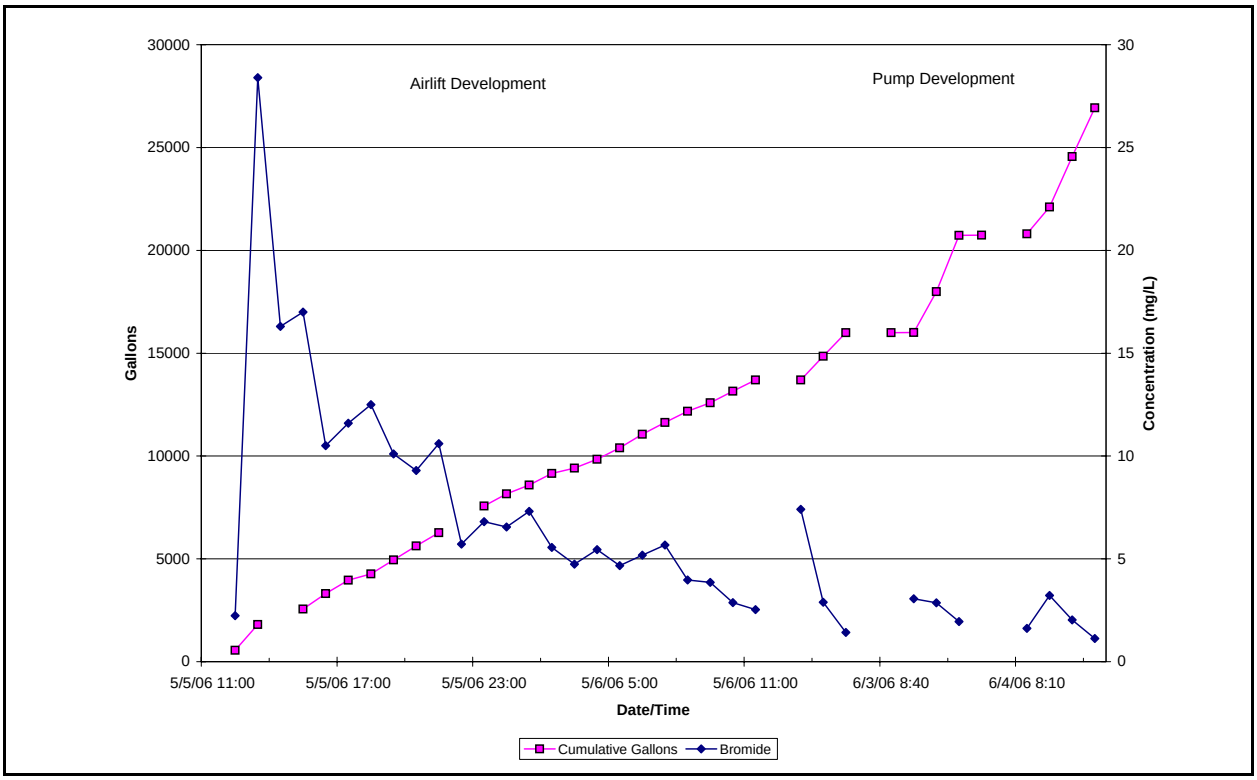



**Figure 3-6**
**Bromide vs. Gallons Removed During MV-3 Development**

# 4.0 Summary of Well MV-1 Field Activities

Monitoring/validation well MV-1 was the second well constructed at CAU 447. This well is located approximately 967 ft north-northeast of SGZ (Figure 1-2). Drilling of the well began on May 8, 2006, with the advancement of a 31-in. diameter borehole for the surface conductor casing. The surface conductor casing was set and drilling resumed on May 11, 2006. Geophysical logging of the borehole was performed at the completion depth and began on May 16, 2006. The final well construction was completed on May 4, 2006, and included a piezometer and main well completed to depths of 1,407.08 ft and 1,749.50 ft bgs, respectively. The airlift development of the main well was completed on May 22, 2006. The installation of the dedicated pump and final well development was performed June 2 through June 14, 2006. Summaries of the well construction, geophysical logging, sampling, and pump installation/final well development activities are provided in the following sections. Refer to Table C.1-1 in Appendix C for a chronology of the drilling operations at MV-1.

## 4.1 Well Construction

The construction of the MV-1 well included the installation of a 24-in. diameter CS surface casing with fully welded joints as a surface seal and wellhead control apparatus. This casing was set to a depth of 100 ft bgs and cemented in place using approximately 218.7 $ft^3$ of Portland Type II cement. The final borehole was advanced with a 12.45-in. diameter hammer bit to the completion depth of 1,788.20 ft bgs. The main well construction consisted of 5.5-in. od internally epoxy-coated CS casing. The well was screened from 1,572.73 to 1,726.54 ft bgs with 3-by-0.08-in. slotted openings on 6-in. centers staggered at 10 degrees with 18 slots per row. The final well construction was completed to a depth of 1,749.50 ft bgs and included approximately 23 ft of blank casing below the well screen for a sump. Four centralizers were placed around the main well casing at 80-ft intervals starting at approximately 1,726 ft bgs to ensure proper spacing of stemming materials between the well casing and borehole annulus.

A piezometer was also constructed within the 12.45-in. diameter borehole. The piezometer consisted of 2.375-in. od CS casing screened from 1,337.50 to 1,397.50 ft bgs. The piezometer was completed to a depth of 1,407.08 ft bgs and included approximately 10 ft of blank casing below the well screen for a sump. A graded filter pack was installed around the slotted intervals of both the main well and

piezometer. A cement seal, approximately 56 ft thick, was placed between the main well filter pack and the piezometer filter pack to ensure separation of water producing zones. Refer to Figure 4-1 for a diagram showing the well construction details.

Filter pack materials for MV-1 include $^{1}/_{8}$-by-$^{1}/_{4}$-in. clean gravel and 6x12 clean silica sand. The gravel filter pack was placed around the well and piezometer screen intervals. The 6x12 silica sand was placed above the gravel as a transition sand. Gravel and sand stemming materials were placed using a sand pump with a clean water flush into the borehole annulus through an NQ tremie pipe. Portland Type II cement was used to seal the formation. The cement seal placed between the well and piezometer included a 2 percent CaCl additive to reduce the cure time. Cement was also pumped down the NQ tremie followed by a clean water rinse. The NQ tremie was raised in stages during the placement of the stemming materials and cement to help ensure proper placement without plugging or bridging. Placement of stemming materials were monitored in real time to ensure correct tagging depths using a NAIL, conducted by COLOG. The stemming materials and volumes used for the construction of MV-1 are provided in Table C.1-2 of Appendix C.

## *4.2 Geophysical Surveys*

Borehole geophysical survey data were acquired from the MV-1 borehole in two separate phases by the geophysical subcontractor COLOG. The first phase of geophysical logging was performed in the 12.45-in. diameter borehole from the surface to the completion depth of approximately 1,788.20 ft bgs. Borehole formation instability resulted in formation bridges leading to several attempts to obtain complete geophysical logs of the borehole. The first attempt at logging began on May 15, 2006, when the logging tool encountered a bridge at approximately 1,362 ft bgs. As a result of the bridge, the decision was made to run the optical televiewer log from surface to the bridged interval before drilling out the bridge using the flooded reverse circulation drilling method. Video logging was completed to 1,362 ft bgs on May 16, 2006. The video confirmed the borehole was blocked at this depth. The borehole was then redrilled using the flooded reverse circulation drilling method with the polymer additive Drispac™ to stabilize the borehole back to the completion depth of approximately 1,788.20 ft bgs.

A second attempt was made to collect geophysical logs on May 17, 2006. COLOG successfully collected logs from 1,778.50 ft bgs to the surface casing for temperature, resistivity (single point,

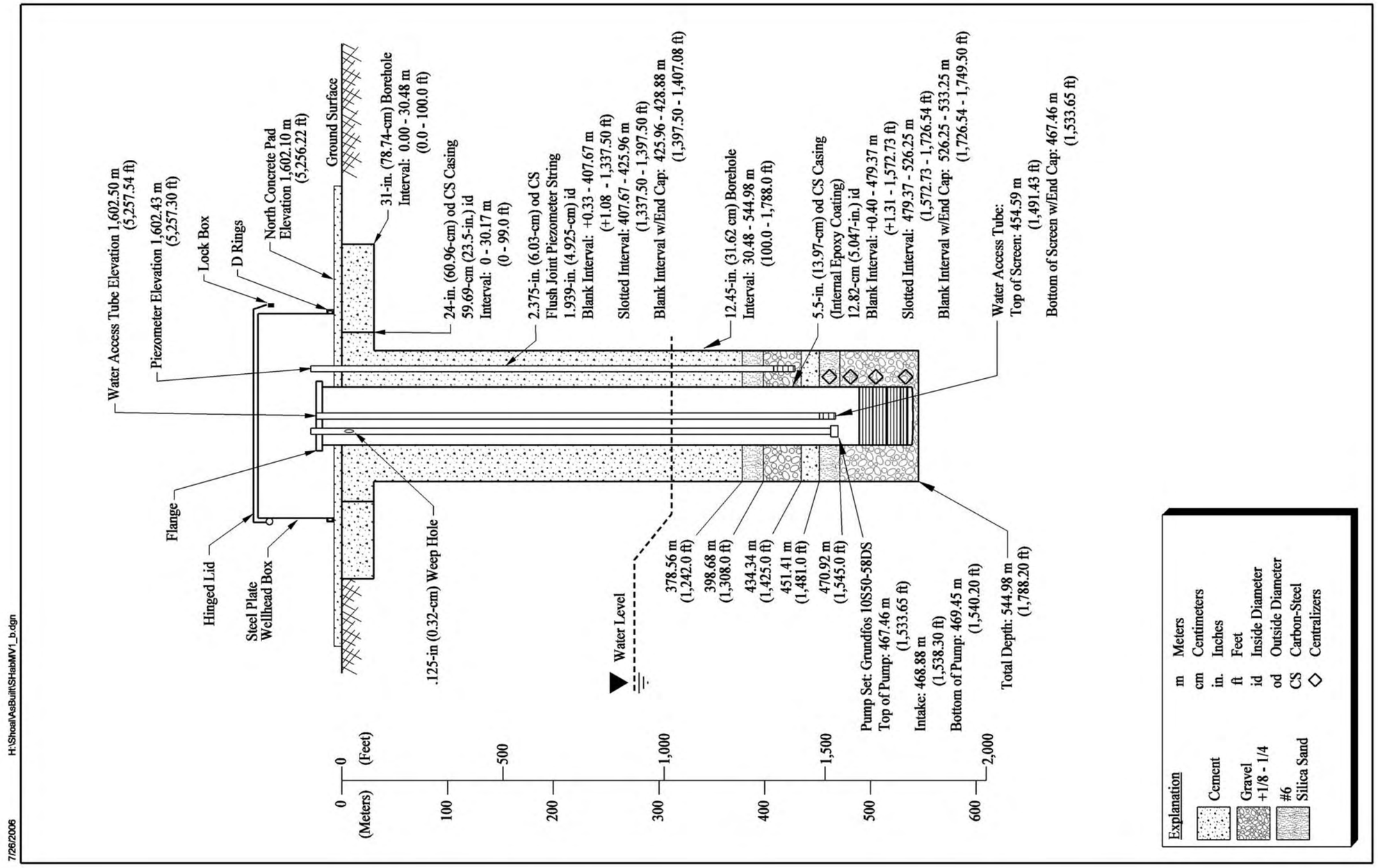



**Figure 4-1**
**As-Built Drawing for Project Shoal Area Well MV-1**

16-in., and 64-in.), and sonic velocity. A bridge was encountered again while running the caliper tool downhole at a depth of approximately 1,609 ft bgs. A second phase of borehole cleaning and stabilization was conducted that required the use of bentonite drilling fluid. The third attempt to complete the geophysical logging began on May 18, 2006. COLOG successfully collected the acoustic televiewer and deviation log from 1,784.50 ft bgs to approximately 1,300 ft bgs. This provided approximately 40 ft of overlap with the video log. Geophysical logging of the borehole included temperature, sonic velocity, resistivity (single point, 16-in., and 64-in.), SP, natural gamma, caliper, optical televiewer, and acoustic televiewer logs.

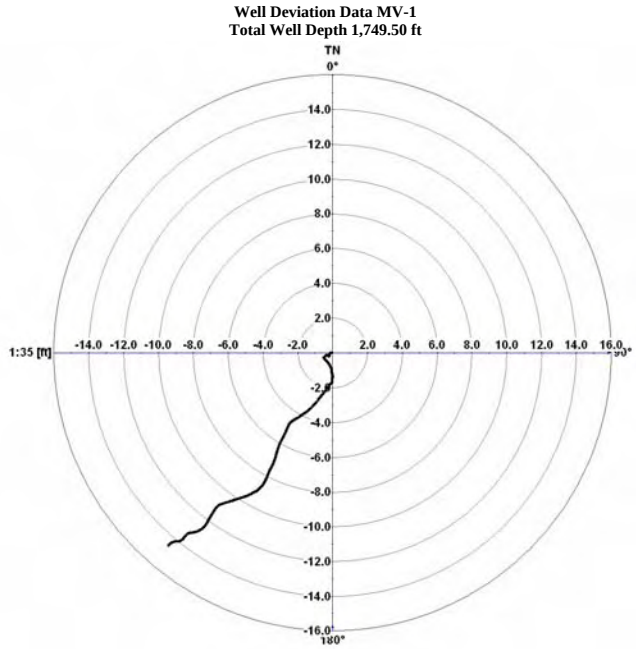
The final phase of geophysical logging consisted of a deviation survey and NAIL. This phase of the geophysical logging was completed on May 20, 2006. The NAIL log was used for real-time tagging of stemming materials during the final well construction. This included the placement of the cement seal between the top of the well gravel pack and the bottom of the piezometer gravel pack. The deviation survey was performed to determine the deviation of the main well from vertical. The deviation survey indicated the bottom of the well had deviated approximately 0.47 degrees from vertical. The deviation survey placed the bottom of the well approximately 14.5 ft from the collar and resulted in a true vertical depth of 1,749.56 ft bgs. Refer to Figure 4-2 for a deviation plot of the MV-1 well. Refer to Appendix C for a condensed version of the geophysical signatures for MV-1. A summary of the geophysical logs utilized in the MV-1 borehole is provided in Table C.1-3 of Appendix C.

## 4.3 Sampling

Lithologic and water quality samples were collected during the advancement of the borehole, construction of the well, and development of the MV-1 well. Samples included rock cuttings for lithologic description and drilling fluid/groundwater for water quality analysis. Samples were collected as directed in the FMP (NNSA/NSO, 2006b) and FI (SNJV, 2006a). Summaries of the sampling activities are provided in the following sections.

### 4.3.1 Geologic Material Sampling

Samples of the drill cuttings were collected during the advancement of the MV-1 borehole. These samples were collected from the drill rig shaker screen. The samples were washed and composited




Note: Northing and Easting computed from open-hole azimuth data and cased-hole tilt data.
All directions are with respect to True North. All distances are in units of feet.

**Figure 4-2**
**Deviation Plot for MV-1**

for each 10-ft interval during the advancement of the borehole. A portion of the washed cuttings were placed in a chip tray for lithologic description upon collection. These samples were later used for a more detailed description using an optical light microscope and the geophysical logs obtained during the drilling. The lithologic descriptions included grain size, mineralogy, alteration, color, fracturing, and other notable geologic characteristics. The lithologic descriptions were documented following the guidance of SBMS UGTA procedure "Geologic Description of Cuttings and Core." A complete lithologic log of the samples collected from MV-1 is provided in Appendix C.

### *4.3.2 Radiological Sampling and Monitoring*

Samples of drilling fluid, makeup/source water, and groundwater from discharge during well development were collected following the guidance of SBMS UGTA procedure "Fluid Sample Collection, Field Filtration, and Processing." Samples obtained during the drilling operation were initially collected at approximate 20-ft intervals but was changed to hourly as a result of the increased penetration rates from the change in drilling method to downhole hammer. This change was

formalized in a Record of Technical Change to the FMP dated May 12, 2006. Samples collected during the drilling operations were obtained from below the cyclone as the fluid entered the mud tank. Samples obtained during well development were collected approximately every four hours from the discharge line. Samples were also collected from the water trucks and frac tanks on site.

Samples collected for radiological monitoring were analyzed in the field for tritium using a Beta Scout field instrument. The analytical results obtained from groundwater samples collected from HS-1 before initiating drilling activities were used as a baseline to establish the background for the area. The EPA and NDWS radiological action level for tritium in groundwater is 20,000 pCi/L. The action level used on site was 10,000 pCi/L. Samples collected and analyzed for tritium during field operations were within the background range throughout the duration of the MV-1 drilling and development activities. The tritium results obtained from samples collected during the drilling, airlift development, and pump development of the MV-1 well are provided in Table C.1-4 of Appendix C.

### *4.3.3 Bromide Sampling*

Samples were collected of drilling fluid, makeup/source water, and groundwater from discharge during well development to monitor bromide concentrations obtained from the LiBr tracer that was added to the makeup/source water used during the drilling operations. The LiBr tracer was added to each tanker truck of water obtained from the source well HS-1 located in Fairview Valley. The makeup water with tracer was used during the drilling, well construction, and development. Bromide concentrations in the makeup/source water were generally maintained between 20 and 40 mg/L. The purpose of the tracer used during drilling and development operations was to:

- Assist in detection of perched water zones
- Assist in detection of groundwater table
- Provide a monitoring parameter to establish effectiveness of well development

Samples obtained during drilling operations were collected at approximate 20-ft intervals and/or every two hours from below the cyclone as the fluid entered the mud tank. Samples obtained during development were collected approximately every four hours from the discharge line. Samples were analyzed using an Orion 290A ion-specific meter. Concentrations of $Br^-$ in the drilling fluid ranged from 29.30 to 3.34 mg/L during drilling operations, 21.10 to 3.67 mg/L during airlift development, and 17.50 to 0.30 mg/L during the final pump development. A summary of well development

activities at MV-1 is provided in Section 4.4. Refer to Figure 4-3 for a graph of the results obtained during drilling, airlift development, and pump development. The $Br^-$ concentrations obtained during drilling, airlift development, and pump development are provided in Table C.1-5 of Appendix C.

### 4.3.4 Water Quality Parameter Sampling

Samples were collected of drilling fluid, makeup/source water, and groundwater from discharge during well development to monitor the water quality parameters pH, specific conductance, and temperature. The samples were collected following the guidance of SBMS UGTA procedure "Water Quality Monitoring." Samples were collected hourly and/or at approximate 20-ft depth intervals as the fluid entered the mud tank below the cyclone. Samples collected during well development were obtained approximately every four hours from the discharge line. Samples were analyzed in the field for pH, temperature, and specific conductance using a YSI-63 water quality meter. The pH values ranged from 11.80 to 6.38, and temperatures ranged from 25.10 to 16.60ºC. Specific conductance ranged from 3,081 to 380 µS/cm during drilling operations, 1,216 to 606 µS/cm during airlift development, and 751 to 350 µS/cm during the final pump development. Refer to Figure 4-4 for a graph of the water quality parameters obtained during the drilling, airlifting development, and pump development operation at MV-1. A summary of the results is provided in Table C.1-5 of Appendix C.

## 4.4 Well Development and Pump Installation

The initial development of the MV-1 well began on May 21, 2006. This development consisted of airlifting and was performed with the LM 140 drill rig using a 1,100-CFM air compressor plumbed to an AQ airline with HQ eductor (Figure 3-5). The initial development was conducted for approximately 34.5 hours and included airlifting and surging. Samples were collected during the development and analyzed on site for water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. Fluid discharge rates averaged approximately 8.9 gpm during the airlift development period. The fluid discharge rate decreased to approximately 5.0 gpm at the completion of airlift development. Concentrations of $Br^-$ obtained from samples collected during the development ranged from 20.7 mg/L at startup to 3.67 mg/L at the completion. A total of approximately 9,183 gal of fluid were removed during the airlift development at MV-1.

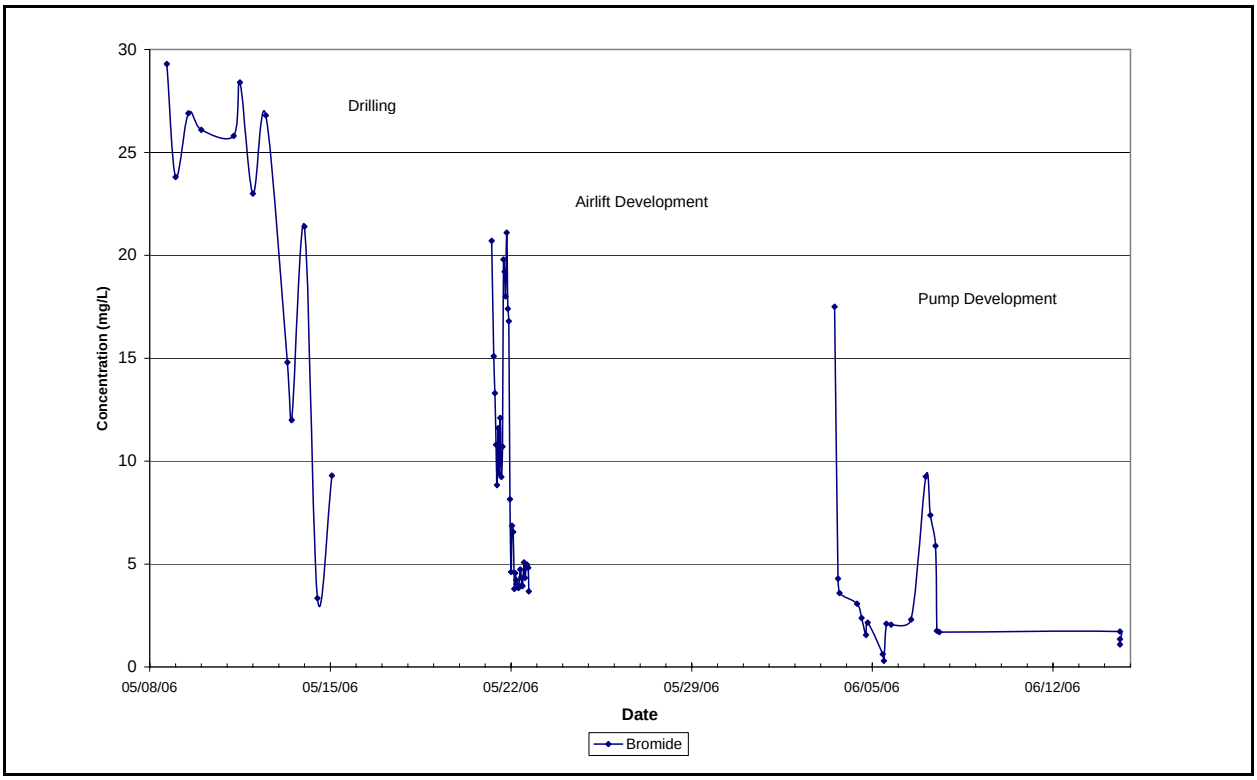



**Figure 4-3**
**Bromide Data from MV-1 During Drilling, Airlift, and Pump Development**

Development of the MV-1 piezometer began on June 4, 2006. This development consisted of airlifting that was performed with the LX29 pump rig using a 1,100 CFM air compressor and 1-in. airline. Fluid discharge rates during development were very low and could not be sustained as a result of slow recharge from the formation. Subsequently, airlifting was performed intermittently. A solution of Aqua Clear PFD and makeup water was pumped into the piezometer at the end of development activities on June 4, 2006. This solution was added to help break down the bentonite used during drilling. A final solution of AquaClear PFD and makeup water was pumped into the piezometer on June 6, 2006. Airlift development of the piezometer ended on June 6, 2006. A total of approximately 400 gal of fluid was removed from the piezometer during the development, most of which was water added for flushing and cleaning the casing. As a result of low discharge rates and slow recharge from the formation, the piezometer could not be fully developed.

The MV-1 well was completed with a 4-in. SS submersible Grundfos® pump, model 10S50-58DS, with a 5-HP Grundfos® motor. The installation of the dedicated pump began on June 2, 2006. The pump was installed using the LX29 pump rig and included the setting of the pump, riser pipe, and

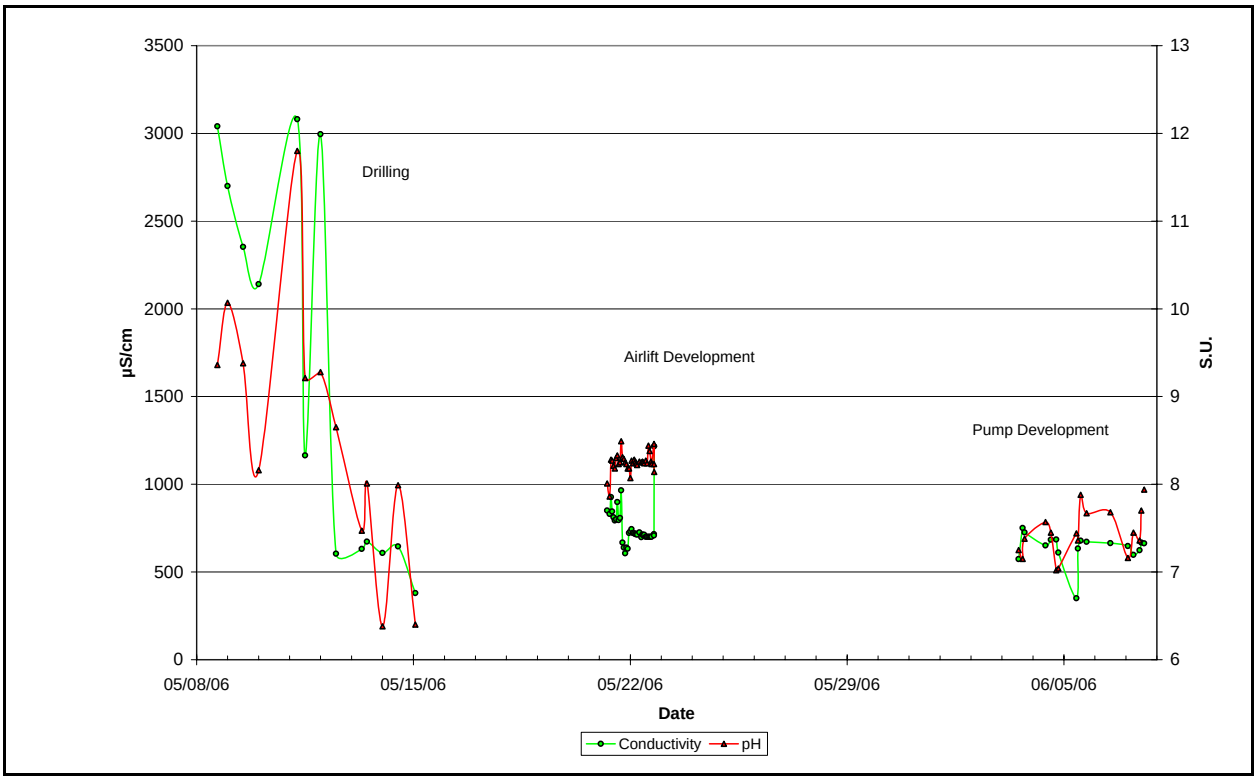



**Figure 4-4**
**Water Quality Parameters from MV-1 During Drilling, Airlift, and Pump Development**

water access line. The installation of the pump was completed on June 3, 2006. The top of the pump was set at 1,533.65 ft bgs, the bottom of the pump motor was set at 1,540.20 ft bgs, and the intake was at 1,538.30 ft bgs. The pump is powered by an MS 4000, 5-HP, 480-volt, three-phase Grundfos® motor. Power is supplied to the pump using 8 AWG 600-volt heavy-duty flat submersible cable, banded and clamped to the 1¼-in. id CS API tubing with EUE. The water access tube is also banded and clamped to the discharge pipe. The water access tube is constructed with 1¼-in. od schedule 80 PVC pipe with flush-joints. The water access tube is completed with 40 ft of 0.02-in. screen that is set just above the top of the pump. The discharge pipe has a $^{1}/_{8}$-in. weep hole approximately 15 ft below the wellhead and a brass check valve just above the pump that is in addition to the pump's internal check valve. The functional test removed approximately 180 gal.

The final development of the MV-1 well was performed using the dedicated pump and began on June 3, 2006. Samples were collected during the development and analyzed on site for water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. The pump development was performed during daytime operations and was completed on June 14, 2006. Concentrations of $Br^-$

obtained from samples collected during development ranged from 17.5 mg/L at startup to 1.69 mg/L at the completion. A total of approximately 23,017 gal of fluid were purged during the pump development at MV-1. Refer to Figure 4-5 for a graph showing $Br^-$ concentrations versus gallons removed during the development of the MV-1 well.

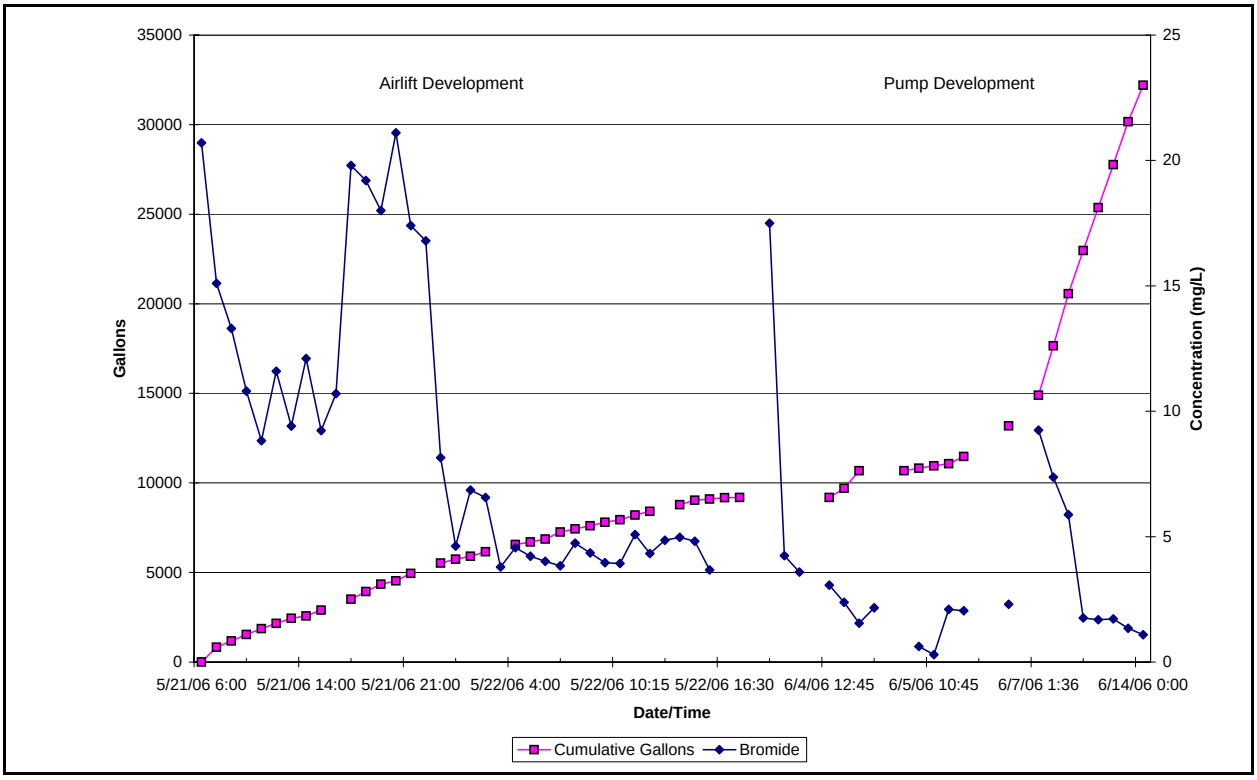



**Figure 4-5**
**Bromide vs. Gallons Removed During MV-1 Development**

# 5.0 Summary of Well MV-2 Field Activities

Monitoring/validation well MV-2 was the last well constructed at CAU 447. This well is located approximately 1,184 feet north of SGZ (Figure 1-2). Drilling of the well began on May 23, 2006 with the advancement of a 31-in. diameter borehole for the surface conductor casing. The surface conductor casing was set and drilling resumed on May 26, 2006. Geophysical logging of the borehole was performed at the completion depth and began on June 2, 2006. The final well construction was completed on June 9, 2006, and included a piezometer and main well completed to depths of 1,257.7 ft and 2,010.95 ft bgs, respectively. The airlift development of the main well was completed on June 10, 2006. The installation of the dedicated pump and final well development was performed June 10 through June 19, 2006. Summaries of the well construction, geophysical logging, sampling, and pump installation/final well development activities are provided in the following sections. Refer to Table D.1-1 in Appendix D for a chronology of the drilling operations at MV-2.

## 5.1 Well Construction

The construction of MV-2 included the installation of a 24-in. diameter CS surface casing with fully welded joints as a surface seal and wellhead control apparatus. This casing was set to a depth of 99 ft bgs and cemented in place with approximately 199.5 $ft^3$ of Portland Type II cement. The final borehole was advanced using a 12.45-in. diameter hammer bit to the completion depth of 2,018.00 ft bgs. The main well construction consisted of 5.5-in. od internally epoxy-coated CS casing. The well was screened from 1,819.87 to 1,990.64 ft bgs with 3-by-0.08-in. slotted openings on 6-in. centers staggered at 10 degrees with 18 slots per row. The main well was completed to a total depth of 2,010.95 ft bgs and included approximately 20 ft of blank casing below the well screen for a sump. Four centralizers were placed around the main well casing at 80-ft intervals, starting at approximately 1,990 ft bgs, to ensure proper spacing of stemming materials between the well casing and borehole annulus.

A piezometer was also constructed within the 12.45-in. diameter borehole. The piezometer consisted of 2.375-in. od CS casing screened from 1,187.70 to 1,247.20 ft bgs. The piezometer was completed to a total depth of 1,257.70 ft bgs and included approximately 10 ft of blank casing below the screen for a sump. A graded filter pack was installed around the slotted intervals of both the well and

piezometer. A cement seal, approximately 459 ft thick, was placed between the main well filter pack and the piezometer filter pack to ensure separation of water producing zones. Refer to Figure 5-1 for a diagram showing the well construction details.

Filter pack materials for MV-2 include $^{1}/_{8}$- by-$^{1}/_{4}$-in. clean gravel and 6x12 clean silica sand. The gravel filter pack was placed around the well and piezometer screen intervals. The 6x12 silica sand was placed above the gravel as a transition sand. Gravel and sand stemming materials were placed using a sand pump with a clean water flush into the borehole annulus through an NQ tremie pipe. Portland Type II cement was used to seal the formation. The cement seal placed between the well and piezometer included a 2 percent CaCl additive to reduce the cure time. Cement was also pumped down the NQ tremie followed by a clean water rinse. The NQ tremie was raised in stages during the placement of the stemming materials and cement seal to help ensure proper placement without plugging or bridging. Placement of stemming materials were monitored in real time to ensure correct tagging depths using a NAIL, conducted by COLOG. Well construction materials and volumes used to complete MV-2 are provided on Table D.1-2 of Appendix D.

## *5.2 Geophysical Surveys*

Borehole geophysical survey data were acquired from the MV-2 borehole in two separate phases by the geophysical subcontractor COLOG. The first phase of geophysical logging was performed in the 12.45-in. diameter borehole from below the surface conductor casing to the completion depth of approximately 2,018 ft bgs. A formation bridge was encountered in the borehole during logging and resulted in an additional attempt to complete the geophysical logging. The first attempt of logging began on June 2, 2006, when a bridge was encountered at approximately 678 ft bgs. The optical televiewer log was utilized from the surface to the bridged interval before drilling out the bridge using the flooded reverse circulation drilling method. Video logging was completed to 656 ft bgs on June 2, 2006. The borehole was then redrilled and stabilized using a bentonite base drilling fluid to condition the borehole back to a total depth of approximately 2,018 ft bgs.

A second attempt at geophysical logging began on June 4, 2006. This attempt at geophysical logging was completed on June 5, 2006, and included the collection of sonic velocity, resistivity (single point, 16-in., and 64-in.), SP, natural gamma, caliper, optical televiewer, and acoustic televiewer logs. The neutron, focused density, and a full sonic velocity logs were not obtained due to a COLOG equipment

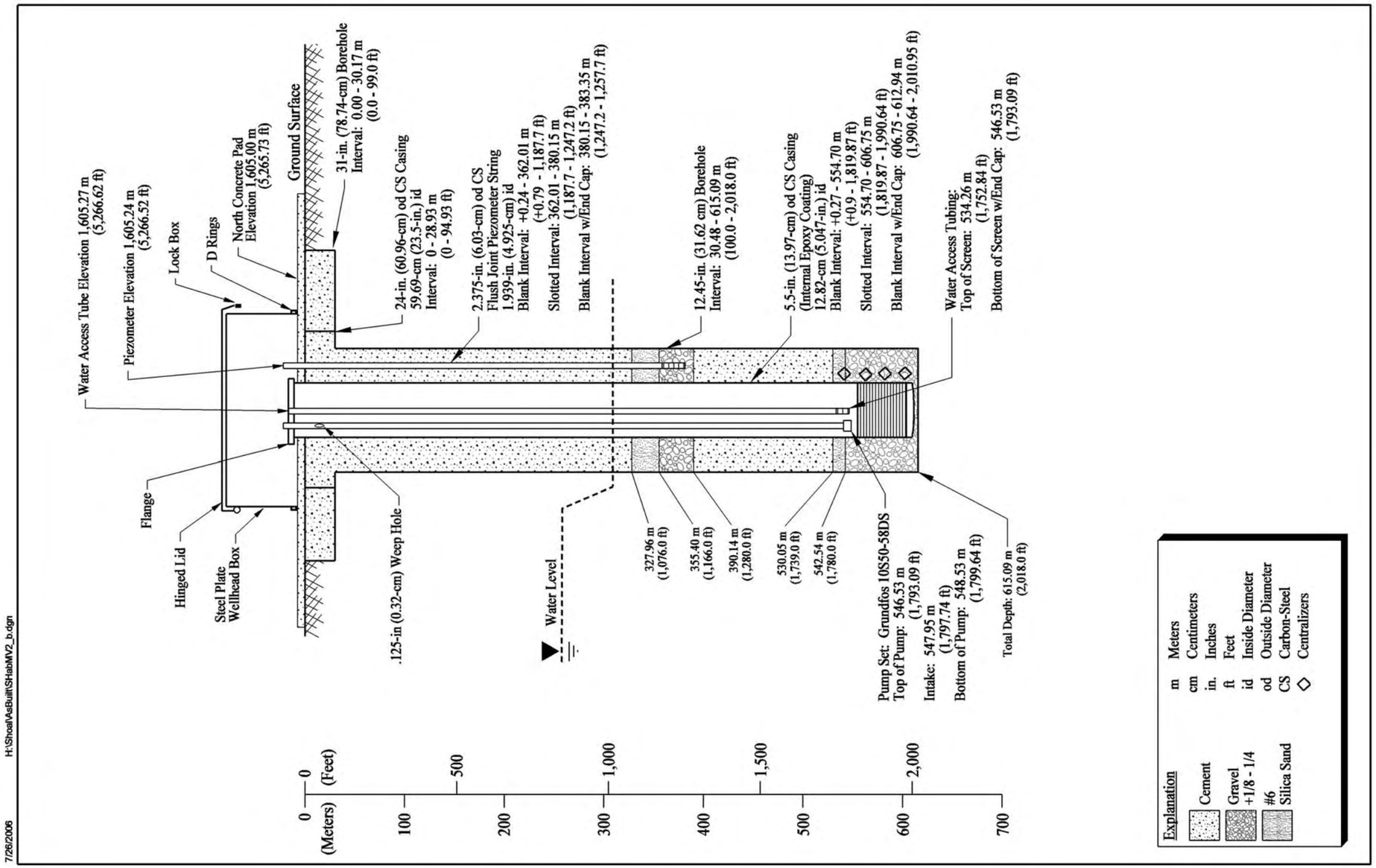
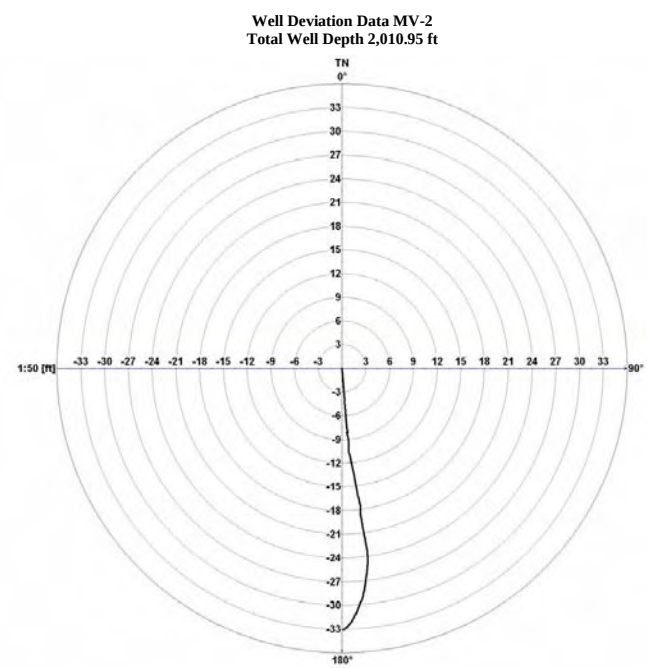



**Figure 5-1**
**As-Built Drawing for Project Shoal Area Well MV-2**

malfunction. Refer to Appendix D for a condensed version of the geophysical signatures for the MV-2 borehole. A summary of the geophysical logs performed is provided in Table D.1-3 of Appendix D.

The final phase of geophysical logging consisted of a temperature, final deviation, and NAIL. This phase of geophysical logging was completed on June 7, 2006. The temperature log was performed during this phase of logging due to a equipment malfunction during the first phase of geophysical logging. The NAIL log was used for real-time tagging of stemming materials during the final well construction. This included the placement of the cement seal between the top of the well gravel pack and the bottom of the piezometer gravel pack. The deviation survey was performed to determine the extent of deviation of the main well from vertical. The deviation survey indicated that the well deviated approximately 0.94 degrees from vertical. The deviation survey placed the bottom of the well approximately 33 ft from the collar and resulted in a true vertical depth of 2,010.68 ft bgs. Refer to Figure 5-2 for a plot of the deviation of the MV-2 well.




Note: Northing and Easting computed from open-hole azimuth data and cased-hole tilt data.
All directions are with respect to True North. All distances are in units of feet.

**Figure 5-2**
**Deviation Plot for MV-2**

## 5.3 Sampling

Lithologic and water quality samples were collected during the advancement of the borehole, construction of the well, and development of the MV-2 well. Samples included rock cuttings for lithologic description and drilling fluid/groundwater for water quality analysis. Samples were collected as directed in the FMP (NNSA/NSO, 2006b) and FI (SNJV, 2006a). Summaries of the sampling activities performed is provided in the following sections.

### 5.3.1 Geologic Material Sampling

Samples of the drill cuttings were collected during the advancement of the MV-2 borehole. These samples were collected from the drill rig shaker screen. The samples were washed and composited for each 10-ft interval during the advancement of the borehole. A portion of the washed cuttings were placed in a chip tray for lithologic description upon collection. These samples were later used for a more detailed description using an optical light microscope and the geophysical logs obtained during the drilling. The lithologic descriptions included grain size, mineralogy, alteration, color, fracturing, and other notable geologic characteristics. The lithologic descriptions were documented following the guidance of SBMS UGTA procedure "Geologic Description of Cuttings and Core." A complete lithologic log of the samples collected from MV-2 is provided in Appendix D.

### 5.3.2 Radiological Sampling and Monitoring

Samples of drilling fluid, makeup/source water, and groundwater from discharge during well development were collected following the guidance of SBMS UGTA procedure "Fluid Sample Collection, Field Filtration, and Processing." Samples obtained during the drilling were collected hourly from below the cyclone as the fluid entered the mud tank. Samples obtained during well development were collected approximately every four hours from the discharge line. Samples were also collected from the water trucks and frac tanks on site.

Samples collected for radiological monitoring were analyzed in the field for tritium using a Beta Scout field instrument. The analytical results obtained from groundwater samples collected from HS-1 before initiating drilling activities were used as a baseline to establish the background for the area. The EPA and NDWS radiological action level for tritium in groundwater is 20,000 pCi/L. The action level used on site was 10,000 pCi/L. Samples collected and analyzed for tritium during field

operations were within the background range throughout the duration of the MV-2 drilling and development activities. The tritium results obtained from samples collected during the drilling, airlift development, and pump development of MV-2 are provided in Table D.1-4 of Appendix D.

### 5.3.3 Bromide Sampling

Samples of drilling fluid, makeup/source water, and groundwater from discharge during well development were collected to monitor bromide concentrations obtained from the LiBr tracer that was added to the makeup/source water. The LiBr tracer was added to each tanker truck of water obtained from the source well HS-1 located in Fairview Valley. The makeup water with tracer was used during the drilling, well construction, and development. Bromide concentrations in the makeup/source water were generally maintained between 20 and 40 mg/L. The purpose of the tracer used during drilling and development operations was to:

- Assist in detection of perched water zones
- Assist in detection of groundwater table
- Provide a monitoring parameter to establish effectiveness of well development

Samples obtained during drilling operations were collected hourly from below the cyclone where the fluid entered the mud tank. Samples collected during development were obtained approximately every four hours from the discharge line. Samples were analyzed during the PSA field operations using an Orion 290A ion-specific meter. Concentrations of $Br^-$ in the drilling fluid ranged from 30.4 to 2.62 mg/L during drilling operations, 52.6 to 1.74 mg/L during airlift development, and 3.53 to 0.32 mg/L during final pump development. A summary of well development activities is provided in Section 5.4. Refer to Figure 5-3 for a graph of the results obtained during drilling, airlift development, and pump development. A summary of the analytical results is provided in Table D.1-5 of Appendix D.

### 5.3.4 Water Quality Parameter Sampling

Samples of drilling fluid, makeup/source water, and groundwater from discharge during well development were collected following the guidance of SBMS UGTA procedure “Water Quality Monitoring.” Samples collected during drilling operations were obtained hourly from below the cyclone as the fluid entered the mud tank. Samples collected during well development were obtained

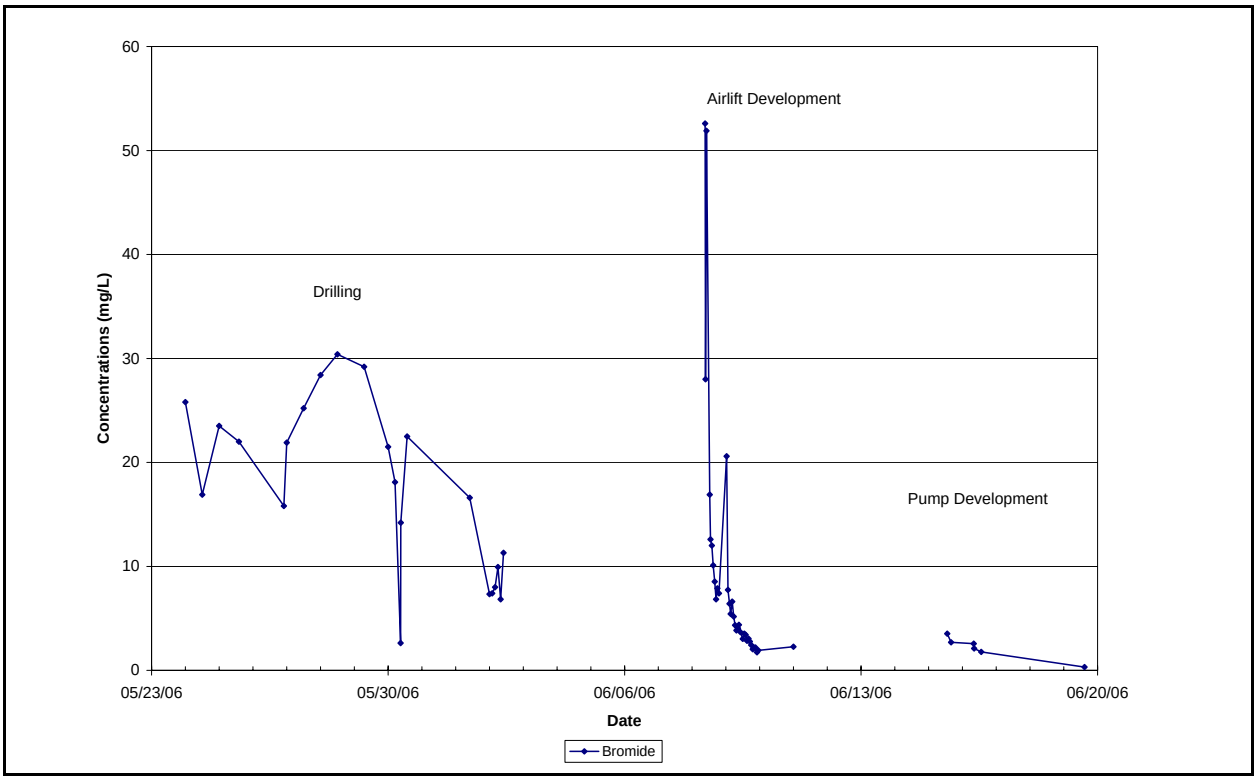



**Figure 5-3**
**Bromide Data for MV-2 During Drilling, Airlift, and Pump Development**

approximately every four hours from the discharge line. Samples were analyzed in the field for the water quality parameters pH, temperature, and specific conductance using a YSI-63 water quality meter. The pH values ranged from 11.83 to 6.35, and temperatures ranged from 25.2 to 16.0ºC. Specific conductance ranged from 3,488 to 132.50 µS/cm during drilling operations, 726.0 to 351.5 µS/cm during airlift development, and 425 to 308 µS/cm during the final pump development. Refer to Figure 5-4 for a graph showing the results of the water quality parameters obtained during drilling, airlift development, and pump development. A summary of the results is provided in Table D.1-5 of Appendix D.

### *5.4 Well Development and Pump Installation*

The initial development of the MV-2 well began on June 8, 2006. This development consisted of airlifting that was performed with the LM 140 drill rig using a 1,100 CFM air compressor plumbed to an AQ airline with HQ eductor (Figure 3-5). The initial development was conducted for approximately 40.7 hours and included airlifting and surging. Samples were collected and analyzed

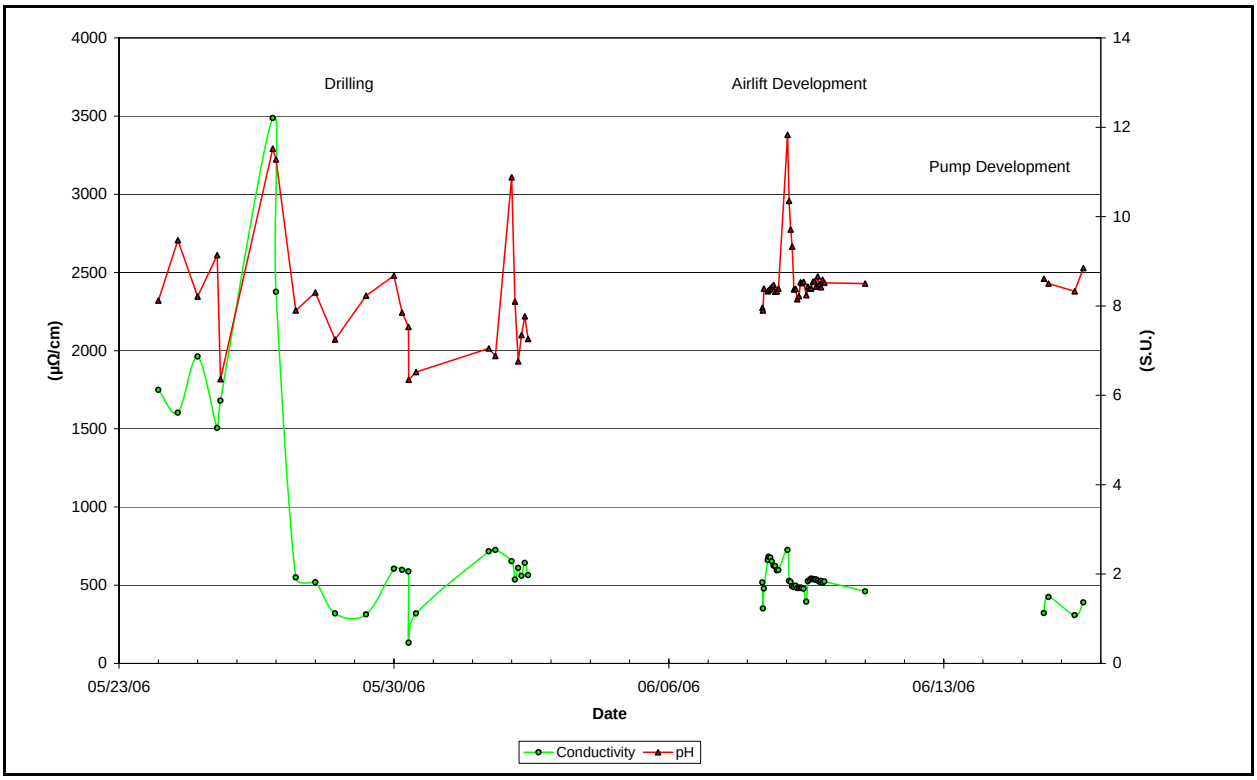



**Figure 5-4**
**Water Quality Parameters from MV-2 During Drilling, Airlift, and Pump Development**

on site for the water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. Fluid discharge rates averaged approximately 5.9 gpm during the airlift development period. The fluid discharge rates decreased to approximately 3.3 gpm at the completion of airlift development. Concentrations of $Br^-$ obtained from samples collected during the development ranged from 52.6 mg/L at startup to 1.92 mg/L at completion. A total of approximately 6,840 gal of fluid, including added water for flushing and cleaning the casing, were purged during the initial airlift development at MV-2.

Development of the MV-2 piezometer began on June 11, 2006. This development consisted of airlifting that was performed with the LX29 pump rig using a 1,100 CFM air compressor and 0.5-in. airline. Fluid discharge rates from the piezometer were very low ranging from 0.43 to 0.80 gpm. Development of the piezometer ended June 14, 2006. A total of approximately 329.1 gal of fluid were removed from the piezometer during the development, most of which was water added for flushing and cleaning the casing. As a result of low discharge rates and slow recharge from the formation, the piezometer could not be fully developed.

The MV-2 well was completed with a 4-in. SS submersible Grundfos® pump, model 10S50-58DS, with a 5-HP Grundfos® motor. The installation of the dedicated pump began on June 10, 2006. The pump was installed using the LX29 pump rig and included the setting of the pump, riser pipe, and water access line. As a result of a shortage in materials for the PVC access line, pump installation activities could not be completed the following day. Airlift development activities were conducted on the piezometer at MV-2 until the necessary materials arrived on June 14, 2006. The installation was completed on June 15, 2006. The top of the pump was set at 1,793.09 ft bgs; the bottom of the pump motor was set at 1,799.64 ft bgs, and the intake was at 1,797.74 ft bgs. The pump is powered by an MS 4000, 5-HP, 480-volt, three-phase Grundfos® motor. Power is supplied to the pump using 8 AWG 600-volt heavy-duty flat submersible cable, banded and clamped to the 1¼-in. id CS API tubing with EUE. The water access tube is also banded and clamped to the discharge pipe. The water access tube is constructed with 1¼-in. od schedule 80 PVC pipe with flush-joints. The water access tube is completed with 40 ft of 0.02-in. screen that is set just above the top of the pump. The discharge pipe has a $^{1}/_{8}$-in. weep hole approximately 15 ft below the wellhead and a brass check valve just above the pump that is in addition to the pump's internal check valve. A functional pump test was performed upon completion of the installation. The functional test removed approximately 450 gal.

The final development of the MV-2 well was performed using the dedicated pump on June 15, 2006. Samples were collected during the development and analyzed for the water quality parameters pH, specific conductance, turbidity, $Br^-$, and tritium. These samples were analyzed at SNJV's field office lab in Mercury, Nevada, and at DRI's lab in Reno, Nevada, because of the site demobilization. Pump development activities was performed June 15 through June 19, 2006. The pump was allowed to run continuously from June 16 through 19, 2006. Final well development at MV-2 was completed on June 19, 2006. Concentrations of $Br^-$ obtained from samples collected during development ranged from 3.53 mg/L at startup to 0.32 mg/L at completion. A total of approximately 24,520 gal of fluid were purged during the pump development at MV-2. Refer to Figure 5-5 for a graph showing $Br^-$ concentrations versus gallons removed during the development of the MV-2 well.

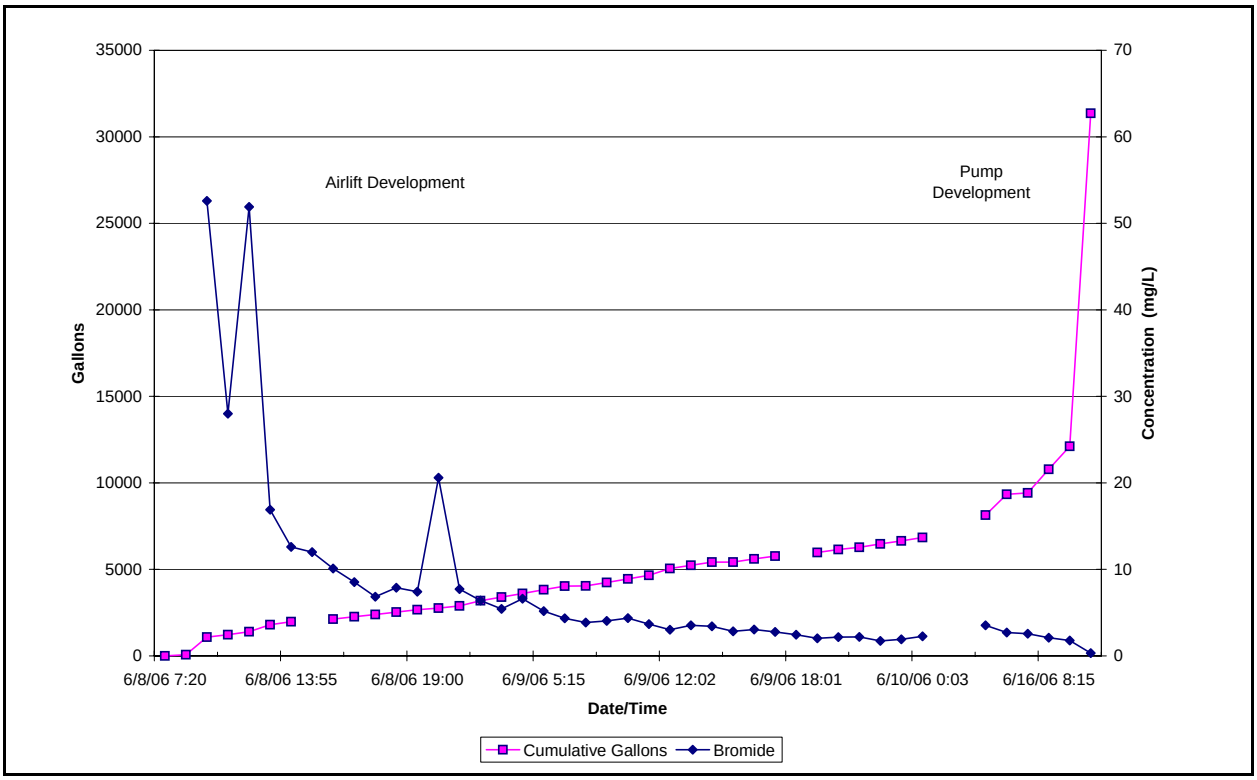



**Figure 5-5**
**Bromide vs. Gallons Removed During MV-2 Development**

# 6.0 Environmental Compliance and Waste Management

Stoller-Navarro Joint Venture had the lead responsibility for environmental compliance and waste management at PSA. The environmental compliance elements of the PSA investigation were addressed in the planning phases of the project by the completion and approval of a *National Environmental Policy Act* checklist, review and evaluation of state and federal regulations potentially applicable to the project, and negotiation and approval of the FMP.

## 6.1 Employee Awareness

Copies of the material safety data sheets and approval forms were readily accessible by site personnel. Spill response equipment was located in marked spill response kits at each well site. Spill response and reporting was guided by the SBMS procedure "Spill Management." Incidental spills occurred during drilling operations; however, no reportable spills occurred during the PSA field activities. Emergency contacts were available to all employees at the site. Archeological surveys were performed and areas delineated for project activities. All employees were briefed on the importance of protecting the archeological, biological, and Native American resources in the area.

## 6.2 Waste Management

Waste management involved the tracking, packaging, labeling, and storage of wastes generated during investigation activities. Waste management orientation was conducted for all personnel before beginning site operations, and as new personnel arrived on location. The PSA investigation generated sanitary/industrial, hydrocarbon, and fluid waste. Sanitary/Industrial waste was disposed of through a local service provider at the Lockwood Landfill. Hydrocarbon liquids and solids were managed and disposed of by Lang. No hazardous or radioactive waste was generated at PSA.

## 6.3 Source Water for Drilling

The source water for drilling was obtained from the HS-1 well, located in Fairview Valley approximately 4 mi east of SGZ. A water truck was used to transport water from HS-1 to temporary storage tanks located on the drill pads. The drilling of MV-1, MV-2, and MV-3 required the use of approximately 70,946 gal, 68,639 gal, and 182,600 gal of water from HS-1, respectively. A total of approximately 322,185 gal of water were used during the drilling of the MV wells at PSA.

## 6.4 Fluid Management

All fluids generated during drilling, well construction, and development/test pumping activities were managed in accordance with the FMP. The FMP provided guidance for the management of fluids generated during well drilling and construction activities and well development/test pumping. The fluid management strategy was based on process knowledge and verification of process knowledge through field screening and on-site monitoring. Fluids produced during drilling, well construction, and development pumping were monitored on site for tritium.

Tritium levels of discharge fluids remained within the background range. Sumps were constructed near each well location in accordance with the FMP. The sumps were used to contain both fluids and cuttings from the drilling, construction, and subsequent development and testing pump. The sumps were surrounded by orange construction fencing.

## 6.5 Clean Air

Stoller-Navarro Joint Venture obtained air permit numbers AP1629-1591 and AP9711-1591 from the State of Nevada Department of Conservation and Natural Resources. In compliance with the permit, fugitive dust was controlled on roads and work surfaces. The recontouring and revegetation of the drill pads is scheduled for completion by the end of December 2006.

# 7.0 Site Health and Safety

All work activities at PSA were conducted in accordance with Title 29 *Code of Federal Regulations* Parts 1910 and 1926 (CFR, 2003a and b); *NV/YMP Radiological Control Manual* (NNSA/NSO, 2004a); Integrated Safety Management System; the Industrial Sites Health and Safety Plan (HASP) (SNJV, 2004); and the *Corrective Action Unit 447 Subsurface, Project Shoal Area Churchill County, Nevada, Site-Specific Health and Safety Plan* (SSHASP) (SNJV, 2006b). Copies of the HASP and SSHASP were maintained on site during project activities. Additionally, all activities were conducted in compliance with DOE orders and Occupational Safety and Health Administration regulations.

All site personnel were required to read the SSHASP and sign the appropriate signature page indicating their understanding. This included any associated Technical Field Changes (TFCs) to the SSHASP. The SSHASP was modified by three TFCs during the investigation. The TFCs 001, 002, and 003 were approved on March 21, April 7, and May 17, 2006, respectively. Tailgate safety briefings (TSBs) were conducted by SNJV personnel for all site personnel at the beginning of each work shift throughout the duration of the project. All attending personnel signed the signature sheet. Visitors and delivery personnel were given a TSB and radiological briefing, and were given the opportunity to read the SSHASP.

# 8.0 References

AEC, see U.S. Atomic Energy Commission, Nevada Operations Office.

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# Appendix A

# Analytical Results and Well Locations

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**Table A.1-1**
**Project Shoal Area HS-1 Analytical Results**
(Page 1 of 2)

| Sample Identification | Sample Date | Parameter | Result | Reporting Units | Detection Limit | Error |
|---|---|---|---|---|---|---|
| HS-1 | 3/13/2006 | Cs-137 | -3.3 | pCi/L | 9.4 | 5.2 |
| HS-1 | 3/13/2006 | Co-60 | -0.9 | pCi/L | 9.8 | 5.4 |
| HS-1 | 3/13/2006 | K-40 | 16 | pCi/L | 139 | 81 |
| HS-1 | 3/13/2006 | Be-7 | 29 | pCi/L | 70 | 42 |
| HS-1 | 3/13/2006 | Cs-134 | 8 | pCi/L | 55 | 34 |
| HS-1 | 3/13/2006 | Co-58 | -1.7 | pCi/L | 9.5 | 5.3 |
| HS-1 | 3/13/2006 | Sb-125 | -12 | pCi/L | 23 | 12 |
| HS-1 | 3/13/2006 | Ac-228 | 3 | pCi/L | 36 | 21 |
| HS-1 | 3/13/2006 | Eu-155 | 0 | pCi/L | 32 | 18 |
| HS-1 | 3/13/2006 | Am-241 | -28 | pCi/L | 70 | 40 |
| HS-1 | 3/13/2006 | Nb-94 | 0.4 | pCi/L | 8.5 | 4.9 |
| HS-1 | 3/13/2006 | Al-26 | -0.3 | pCi/L | 10.2 | 5.6 |
| HS-1 | 3/13/2006 | Eu-152 | 10 | pCi/L | 47 | 27 |
| HS-1 | 3/13/2006 | Bi-214 | 45 | pCi/L | 29 | 17 |
| HS-1 | 3/13/2006 | Bi-212 | 6 | pCi/L | 123 | 71 |
| HS-1 | 3/13/2006 | Tl-208 | 7 | pCi/L | 7.8 | 5 |
| HS-1 | 3/13/2006 | Th-234 | -61 | pCi/L | 169 | 97 |
| HS-1 | 3/13/2006 | Pb-214 | 33.9 | pCi/L | 19.4 | 10 |
| HS-1 | 3/13/2006 | Pb-212 | -14 | pCi/L | 21 | 12 |
| HS-1 | 3/13/2006 | U-235 | -2 | pCi/L | 60 | 35 |
| HS-1 | 3/13/2006 | Eu-154 | -14 | pCi/L | 51 | 28 |
| HS-1 | 3/13/2006 | Th-227 | -24 | pCi/L | 63 | 36 |
| HS-1 | 3/13/2006 | Cm-243 | 0 | pCi/L | 53 | 31 |
| HS-1 | 3/13/2006 | Mercury | 2.20E-05 | mg/L | 2.00E-04 | NA |
| HS-1 | 3/13/2006 | Lead | 0.003 | mg/L | 0.003 | NA |
| HS-1 | 3/13/2006 | Silver | 0.01 | mg/L | 0.01 | NA |
| HS-1 | 3/13/2006 | Arsenic | 0.014 | mg/L | 0.01 | NA |
| HS-1 | 3/13/2006 | Barium | 0.04 | mg/L | 0.1 | NA |
| HS-1 | 3/13/2006 | Cadmium | 0.005 | mg/L | 0.005 | NA |

# Table A.1-1
## Project Shoal Area HS-1 Analytical Results
(Page 2 of 2)

| Sample Identification | Sample Date | Parameter | Result | Reporting Units | Detection Limit | Error |
|---|---|---|---|---|---|---|
| HS-1 | 3/13/2006 | Chromium | 0.01 | mg/L | 0.01 | NA |
| HS-1 | 3/13/2006 | Selenium | 0.005 | mg/L | 0.005 | NA |
| HS-1 | 3/13/2006 | Tritium | 457.10 | pCi/L | 753.39 | 19.36 |

Al = Aluminum
Ac = Actinium
Am= Americium
Be = Beryllium
Bi = Bismuth
Cm = Curium
Co = Cobalt
Cs = Cesium
Eu = Europium
K = Potassium
Nb = Niobium
Sb = Antimony
Tl = Thallium
Th = Thorium
Pb = Lead
U = Uranium

mg/L = Milligrams per liter
NA = Not analyzed
PCi/L = Picocuries per liter

# Table A.1-2
# Project Shoal Area Survey Data

| Location | Northing (m) | Easting (m) | Elevation (m) | Elevation (ft) |
|---|---|---|---|---|
| HC-1 | 4340242.945 | 380850.3 | 1618.25044 | 5309.21 |
| HC-2 | 4339729.361 | 380258.4 | 1629.80574 | 5347.12 |
| HC-3 | 4339282.358 | 381673.1 | 1548.85039 | 5081.52 |
| HC-4 | 4339522.691 | 380785.3 | 1603.52644 | 5260.90 |
| HC-5 | 4339338.752 | 380957.7 | 1599.4034 | 5247.37 |
| HC-6 | 4339417.404 | 380930.8 | 1593.70638 | 5228.68 |
| HC-7 | 4339394.085 | 380951.5 | 1594.02337 | 5229.72 |
| HC-8 | 4339255.660 | 381056.0 | 1603.22591 | 5259.91 |
| RICE-UTD | 4339692.322 | 380812.2 | 1600.79451 | 5251.94 |
| GOTE/FLAT | 4339679.951 | 380796.5 | 1600.88138 | 5252.22 |
| MV-1 MAIN WELL | 4339959.482 | 380918.5 | 1602.50323 | 5257.54 |
| MV-1PIEZOMETER | 4339959.522 | 380918.6 | 1602.42855 | 5257.30 |
| MV-1 N.CONCRETE PAD | 4339959.916 | 380918.4 | 1602.10302 | 5256.23 |
| MV-2 MAIN WELL | 4340042.839 | 380875.2 | 1605.26899 | 5266.62 |
| MV-2 PIEZOMETER | 4340042.973 | 380875.1 | 1605.23607 | 5266.51 |
| MV-2 N.CONCRETE PAD | 4340043.024 | 380874.8 | 1604.99802 | 5265.73 |
| MV-3 MAIN WELL | 4339986.122 | 381026.9 | 1603.70871 | 5261.50 |
| MV-3 PIEZOMETER | 4339986.024 | 381026.7 | 1603.60935 | 5261.17 |
| MV-3 N.CONCRETE PAD | 4339986.317 | 381026.5 | 1603.40635 | 5260.50 |
| LUMOS CONTROL | 4340182.339 | 380565.2 | 1619.99086 | 5314.92 |

Coordinate system: Universal Transverse Mercator (UTM) Zone 11
North American Datum 27, Vertical Datum NAVD 29
Coordinate units: U.S. survey meters (m) and feet (ft)

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# Appendix B

# Project Shoal Area MV-3 Data

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**Table B.1-1**
**Project Shoal Area MV-3 Chronology**
(Page 1 of 4)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 4/2/2006 | 18:00 | 0 | Mobilization to site completed. Rig is ready to drill. |
| 4/3/2006 | 16:00 | 0 | NNSA/NSO personnel complete safety walkdown. DOE gives OK to proceed. |
| | 16:00 | 0 | MV-3 spudded for 31-in. surface casing borehole. |
| | 19:40 | 23 | Pilot hole completed. Changed over bottom hole assembly. |
| 4/4/2006 | 23:00 | 97 | Advanced 31-in. diameter borehole for surface casing to completion depth of approximately 97 ft bgs. |
| 4/5/2006 | 15:30 | 97 | Completed tripping out of hole, setting and cementing 24-in. CS surface casing with 214.2 $ft^3$ cement. |
| 4/6/2006 | 1:00 | 97 | Began drilling 22-in. intermediate borehole with tricone bit. |
| 4/10/2006 | 11:00 | 400 | Tripped out for bit inspection and deviation survey. |
| 4/11/2006 | 0:45 | 400 | Changed out bit. Tripped back in, resumed drilling. |
| 4/12/2006 | 8:50 | 540 | Representative from NDEP and DOE on site. |
| 4/14/2006 | 14:15 | 680 | Tripped out for bit change. |
| 4/15/2006 | 1:40 | 680 | Changed out bit. Tripped back in, resumed drilling. |
| 4/16/2006 | 4:00 | 767 | Encountered fault gouge (clay, heavy fracturing, iron staining, and alteration). |
| | 6:00 | 780 | Drilled through fault zone. |
| 4/19/2006 | 0:30 | 970 | Tripped out for bit change. |
| | 16:00 | 970 | Changed out bit. Tripped back in, resumed drilling. |
| 4/23/2006 | 10:00 | 1,224.61 | Completed intermediate depth borehole, trip out. |
| | 19:00 | 1,224.61 | Hydraulic leak developed in rear jack during routine maintenance. Stand by for mechanic and parts. |
| 4/24/2006 | 12:20 | 1,224.61 | Completed jack repairs. COLOG (geophysical contractor) arrived on site. |

**Table B.1-1**
**Project Shoal Area MV-3 Chronology**
(Page 2 of 4)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 4/24/2006 | 13:50 | 1,224.61 | Began Phase I geophysical logging. |
| 4/25/2006 | 3:15 | 1,224.61 | Secured from geophysical logging to clean/evacuate hole. |
| | 18:25 | 1,224.61 | Hole cleaned, resumed geophysical logging. |
| 4/26/2006 | 14:00 | 1,224.61 | Completed Phase I geophysical logging suite. Started tripping in intermediate casing, piezometer, and tremie pipes. |
| 4/26/2006 | 20:30 | 1,224.61 | Completed installation of piezometer casing. |
| 4/27/2006 | 15:45 | 1,224.61 | Completed setting 13.375-in. intermediate casing. Start cementing intermediate casing. |
| | 23:30 | 1,224.61 | Completed cementing intermediate casing from approximately 1,224.61 to 1,203 ft bgs. |
| 4/28/2006 | 1:00 | 1,224.61 | Started piezometer gravel pack installation. |
| 4/29/2006 | 19:00 | 1,224.61 | Completed piezometer installation, cement intermediate casing to surface. |
| 4/30/2006 | 0:00 | 1,224.61 | Started tripping in 12.45-in. hammer bit to drill final borehole. |
| | 12:15 | 1,224.61 | Completed tripping-in, resume drilling. |
| 5/2/2006 | 7:45 | 1,668.84 | TD borehole at 1,673.72 ft. Drilling rate with hammer 3-6 minutes per ft. |
| | 13:00 | 1,668.84 | Completed trip out of hole, COLOG on site and set up for Phase II geophysical logging. |
| 5/3/2006 | 9:15 | 1,668.84 | Completed Phase II geophysical logging. Set up to install tremie pipes, and well screen and casing. |
| 5/4/2006 | 3:30 | 1,668.84 | Completed setting well screen and casing, and tremie pipes. |
| | 13:30 | 1,668.84 | Completed installation of gravel pack to 1,368 ft. |
| | 22:30 | 1,668.84 | Completed cementing casing to surface. Started running HQ eductor AQ airline piping for airlift development. |
| 5/5/2006 | 11:00 | N/A | Began initial airlift development and moving equipment to MV-1 pad. |

**Table B.1-1**
**Project Shoal Area MV-3 Chronology**
(Page 3 of 4)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 5/6/2006 | 11:00 | N/A | Completed initial airlift development. Total gal purged 13,699.72. |
| | 14:45 | N/A | Completed tripping out airlift setup. |
| 5/6/2006 | 16:40 | N/A | Rig and equipment mobilized to MV-1 pad. |
| 5/7/2006 | 21:30 | N/A | Well pad and protective box set at MV-3. |
| 5/31/2006 | 9:50 | N/A | Pump crew set up to install submersible pump. |
| | 18:00 | N/A | Pump/motor, 1¼-in. discharge line, and 1¼-in. water access tubing set at 227 ft. Pump crew off site. |
| 6/1/2006 | 6:40 | N/A | Pump crew on site. Continued pump installation. |
| | 16:00 | N/A | Top flange installed, completed pump installation. Began making cable splice. Water level at 984.0 ft. |
| 6/1/2006 | 17:00 | N/A | Splice completed. Generator would not run. Began bailing. |
| | 18:30 | N/A | Bailed approximately 3 gal from MV-3 piezometer. |
| 6/2/2006 | 14:50 | N/A | Started pump at MV-3. |
| | 18:00 | N/A | Shut off pump. Purged approximately 2,300 gal at approximately 12 gpm. Water level at 1,063.92 ft. |
| 6/3/2006 | 8:42 | N/A | Pump started. Water level at 985.55 ft. |
| | 18:00 | N/A | Pump shut off. Purged 5,883 gal with 93.45 ft of drawdown over 8.5 hours of pumping time. Water level at 1,079.6.2 ft. |
| 6/4/2006 | 7:55 | N/A | Pump started. |
| | 18:00 | N/A | Pump shut off. Development of MV-3 Well complete. Approximately 14,150 gal were purged during the development. |

# Table B.1-1
# Project Shoal Area MV-3 Chronology
(Page 4 of 4)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/6/2006 | 13:30 | N/A | Set up to airlift MV-3 piezometer. |
| | 16:30 | N/A | Set ½-in. airlift line in MV-3 piezometer. |
| | 16:55 | N/A | Began airlift development of MV-3 piezometer. |
| | 18:00 | N/A | End airlift development for the day. |
| 6/7/2006 | 7:00 | N/A | Began airlift at MV-3 piezometer. |
| | 12:00 | N/A | Add on length to airline. Performed surge cycles of 1 minute on, 3 minutes off. |
| | 13:00 | N/A | Restarted airlift at 1 gpm. |
| | 18:00 | N/A | Completed airlifting at MV-3 piezometer with an average production of 1 gpm. |
| 6/8/2006 | 6:00 | N/A | Pump crew on site. Tripped out ½-in. airlift line. |
| | 7:20 | N/A | Completed tripping out ½-in. airline. This completed development at MV-3 piezometer. |
| | 12:00 | N/A | Rig down to move back to MV-1 piezometer. |
| 6/13/2006 | 17:00 | N/A | Crane truck used to lift pump string. Drill 0.125-in. weep hole approximately 15 ft below top flange. |
| | 18:00 | N/A | Pump string reinstalled. |
| 6/14/2006 | 7:00 | N/A | Repaired (weld) pinhole leak on well head. Reset D-rings on well box. |

COLOG = Colog, Inc.
CS = Carbon steel
DOE = U.S. Department of Energy
ft bgs = Feet below ground surface
$ft^3$ = Cubic foot
gal = Gallon
gpm = Gallons per minute
in. = Inch
N/A = Not applicable
NDEP = Nevada Division of Environmental Protection
NNSA/NSO = U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
TD = Total depth

# Table B.1-2
# Project Shoal Area MV-3 Well Construction Materials

| Construction | Material | Type | Interval (ft) | Stemming Material | Volume ($ft^3$) | Interval (ft) |
|---|---|---|---|---|---|---|
| Surface Casing | 24-in. CS Casing | Blank | 0 – 97.00 | Cement Seal | 214.2 | 0.0 – 97.00 |
| Intermediate Casing | 13.375-in. CS Casing | Blank | 0 – 1,224.61 | Cement Seal | 1,900.8 | 0.0 – 1,049.00 |
| Piezometer Casing | 2.375-in. CS Flush Joint Tubing | Blank | +0.65 – 1,140.42 | 20x40 Sand Pack | 69.0 | 1,049.00 – 1,080.00 |
| | | Screen | 1,140.42 – 1,200.45 | #6 Sand Pack | 60.0 | 1,080.00 – 1,110.00 |
| | | Blank w/end cap | 1,200.45 – 1,210.03 | 1/8-1/4" Gravel Pack | 180.0 | 1,110.00 – 1,203.00 |
| Bottom Seal | N/A | | | Cement Seal | 32.0 | 1,203.00 – 1,225.00 |
| Monitoring Well Casing | 5.5-in. CS Casing (Internal Epoxy Coated) | Blank | +1.0 – 1,463.59 | Cement Seal | 968.0 | 0.0 – 1,363.00 |
| | | | | 20x40 Sand Pack | 25.0 | 1,363.00 – 1,391.05 |
| | | Screen | 1,463.59 – 1,634.75 | #6 Sand Pack | 22.5 | 1,391.00 – 1,428.50 |
| | | Blank w/end cap | 1,634.75 – 1,657.59 | 1/8-1/4 in. Gravel Pack | 180.0 | 1,428.50 – 1,668.84 |
| Submersible Pump | Grundfos® 10S50-58DS Pump | Top | 1,438.42 | N/A | | |
| | | Intake | 1,443.07 | N/A | | |
| | | Bottom | 1,444.97 | N/A | | |
| Pump Column | 1.25-in. CS EUE | Blank | +1.0 – 1,438.42 | N/A | | |
| Water Access Line | 1.25 -in. Flush Joint Schedule 80 PVC | Blank | +1.0 – 1,396.24 | N/A | | |
| | | Screen w/end cap | 1,396.24 – 1,438.42 | N/A | | |

CS = Carbon steel
EUE = External Upset Ends
ft = Foot
$ft^3$ = Cubic foot
in. = Inch
N/A = Not applicable
PVC = Polyvinyl chloride

**Table B.1-3**
**Project Shoal Area MV-3 Geophysical Data Collected**
(Page 1 of 2)

| Geophysical Tool | Run Date | Top of Interval (ft bgs) | Bottom of Interval (ft bgs) | Interval (ft) | Contractor |
|---|---|---|---|---|---|
| **Phase I** | | | | | |
| Caliper | 4/25/2006 | 97 | 1,225 | 1,128 | COLOG |
| Epithermal Neutron (Short and Long Spaced) | 4/25/2006 | 97 | 1,224 | 1,127 | |
| Natural Gamma | 4/24/2006 | 97 | 1,224 | 1,127 | |
| Spectral Gamma | 4/25/2006 | 97 | 540 | 443 | |
| Spontaneous Potential | 4/24/2006 | 97 | 1,224 | 1,127 | |
| Focused Density | 4/25/2006 | 97 | 1,225 | 1,128 | |
| Resistivity (Single point, 16-in., and 64-in.) | 4/24/2006 | 97 | 1,224 | 1,127 | |
| Sonic Velocity | 4/24/2006 | 97 | 1,224 | 1,127 | |
| Optical Televiewer | 4/25/2006 | 97 | 958 | 861 | |
| Acoustic Televiewer | 4/25/2006 | 97 | 1,220 | 1,123 | |
| **Phase II** | | | | | |
| Caliper | 5/3/2006 | 1,160 | 1,664 | 504 | COLOG |
| Epithermal Neutron (Short and Long Spaced) | 5/3/2006 | 1,216 | 1,664 | 448 | |
| Natural Gamma | 5/2/2006 | 1,224 | 1,664 | 440 | |
| Spectral Gamma | 5/3/2006 | 540 | 1,211 | 671 | |
| Spontaneous Potential | 5/3/2006 | 1,224 | 1,664 | 440 | |
| Deviation Survey | 5/3/2006 | 97 | 1,664 | 1,567 | |
| Focused Density | 5/3/2006 | 1,200 | 1,664 | 464 | |

**Table B.1-3**
**Project Shoal Area MV-3 Geophysical Data Collected**
(Page 2 of 2)

| Geophysical Tool | Run Date | Top of Interval (ft bgs) | Bottom of Interval (ft bgs) | Interval (ft) | Contractor |
|---|---|---|---|---|---|
| Resistivity (Single point, 16-in., and 64-in.) | 5/2/2006 | 1,224 | 1,664 | 440 | COLOG |
| Temperature and Differential Temperature | 5/3/2006 | 1,158 | 1,665 | 507 | |
| Sonic Velocity | 5/2/2006 | 1,220 | 1,660 | 440 | |
| Acoustic Televiewer | 5/3/2006 | 1,218 | 1,664 | 446 | |
| **Phase III** | | | | | |
| Nuclear Annulus Investigation Log | 5/4/2006 | 100 | 1,653.9 | 1,553.9 | COLOG |
| Deviation | 5/4/2006 | 100 | 1,652.9 | 1,552.9 | |

COLOG = Colog, Inc.
ft bgs = Feet below ground surface
in. = Inch

# Table B.1-4
## Project Shoal Area MV-3 Tritium Results
(Page 1 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/3/2006 | 18:00 | 15 | 1.35E+03 | 9.47E+02 |
| 4/3/2006 | 20:00 | 20 | -2.70E+02 | 8.90E+02 |
| 4/3/2006 | 22:00 | 31 | -7.21E+02 | 9.12E+02 |
| 4/4/2006 | 0:00 | 40 | 9.01E+01 | 9.04E+02 |
| 4/4/2006 | 2:00 | 45 | -3.60E+02 | 8.86E+02 |
| 4/4/2006 | 4:00 | 52 | -4.51E+02 | 8.89E+02 |
| 4/4/2006 | 6:00 | 57 | 3.60E+02 | 8.95E+02 |
| 4/4/2006 | 8:00 | 65 | 1.80E+03 | 9.28E+02 |
| 4/4/2006 | 10:00 | 72 | 1.80E+02 | 8.78E+02 |
| 4/4/2006 | 14:00 | 81 | -1.35E+03 | 8.78E+02 |
| 4/4/2006 | 16:00 | 88 | -1.89E+03 | 8.78E+02 |
| 4/4/2006 | 18:00 | 93 | -1.44E+03 | 8.88E+02 |
| 4/4/2006 | 20:00 | 95 | -1.35E+03 | 8.71E+02 |
| 4/4/2006 | 22:00 | 98 | -1.35E+03 | 8.85E+02 |
| 4/6/2006 | 14:00 | 152 | -9.01E+01 | 8.89E+02 |
| 4/6/2006 | 16:00 | 160 | 1.44E+03 | 9.11E+02 |
| 4/6/2006 | 18:00 | 169 | 7.21E+02 | 8.80E+02 |
| 4/6/2006 | 20:00 | 180 | 1.35E+03 | 8.99E+02 |
| 4/6/2006 | 2:00 | 105 | 8.11E+02 | 8.71E+02 |
| 4/6/2006 | 4:00 | 116 | 9.01E+02 | 8.68E+02 |
| 4/6/2006 | 6:00 | 120 | 2.25E+03 | 9.04E+02 |
| 4/6/2006 | 8:15 | 126 | 6.31E+02 | 8.61E+02 |
| 4/6/2006 | 10:00 | 135 | 8.11E+02 | 8.55E+02 |
| 4/7/2006 | 14:00 | 206 | 1.71E+03 | 9.26E+02 |
| 4/7/2006 | 16:05 | 212 | 1.08E+03 | 9.14E+02 |
| 4/7/2006 | 18:00 | 220 | 4.51E+02 | 8.95E+02 |
| 4/7/2006 | 8:00 | 182 | 8.11E+02 | 8.78E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 2 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/7/2006 | 10:00 | 187 | 8.11E+02 | 8.86E+02 |
| 4/8/2006 | 2:00 | 221 | -6.31E+02 | 9.02E+02 |
| 4/8/2006 | 4:00 | 230 | 1.08E+03 | 9.42E+02 |
| 4/8/2006 | 6:00 | 238 | -1.35E+03 | 8.69E+02 |
| 4/8/2006 | 8:00 | 243 | 2.70E+02 | 9.46E+02 |
| 4/8/2006 | 10:00 | 250 | -8.11E+02 | 8.84E+02 |
| 4/8/2006 | 14:00 | 264 | 1.08E+03 | 9.02E+02 |
| 4/8/2006 | 16:00 | 271 | 8.11E+02 | 9.02E+02 |
| 4/8/2006 | 18:00 | 275 | 1.80E+02 | 8.98E+02 |
| 4/8/2006 | 20:00 | 284 | 1.08E+03 | 9.17E+02 |
| 4/8/2006 | 22:00 | 290 | 4.51E+02 | 8.90E+02 |
| 4/9/2006 | 0:05 | 299 | 3.60E+02 | 8.66E+02 |
| 4/9/2006 | 2:00 | 303 | 1.17E+03 | 8.88E+02 |
| 4/9/2006 | 4:00 | 309 | 1.98E+03 | 8.94E+02 |
| 4/9/2006 | 6:00 | 316 | 1.17E+03 | 8.88E+02 |
| 4/9/2006 | 8:00 | 322 | 1.35E+03 | 8.82E+02 |
| 4/9/2006 | 10:00 | 329 | 8.11E+02 | 8.91E+02 |
| 4/9/2006 | 18:00 | 345 | -3.60E+02 | 8.92E+02 |
| 4/9/2006 | 20:00 | 358 | -4.51E+02 | 9.10E+02 |
| 4/9/2006 | 22:00 | 371 | -2.70E+02 | 9.12E+02 |
| 4/10/2006 | 2:00 | 386 | 1.26E+03 | 9.00E+02 |
| 4/10/2006 | 4:00 | 394 | 5.41E+02 | 8.68E+02 |
| 4/10/2006 | 6:00 | 401 | 9.01E+02 | 8.88E+02 |
| 4/10/2006 | 8:00 | 408 | 1.80E+02 | 8.71E+02 |
| 4/10/2006 | 10:00 | 418 | 7.21E+02 | 8.94E+02 |
| 4/10/2006 | 21:00 | 421 | -2.70E+02 | 8.43E+02 |
| 4/10/2006 | 22:00 | 425 | 1.44E+03 | 9.15E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 3 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/11/2006 | 0:00 | 441 | -8.11E+02 | 8.86E+02 |
| 4/11/2006 | 2:00 | 446 | -1.80E+02 | 9.06E+02 |
| 4/11/2006 | 4:00 | 454 | 0.00E+00 | 9.08E+02 |
| 4/11/2006 | 6:00 | 461 | 1.80E+02 | 9.10E+02 |
| 4/11/2006 | 8:00 | 467 | 0.00E+00 | 9.25E+02 |
| 4/11/2006 | 10:00 | 473 | -7.21E+02 | 8.84E+02 |
| 4/11/2006 | 12:00 | 478 | 4.51E+02 | 9.29E+02 |
| 4/11/2006 | 14:00 | 484 | 2.70E+02 | 9.12E+02 |
| 4/11/2006 | 16:00 | 492 | 8.11E+02 | 9.26E+02 |
| 4/11/2006 | 18:00 | 498 | 6.31E+02 | 9.16E+02 |
| 4/11/2006 | 20:00 | 504 | 1.53E+03 | 9.56E+02 |
| 4/11/2006 | 22:00 | 510 | 0.00E+00 | 9.05E+02 |
| 4/12/2006 | 0:00 | 516 | -7.21E+02 | 8.60E+02 |
| 4/12/2006 | 2:00 | 520 | -1.26E+03 | 8.61E+02 |
| 4/12/2006 | 4:00 | 524 | -1.35E+03 | 8.56E+02 |
| 4/12/2006 | 6:00 | 527 | -7.21E+02 | 8.92E+02 |
| 4/12/2006 | 8:00 | 531 | -5.41E+02 | 8.78E+02 |
| 4/12/2006 | 10:00 | 537 | -1.80E+02 | 9.24E+02 |
| 4/12/2006 | 12:00 | 542 | 1.71E+03 | 9.09E+02 |
| 4/12/2006 | 14:00 | 545 | 1.62E+03 | 8.97E+02 |
| 4/12/2006 | 16:00 | 552 | 1.71E+03 | 9.09E+02 |
| 4/12/2006 | 18:00 | 556 | 9.01E+02 | 8.73E+02 |
| 4/12/2006 | 20:00 | 560 | 1.71E+03 | 8.94E+02 |
| 4/12/2006 | 22:00 | 563 | 2.16E+03 | 9.18E+02 |
| 4/13/2006 | 0:00 | 568 | 1.80E+02 | 8.78E+02 |
| 4/13/2006 | 2:00 | 575 | 0.00E+00 | 8.76E+02 |
| 4/13/2006 | 6:00 | 585 | 1.80E+02 | 8.56E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 4 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/13/2006 | 8:00 | 590 | 2.70E+02 | 8.83E+02 |
| 4/13/2006 | 10:00 | 596 | 1.80E+02 | 8.78E+02 |
| 4/13/2006 | 12:00 | 602 | 4.51E+02 | 9.09E+02 |
| 4/13/2006 | 14:00 | 605 | 9.01E+01 | 8.97E+02 |
| 4/13/2006 | 16:00 | 610 | 9.91E+02 | 9.23E+02 |
| 4/13/2006 | 18:00 | 619 | 9.01E+02 | 9.26E+02 |
| 4/13/2006 | 20:00 | 628 | 3.60E+02 | 9.12E+02 |
| 4/13/2006 | 22:00 | 635 | 9.01E+01 | 8.97E+02 |
| 4/14/2006 | 2:00 | 644 | -2.88E+03 | 8.86E+02 |
| 4/14/2006 | 4:00 | 652 | -2.16E+03 | 9.36E+02 |
| 4/14/2006 | 6:00 | 660 | -1.35E+03 | 9.33E+02 |
| 4/14/2006 | 8:00 | 686 | -1.98E+03 | 9.13E+02 |
| 4/14/2006 | 10:00 | 692 | -1.89E+03 | 9.18E+02 |
| 4/14/2006 | 12:00 | 673 | 1.98E+03 | 9.32E+02 |
| 4/14/2006 | 14:00 | 680 | 8.11E+02 | 9.14E+02 |
| 4/14/2006 | 22:00 | 750 | 1.35E+03 | 9.08E+02 |
| 4/15/2006 | 2:00 | 683 | 8.11E+02 | 8.95E+02 |
| 4/15/2006 | 4:00 | 693 | -3.60E+02 | 8.68E+02 |
| 4/15/2006 | 6:00 | 700 | 1.80E+02 | 8.99E+02 |
| 4/15/2006 | 8:00 | 708 | -2.70E+02 | 8.66E+02 |
| 4/15/2006 | 10:00 | 715 | -3.60E+02 | 8.60E+02 |
| 4/15/2006 | 12:00 | 722 | 1.35E+03 | 9.00E+02 |
| 4/15/2006 | 14:00 | 728 | 1.62E+03 | 8.92E+02 |
| 4/15/2006 | 16:00 | 734 | 3.60E+02 | 8.76E+02 |
| 4/15/2006 | 18:00 | 737 | 2.07E+03 | 9.24E+02 |
| 4/15/2006 | 20:00 | 743 | 1.98E+03 | 9.04E+02 |
| 4/16/2006 | 0:00 | 754 | -2.61E+03 | 8.80E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 5 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/16/2006 | 2:00 | 760 | -1.62E+03 | 8.80E+02 |
| 4/16/2006 | 4:00 | 770 | -1.53E+03 | 9.02E+02 |
| 4/16/2006 | 6:00 | 780 | -1.26E+03 | 9.09E+02 |
| 4/16/2006 | 8:00 | 785 | -2.07E+03 | 8.95E+02 |
| 4/16/2006 | 10:00 | 793 | -9.01E+02 | 9.29E+02 |
| 4/16/2006 | 12:00 | 800 | -2.70E+02 | 8.94E+02 |
| 4/16/2006 | 14:00 | 808 | 6.31E+02 | 9.13E+02 |
| 4/16/2006 | 16:00 | 815 | 4.51E+02 | 9.11E+02 |
| 4/16/2006 | 18:00 | 821 | -4.51E+02 | 8.53E+02 |
| 4/16/2006 | 20:00 | 828 | 7.21E+02 | 8.87E+02 |
| 4/16/2006 | 22:00 | 834 | 1.35E+03 | 9.37E+02 |
| 4/17/2006 | 0:00 | 840 | -1.26E+03 | 8.81E+02 |
| 4/17/2006 | 2:00 | 844 | -1.71E+03 | 8.80E+02 |
| 4/17/2006 | 6:00 | 845 | -6.31E+02 | 9.35E+02 |
| 4/17/2006 | 8:00 | 851 | -7.21E+02 | 9.12E+02 |
| 4/17/2006 | 10:00 | 857 | -8.11E+02 | 9.33E+02 |
| 4/17/2006 | 12:00 | 862 | -4.51E+02 | 8.82E+02 |
| 4/17/2006 | 14:00 | 867 | -7.21E+02 | 8.83E+02 |
| 4/17/2006 | 16:00 | 872 | -2.70E+03 | 8.81E+02 |
| 4/17/2006 | 18:00 | 877 | -1.80E+02 | 8.81E+02 |
| 4/17/2006 | 20:00 | 882 | -6.31E+02 | 8.88E+02 |
| 4/17/2006 | 22:00 | 888 | 6.31E+02 | 9.03E+02 |
| 4/18/2006 | 0:00 | 894 | -4.51E+02 | 9.18E+02 |
| 4/18/2006 | 2:00 | 900 | -1.08E+03 | 8.81E+02 |
| 4/18/2006 | 4:00 | 903 | -6.31E+02 | 8.99E+02 |
| 4/18/2006 | 6:00 | 911 | -1.08E+03 | 8.90E+02 |
| 4/18/2006 | 8:00 | 920 | -1.35E+03 | 8.82E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 6 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/18/2006 | 10:00 | 927 | -1.08E+03 | 8.90E+02 |
| 4/18/2006 | 12:00 | 937 | -9.91E+02 | 8.58E+02 |
| 4/18/2006 | 14:00 | 943 | -1.17E+03 | 8.64E+02 |
| 4/18/2006 | 16:00 | 947 | 6.31E+02 | 8.88E+02 |
| 4/18/2006 | 18:00 | 952 | 9.01E+01 | 8.89E+02 |
| 4/18/2006 | 20:00 | 958 | 6.31E+02 | 8.88E+02 |
| 4/18/2006 | 22:00 | 963 | 1.26E+03 | 9.07E+02 |
| 4/19/2006 | 0:00 | 968 | 2.61E+03 | 9.78E+02 |
| 4/19/2006 | 16:00 | 969 | -2.70E+02 | 8.74E+02 |
| 4/19/2006 | 18:00 | 976 | -1.80E+02 | 8.88E+02 |
| 4/19/2006 | 20:00 | 982 | 8.11E+02 | 8.88E+02 |
| 4/19/2006 | 22:00 | 986 | 2.52E+03 | 9.66E+02 |
| 4/20/2006 | 0:00 | 996 | -5.41E+02 | 8.68E+02 |
| 4/20/2006 | 2:00 | 1,002 | 1.35E+03 | 9.12E+02 |
| 4/20/2006 | 4:00 | 1,007 | 7.21E+02 | 8.85E+02 |
| 4/20/2006 | 6:00 | 1,013 | 1.35E+03 | 9.04E+02 |
| 4/20/2006 | 8:00 | 1,020 | 6.31E+02 | 8.88E+02 |
| 4/20/2006 | 10:00 | 1,027 | 1.08E+03 | 9.05E+02 |
| 4/20/2006 | 12:00 | 1,031 | 3.60E+02 | 9.00E+02 |
| 4/20/2006 | 14:00 | 1,038 | -9.01E+01 | 9.06E+02 |
| 4/20/2006 | 16:00 | 1,044 | 4.51E+02 | 9.20E+02 |
| 4/20/2006 | 18:00 | 1,050 | -4.51E+02 | 9.10E+02 |
| 4/20/2006 | 20:00 | 1,055 | -9.01E+01 | 9.14E+02 |
| 4/20/2006 | 22:00 | 1,060 | -5.41E+02 | 8.81E+02 |
| 4/21/2006 | 0:00 | 1,065 | 2.70E+02 | 9.27E+02 |
| 4/21/2006 | 2:00 | 1,071 | -3.60E+02 | 9.16E+02 |
| 4/21/2006 | 4:00 | 1,076 | 8.11E+02 | 9.19E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 7 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/21/2006 | 6:00 | 1,080 | 3.60E+02 | 9.17E+02 |
| 4/21/2006 | 8:00 | 1,086 | 8.11E+02 | 9.41E+02 |
| 4/21/2006 | 10:00 | 1,090 | 4.51E+02 | 9.22E+02 |
| 4/21/2006 | 12:00 | 1,095 | -1.35E+03 | 8.83E+02 |
| 4/21/2006 | 14:00 | 1,100 | -1.44E+03 | 8.70E+02 |
| 4/21/2006 | 16:00 | 1,105 | 0.00E+00 | 9.20E+02 |
| 4/21/2006 | 18:00 | 1,110 | -3.60E+02 | 8.93E+02 |
| 4/21/2006 | 20:00 | 1,115 | -1.44E+03 | 8.78E+02 |
| 4/21/2006 | 22:00 | 1,120 | -1.71E+03 | 9.13E+02 |
| 4/22/2006 | 0:00 | 1,125 | 1.53E+03 | 9.09E+02 |
| 4/22/2006 | 2:00 | 1,131 | 0.00E+00 | 8.95E+02 |
| 4/22/2006 | 4:00 | 1,138 | 1.08E+03 | 8.93E+02 |
| 4/22/2006 | 6:00 | 1,144 | 1.17E+03 | 8.83E+02 |
| 4/22/2006 | 8:00 | 1,148 | 4.51E+02 | 8.73E+02 |
| 4/22/2006 | 10:00 | 1,156 | 9.01E+02 | 8.83E+02 |
| 4/22/2006 | 12:00 | 1,161 | -6.31E+02 | 8.35E+02 |
| 4/22/2006 | 14:00 | 1,168 | 7.21E+02 | 8.96E+02 |
| 4/22/2006 | 16:00 | 1,173 | 5.41E+02 | 8.78E+02 |
| 4/22/2006 | 18:00 | 1,180 | 9.91E+02 | 8.95E+02 |
| 4/22/2006 | 20:00 | 1,185 | -4.51E+02 | 8.30E+02 |
| 4/22/2006 | 22:00 | 1,193 | 1.08E+03 | 9.00E+02 |
| 4/23/2006 | 0:00 | 1,199 | 2.70E+02 | 8.88E+02 |
| 4/23/2006 | 2:00 | 1,207 | 9.91E+02 | 9.28E+02 |
| 4/23/2006 | 4:00 | 1,214 | 1.26E+03 | 9.27E+02 |
| 4/23/2006 | 6:00 | 1,220 | 1.35E+03 | 9.09E+02 |
| 4/23/2006 | 8:00 | 1,226 | 1.17E+03 | 8.99E+02 |
| 4/23/2006 | 10:00 | 1,230 | 1.80E+03 | 9.26E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 8 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | |
| 4/25/2006 | 7:30 | Bit Trip | 8.11E+02 | 8.97E+02 |
| 4/25/2006 | 10:00 | Bit Trip | 9.91E+02 | 9.07E+02 |
| 4/25/2006 | 12:00 | 1,230 | 0.00E+00 | 9.37E+02 |
| Drilling with 12.45-in. hammer bit | | | | |
| 4/30/2006 | 12:00 | 1,260 | 9.01E+02 | 9.31E+02 |
| 4/30/2006 | 16:00 | 1,290 | 6.31E+02 | 9.24E+02 |
| 4/30/2006 | 18:00 | 1,322 | -4.51E+02 | 8.95E+02 |
| 4/30/2006 | 20:00 | 1,350 | 6.31E+02 | 9.39E+02 |
| 4/30/2006 | 22:00 | 1,380 | -3.60E+02 | 9.08E+02 |
| 5/1/2006 | 0:00 | 1,409 | -9.91E+02 | 8.95E+02 |
| 5/1/2006 | 2:00 | 1,428 | -7.21E+02 | 8.94E+02 |
| 5/1/2006 | 4:00 | 1,450 | -9.01E+02 | 8.84E+02 |
| 5/1/2006 | 6:00 | 1,470 | -1.17E+03 | 8.76E+02 |
| 5/1/2006 | 8:00 | 1,490 | -4.51E+02 | 9.17E+02 |
| 5/1/2006 | 10:00 | 1,491 | -8.11E+02 | 8.97E+02 |
| 5/1/2006 | 12:00 | 1,510 | 1.35E+03 | 9.16E+02 |
| 5/1/2006 | 14:00 | 1,530 | 1.35E+03 | 9.16E+02 |
| 5/1/2006 | 16:00 | 1,560 | 1.17E+03 | 9.29E+02 |
| 5/1/2006 | 18:00 | 1,580 | 9.01E+02 | 9.14E+02 |
| 5/1/2006 | 20:00 | 1,600 | 8.11E+02 | 9.17E+02 |
| 5/2/2006 | 0:30 | 1,610 | -1.71E+03 | 8.64E+02 |
| 5/2/2006 | 2:00 | 1,628 | -6.31E+02 | 9.19E+02 |
| 5/2/2006 | 4:00 | 1,644 | 0.00E+00 | 9.13E+02 |
| 5/2/2006 | 6:00 | 1,659 | -9.91E+02 | 8.98E+02 |
| 5/2/2006 | 7:25 | 1,669 | -1.17E+03 | 8.71E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 9 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Airlift Development | | | | |
| 5/5/2006 | 11:05 | WD | -2.70E+02 | 8.85E+02 |
| 5/5/2006 | 12:00 | WD | 9.01E+01 | 8.96E+02 |
| 5/5/2006 | 13:00 | WD | 2.43E+03 | 9.54E+02 |
| 5/5/2006 | 14:00 | WD | 1.26E+03 | 9.14E+02 |
| 5/5/2006 | 15:00 | WD | 1.62E+03 | 9.26E+02 |
| 5/5/2006 | 16:00 | WD | 9.01E+01 | 9.12E+02 |
| 5/5/2006 | 17:00 | WD | 2.07E+03 | 9.21E+02 |
| 5/5/2006 | 18:00 | WD | 1.26E+03 | 9.07E+02 |
| 5/5/2006 | 19:00 | WD | 1.53E+03 | 9.29E+02 |
| 5/5/2006 | 20:00 | WD | 1.44E+03 | 9.24E+02 |
| 5/5/2006 | 21:00 | WD | 1.53E+03 | 9.14E+02 |
| 5/5/2006 | 22:00 | WD | 2.16E+03 | 9.47E+02 |
| 5/6/2006 | 0:00 | WD | -2.16E+03 | 8.74E+02 |
| 5/6/2006 | 1:00 | WD | -2.79E+03 | 8.70E+02 |
| 5/6/2006 | 2:00 | WD | -1.53E+03 | 8.78E+02 |
| 5/6/2006 | 3:14 | WD | -1.08E+03 | 8.96E+02 |
| 5/6/2006 | 4:00 | WD | 5.41E+02 | 9.16E+02 |
| 5/6/2006 | 5:00 | WD | -1.44E+03 | 8.83E+02 |
| 5/6/2006 | 6:00 | WD | -6.31E+02 | 9.13E+02 |
| 5/6/2006 | 7:00 | WD | -1.35E+03 | 9.13E+02 |
| 5/6/2006 | 8:00 | WD | -8.11E+02 | 9.19E+02 |
| 5/6/2006 | 9:00 | WD | -2.07E+03 | 8.87E+02 |
| 5/6/2006 | 10:00 | WD | -9.01E+02 | 8.90E+02 |
| 5/6/2006 | 11:00 | WD | -1.26E+03 | 8.93E+02 |

**Table B.1-4**
**Project Shoal Area MV-3 Tritium Results**
(Page 10 of 10)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Pump Development | | | | |
| 6/1/2006 | 18:00 | WD | 5.41E+02 | 9.42E+02 |
| 6/2/2006 | 14:35 | WD | 9.01E+01 | 9.54E+02 |
| 6/2/2006 | 16:20 | WD | -1.26E+03 | 9.11E+02 |
| 6/2/2006 | 18:00 | WD | -2.70E+02 | 9.35E+02 |
| 6/3/2006 | 8:45 | WD | -1.08E+03 | 8.99E+02 |
| 6/3/2006 | 13:05 | WD | 1.17E+03 | 9.45E+02 |
| 6/3/2006 | 17:30 | WD | 5.86E+03 | 1.07E+03 |
| 6/4/2006 | 8:10 | WD | -2.25E+03 | 8.60E+02 |
| 6/4/2006 | 10:00 | WD | 1.80E+02 | 9.26E+02 |
| 6/4/2006 | 14:00 | WD | 9.01E+01 | 9.07E+02 |
| 6/4/2006 | 17:50 | WD | -6.31E+02 | 8.97E+02 |

ft = Foot
pCi/L = Picocuries per liter
WD = Well Development

**Table B.1-5**
**Project Shoal Area MV-3 Water Quality Parameter Results**
(Page 1 of 4)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | | | |
| 4/3/2006 | 22:00 | 31 | 9.49 | 20.6 | 1,600.0 | 54.40 |
| 4/4/2006 | 16:00 | 88 | 9.25 | 21.1 | 1,700.0 | 67.10 |
| 4/6/2006 | 12:00 | 142 | 9.43 | 20.2 | 2,200.0 | 30.50 |
| 4/7/2006 | 8:00 | 182 | 8.04 | 21.9 | 2,320.0 | 21.70 |
| 4/7/2006 | 11:30 | 187 | 7.72 | 18.0 | 3,249.0 | 33.40 |
| 4/7/2006 | 15:30 | 208 | 9.83 | 21.0 | 2,200.0 | 24.10 |
| 4/8/2006 | 6:07 | 238 | 8.24 | 21.0 | 2,420.0 | 28.70 |
| 4/8/2006 | 15:15 | 264 | 9.57 | 20.3 | 2,229.0 | 28.70 |
| 4/9/2006 | 8:15 | 322 | 8.32 | 20.4 | 2,067.0 | 25.60 |
| 4/9/2006 | 13:00 | 335 | 9.48 | 17.3 | 2,171.0 | 21.00 |
| 4/10/2006 | 0:00 | 380 | 8.98 | 22.9 | 2,019.0 | 25.90 |
| 4/10/2006 | 21:00 | 421 | 8.77 | 20.2 | 2,167.0 | 29.20 |
| 4/11/2006 | 0:00 | 441 | 9.19 | 20.1 | 2,045.0 | 25.80 |
| 4/11/2006 | 12:00 | 542 | 9.02 | 22.1 | 2,002.0 | 24.70 |
| 4/12/2006 | 0:00 | 516 | 9.13 | 21.4 | 1,945.0 | 24.20 |
| 4/12/2006 | 12:00 | 542 | 9.02 | 22.1 | 2,000.0 | 29.60 |
| 4/13/2006 | 0:00 | 568 | 9.00 | 22.4 | 1,986.0 | 26.10 |
| 4/13/2006 | 12:00 | 602 | 8.98 | 21.8 | 1,928.0 | 27.30 |
| 4/14/2006 | 2:00 | 644 | 9.01 | 22.1 | 1,958.0 | 29.30 |
| 4/14/2006 | 12:00 | 673 | 9.03 | 21.0 | 1,907.0 | 28.20 |
| 4/15/2006 | 2:00 | 683 | 8.97 | 22.8 | 1,968.0 | NA |
| 4/15/2006 | 3:00 | 688 | NA | NA | NA | 27.90 |
| 4/15/2006 | 12:00 | 722 | 9.00 | 19.4 | 1,803.0 | 27.90 |
| 4/16/2006 | 0:00 | 754 | 8.96 | 23.5 | 2,017.0 | 25.60 |
| 4/16/2006 | 12:00 | 800 | 9.11 | 18.3 | 1,889.0 | 27.60 |
| 4/17/2006 | 0:00 | 840 | 8.76 | 25.5 | 2,006.0 | 25.80 |
| 4/17/2006 | 12:00 | 862 | 9.13 | 17.5 | 1,949.0 | 30.00 |

**Table B.1-5**
**Project Shoal Area MV-3 Water Quality Parameter Results**
(Page 2 of 4)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Drilling with 22-in. tricone bit | | | | | | |
| 4/18/2006 | 0:00 | 894 | 8.87 | 25.2 | 2,067.0 | 23.10 |
| 4/18/2006 | 12:00 | 937 | 9.13 | 17.5 | 1,960.0 | 25.30 |
| 4/19/2006 | 0:00 | 968 | 8.94 | 22.4 | 2,047.0 | 23.70 |
| 4/19/2006 | 16:00 | 969 | 8.49 | 20.4 | 1,927.0 | 24.20 |
| 4/20/2006 | 0:00 | 996 | 9.02 | 22.5 | 2,021.0 | 26.60 |
| 4/20/2006 | 12:00 | 1,031 | 9.23 | 20.5 | 2,082.0 | 29.60 |
| 4/21/2006 | 0:00 | 1,065 | 9.22 | 17.7 | 2,105.0 | 27.60 |
| 4/21/2006 | 12:00 | 1,095 | 8.95 | 21.5 | 2,089.0 | 37.00 |
| 4/22/2006 | 0:00 | 1,125 | 9.47 | 21.2 | 2,355.0 | 26.60 |
| 4/22/2006 | 12:00 | 1,161 | 8.72 | 19.4 | 2,112.0 | 29.30 |
| 4/23/2006 | 0:00 | 1,199 | 9.22 | 22.8 | 2,455.0 | 29.40 |
| Drilling with 12.45-in. hammer bit | | | | | | |
| 4/30/2006 | 14:00 | 1,290 | 7.57 | 23.4 | 785.0 | 17.10 |
| 5/1/2006 | 1:42 | 1,409 | 7.25 | 22.0 | 720.0 | 11.20 |
| 5/1/2006 | 2:58 | 1,428 | 7.03 | 21.5 | 818.0 | 7.58 |
| 5/1/2006 | 4:16 | 1,450 | 6.67 | 19.9 | 791.0 | 6.03 |
| 5/1/2006 | 0:00 | 1,470 | 6.86 | 19.6 | 736.0 | 8.18 |
| 5/1/2006 | 7:55 | 1,490 | 6.71 | 18.7 | 770.0 | 6.11 |
| 5/1/2006 | 10:00 | 1,491 | 6.61 | 20.9 | 780.0 | 12.10 |
| 5/1/2006 | 14:00 | 1,510 | 6.71 | 22.3 | 750.0 | 12.00 |
| 5/1/2006 | 16:20 | 1,530 | 6.22 | 23.1 | 722.0 | 21.70 |
| 5/1/2006 | 18:30 | 1,560 | 6.23 | 22.2 | 772.0 | 11.10 |
| 5/1/2006 | 20:30 | 1,580 | 7.01 | 21.2 | 782.0 | 11.00 |
| 5/1/2006 | 22:30 | 1,600 | 6.81 | 19.5 | 757.0 | 11.10 |
| 5/2/2006 | 0:30 | 1,610 | 8.90 | 17.0 | 700.0 | 29.80 |
| 5/2/2006 | 2:00 | 1,628 | 6.36 | 21.2 | 791.0 | 15.70 |
| 5/2/2006 | 4:00 | 1,644 | 6.64 | 24.0 | 110.1 | 5.06 |

# Table B.1-5
## Project Shoal Area MV-3 Water Quality Parameter Results
(Page 3 of 4)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Drilling with 12.45-in. hammer bit | | | | | | |
| 5/2/2006 | 6:00 | 1,659 | 8.18 | 18.8 | 698.0 | 10.02 |
| 5/2/2006 | 7:25 | 1,669 | 7.95 | 18.4 | 754.0 | 10.06 |
| Airlift Development | | | | | | |
| 5/5/2006 | 11:15 | WD | 7.29 | 32.3 | 934.0 | 2.24 |
| 5/5/2006 | 13:00 | WD | 7.26 | 22.3 | 716.0 | 28.40 |
| 5/5/2006 | 14:00 | WD | 7.18 | 22.1 | 763.0 | 16.30 |
| 5/5/2006 | 15:00 | WD | 6.61 | 22.1 | 758.0 | 17.00 |
| 5/5/2006 | 16:00 | WD | 7.65 | 21.8 | 819.0 | 10.50 |
| 5/5/2006 | 17:00 | WD | 7.62 | 21.8 | 833.0 | 11.60 |
| 5/5/2006 | 18:00 | WD | 7.81 | 21.8 | 825.0 | 12.50 |
| 5/5/2006 | 19:00 | WD | 7.56 | 21.6 | 836.0 | 10.10 |
| 5/5/2006 | 20:00 | WD | 7.21 | 20.8 | 843.0 | 9.30 |
| 5/5/2006 | 21:00 | WD | 7.52 | 19.5 | 852.0 | 10.60 |
| 5/5/2006 | 22:00 | WD | 7.56 | 20.5 | 816.0 | 5.72 |
| 5/5/2006 | 23:00 | WD | 7.40 | 19.9 | 829.0 | 6.81 |
| 5/6/2006 | 0:00 | WD | 7.78 | 20.2 | 810.0 | 6.55 |
| 5/6/2006 | 1:00 | WD | 7.69 | 19.4 | 813.0 | 7.31 |
| 5/6/2006 | 2:00 | WD | 7.61 | 19.1 | 821.0 | 5.56 |
| 5/6/2006 | 3:14 | WD | 8.07 | 21.5 | 809.0 | 4.74 |
| 5/6/2006 | 4:00 | WD | 7.79 | 21.3 | 816.0 | 5.45 |
| 5/6/2006 | 5:00 | WD | 8.03 | 19.5 | 818.0 | 4.67 |
| 5/6/2006 | 6:00 | WD | 8.11 | 19.3 | 815.0 | 5.18 |
| 5/6/2006 | 7:00 | WD | 8.06 | 19.5 | 821.0 | 5.67 |
| 5/6/2006 | 8:00 | WD | 8.05 | 19.1 | 810.0 | 3.97 |
| 5/6/2006 | 9:00 | WD | 7.69 | 19.7 | 828.0 | 3.86 |
| 5/6/2006 | 10:00 | WD | 7.06 | 20.3 | 814.0 | 2.87 |
| 5/6/2006 | 11:00 | WD | 8.03 | 20.7 | 812.0 | 2.53 |

# Table B.1-5
## Project Shoal Area MV-3 Water Quality Parameter Results
(Page 4 of 4)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Pump Development | | | | | | |
| 6/1/2006 | 18:00 | WD | 12.66 | 21.8 | 2614.0 | 26.20 |
| 6/2/2006 | 14:35 | WD | 6.82 | 21.3 | 760.0 | 7.41 |
| 6/2/2006 | 16:20 | WD | 7.28 | 21.6 | 803.0 | 2.89 |
| 6/2/2006 | 18:00 | WD | 7.21 | 23.3 | 799.0 | 1.42 |
| 6/3/2006 | 8:45 | WD | 7.23 | 16.3 | 376.6 | 3.06 |
| 6/3/2006 | 13:05 | WD | 6.30 | 21.4 | 766.0 | 2.86 |
| 6/3/2006 | 17:30 | WD | 6.41 | 21.6 | 791.0 | 1.95 |
| 6/4/2006 | 8:10 | WD | 8.01 | 21.0 | 678.0 | 1.62 |
| 6/4/2006 | 10:00 | WD | 7.43 | 21.7 | 689.0 | 3.22 |
| 6/4/2006 | 14:00 | WD | 7.40 | 22.8 | 755.0 | 2.03 |
| 6/4/2006 | 17:40 | WD | 6.83 | 24.4 | 772.0 | 1.13 |

$Br^-$ = Bromide
°C= Degrees Celsius
ft = Foot
mg/L = Milligrams per liter
NA = Not analyzed
SU = Standard unit
WD = Well Development
µS/cm = Microsiemens per centimeter

# *MV-3 Lithologic Log*

The following lithologic description for borehole MV-3 was produced using the geophysical logs and borehole cutting samples. The caliper log was used from the surface to 1,220 ft. The sonic velocity log was used from 1,200 to 1,660 ft. The acoustic televiewer log was used from 1,215 to 1,660 ft. The SP, resistivity, natural gamma, and neutron density logs were used from the surface to 1,660 ft. The bottom 10 ft of the hole were not logged because of the configuration of the downhole geophysical tools. Depths are reported as ft because this is the standard used by the drillers and by the geophysical loggers. Colors were determined using the Munsell® Classification System.

| **Depth (ft)** | **Lithology** |
|---|---|
| 0 – 50 | Porphyritic granite, very light gray (N8) to light gray (N7) to yellowish gray (5Y 8/1); euhedral to subhedral phenocrysts of microcline up to 2 centimeters (cm) in a medium to coarsely crystalline subhedral groundmass of plagioclase, microcline, quartz, and biotite, 1 to 5 millimeters (mm) in size; plagioclase = 40-45 %, microcline = 35-40%, quartz = 15%, biotite = 3-5%, trace hornblende, trace sphene, trace magnetite; |
| 50 – 92 | Porphyritic granite, yellowish gray (5Y 8/1) to very light gray (N8); with minor iron oxide staining.<br><br>**Note:** 29-in. diameter surface casing set to a depth of 92 ft. The drill cuttings from 92 to 118 ft are contaminated with cement from drilling out the plug at the base of the surface casing. |
| 92 – 118 | Porphyritic granite, grayish orange pink (5YR 7/2) to very light gray (N8); with minor iron oxide staining; sample is overwhelmed with cement chips. |
| 118 - 160 | Porphyritic granite, very light gray (N8) to light gray (N7); with fractures and minor iron oxide staining. |
| 160 – 170 | Porphyritic granite; with fractures and prominent iron oxide staining. |
| 170 – 180 | Porphyritic granite; with fractures and minor iron oxide staining. |
| 180 – 270 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1); with minor fracturing. |
| 270 - 280 | Pegmatite dike, very light gray (N8); light pale red (5R 7/2) to grayish orange pink (10R 8/2); subhedral and very coarsely crystalline, with crystals as large as 3 to 4 cm; microcline = 65%, plagioclase = 20%, quartz = 14%, biotite = 1%; no alteration. |
| 280 – 310 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1). |
| 310 – 320 | Pegmatite dike; light pale red (5R 7/2) to grayish orange pink (10R 8/2); subhedral and very coarsely crystalline, with crystals as large as 3 to 4 cm; microcline = 65%, plagioclase = 20%, quartz = 14%, biotite = 1%; no alteration. |
| 320 – 330 | Porphyritic granite, very light gray (N8); no fractures. |

| | |
|---|---|
| 330 – 390 | Porphyritic granite; with minor fracturing. |
| 390 – 410 | Porphyritic granite; with minor fracturing and minor iron oxide staining. |
| 410 – 430 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4); with significant fracturing and minor iron oxide staining. |
| 430 – 445 | SHEAR ZONE in porphyritic granite; characterized by crushed granite, minor argillic alteration (feldspars altering to clay), minor propylitic alteration (biotite altering to chlorite). |
| 445 – 480 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); with significant fracturing and thin clay-filled joints, iron oxide staining, and minor propylitic alteration of biotite. |
| 480 – 502 | Porphyritic granite, very light gray (N8); no fractures and no alteration. |
| 502 – 516 | Porphyritic granite, very light gray (N8) to yellowish gray (5Y 8/1); with fractures. |
| 516 – 528 | Porphyritic granite; no fractures and no alteration. |
| 528 – 535 | Porphyritic granite; with fractures. |
| 535 – 548 | Aplite/pegmatite dike. Aplite; yellowish gray (5Y 8/1); equicrystalline and very finely crystalline with crystals <1 mm; microcline, quartz, and plagioclase, with trace of biotite. Pegmatite; very light gray (N8) to pinkish gray (5YR 8/1); very coarsely crystalline with microcline crystals typically as large as 4 cm, plagioclase and quartz crystals 1 to 2 cm, and books of biotite as large as 1 cm; microcline = 50-60%, plagioclase = 25-30%, quartz = 15-20%, biotite = 2-4%; Minor propylitic alteration, with biotite partly to predominantly altered to chlorite and thin (<1 mm) fractures coated with chlorite. |
| 548 – 562 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); no fractures and no alteration. |
| 562 - 622 | Porphyritic granite; propylitic alteration increasing with depth, including increasing alteration of biotite to chlorite. Pyrite appears at 611 ft. |
| 622 - 680 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1) to greenish gray (5G 6/1); with fractures, some coated with chlorite and calcite, some filled with clay, and some with iron oxide staining; propylitic alteration with disseminated pyrite increases with depth. |
| 680 – 702 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4); with intermittent fractures and minor iron oxide staining, no propylitic alteration and no disseminated sulfides. |
| 702 – 734 | Porphyritic granite; no fractures, no propylitic alteration. |
| 734 – 760 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); with intermittent fractures that diminish downward, minor iron staining, very minor propylitic alteration, no pyrite. |

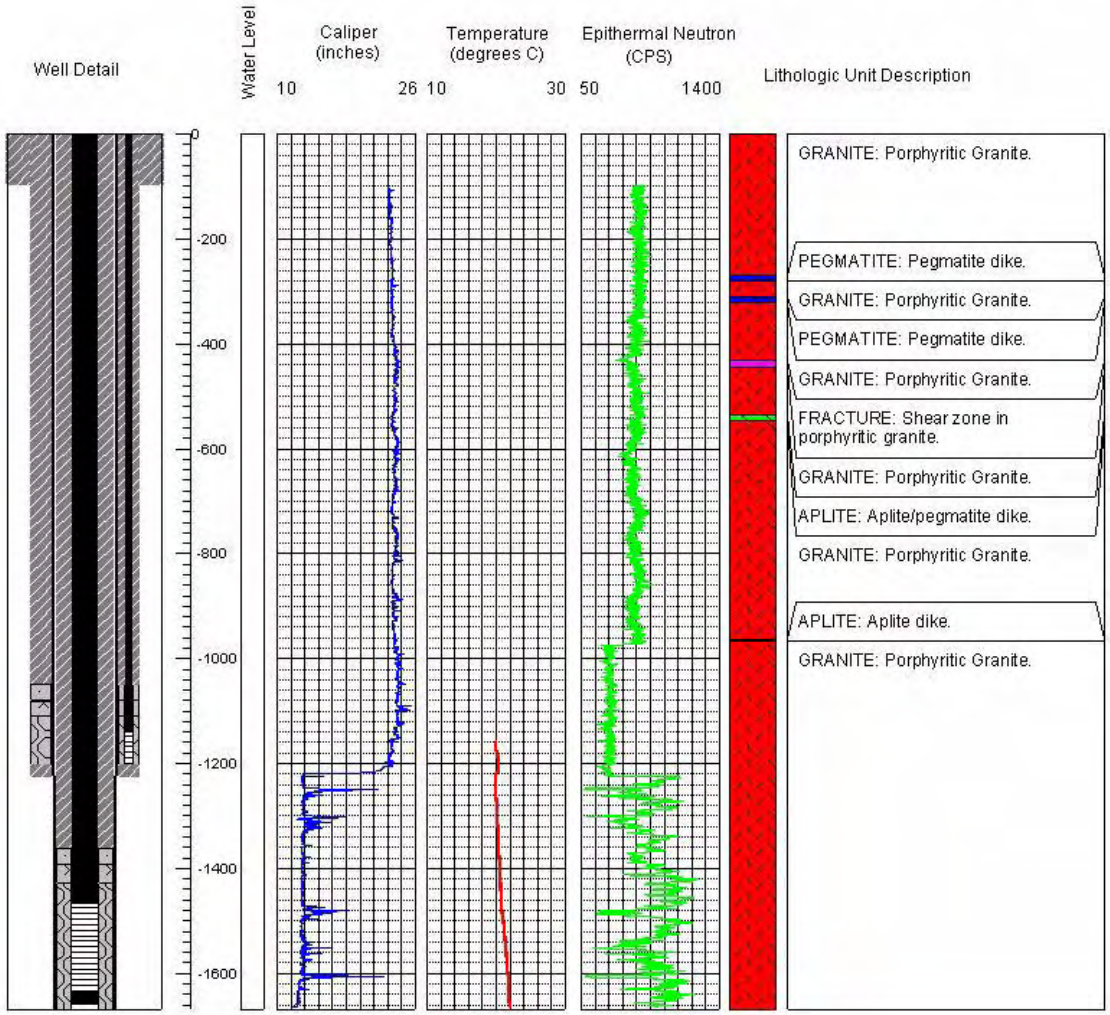
| | |
|---|---|
| 760 – 815 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6); with fractures that diminish downward, iron oxide staining, propylitic alteration that increases downward but no disseminated pyrite, and local argillic alteration. |
| 815 – 880 | Porphyritic granite, very light gray (N8) to pale green (10G 7/2) to grayish orange (10YR 7/4); with few fractures, and minor local propylitic alteration. |
| 880 – 938 | Porphyritic granite, very light gray (N8) to pale greenish gray (5GY 7/1); with more fractures with some propylitic alteration, minor disseminated pyrite from 910 to 938. |
| 938 – 965 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); with few fractures. The cuttings revealed no alteration, but the neutron density log suggests the presence of propylitic alteration. |
| 965 – 967 | Aplite dike; very light gray (N8) to pinkish gray (5YR 8/1); medium grained, subhedral equicrystalline; plagioclase = 40-45%, microcline = 35-40%, quartz = 20%, biotite = 1-2%. |
| 967 – 1,058 | Porphyritic granite, very light gray (N8) to greenish gray (5G 71) to grayish orange (10YR 7/4); with some local fractures with some clay gouge; propylitic alteration with disseminated pyrite, and iron oxide staining. |
| 1,058 – 1,072 | Porphyritic granite; with a few fractures and minor iron oxide staining, but no propylitic alteration. |
| 1,072 – 1,090 | Porphyritic granite; with increasing fractures and propylitic alteration. |
| 1,090 – 1,114 | Porphyritic granite; with iron oxide staining but no propylitic alteration. |
| 1,114 – 1,120 | Porphyritic granite, very light gray (N8) to light gray (N7); no fractures, no alteration. |
| 1,120 – 1,153 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4); with more fractures and iron staining, and minor local propylitic alteration. |
| 1,153 – 1,167 | Porphyritic granite; with very sparse fractures and minor iron oxide staining. |
| 1,167 – 1,180 | Porphyritic granite, light gray (N7) to grayish orange (10YR 7/4) to pale green (10G 6/2); with fractures and propylitic alteration increasing downward. |
| 1,180 – 1,204 | Porphyritic granite, very light gray (N8) to pale greenish gray (5G 7/1); with minor fractures, minor propylitic alteration, and minor iron staining. |
| 1,204 – 1,214 | Porphyritic granite; with extensive fractures and propylitic alteration. |
| 1,214 – 1,230 | Porphyritic granite; with minor fractures, minor propylitic alteration, and very minor iron oxide staining. |
| | **Note:** Drilling method changes from rotary tricone button bit to a downhole pneumatic hammer bit. This results in chip samples that are larger in fractured granite but much smaller in unfractured granite. |
| 1,230 – 1,246 | Porphyritic granite; no fractures, minor propylitic alteration and iron oxide staining. |

| | |
|---|---|
| 1,246 – 1,266 | Porphyritic granite, very light gray (N8) to pale greenish gray (5G 7/1) to grayish orange (10YR 7/4); extensively fractured, with propylitic alteration and iron oxide staining. |
| 1,266 – 1,300 | Porphyritic granite, very light gray (N8) to pale green (10G 6/2); with minor fractures but extensive propylitic alteration and iron oxide staining. |
| 1,300 – 1,330 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1) to pale greenish gray (5G 7/1); extensively fractured, with propylitic alteration and iron oxide staining. |
| 1,330 – 1,355 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1); with minor fractures, extensive propylitic alteration but only minor iron oxide staining. |
| 1,355 – 1,370 | Porphyritic granite, greenish gray (5G 6/1) to pinkish gray (5YR 8/1); no fractures, but some propylitic alteration. |
| 1,370 – 1,382 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1); with minor fractures, and some propylitic alteration. |
| 1,382 – 1,390 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1) to grayish orange (10YR 7/1); with fractures, propylitic alteration and minor iron oxide staining. |
| 1,390 – 1,408 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1); with minor fractures, propylitic alteration, and minor iron oxide staining. |
| 1,408 – 1,412 | Porphyritic granite; with fractures, only modest propylitic alteration, and very little iron oxide staining. |
| 1,412 – 1,424 | Porphyritic granite; no fractures, some propylitic alteration. |
| 1,424 – 1,470 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1); fractured, with some open fractures that manifest secondary mineral coatings on fracture surfaces; increasing propylitic alteration and increasing iron staining. |
| 1,470 – 1,495 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to grayish orange (10YR 7/4); extensively fractured, with much propylitic alteration and iron oxide staining. |
| 1,495 – 1,505 | Porphyritic granite; no fractures but extensive propylitic alteration and iron oxide staining. |
| 1,505 – 1,535 | Porphyritic granite, very light gray (N8) to very pale orange (10YR 8/2); with fractures, diminishing propylitic alteration, and minor iron oxide staining. |
| 1,535 – 1,555 | Porphyritic alteration; with extensive fractures but only minor propylitic alteration and minor iron oxide staining. |
| 1,555 – 1,560 | Porphyritic granite, very light gray (N8) to pale greenish gray (5G 7/1) to very pale orange (10YR 8/2); no fractures, minor alteration. |
| 1,560 – 1,575 | Porphyritic granite; with extensive fractures and some propylitic alteration but minor iron oxide staining. |

| | |
|---|---|
| 1,575 – 1,600 | Porphyritic granite; with some fractures, and some propylitic alteration but minor iron oxide staining. |
| 1,600 – 1,610 | Porphyritic granite; extensively fractured with propylitic alteration and minor iron oxide staining. |
| 1,610 – 1,670 | Porphyritic granite; with some fractures, some propylitic alteration, but only minor iron oxide staining. |

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Caliper/Temperature/Epithermal Neutron**
**Dates Logged: April 24, April 25, May 2, and May 3, 2006**

**Well/Borehole Identification: MV-3**
**Surface Elevation: 1,603.41 (m) / 5,260.50 (ft)**
**Northing: 4339986.317 (m)**
**Easting: 381026.50 (m)**
**Coordinate System: UTM Zone 11**

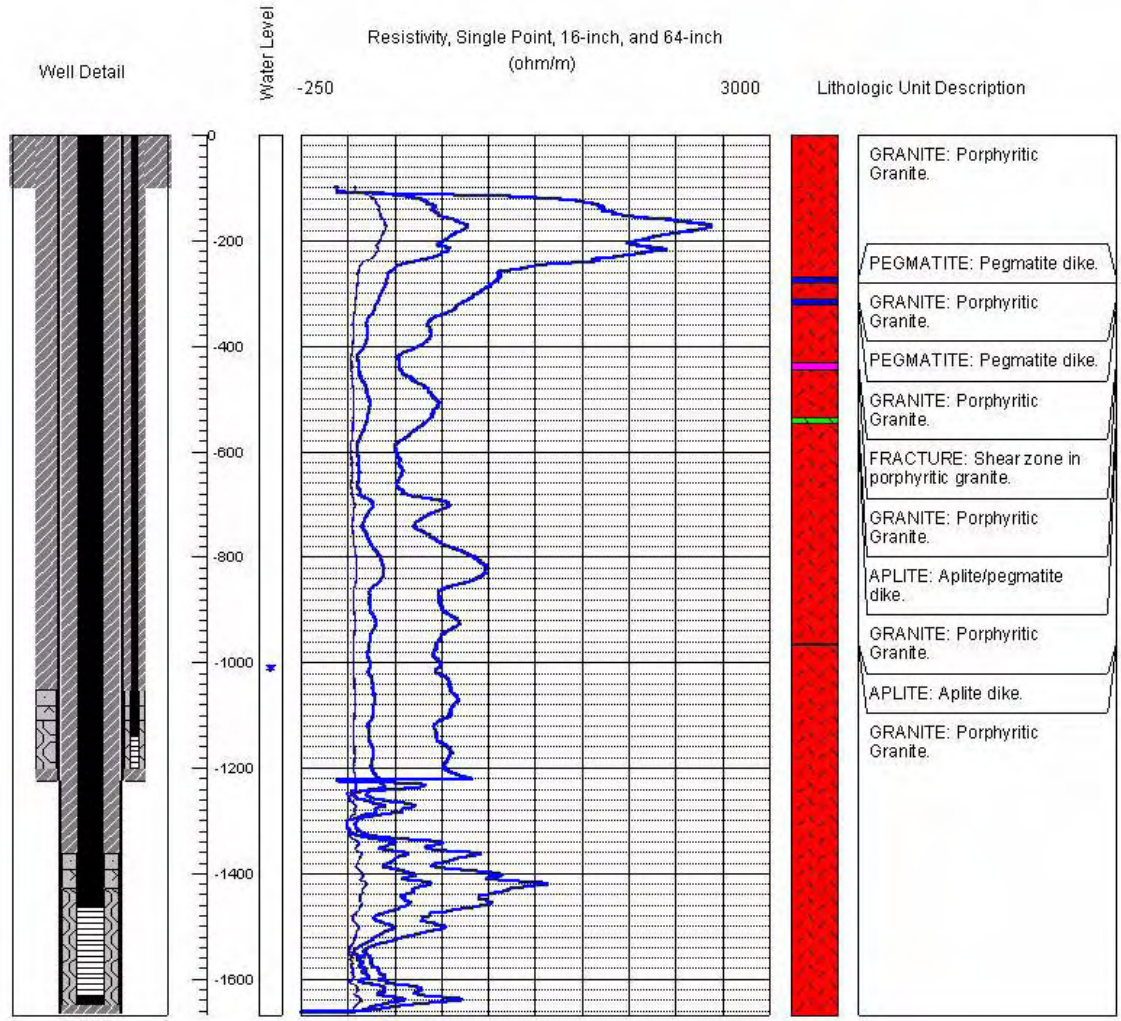



Total Depth: -1668.84 Page 1 of 1

**Log Plot B.1-1**
**Geophysical Data**
**Project Shoal Area MV-3 Caliper and Temperature**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Resistivity**
**Dates Logged: April 24, April 25, May 2, and May 3, 2006**

**Well/Borehole Identification: MV-3**
**Surface Elevation: 1,603.41 (m) / 5,260.51 (ft)**
**Northing: 4339986.317 (m)**
**Easting: 381026.50 (m)**
**Coordinate System: UTM Zone 11**

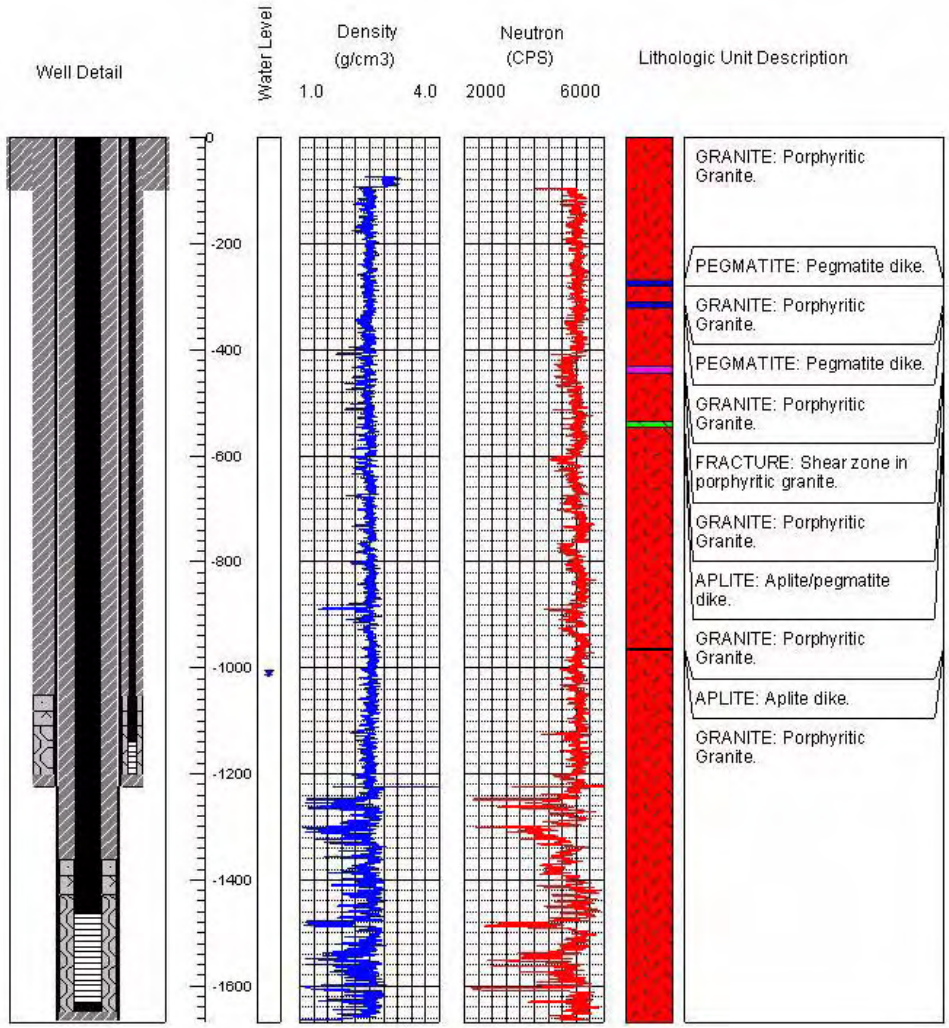



Total Depth: Page 1 of 1

**Log Plot B.1-2**
**Geophysical Data**
**Project Shoal Area MV-3 Resistivity (Single Point, 16-inch, and 64-inch)**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Sonic Velocity/Density/Neutron**
**Dates Logged: April 24, April 25, May 2, and May 3, 2006**

**Well/Borehole Identification: MV-3**
**Surface Elevation: 1,603.41 (m) / 5,260.50 (ft)**
**Northing: 4339986.317 (m)**
**Easting: 381026.5 (m)**
**Coordinate System: UTM Zone 11**

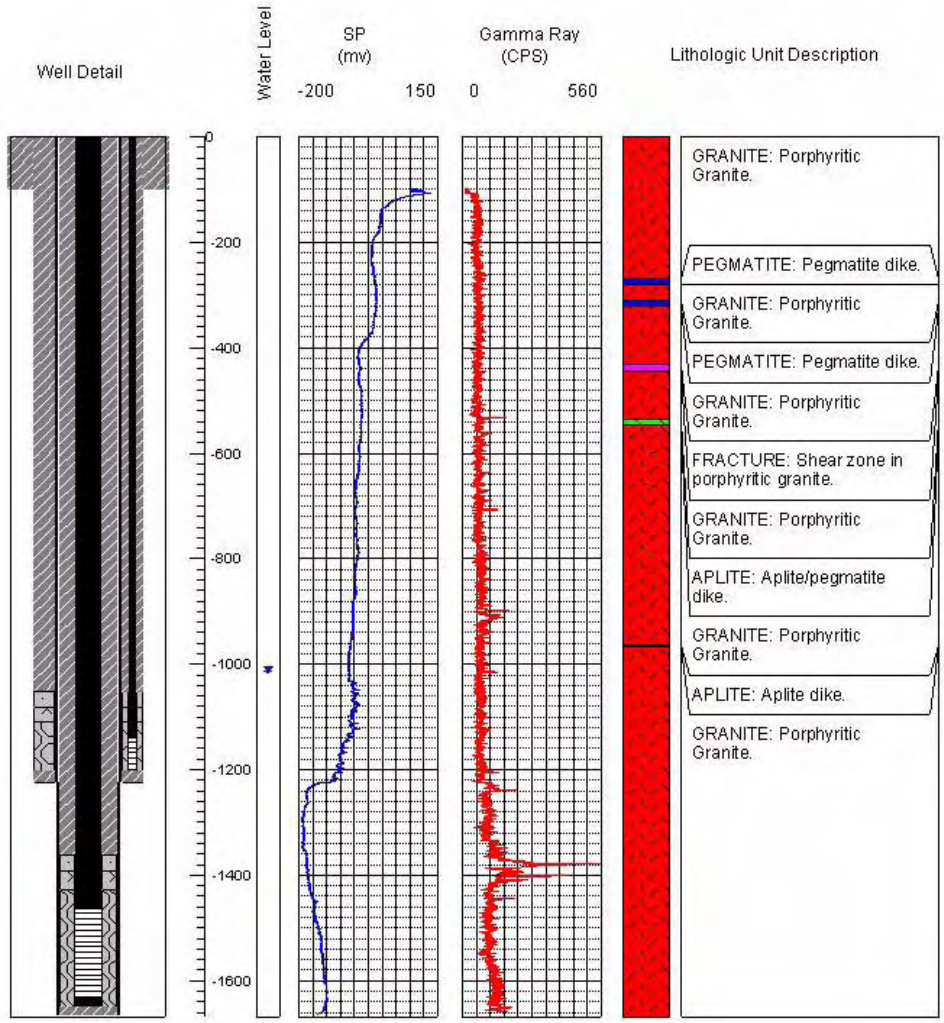



Total Depth: -1668.84 Page 1 of 1

**Log Plot B.1-3**
**Geophysical Data**
**Project Shoal Area MV-3 Density and Neutron**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Spontaneous Potential/Gamma Ray/SGR**
**Dates Logged: April 24, April 25, May2, and May 3, 2006**

**Well/Borehole Identification: MV-3**
**Surface Elevation: 1,603.41 (m) / 5,260.50 (ft)**
**Northing: 4339986.317 (m)**
**Easting: 381026.50 (m)**
**Coordinate System: UTM Zone 11**




Total Depth: -1668.84 Page 1 of 1

**Log Plot B.1-4**
**Geophysical Data**
**Project Shoal Area MV-3 Spontaneous Potential and Gamma Ray**

# Appendix C

# Project Shoal Area MV-1 Data

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**Table C.1-1**
**Project Shoal Area MV-1 Chronology**
(Page 1 of 5)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 5/6/2006 | 16:45 | 0 | Rig and equipment mobilized from MV-3 pad. |
| 5/7/2006 | 12:00 | 0 | Ready to drill at MV-1. |
| | 17:00 | 0 | SNJV safety walkdown. |
| 5/8/2006 | 11:00 | 0 | NNSA/NSO personnel on site for safety walkdown. |
| | 12:45 | 0 | Safety walkdown completed. NNSA/NSO gives OK to proceed. |
| | 12:55 | 0 | MV-1 spudded for 31-in. surface casing borehole. |
| | 17:15 | 20 | Pilot hole completed, changed over bottom hole assembly. |
| 5/10/2006 | 1:00 | 100 | Completed 31-in. surface casing borehole. |
| | 18:00 | 100 | Completed tripping out of hole, setting and cementing 24-in. CS surface casing. |
| 5/11/2006 | 1:50 | 106 | Completed setup of diverter and drilling of pilot hole. |
| | 4:45 | 106 | Started drilling final borehole with 12.45-in. hammer bit. |
| 5/12/2006 | 18:00 | 1,020 | Driller indicated hole is beginning to make water. |
| 5/13/2006 | 0:00 | 1,150 | Began trip out for bit change. |
| | 7:00 | 1,150 | Resumed drilling. |
| | 21:00 | 1,370 | Encountered fault zone from 1,358 to 1,370 ft. Conditioned borehole. |
| 5/15/2006 | 4:30 | 1,788.20 | TD borehole at 1,788.20. |
| | 9:50 | 1,788.20 | Tripped out of hole, COLOG set up for geophysical logging. |
| | 19:10 | 1,788.20 | Logging tool encountered a bridge at 1,362 ft. Rigged up to clean borehole. |

**Table C.1-1**
**Project Shoal Area MV-1 Chronology**
(Page 2 of 5)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 5/16/2006 | 2:00 | 1,788.20 | Borehole cleaned to 1,362 ft. Decision was made to log from 1,362 up while hole is clean. |
| | 5:30 | 1,788.20 | COLOG started with optical televiewer (video). |
| | 12:00 | 1,788.20 | COLOG completed video logging. Tripped in to clean/condition borehole to bottom. |
| 5/17/2006 | 4:00 | 1,788.20 | Spent four hours conditioning zone from 1,430 to 1,450 ft due to borehole erosion. No sample collected while drilling. |
| | 9:30 | 1,788.20 | Completed cleaning/conditioning to TD of 1,788.20 ft. |
| 5/17/2006 | 14:00 | 1,788.20 | Tripped out of hole, COLOG set up for geophysical logging. |
| | 16:45 | 1,788.20 | Started geophysical logging. Bottom tagged at 1,778.5 ft. |
| 5/18/2006 | 0:00 | 1,788.20 | Tagged bridge with caliper. Run log from 1,609 ft. |
| | 1:00 | 1,788.20 | Re-ran caliper log. Driller set up to trip in borehole. |
| | 15:00 | 1,788.20 | Completed trip in, cleaning, and trip out. Started geophysical logging. Bottom tagged at 1,7785 ft. |
| | 19:45 | 1,788.20 | Completed geophysical logging. Set up to install tremie pipes, piezometer, and well screen and casing. |
| 5/19/2006 | 12:00 | 1,788.20 | Completed setting well screen and casing, piezometer (1,407.08 ft), and tremie pipes. |
| 5/20/2006 | 3:15 | 1,788.20 | Completed installation of gravel pack to 1,481.0 ft. |
| | 13:15 | 1,788.20 | Completed installation of cement plug and piezometer gravel pack to 1,242 ft. Moved equipment to MV-2 pad. |
| | 20:45 | 1,788.20 | Completed cementing casing to surface. Started running HQ eductor AQ airline piping for airlift development. |
| 5/21/2006 | 6:00 | N/A | Began initial airlift development. |
| 5/22/2006 | 16:30 | N/A | Completed initial airlift development. Total gal purged 9,183. |
| | 20:15 | N/A | Completed tripping out airlift set up. |
| 5/23/2006 | 7:00 | N/A | Rig and equipment mobilized to MV-2 pad. |

# Table C.1-1
# Project Shoal Area MV-1 Chronology
(Page 3 of 5)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/2/2006 | 6:00 | N/A | Pump crew on site. Began moving from MV-3 to MV-1 for pump installation. |
| | 12:45 | N/A | Began pump set at MV-1 |
| | 18:00 | N/A | Pump/motor, 1¼-in. discharge line, and 1¼-in. instrument access run in to 900 ft. Crew off site. |
| 6/3/2006 | 6:00 | N/A | Pump crew on site. Set up to complete pump installation. |
| | 11:15 | N/A | Top flange installed. |
| | 12:45 | N/A | Started pump. Water level at 1,008.6 ft. |
| | 18:00 | N/A | MV-1 pump shut off. Purged 2,865 gal. Water level at 1,172.2 over 4.5 hours of pumping time. |
| 6/4/2006 | 6:00 | N/A | Pump crew on site. Set up to run 1-in. airlift line in MV-1 piezometer. |
| | 7:35 | N/A | Pump started at MV-1 |
| 6/4/2006 | 13:25 | N/A | Began airlift at MV-1 piezometer. |
| | 17:30 | N/A | Ceased airlift at MV-1 piezometer. Pumped in approximately 100 gal of AquaClear/water mixture. Rate 5 to 0.5 gpm. |
| | 18:00 | N/A | MV-1 pump shut off. Purged of a total of 8,560 gals. |
| 6/5/2006 | 6:15 | N/A | Pump crew on site to continue airlift of piezometer. |
| | 6:43 | N/A | Pump started at MV-1 |
| | 15:00 | N/A | Airlift surging complete. Continuous air on, producing approximately 1.5 gpm. |
| 6/6/2006 | 6:05 | N/A | Pump crew on site. Trip out 60-ft of 1-in. from piezometer. Water level at 1,275 ft in MV-1 well. |
| | 12:00 | N/A | No returns when air applied. Added 200 gal AquaClear/water mixture. Surged (1 minutes on, 3 minutes off). |
| | 12:15 | N/A | Broke down equipment and moved to MV-3 piezometer. |

**Table C.1-1**
**Project Shoal Area MV-1 Chronology**
(Page 4 of 5)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/7/2006 | 6:54 | N/A | Started pump at MV-1. Water level at 1,028.01 ft. |
| | 18:00 | N/A | MV-1 pump shut off. Water level at 1,246.91 ft. |
| 6/8/2006 | 12:00 | N/A | Move back from MV-3. Rig up to change out airlines. |
| | 12:15 | N/A | Began tripping out 1-in. airline to replace with ½-in. airline. |
| | 17:00 | N/A | Airlines switched out. Began airlifting at approximately ½ gal or less. |
| | 18:00 | N/A | Completed airlifting for the day. |
| 6/9/2006 | 7:00 | N/A | Set up to flush piezometer. |
| | 8:00 | N/A | Completed piezometer flush with 240 gal of water. Restarted airlifting. |
| | 9:15 | N/A | Airlift discharge less than ½ gpm. Shut off airlift and flush with 250 gal of water. |
| | 10:15 | N/A | Pulled one length or airline. Restart airlift. |
| | 12:15 | N/A | Shut off airlift and flushed with 250 gal of water. |
| | 13:41 | N/A | Restarted airlift. |
| | 14:00 | N/A | Completed airlifting for the day at approximately 1.2 gpm. Began tripping out ½-in. airline. |
| | 18:00 | N/A | Airline tripped out. This completed development of MV-1 piezometer. |

# Table C.1-1
# Project Shoal Area MV-1 Chronology
(Page 5 of 5)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/14/2006 | 08:15 | N/A | Start pump in MV-1 Well. |
| | 18:00 | N/A | Pump shut off. Total of 4,435.2 gal pumped. Development of well MV-1 complete. A total of approximately 32,200 gal purged during pump development. |

COLOG = Colog, Inc.
CS = Carbon steel
ft bgs = Feet below ground surface
gal = Gallon
gpm = Gallons per minute
in. = Inch
N/A = Not applicable
NNSA/NSO = U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
SNJV = Stoller-Navarro Joint Venture
TD = Total depth

# Table C.1-2
# Project Shoal Area MV-1 Well Construction Materials

| Construction | Material | Type | Interval (ft) | Stemming Material | Volume ($ft^3$) | Interval (ft) |
|---|---|---|---|---|---|---|
| Surface Casing | 24-in. CS Casing | Blank | 0 – 99.00 | Cement Seal | 218.7 | 0 – 100.00 |
| Piezometer Casing | 2.375-in. CS Flush Joint Tubing | Blank | +1.08 – 1,337.50 | Cement Seal | 1,026 | 0 – 1,242.00 |
| | | Screen | 1,337.50 – 1,397.50 | #6 Sand Pack | 105.3 | 1,242.00 – 1,308.00 |
| | | Blank w/end cap | 1,397.50 – 1,407.08 | 1/8–1/4 in. Gravel Pack | 148.5 | 1,308.00 – 1,425.00 |
| Interval Seal | N/A | | | Cement Seal | 59.4 | 1,425.00 – 1,481.00 |
| Monitoring Well Casing | 5.5-in. CS Casing (Internal Epoxy Coated) | Blank | +1.31 – 1,572.73 | See above | | |
| | | Screen | 1,572.73 – 1,726.54 | #6 Sand Pack | 59.4 | 1,481.00 – 1,545.00 |
| | | Blank w/end cap | 1,726.54 – 1,749.50 | 1/8–1/4 in. Gravel Pack | 210.6 | 1,545.00 – 1,788.20 |
| Submersible Pump | Grundfos® 10S50-58DS Pump | Top | 1,533.65 | N/A | | |
| | | Intake | 1,538.30 | N/A | | |
| | | Bottom | 1,540.20 | N/A | | |
| Pump Column | 1.25-in. CS EUE | Blank | +1.31 – 1,533.65 | N/A | | |
| Water Access Line | 1.25-in. Flush Joint Schedule 80 PVC | Blank | +1.31 – 1,491.43 | N/A | | |
| | | Screen w/end cap | 1,491.43 – 1,533.65 | N/A | | |

CS = Carbon steel
EUE = External Upset Ends
ft = Foot
$ft^3$ = Cubic foot
in. = Inch
N/A = Not applicable
PVC = Polyvinyl chloride

# Table C.1-3
# Project Shoal Area MV-1 Geophyiscal Data Collected

| Geophysical Tool | Run Date | Top of Interval (ft bgs) | Bottom of Interval (ft bgs) | Interval (ft) | Contractor |
|---|---|---|---|---|---|
| **Phase I** | | | | | |
| Caliper | 5/18/2006 | 100 | 1,396.0 | 1,296.0 | COLOG |
| Natural Gamma | 5/17/2006 | 993 | 1,772.0 | 779.0 | |
| Spontaneous Potential | 5/17/2006 | 996 | 1,775.0 | 779.0 | |
| Deviation Survey | 5/18/2006 | 100 | 1,784.5 | 1,684.5 | |
| Resistivity (Single point, 16-in., and 64-in.) | 5/17/2006 | 996 | 1,775.0 | 779.0 | |
| Temperature and Differential Temperature | 5/17/2006 | 994 | 1,778.0 | 784.0 | |
| Sonic Velocity | 5/17/2006 | 1,003 | 1,778.0 | 775.0 | |
| Optical Televiewer/Video | 5/16/2006 | 100 | 1,353.0 | 1,253.0 | |
| Acoustic Televiewer | 5/18/2006 | 1,289 | 1,784.5 | 495.5 | |
| **Phase II** | | | | | |
| Nuclear Annulus Investigation Log | 5/19/2006 | 100 | 1,753.0 | 1,653.0 | COLOG |
| Deviation | 5/20/2006 | 100 | 1,753.0 | 1,653.0 | |

COLOG = Colog, Inc.
ft bgs = Feet below ground surface
in. = Inch

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 1 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/8/2006 | 16:00 | 14 | 9.91E+02 | 9.37E+02 |
| 5/8/2006 | 18:00 | 14 | 8.11E+02 | 9.35E+02 |
| 5/8/2006 | 20:00 | 14 | 1.80E+03 | 9.72E+02 |
| 5/8/2006 | 22:00 | 14 | -7.21E+02 | 9.14E+02 |
| 5/9/2006 | 0:00 | 14 | -2.79E+03 | 8.77E+02 |
| 5/9/2006 | 2:00 | 49 | -9.01E+02 | 9.13E+02 |
| 5/9/2006 | 4:00 | 51 | -1.17E+03 | 9.22E+02 |
| 5/9/2006 | 6:00 | 55 | -1.35E+03 | 9.11E+02 |
| 5/9/2006 | 8:00 | 63 | -1.35E+03 | 9.03E+02 |
| 5/9/2006 | 10:00 | 69 | -1.80E+02 | 9.37E+02 |
| 5/9/2006 | 12:00 | 75 | 9.01E+01 | 8.97E+02 |
| 5/9/2006 | 14:00 | 78 | 5.41E+02 | 9.14E+02 |
| 5/9/2006 | 16:00 | 86 | 9.91E+02 | 9.23E+02 |
| 5/9/2006 | 18:00 | 90 | 7.21E+02 | 9.16E+02 |
| 5/9/2006 | 20:00 | 94 | 1.80E+02 | 9.17E+02 |
| 5/9/2006 | 22:00 | 101 | 9.01E+01 | 9.27E+02 |
| 5/10/2006 | 0:00 | 95 | 6.31E+02 | 9.04E+02 |
| 5/10/2006 | 2:00 | 99 | -1.44E+03 | 8.82E+02 |
| 5/11/2006 | 6:00 | 130 | 3.24E+03 | 9.78E+02 |
| 5/11/2006 | 8:00 | 170 | 0.00E+00 | 9.12E+02 |
| 5/11/2006 | 10:00 | 250 | 6.31E+02 | 9.39E+02 |
| 5/11/2006 | 13:00 | 330 | 1.35E+03 | 9.67E+02 |
| 5/11/2006 | 14:00 | 364 | 0.00E+00 | 9.02E+02 |
| 5/11/2006 | 15:00 | 376 | 1.26E+03 | 9.47E+02 |
| 5/11/2006 | 16:00 | 428 | 5.41E+02 | 9.02E+02 |
| 5/11/2006 | 17:00 | 463 | -9.01E+01 | 9.12E+02 |
| 5/11/2006 | 17:30 | 478 | 4.51E+02 | 9.49E+02 |

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 2 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/11/2006 | 18:00 | 488 | -9.01E+01 | 9.05E+02 |
| 5/11/2006 | 18:50 | 505 | 2.07E+03 | 9.60E+02 |
| 5/11/2006 | 19:30 | 517 | -2.70E+02 | 9.10E+02 |
| 5/11/2006 | 19:42 | 528 | 4.51E+02 | 9.34E+02 |
| 5/11/2006 | 20:15 | 547 | 9.01E+02 | 9.50E+02 |
| 5/11/2006 | 20:41 | 564 | 1.08E+03 | 9.52E+02 |
| 5/11/2006 | 21:42 | 583 | 1.08E+03 | 9.45E+02 |
| 5/11/2006 | 22:20 | 603 | 9.01E+01 | 9.07E+02 |
| 5/12/2006 | 0:00 | 610 | 9.91E+02 | 9.16E+02 |
| 5/12/2006 | 1:35 | 630 | 1.08E+03 | 9.21E+02 |
| 5/12/2006 | 2:10 | 650 | 0.00E+00 | 8.93E+02 |
| 5/12/2006 | 3:00 | 670 | 1.80E+02 | 8.88E+02 |
| 5/12/2006 | 3:25 | 690 | 1.53E+03 | 9.16E+02 |
| 5/12/2006 | 4:00 | 710 | 1.44E+03 | 9.56E+02 |
| 5/12/2006 | 5:10 | 730 | 1.26E+03 | 9.09E+02 |
| 5/12/2006 | 6:00 | 750 | 6.31E+02 | 9.19E+02 |
| 5/12/2006 | 6:35 | 770 | 3.60E+02 | 9.05E+02 |
| 5/12/2006 | 7:15 | 790 | -9.01E+01 | 8.95E+02 |
| 5/12/2006 | 7:35 | 810 | 0.00E+00 | 9.08E+02 |
| 5/12/2006 | 8:05 | 830 | 1.80E+02 | 8.95E+02 |
| 5/12/2006 | 9:25 | 850 | 5.41E+02 | 9.31E+02 |
| 5/12/2006 | 10:15 | 870 | 8.11E+02 | 9.37E+02 |
| 5/12/2006 | 12:00 | 900 | -2.25E+03 | 9.13E+02 |
| 5/12/2006 | 13:00 | 927 | -1.08E+03 | 9.39E+02 |
| 5/12/2006 | 14:00 | 951 | -1.26E+03 | 9.29E+02 |
| 5/12/2006 | 15:00 | 969 | -9.01E+02 | 9.34E+02 |
| 5/12/2006 | 16:00 | 989 | -1.62E+03 | 9.25E+02 |

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 3 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/12/2006 | 17:00 | 1,009 | -2.70E+02 | 9.83E+02 |
| 5/12/2006 | 18:00 | 1,029 | -1.35E+03 | 9.40E+02 |
| 5/12/2006 | 19:00 | 1,051 | -2.43E+03 | 8.95E+02 |
| 5/12/2006 | 20:00 | 1,070 | -5.41E+02 | 9.61E+02 |
| 5/12/2006 | 21:00 | 1,101 | -6.31E+02 | 9.41E+02 |
| 5/12/2006 | 22:00 | 1,117 | -7.21E+02 | 9.59E+02 |
| 5/12/2006 | 23:00 | 1,147 | -4.51E+02 | 9.58E+02 |
| 5/13/2006 | 8:00 | 1,170 | 7.21E+02 | 9.24E+02 |
| 5/13/2006 | 9:00 | 1,190 | 2.70E+02 | 9.07E+02 |
| 5/13/2006 | 10:00 | 1,210 | 1.17E+03 | 9.41E+02 |
| 5/13/2006 | 11:00 | 1,230 | 4.51E+02 | 9.09E+02 |
| 5/13/2006 | 12:00 | 1,251 | 8.11E+02 | 9.56E+02 |
| 5/13/2006 | 13:00 | 1,270 | -5.41E+02 | 9.14E+02 |
| 5/13/2006 | 14:00 | 1,286 | -1.08E+03 | 9.00E+02 |
| 5/13/2006 | 15:00 | 1,310 | -8.11E+02 | 9.23E+02 |
| 5/13/2006 | 16:00 | 1,323 | -1.08E+03 | 9.00E+02 |
| 5/13/2006 | 17:00 | 1,355 | -7.21E+02 | 9.20E+02 |
| 5/13/2006 | 18:00 | 1,370 | -9.01E+01 | 9.62E+02 |
| 5/13/2006 | 19:00 | 1,370 | -9.91E+02 | 9.37E+02 |
| 5/13/2006 | 20:00 | 1,370 | -8.11E+02 | 9.15E+02 |
| 5/13/2006 | 21:00 | 1,400 | -6.31E+02 | 9.17E+02 |
| 5/13/2006 | 22:00 | 1,410 | 7.21E+02 | 9.44E+02 |
| 5/13/2006 | 23:00 | 1,430 | 3.60E+02 | 9.48E+02 |
| 5/14/2006 | 0:00 | 1,450 | 1.80E+02 | 8.98E+02 |
| 5/14/2006 | 1:30 | 1,470 | 1.26E+03 | 9.33E+02 |
| 5/14/2006 | 2:30 | 1,490 | 9.01E+02 | 9.07E+02 |
| 5/14/2006 | 3:45 | 1,510 | 2.70E+02 | 8.95E+02 |

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 4 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/14/2006 | 6:00 | 1,530 | 9.01E+02 | 9.21E+02 |
| 5/14/2006 | 7:00 | 1,550 | 4.51E+02 | 9.05E+02 |
| 5/14/2006 | 8:30 | 1,570 | 8.11E+02 | 9.09E+02 |
| 5/14/2006 | 10:00 | 1,590 | 8.11E+02 | 9.09E+02 |
| 5/14/2006 | 12:00 | 1,630 | -1.80E+02 | 9.28E+02 |
| 5/14/2006 | 13:00 | 1,634 | -4.51E+02 | 8.97E+02 |
| 5/14/2006 | 14:00 | 1,646 | 4.51E+02 | 9.16E+02 |
| 5/14/2006 | 15:00 | 1,665 | -7.21E+02 | 8.98E+02 |
| 5/14/2006 | 16:00 | 1,670 | -9.01E+01 | 9.25E+02 |
| 5/14/2006 | 17:00 | 1,675 | 2.70E+02 | 9.14E+02 |
| 5/14/2006 | 18:00 | 1,690 | 2.70E+02 | 9.29E+02 |
| 5/14/2006 | 19:00 | 1,708 | 8.11E+02 | 9.28E+02 |
| 5/14/2006 | 20:00 | 1,710 | -1.80E+02 | 9.12E+02 |
| 5/14/2006 | 21:00 | 1,727 | 4.51E+02 | 9.24E+02 |
| 5/14/2006 | 22:00 | 1,735 | 4.51E+02 | 9.16E+02 |
| 5/14/2006 | 23:00 | 1,750 | 1.08E+03 | 9.50E+02 |
| 5/15/2006 | 1:30 | 1,765 | -1.98E+03 | 9.02E+02 |
| 5/15/2006 | 3:45 | 1,780 | -1.08E+03 | 9.29E+02 |
| Airlift Development | | | | |
| 5/21/2006 | 6:00 | WD | 1.35E+03 | 9.49E+02 |
| 5/21/2006 | 8:00 | WD | 6.31E+02 | 9.17E+02 |
| 5/21/2006 | 9:00 | WD | 1.08E+03 | 9.12E+02 |
| 5/21/2006 | 10:00 | WD | 1.26E+03 | 9.29E+02 |
| 5/21/2006 | 11:00 | WD | 1.08E+03 | 9.12E+02 |
| 5/21/2006 | 12:00 | WD | -1.35E+03 | 9.18E+02 |
| 5/21/2006 | 13:00 | WD | -1.71E+03 | 8.89E+02 |
| 5/21/2006 | 14:00 | WD | -1.62E+03 | 8.78E+02 |

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 5 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Airlift Development | | | | |
| 5/21/2006 | 15:00 | WD | -9.91E+02 | 9.14E+02 |
| 5/21/2006 | 16:05 | WD | -1.26E+03 | 9.32E+02 |
| 5/21/2006 | 17:00 | WD | -5.41E+02 | 9.23E+02 |
| 5/21/2006 | 18:00 | WD | -1.35E+03 | 8.93E+02 |
| 5/21/2006 | 19:00 | WD | -2.34E+03 | 8.85E+02 |
| 5/21/2006 | 20:00 | WD | -1.53E+03 | 9.08E+02 |
| 5/21/2006 | 21:00 | WD | -1.08E+03 | 9.01E+02 |
| 5/21/2006 | 22:08 | WD | 9.01E+01 | 9.27E+02 |
| 5/21/2006 | 23:00 | WD | 1.35E+03 | 9.49E+02 |
| 5/22/2006 | 0:00 | WD | 1.08E+03 | 9.19E+02 |
| 5/22/2006 | 1:00 | WD | 1.35E+03 | 9.69E+02 |
| 5/22/2006 | 2:00 | WD | -5.41E+02 | 8.90E+02 |
| 5/22/2006 | 3:15 | WD | 6.31E+02 | 9.54E+02 |
| 5/22/2006 | 4:00 | WD | -1.80E+02 | 9.17E+02 |
| 5/22/2006 | 4:45 | WD | -2.70E+02 | 9.20E+02 |
| 5/22/2006 | 5:15 | WD | -4.51E+02 | 9.02E+02 |
| 5/22/2006 | 7:00 | WD | 2.70E+02 | 9.19E+02 |
| 5/22/2006 | 8:30 | WD | 1.80E+02 | 9.29E+02 |
| 5/22/2006 | 9:30 | WD | 1.08E+03 | 9.33E+02 |
| 5/22/2006 | 10:00 | WD | 9.91E+02 | 9.43E+02 |
| 5/22/2006 | 10:45 | WD | 1.80E+03 | 9.78E+02 |
| 5/22/2006 | 12:00 | WD | -1.26E+03 | 9.02E+02 |
| 5/22/2006 | 13:00 | WD | -6.31E+02 | 9.14E+02 |
| 5/22/2006 | 14:00 | WD | -3.60E+02 | 9.29E+02 |
| 5/22/2006 | 15:00 | WD | -1.62E+03 | 8.98E+02 |
| 5/22/2006 | 16:00 | WD | -1.53E+03 | 8.55E+02 |
| 5/22/2006 | 16:30 | WD | -9.01E+02 | 8.99E+02 |

# Table C.1-4
## Project Shoal Area MV-1 Tritium Results
(Page 6 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Pump Development | | | | |
| 6/3/2006 | 12:50 | WD | 1.08E+03 | 9.97E+02 |
| 6/3/2006 | 16:00 | WD | 9.91E+02 | 9.51E+02 |
| 6/3/2006 | 17:40 | WD | 1.80E+02 | 8.93E+02 |
| 6/4/2006 | 7:45 | WD | 4.51E+02 | 9.41E+02 |
| 6/4/2006 | 9:45 | WD | -4.51E+02 | 9.39E+02 |
| 6/4/2006 | 13:55 | WD | 9.01E+01 | 9.07E+02 |
| 6/4/2006 | 18:01 | WD | -1.08E+03 | 8.95E+02 |
| 6/5/2006 | 9:40 | WD | -2.70E+02 | 9.14E+02 |
| 6/5/2006 | 10:48 | WD | -9.01E+01 | 9.55E+02 |
| 6/5/2006 | 13:00 | WD | -2.70E+02 | 9.28E+02 |
| 6/5/2006 | 17:30 | WD | -7.21E+02 | 8.98E+02 |
| 6/6/2006 | 12:00 | WD | -1.53E+03 | 9.10E+02 |
| 6/7/2006 | 1:36 | WD | -1.89E+03 | 8.98E+02 |
| 6/7/2006 | 5:50 | WD | -1.98E+03 | 8.93E+02 |
| 6/7/2006 | 10:37 | WD | -2.70E+02 | 9.49E+02 |
| 6/7/2006 | 12:00 | WD | -1.80E+02 | 9.09E+02 |
| 6/7/2006 | 14:15 | WD | 2.70E+02 | 9.47E+02 |
| 6/13/2006 | 8:30 | WD | -9.01E+01 | 9.24E+02 |
| 6/13/2006 | 12:00 | WD | -3.60E+02 | 9.24E+02 |
| 6/14/2006 | 6:00 | WD | 9.01E+01 | 9.24E+02 |
| 6/14/2006 | 12:00 | WD | -9.01E+01 | 9.00E+02 |
| 6/14/2006 | 17:00 | WD | 3.60E+02 | 9.16E+02 |

ft = Foot
pCi/L = Picocuries per liter
WD = Well Development

# Table C.1-5
## Project Shoal Area MV-1 Water Quality Parameter Results
(Page 1 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Drilling | | | | | | |
| 5/8/2006 | 16:00 | 14 | 9.36 | 21.7 | 3,040.0 | 29.30 |
| 5/9/2006 | 0:00 | 45 | 10.07 | 18.1 | 2,700.0 | 23.80 |
| 5/9/2006 | 12:00 | 75 | 9.38 | 20.4 | 2,353.0 | 26.90 |
| 5/10/2006 | 0:00 | 95 | 8.16 | 23.1 | 2,141.0 | 26.10 |
| 5/11/2006 | 6:00 | 130 | 11.80 | 21.0 | 3,081.0 | 25.80 |
| 5/11/2006 | 12:00 | 330 | 9.21 | 21.8 | 1,165.0 | 28.40 |
| 5/12/2006 | 0:00 | 610 | 9.28 | 21.0 | 2,996.0 | 23.00 |
| 5/12/2006 | 12:00 | 1,251 | 8.65 | 21.5 | 604.0 | 26.80 |
| 5/13/2006 | 8:00 | 1,170 | 7.47 | 18.8 | 632.0 | 14.80 |
| 5/13/2006 | 12:00 | 1,251 | 8.01 | 23.7 | 673.0 | 12.00 |
| 5/14/2006 | 0:00 | 1,450 | 6.38 | 19.2 | 609.0 | 21.40 |
| 5/14/2006 | 12:00 | 1,630 | 7.99 | 20.6 | 646.0 | 3.34 |
| 5/15/2006 | 1:30 | 1,765 | 6.40 | 20.6 | 380.0 | 9.30 |
| Airlift Development | | | | | | |
| 5/21/2006 | 6:00 | WD | 8.01 | 21.2 | 850.0 | 20.70 |
| 5/21/2006 | 8:00 | WD | 7.86 | 21.1 | 831.0 | 15.10 |
| 5/21/2006 | 9:00 | WD | 8.28 | 21.7 | 927.0 | 13.30 |
| 5/21/2006 | 10:00 | WD | 8.27 | 21.5 | 845.0 | 10.80 |
| 5/21/2006 | 11:00 | WD | 8.21 | 21.4 | 812.0 | 8.83 |
| 5/21/2006 | 12:00 | WD | 8.18 | 20.1 | 794.0 | 11.60 |
| 5/21/2006 | 13:00 | WD | 8.30 | 20.5 | 800.0 | 9.41 |
| 5/21/2006 | 14:00 | WD | 8.33 | 20.5 | 899.0 | 12.10 |
| 5/21/2006 | 15:00 | WD | 8.23 | 20.3 | 796.0 | 9.23 |
| 5/21/2006 | 16:00 | WD | 8.25 | 23.4 | 808.0 | 10.70 |
| 5/21/2006 | 17:00 | WD | 8.49 | 21.3 | 965.0 | 19.80 |
| 5/21/2006 | 18:00 | WD | 8.31 | 20.5 | 668.0 | 19.20 |
| 5/21/2006 | 19:00 | WD | 8.29 | 20.5 | 639.0 | 18.00 |

**Table C.1-5**
**Project Shoal Area MV-1 Water Quality Parameter Results**
(Page 2 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Airlift Development | | | | | | |
| 5/21/2006 | 20:00 | WD | 8.25 | 20.0 | 606.0 | 21.10 |
| 5/21/2006 | 21:00 | WD | 8.23 | 20.5 | 639.0 | 17.40 |
| 5/21/2006 | 22:00 | WD | 8.18 | 18.9 | 633.0 | 16.80 |
| 5/21/2006 | 23:00 | WD | 8.18 | 18.6 | 722.0 | 8.15 |
| 5/22/2006 | 0:00 | WD | 8.07 | 20.4 | 731.0 | 4.62 |
| 5/22/2006 | 1:00 | WD | 8.27 | 20.5 | 744.0 | 6.86 |
| 5/22/2006 | 2:00 | WD | 8.24 | 19.8 | 722.0 | 6.56 |
| 5/22/2006 | 3:00 | WD | 8.28 | 20.5 | 720.0 | 3.79 |
| 5/22/2006 | 4:00 | WD | 8.26 | 19.7 | 716.0 | 4.56 |
| 5/22/2006 | 4:45 | WD | 8.24 | 18.0 | 718.0 | 4.22 |
| 5/22/2006 | 5:15 | WD | 8.22 | 16.6 | 713.0 | 4.02 |
| 5/22/2006 | 7:00 | WD | 8.26 | 18.7 | 726.0 | 3.84 |
| 5/22/2006 | 8:30 | WD | 8.25 | 19.7 | 698.0 | 4.74 |
| 5/22/2006 | 9:30 | WD | 8.26 | 18.4 | 714.0 | 4.35 |
| 5/22/2006 | 10:00 | WD | 8.25 | 19.3 | 709.0 | 3.96 |
| 5/22/2006 | 10:45 | WD | 8.24 | 19.0 | 712.0 | 3.93 |
| 5/22/2006 | 12:00 | WD | 8.27 | 19.4 | 700.0 | 5.08 |
| 5/22/2006 | 13:00 | WD | 8.24 | 18.3 | 700.0 | 4.33 |
| 5/22/2006 | 14:00 | WD | 8.44 | 20.4 | 700.0 | 4.86 |
| 5/22/2006 | 15:00 | WD | 8.38 | 20.1 | 700.0 | 4.97 |
| 5/22/2006 | 16:00 | WD | 8.26 | 18.0 | 700.0 | 4.82 |
| 5/22/2006 | 16:30 | WD | 8.23 | 18.4 | 700.0 | 3.67 |
| 5/22/2006 | 18:23 | WD | 8.46 | 20.4 | 716.0 | NA |
| 5/22/2006 | 18:25 | WD | 8.23 | 19.6 | 708.0 | NA |
| 5/22/2006 | 18:27 | WD | 8.14 | 19.5 | 1,216.0 | NA |

# Table C.1-5
## Project Shoal Area MV-1 Water Quality Parameter Results
(Page 3 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Pump Development | | | | | | |
| 6/3/2006 | 12:50 | WD | 7.25 | 22.0 | 573.0 | 17.50 |
| 6/3/2006 | 16:00 | WD | 7.15 | 22.1 | 751.0 | 4.29 |
| 6/3/2006 | 17:30 | WD | 7.38 | 23.5 | 726.0 | 3.59 |
| 6/4/2006 | 9:45 | WD | 7.57 | 22.1 | 651.0 | 3.07 |
| 6/4/2006 | 13:55 | WD | 7.45 | 23.0 | 684.0 | 2.38 |
| 6/4/2006 | 18:01 | WD | 7.02 | 24.4 | 685.0 | 1.55 |
| 6/4/2006 | 19:45 | WD | 7.04 | 21.2 | 611.0 | 2.16 |
| 6/5/2006 | 9:40 | WD | 7.44 | 23.2 | 350.0 | 0.62 |
| 6/5/2006 | 10:48 | WD | 7.36 | 22.2 | 634.0 | 0.30 |
| 6/5/2006 | 13:00 | WD | 7.88 | 22.6 | 679.0 | 2.10 |
| 6/5/2006 | 17:30 | WD | 7.67 | 23.0 | 672.0 | 2.05 |
| 6/6/2006 | 12:00 | WD | 7.68 | 25.1 | 664.0 | 2.30 |
| 6/7/2006 | 1:36 | WD | 7.16 | 21.7 | 648.0 | 9.25 |
| 6/7/2006 | 5:50 | WD | 7.45 | 21.0 | 598.0 | 7.37 |
| 6/7/2006 | 10:37 | WD | 7.36 | 22.8 | 624.0 | 5.88 |
| 6/7/2006 | 12:00 | WD | 7.70 | 23.1 | 668.0 | 1.76 |
| 6/7/2006 | 14:15 | WD | 7.94 | 23.6 | 663.0 | 1.69 |
| 6/14/06 | 06:00 | WD | NA | 25.0 | NA | 1.72 |
| 6/14/06 | 12:00 | WD | NA | 25.2 | NA | 1.35 |
| 6/14/06 | 17:00 | WD | NA | 25.2 | NA | 1.09 |

$Br^-$ = Bromide
°C = Degrees Celsius
ft = Foot
mg/L = Milligrams per liter
NA = Not analyzed
SU = Standard unit
WD = Well Development
µS/cm = Microsiemens per centimeter

# MV-1 Lithologic Log

The following lithologic description for borehole MV-1 was produced using the geophysical logs and borehole cutting samples. The caliper log was used from 99 to 1,390 ft. The SP, resistivity, natural gamma, and sonic velocity logs were used from 1,000 to 1,772 ft. The acoustic televiewer log was used from 1,300 to 1,785 ft. The bottom 20 ft of the borehole was not logged due to the configuration of the downhole geophysical logging tools. Depths are reported as ft because this is the standard used by the drillers and by the geophysical loggers. Colors were determined using the Munsell® Classification System.

| Depth (ft) | Lithology |
|---|---|
| 0 – 15 | Fill dirt (dark yellowish brown 10YR 6/6) from drill pad construction mixed with alluvium (grayish orange 10YR 7/4) derived from weathered porphyritic granite, very light gray (N8) to very pale orange (10YR 8/2). |
| 15 – 97 | Porphyritic granite, very light gray (N8) to light gray (N7); euhedral to subhedral phenocrysts of microcline (> 1 cm in cutting samples, up to 2 cm in adjacent surface exposures) in a medium to coarsely crystalline subhedral groundmass of plagioclase, microcline, quartz, and biotite, 1 to 5 mm in size; plagioclase = 40-45%, microcline = 35-40%, quartz = 15%, biotite = 3-5%, trace hornblende, trace sphene, trace magnetite; alteration is confined to very minor iron staining and slight oxidation of biotite, and local hematite halos surrounding some biotite and magnetite crystals. |
| 97 – 99 | Porphyritic granite; with clay gouge-filled fractures.<br>**Note:** 29-in. diameter surface casing set to a depth of 99 ft. The drill cuttings from 99 to 170 ft are contaminated with cement from drilling out the plug at the base of the surface casing. |
| 99 – 140 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); similar to above, but without oxidized biotite crystals. |
| 140 – 200 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1) to light greenish gray (5G 8/1); minor propylitic alteration, and very minor iron oxide staining. |
| 200 – 256 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); minor iron oxide staining, and very minor propylitic alteration. |
| 256 – 266 | Porphyritic granite, light gray (N7) to pale greenish gray (5G 7/1); fracture zone; with significant propylitic alteration including incipient alteration of biotite crystals to chlorite, and minor iron oxide staining. Caliper log shows out-of-gage hole in this interval. |

| | |
|---|---|
| 266 – 300 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); with incipient propylitic alteration (minor alteration of biotite crystals to chlorite), and some iron oxide staining. |
| 300 – 322 | Porphyritic granite, very light gray (N8); no alteration. |
| 322 – 354 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); minor fractures; iron oxide staining increases downward to 350 ft. |
| 354 – 390 | Porphyritic granite, very light gray (N8); decreasing iron oxide staining down to 390 ft, with some isolated traces of propylitic alteration. |
| 390 – 412 | Porphyritic granite; no alteration. |
| 412 – 418 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); with some fractures; iron oxide staining and propylitic alteration. |
| 418 – 430 | Porphyritic granite; with few fractures; some iron oxide staining. |
| 430 – 508 | Porphyritic granite; with minor fractures; very minor iron oxide staining. |
| 508 – 524 | Porphyritic granite, very light gray (N8) to yellowish gray (5Y 8/1); with fractures; iron oxide staining and very minor propylitic alteration. |
| 524 – 546 | Porphyritic granite; significantly fractured; with iron oxide staining and minor propylitic alteration. The caliper log shows out-of-gage hole in two locations within this interval. |
| 546 – 588 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); with minor fractures; iron oxide staining and very minor propylitic alteration. |
| 588 – 610 | Porphyritic granite, very light gray (N8); no alteration. |
| 610 – 628 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1) to light greenish gray (5G 8/1); with minor fractures; propylitic alteration and some iron oxide staining. |
| 628 - 695 | Porphyritic granite, very light gray (N8) to pinkish gray 5YR 8/1); with minor fractures; minor iron oxide staining. |
| 695 – 731 | Porphyritic granite, very light gray (N8); no fractures; no alteration. |
| 731 – 748 | Porphyritic granite; minor fractures; some iron oxide staining. |
| 748 – 760 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4); minor fractures; some propylitic alteration, some iron oxide staining. |
| 760 – 768 | Porphyritic granite; minor fractures; some iron oxide staining. |
| 768 – 778 | Porphyritic granite, very light gray (N8); no fractures; no alteration. |
| 778 – 806 | Porphyritic granite, very light gray (N8) to very pale orange (10YR 8/2); minor fractures; iron oxide staining and some argillic alteration (alteration of feldspar crystals to clay). |

| | |
|---|---|
| 806 – 818 | Porphyritic granite, very light gray (N8); no fractures; no alteration. |
| 818 – 846 | Porphyritic granite, very light gray (N8) to very pale orange (10YR 8/2) to light greenish gray (5G 8/1); iron oxide staining. |
| 846 – 868 | Porphyritic granite; propylitic alteration and iron oxide staining. |
| 868 – 885 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1); some iron oxide staining. |
| 885 – 890 | Porphyritic granite; minor propylitic alteration and minor iron oxide staining. |
| 890 – 900 | Porphyritic granite; with minor iron oxide staining. |
| 900 – 930 | Porphyritic granite, very light gray (N8) to light gray (N7) to greenish gray (5G 6/1); with some open fractures (samples exhibited mineral-coated fracture surfaces, and there was lost circulation around 928); extensive propylitic alteration with minor disseminated pyrite, minor iron oxide staining. The caliper log shows one location with slightly out-of-gage hole within this interval. |
| 930 – 960 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1) to pale yellowish orange (10YR 8/6); iron oxide staining and minor propylitic alteration. |
| 960 – 1,011 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1) to grayish orange (10YR 7/4); propylitic alteration (includes first appearance of small epidote crystals), iron oxide staining, minor argillic alteration of feldspar crystals. |
| 1,011 – 1,028 | Porphyritic granite, light gray (N7) to grayish orange (10YR 7/4); some fractures; iron oxide staining and some propylitic alteration. The static water table was encountered within this interval as the borehole started producing water. |
| 1,028 – 1,048 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1); significant propylitic alteration and some iron oxide staining. |
| 1,048 – 1,056 | Porphyritic granite, very light gray (N8) to grayish pink (5R 8/2); some iron oxide staining and minor propylitic alteration. |
| 1,056 – 1,090 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1); few fractures; some iron oxide staining. |
| 1,090 – 1,100 | Porphyritic granite, light gray (N7) to grayish pink (5R 8/2) to yellowish gray (5Y 8/1); fractured; some iron oxide staining, and minor propylitic alteration. The caliper log indicates an out-of gage hole in this interval, the geophysical log indicates low resistivity, and the sonic velocity log indicates fractured rock for this interval. |
| 1,100 – 1,173 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1) to grayish orange (10YR 7/4); with some fractures; some iron oxide staining and minor propylitic alteration. |
| 1,173 – 1,190 | Porphyritic granite, very light gray (N8) to grayish pink (5R 8/2); minor fractures; pervasive propylitic alteration and some iron oxide staining. |

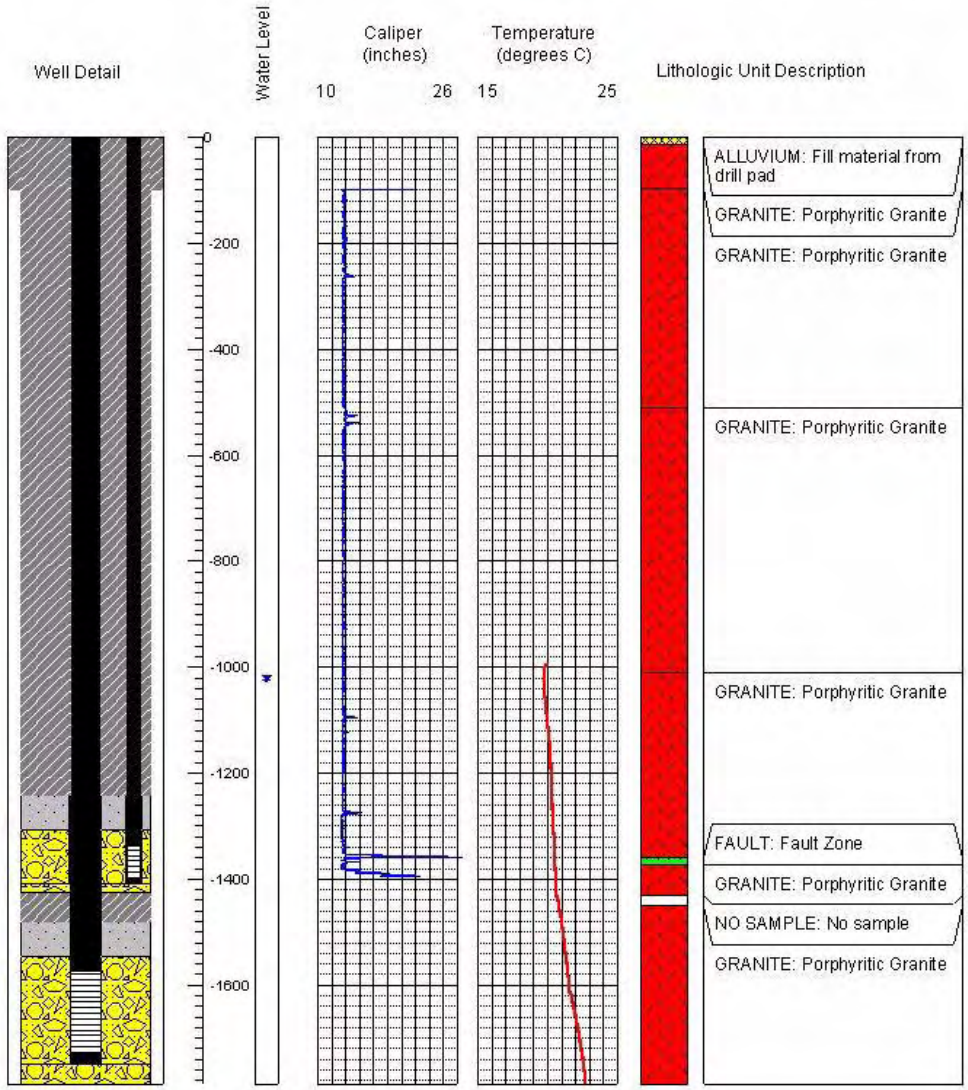
| | |
|---|---|
| 1,190 – 1,228 | Porphyritic granite, very light gray (N8) to grayish pink (5R 8/2) to greenish gray (5G 6/1); minor fractures; minor propylitic alteration and minor iron oxide staining. |
| 1,228 – 1,270 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1); minor fractures; pervasive propylitic alteration characterized by some disseminated pyrite, and minor iron oxide staining. |
| 1,270 – 1,278 | Porphyritic granite; fracture zone; pervasive propylitic alteration with disseminated pyrite, and minor iron oxide staining. The caliper log shows an out-of-gage hole in this interval, and the sonic velocity log shows some fractured rock. |
| 1,278 – 1,352 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1); fractures increase downward from 1,300 to 1,352 ft; pervasive propylitic alteration with increasing amounts of disseminated sulfides (includes pyrite and chalcopyrite). Sulfide content is highest between 1,310 and 1,350 ft. Sonic velocity log shows increasingly fractured rock from 1,320 ft down to 1,352 ft, and the acoustic televiewer shows increasing numbers of high-angle fractures from 1,305 ft down to 1,352 ft. |
| 1,352 – 1,372 | FAULT ZONE; 80% very light gray (N8) clay gouge and 20% subrounded to subangular clasts of pale greenish gray (5G 7/1) porphyritic granite from the fault breccia. The caliper log shows the hole is way out-of-gage in this interval, the sonic velocity log shows large voids and shattered rock throughout this interval, and the resistivity log shows extremely low resistivity. Abnormally high peaks above background in the natural gamma log throughout this interval indicate very high clay content. |
| 1,372 – 1,424 | Porphyritic granite in fault zone; pervasively fractured and locally brecciated; propylitic alteration (biotite completely altered to chlorite) with very sparse sulfides, possible sericitic alteration (feldspars altered to white mica). |
| 1,424 – 1,436 | FAULT ZONE; lost circulation and no return of cuttings. The sonic velocity log reveals an out-of-gage borehole with massively fractured rock in this interval, and the natural gamma log shows anomalously high counts that indicates a high clay content. |
| 1,436 – 1,485 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to grayish orange pink (5YR 7/2); extensively fractured, fracturing diminishes downward; extensive propylitic alteration without disseminated sulfides, and argillic alteration. |
| 1,485 – 1,500 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) and some grayish orange pink (5YR 7/2); with many fractures; extensive propylitic alteration without disseminated sulfides, argillic alteration, and minor iron oxide staining (from oxidation of hematite crystals). |

| | |
|---|---|
| 1,500 – 1,512 | Porphyritic granite, very light gray (N8) to very light brownish gray (5YR 7/1); with some prominent fractures; some propylitic alteration with sparse disseminated sulfides, some local iron oxide staining, minor argillic alteration. |
| 1,512 – 1,532 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1) and some very light brownish gray (5YR 7/1); with minor fractures; increasing propylitic and argillic alteration, no iron oxide staining. |
| 1,532 – 1,545 | Porphyritic granite, light gray (N7) to medium gray (N5) to greenish gray (5G 6/1); no fractures; extensive propylitic with sparse disseminated sulfides, and minor argillic alteration, and minor iron staining. |
| 1,545 – 1,602 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1 to greenish gray (5G 6/1); with minor low- and high-angle fractures; extensive propylitic alteration with sparse disseminated sulfides, minor argillic alteration, and minor iron staining. |
| 1,602 – 1,615 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1) to very light brownish gray (5YR 7/1); with major clay-filled fractures and fractures with possible open apertures; extensive propylitic alteration with disseminated sulfides (predominantly pyrite but some chalcopyrite), some sericitic alteration, very minor iron oxide staining, some specular hematite. The sonic velocity log shows an out-of-gage hole and much fractured rock within this interval, and the resistivity log shows low resistivity. |
| 1,615 – 1,625 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1); with some low-angle fractures; extensive propylitic alteration with disseminated sulfides, minor argillic alteration. |
| 1,625 – 1,630 | Porphyritic granite, with clay gouge-filled fractures; extensive propylitic alteration with disseminated sulfides, minor argillic alteration. The sonic velocity log indicates an out-of-gage hole and much fractured rock, and the resistivity log records low resistivity in this interval. |
| 1,630 – 1,655 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1) to very light brownish gray (5YR 7/1); with some low- and high-angle fractures; extensive propylitic alteration with minor disseminated sulfides predominantly pyrite but some chalcopyrite), some sericitic alteration, and some specular hematite. |
| 1,655 – 1,688 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1), minor yellowish orange (10YR 7/6); with very few small fractures; some propylitic alteration, some iron oxide staining, minor sericitic alteration. |
| 1,688 – 1,712 | Porphyritic granite, very light gray (N8) to medium light gray (N6), light greenish gray (5G 8/1) to greenish gray (5G 6/1), minor yellowish orange (10YR 7/6); with some low-angle fractures, some with clay filling; some propylitic alteration, increasing iron oxide staining, and a trace of sericitic alteration. |

| | |
|---|---|
| 1,712 – 1,738 | Porphyritic granite, very light gray (N8) to light gray (N7), light greenish gray (5G 8/1), minor yellowish orange (10YR 7/6); with some clay gouge-filled fractures; some propylitic alteration with disseminated pyrite, trace of sericitic alteration, trace of iron oxide staining. |
| 1,738 – 1,754 | Porphyritic granite; minor fractures; increasing propylitic alteration with sparsely disseminated sulfides (pyrite and chalcopyrite), some sericitic alteration, and some iron oxide staining. |
| 1,754 – 1,790 | Porphyritic granite; no fractures; extensive propylitic alteration with sparsely disseminated pyrite, some sericitic alteration, no iron oxide staining. |

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Caliper/Temperature**
**Dates Logged: May 17 and May 18, 2006**

**Well/Borehole Identification: MV-1**
**Surface Elevation: 1,602.10 (m) / 5,256.23 (ft)**
**Northing: 4339959.916 (m)**
**Easting: 380918.40 (m)**
**Coordinate System: UTM Zone 11**

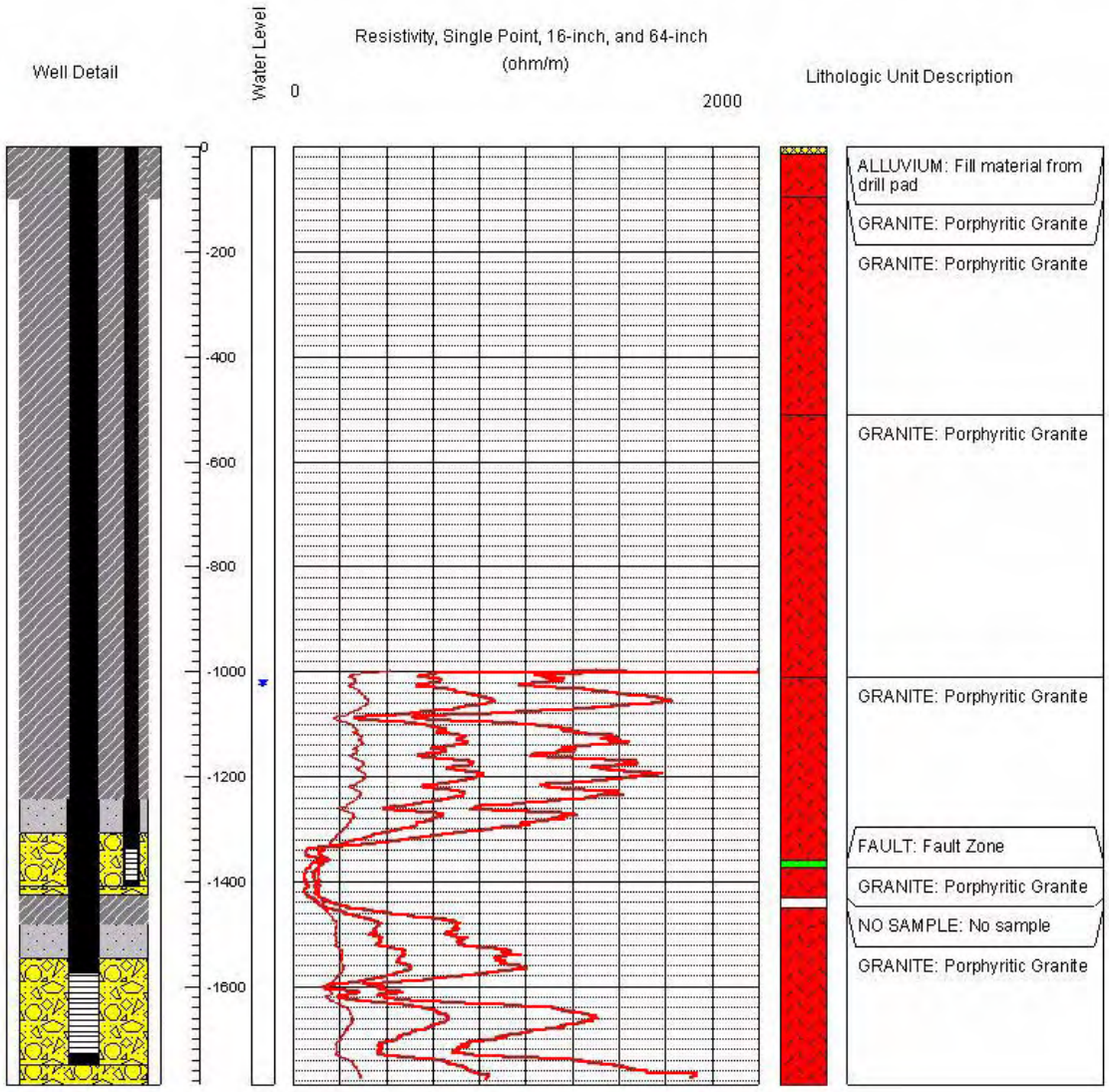



Total Depth: -1788 Page 1 of 1

**Log Plot C.1-1**
**Geophysical Data**
**Project Shoal Area MV-1 Caliper and Temperature**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Resistivity**
**Dates Logged: May 17 and May 18, 2006**

**Well/Borehole Identification: MV-1**
**Surface Elevation: 1,602.10 (m) / 5,256.23 (ft)**
**Northing: 4339959.916 (m)**
**Easting: 380918.40 (m)**
**Coordinate System: UTM Zone 11**



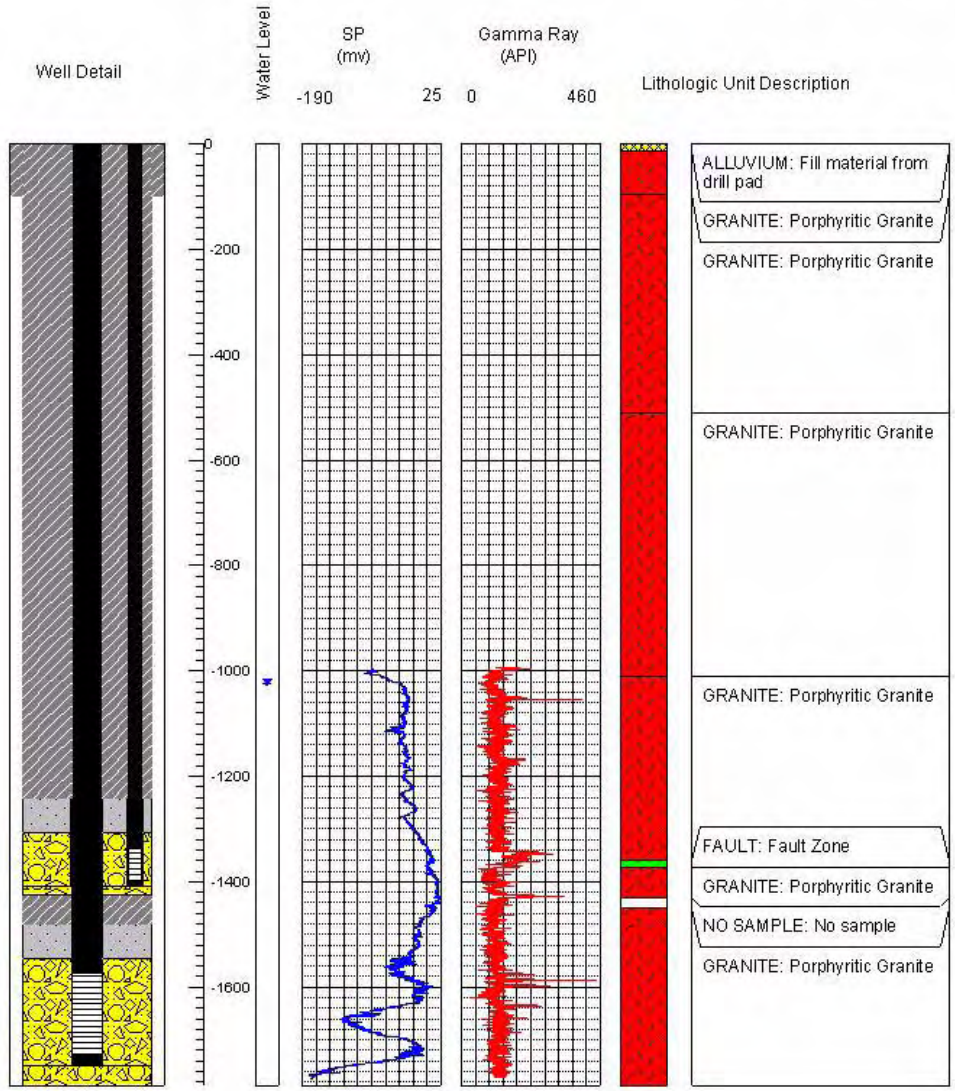

Total Depth: -1788

Page 1 of 1

**Log Plot C.1-2**
**Geophysical Data**
**Project Shoal Area MV-1 Resistivity (Single Point, 16-inch, and 64-inch)**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Spontaneous Potential/Gamma Ray**
**Dates Logged: May 17 and May 18, 2006**

**Well/Borehole Identification: MV-1**
**Surface Elevation: 1,602.10 (m) / 5,256.23 (ft)**
**Northing: 4339959.916 (m)**
**Easting: 380918.40 (m)**
**Coordinate System: UTM Zone 11**




Total Depth: -1788

Page 1 of 1

**Log Plot C.1-3**
**Geophysical Data**
**Project Shoal Area MV-1 Spontaneous Potential and Gamma Ray**

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# Appendix D

# Project Shoal Area MV-2 Data

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**Table D.1-1**
**Project Shoal Area MV-2 Chronology**
(Page 1 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 5/23/2006 | 4:00 | 0 | Rig and equipment mobilized from MV-1 pad. |
| | 8:30 | 0 | Ready to drill at MV-2. |
| | 11:10 | 0 | SNJV and DOE NNSA/NSO personnel on site for safety walkdown. |
| | 13:30 | 0 | Safety walkdown completed. DOE gives OK to proceed. |
| | 13:55 | 0 | MV-2 spudded for 31-in. surface casing borehole. |
| | 15:50 | 16 | Pilot hole completed. Changed over bottom hole assembly. |
| 5/25/2006 | 14:00 | 99 | Completed 31-in surface casing borehole. |
| 5/26/2006 | 5:00 | 99 | Completed tripping out of hole, setting and cementing 24-in. CS surface casing with ~210 $ft^3$ cement. |
| | 18:00 | 99 | Completed setup of diverter and drilling of pilot hole. |
| | 20:30 | 99 | Started drilling final borehole with 12.45-in. hammer bit. Penetration 1-2 minutes per ft. |
| 5/28/2006 | 3:00 | 690 | Encountered fault zone from 640 to 690 ft. Minor fault zone 540 to 550. Conditioning hole. |
| | 17:00 | 1,000 | Started up third compressor to compensate for air volume loss. |
| | 20:10 | 1,070 | Began trip out for bit change. |
| 5/29/2006 | 4:50 | 1,070 | Completed bit change, trip in. Resumed drilling. |
| | 23:45 | 1,450 | Lost circulation. Worked to regain. |
| 5/30/2006 | 4:50 | 1,490 | Regained circulation and resumed drilling. |
| | 17:00 | 1,650 | Began trip out for bit change. |

# Table D.1-1
# Project Shoal Area MV-2 Chronology
(Page 2 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 5/31/2006 | 14:00 | 1,650 | Completed bit change. Encountered bridging from 1,610 to 1,630 ft. |
| | 15:15 | 1,650 | Downhole hammer not working. Started tripping back out. |
| | 22:30 | 1,650 | Hammer changed out and test fired. Began tripping back in borehole. |
| 6/1/2006 | 6:00 | 1,650 | Bridge encountered at 1,244 ft bgs. Cleaned borehole. |
| | 9:45 | 1,650 | Cleared bridges/fill from 1,244 to 1,650. Resumed drilling. |
| 6/2/2006 | 10:05 | 2,018 | TD borehole at 2,018 ft. |
| 6/2/2006 | 18:15 | 2,018 | Conditioned hole. Tripped out of hole, set up for geophysical logging. |
| | 20:00 | 2,018 | Geophysical tool encountered a bridge at 675 ft. Rig up to run in and clean hole. |
| | 23:00 | 2,018 | COLOG started with optical televiewer (video). Driller staging 12.25-in. tricone to clean out hole. |
| 6/3/2006 | 3:10 | 2,018 | COLOG completed video logging. Trip in to clean/condition hole to bottom. |
| 6/4/2006 | 15:30 | 2,018 | Hole cleaned to 2,023 ft. Bridges encountered at 690, 1,030, 1,085, 1,330, 1,818, 1,850, 1,910, 1,930, and 1,970 ft bgs. |
| | 16:35 | 2,018 | Complete cleaning/conditioning to TD of 2,018 ft. |
| | 20:45 | 2,018 | Tripped out of hole, COLOG set up for geophysical logging. |
| | 21:15 | 2,018 | Started geophysical logging. |
| | 22:40 | 2,018 | Geophysical tool encountered a bridge at 684 ft bgs. |
| | 23:00 | 2,018 | Bottomed tagged at 2,014 ft. |
| 6/5/2006 | 20:00 | 2,018 | Completed geophysical logging. Set up to install tremie pipes, piezometer, and well screen and casing. |
| | 21:00 | 2,018 | Started tripping in well screen and casing, piezometer, and tremie pipes. |

**Table D.1-1**
**Project Shoal Area MV-2 Chronology**
(Page 3 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/6/2006 | 13:30 | 2,018 | Completed setting well screen and casing, piezometer (1,260 ft), and tremie pipes. |
| | 14:45 | 2,018 | Started stemming operations. |
| 6/7/2006 | 5:15 | 2,018 | Completed installation of gravel pack to 1,739 ft. Started placement of cement seal to bottom of piezometer. |
| | 22:45 | 2,018 | Completed installation of cement plug and piezometer gravel pack to 1,076 ft. Prepared equipment for demobilization. |
| 6/8/2006 | 0:45 | N/A | Started running HQ eductor AQ airline piping for airlift development. |
| | 7:20 | N/A | Began initial airlift development. |
| | 19:40 | N/A | Paused initial airlift to complete casing grouting. |
| | 23:30 | N/A | Completed cementing of casing. |
| 6/9/2006 | 0:15 | N/A | Restarted airlift development. |
| | 10:30 | N/A | Paused initial airlift to complete casing grouting. |
| 6/9/2006 | 11:30 | N/A | Completed cementing casing to surface. Restarted airlift development. |
| 6/10/2006 | 0:03 | N/A | Completed initial airlift development. Total gal purged 6,840. |
| | 3:00 | N/A | Completed tripping out airlift setup. |
| | 6:00 | N/A | Pump crew on site. Making preparations for pump installation at MV-2. |
| | 7:45 | N/A | Drill crew places compressor, booster, rig and rig floor into staging area. |
| | 10:00 | N/A | Pump crew moved from MV-1. Rigged up for pump installation. |
| | 11:30 | N/A | Began MV-2 pump installation. |
| | 18:00 | N/A | Pump was temporarily set at 1,640.91 ft bgs due to shortage of PVC water access tubing. Staged ½ -in. airline for piezometer development. |

**Table D.1-1**
**Project Shoal Area MV-2 Chronology**
(Page 4 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/11/06 | 6:00 | N/A | Crews on site. Prepared to trip ½-in. airline in piezometer. |
| | 8:45 | N/A | Completed tripping in ½-in. airline. Started airlift development of MV-2 piezometer. |
| | 9:07 | 801 | No discharge. Tripped airline back to 801 ft. Restarted airlift at approximately 0.25 gpm. |
| | 11:03 | N/A | Airline periodically lowered to 1,076 ft. Airlifting from 0.5 gpm to less than 0.1 gpm. |
| | 12:30 | N/A | Airline lowered to 1,203. Restart airlift at 0.5 gpm. |
| | 13:45 | N/A | Paused airlift as discharge is less than 0.1 gpm. |
| | 16:00 | N/A | Flushed pdiezometer with 160 gal of water. Performed four surge cycles. Restart airlift. |
| | 17:20 | N/A | No discharge. Attempted airlift at 1,119 ft, 1,035 ft, 930 ft and 804 ft with no discharge. |
| | 18:00 | N/A | Airlift restarted at 699 ft. Discharge approximately 2.5 gpm at end of shift. |
| 6/12/2006 | 5:45 | N/A | Resumed airlifting MV-2 piezometer. |
| | 9:30 | N/A | No discharge, flushed piezometer with 10 gal water. Conducted four surge cycles. Restarted airlift. No discharge. |
| | 10:45 | N/A | Lowered airline to approximately 1,199 ft. Restarted airlift. No discharge. Suspended airlift to allow for recovery. |
| | 13:45 | N/A | Resumed airlifting. No discharge. |
| | 14:45 | N/A | Suspended airlift to allow for recharge. |
| 6/12/2006 | 17:30 | N/A | Restarted airlift. Less than 0.1 gpm. Suspended airlift overnight. |

**Table D.1-1**
**Project Shoal Area MV-2 Chronology**
(Page 5 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/13/2006 | 6:00 | N/A | Pump crew on site. Restart airlifting MV-2 piezometer. No discharge. |
| | 8:15 | N/A | Flushed with 15 gal water. Conducted four surge cycles. Restarted airlift. |
| | 10:00 | N/A | Flushed with 15 gal water. Conducted five surge cycles. Restarted airlift. |
| | 12:30 | N/A | Performed two flushes, one with 22 gal water, one with 20 gal water. Conducted five surge cycles. Restarted airlift. |
| | 14:45 | N/A | Performed two flushes, one with 22 gal water, one with 20 gal water. Conducted five surge cycles. Restarted airlift. |
| | 15:50 | N/A | Weep hole drilled in 1¼-in. discharge pipe. |
| | 16:25 | N/A | Flushed with 20 gal water. Conducted four surge cycles. |
| 6/14/2006 | 6:00 | 1,199 | Restarted airlift. |
| | 9:00 | N/A | Performed two flushes, one with 10 gal water, one with 20 gal water. Conducted five surge cycles. Restarted airlift. |
| | 12:00 | N/A | Ended airlift operations. Started to trip out ½-in. airline in preparation of bailing. |
| | 13:00 | N/A | Completed tripping out ½-in. airline. Made two attempts to bail with aluminum bailer. No recovery. |
| | 17:00 | N/A | Completed bailing with steel bailer. Approximately 1 gal recovered. |
| | 17:45 | N/A | Suspended operations due to lightening. PVC water access tubing arrived on site. |

# Table D.1-1
# Project Shoal Area MV-2 Chronology
(Page 6 of 6)

| Date | Time | Depth (ft bgs) | Activity |
|---|---|---|---|
| 6/15/2006 | 6:00 | N/A | Made preparations to complete pump installation. |
| | 7:30 | 1,800.91 | Completed pump installation. Set up to make cable splice. |
| | 9:30 | N/A | Splice completed. Rigged down and moved pump truck. Poured well pad and installed protective box. |
| | 10:23 | N/A | Turned on MV-2 pump. Discharge at 8.23 gpm. |
| | 11:00 | N/A | Rig and equipment demobilized from site. |
| | 11:23 | N/A | Well pad and box set. Installed flow meter in pump discharge line and began final development of MV-2 well. Approximately 450 gal pumped before installation of flow meter. |
| | 16:41 | N/A | Pump shut off. Purged approximately 2,036 gal. |
| 6/16/2006 | 8:00 | N/A | Started pump at MV-2. |
| | 12:00 | N/A | Pump truck and equipment demobilized from site. |
| 6/19/2006 | 14:40 | N/A | DRI shut off pump. Development of well completed. Approximately 22,470 gal purged from pump. |

COLOG = Colog, Inc.
CS = Carbon steel
DRI = Desert Research Institute
ft bgs = Feet below ground surface
$ft^3$ = Cubic foot
gal = Gallon
gpm = Gallons per minute
in. = Inch
N/A = Not applicable
NNSA/NSO = U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
PVC = Polyvinyl chloride
SNJV = Stoller-Navarro Joint Venture
TD = Total depth

# Table D.1-2
# Project Shoal Area MV-2 Well Construction Materials

| Construction | Material | Type | Interval (ft) | Stemming Material | Volume ($ft^3$) | Interval (ft) |
|---|---|---|---|---|---|---|
| Surface Casing | 24-in. CS Casing | Blank | 0 – 99.00 | Cement Seal | *199.5 | 0.0 – 99.00 |
| Piezometer Casing | 2.375-in. CS Flush Joint Tubing | Blank | +0.79 – 1,187.70 | Cement Seal | 888.3 | 0.0 – 1,076.00 |
| | | Screen | 1,187.70 – 1,247.20 | #6 Sand Pack | 50.0 | 1,076.00 – 1,166.00 |
| | | Blank w/end cap | 1,247.20 – 1,257.70 | 1/8-1/4” Gravel Pack | 62.1 | 1,166.00 – 1,280.00 |
| Interval Seal | N/A | | | Cement Seal | 283.5 | 1,280.00 – 1,739.00 |
| Monitoring Well Casing | 5.5-in. CS Casing (Internal Epoxy Coated) | Blank | +0.90 – 1,819.87 | See above | | |
| | | Screen | 1,819.87 – 1,990.64 | #6 Sand Pack | 30.0 | 1,739.00 – 1,780.00 |
| | | Blank w/end cap | 1,990.64 – 2,010.95 | 1/8-1/4 in Gravel Pack | 150.1 | 1,780.00 – 2,018.00 |
| Submersible Pump | Grundfos® 10S50-58DS Pump | Top | 1,739.09 | N/A | | |
| | | Intake | 1,797.74 | N/A | | |
| | | Bottom | 1,799.64 | N/A | | |
| Pump Column | 1.25-in. CS EUE | Blank | +0.90 – 1,793.09 | N/A | | |
| Water Access Line | 1.25-in. Flush Joint Schedule 80 PVC | Blank | +0.90 – 1,752.84 | N/A | | |
| | | Screen w/end cap | 1,752.84 – 1,793.09 | N/A | | |

* = Volume estimated
CS =Carbon steel
EUE= External Upset Ends
ft = Foot
$ft^3$ =Cubic foot
in. = Inch
N/A = Not applicable
PVC=Polyvinyl chloride

## Table D.1-3
## Project Shoal Area MV-2 Geophysical Data Collected

| Geophysical Tool | Run Date | Top of Interval (ft bgs) | Bottom of Interval (ft bgs) | Interval (ft) | Contractor |
|---|---|---|---|---|---|
| Phase I | | | | | |
| Caliper | 6/4/2006 | 100 | 2,015.0 | 1,915.0 | COLOG |
| Natural Gamma | 6/5/2006 | 100 | 2,014.0 | 1,916.0 | |
| Spontaneous Potential | 6/5/2006 | 669 | 2,014.0 | 1,345.0 | |
| Deviation Survey | 6/5/2006 | 649 | 2,015.0 | 1,366.0 | |
| Resistivity (Single point, 16-in., and 64-in.) | 6/6/2006 | 669 | 2,014.0 | 1,345.0 | |
| Sonic Velocity | 6/5/2006 | 1,715 | 2,009.0 | 294.0 | |
| Optical Televiewer/Video | 6/2/2006 | 100 | 656.0 | 556.0 | |
| Acoustic Televiewer | 6/5/2006 | 647 | 2,015.0 | 1,368.0 | |
| Phase II | | | | | |
| Nuclear Annulus Investigation Log | 6/7/2006 | 100 | 2,009.5 | 1,909.5 | COLOG |
| Deviation | 6/7/2006 | 100 | 2,009.5 | 1,909.5 | |
| Temperature and Differential Temperature | 6/7/2006 | 550 | 2,012.0 | 1,462.0 | |

COLOG = Colog, Inc.
ft bgs = Feet below ground surface
in. = Inch

# Table D.1-4
# Project Shoal Area MV-2 Tritium Results
(Page 1 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/23/2006 | 14:00 | 7 | -1.08E+03 | 8.76E+02 |
| 5/23/2006 | 16:00 | 16 | -8.11E+02 | 9.15E+02 |
| 5/23/2006 | 18:00 | 33 | -1.44E+03 | 8.87E+02 |
| 5/23/2006 | 20:00 | 42 | -9.01E+02 | 8.86E+02 |
| 5/23/2006 | 22:00 | 49 | -1.08E+03 | 8.76E+02 |
| 5/24/2006 | 0:00 | 53 | -2.70E+02 | 8.83E+02 |
| 5/24/2006 | 2:00 | 55 | 1.80E+02 | 8.93E+02 |
| 5/24/2006 | 4:00 | 57 | 1.26E+03 | 9.21E+02 |
| 5/24/2006 | 6:00 | 59 | 8.11E+02 | 9.27E+02 |
| 5/24/2006 | 8:00 | 60 | -2.70E+02 | 8.83E+02 |
| 5/24/2006 | 10:00 | 62 | -8.11E+02 | 8.76E+02 |
| 5/24/2006 | 12:00 | 61 | -1.44E+03 | 8.58E+02 |
| 5/24/2006 | 14:00 | 63 | -1.89E+03 | 8.55E+02 |
| 5/24/2006 | 16:00 | 66 | -1.53E+03 | 8.69E+02 |
| 5/24/2006 | 18:00 | 70 | -8.11E+02 | 9.03E+02 |
| 5/24/2006 | 20:00 | 72 | -1.44E+03 | 8.82E+02 |
| 5/24/2006 | 22:00 | 74 | -1.08E+03 | 8.95E+02 |
| 5/25/2006 | 0:00 | 77 | 9.01E+02 | 9.08E+02 |
| 5/25/2006 | 2:00 | 80 | 1.17E+03 | 9.07E+02 |
| 5/25/2006 | 4:00 | 81 | 1.80E+02 | 8.83E+02 |
| 5/25/2006 | 6:00 | 83 | 1.53E+03 | 9.42E+02 |
| 5/25/2006 | 8:00 | 85 | 1.71E+03 | 9.14E+02 |
| 5/25/2006 | 10:00 | 89 | 6.31E+02 | 8.85E+02 |
| 5/25/2006 | 12:00 | 93 | -1.89E+03 | 8.63E+02 |
| 5/25/2006 | 14:00 | 96 | -2.79E+03 | 8.75E+02 |
| 5/26/2006 | 22:00 | 120 | -1.44E+03 | 9.34E+02 |
| 5/27/2006 | 0:00 | 170 | 5.41E+02 | 9.33E+02 |

**Table D.1-4**
**Project Shoal Area MV-2 Tritium Results**
(Page 2 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/27/2006 | 1:00 | 185 | 0.00E+00 | 9.12E+02 |
| 5/27/2006 | 2:00 | 195 | -2.70E+02 | 9.05E+02 |
| 5/27/2006 | 3:00 | 215 | -9.01E+01 | 9.15E+02 |
| 5/27/2006 | 4:00 | 259 | 2.70E+02 | 9.27E+02 |
| 5/27/2006 | 5:00 | 283 | -9.01E+01 | 9.38E+02 |
| 5/27/2006 | 6:00 | 320 | -6.31E+02 | 9.08E+02 |
| 5/27/2006 | 7:00 | 344 | -1.17E+03 | 8.85E+02 |
| 5/27/2006 | 10:00 | 360 | -1.08E+03 | 8.75E+02 |
| 5/27/2006 | 11:00 | 370 | 2.70E+02 | 9.34E+02 |
| 5/27/2006 | 14:00 | 390 | -2.70E+02 | 9.03E+02 |
| 5/27/2006 | 15:00 | 430 | 6.31E+02 | 9.46E+02 |
| 5/27/2006 | 16:00 | 450 | 7.21E+02 | 9.43E+02 |
| 5/27/2006 | 17:00 | 470 | 7.21E+02 | 9.19E+02 |
| 5/27/2006 | 18:00 | 510 | 1.80E+02 | 9.13E+02 |
| 5/27/2006 | 19:00 | 540 | 9.91E+02 | 9.19E+02 |
| 5/27/2006 | 20:00 | 570 | 6.31E+02 | 9.38E+02 |
| 5/27/2006 | 21:00 | 590 | 2.70E+02 | 9.02E+02 |
| 5/27/2006 | 22:00 | 630 | 5.41E+02 | 9.33E+02 |
| 5/28/2006 | 0:00 | 670 | -7.21E+02 | 8.88E+02 |
| 5/28/2006 | 1:00 | 684 | 9.01E+01 | 9.17E+02 |
| 5/28/2006 | 2:00 | 697 | -3.60E+02 | 9.00E+02 |
| 5/28/2006 | 3:00 | 715 | -5.41E+02 | 8.90E+02 |
| 5/28/2006 | 5:00 | 735 | -6.31E+02 | 8.93E+02 |
| 5/28/2006 | 6:00 | 750 | 9.01E+01 | 9.25E+02 |
| 5/28/2006 | 7:00 | 790 | 1.80E+02 | 9.07E+02 |
| 5/28/2006 | 8:00 | 810 | -5.41E+02 | 9.13E+02 |
| 5/28/2006 | 9:00 | 813 | -3.60E+02 | 9.08E+02 |

**Table D.1-4**
**Project Shoal Area MV-2 Tritium Results**
(Page 3 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/28/2006 | 10:00 | 845 | -9.01E+01 | 9.15E+02 |
| 5/28/2006 | 11:00 | 860 | 9.01E+01 | 9.17E+02 |
| 5/28/2006 | 14:00 | 910 | -9.01E+02 | 9.20E+02 |
| 5/28/2006 | 15:00 | 950 | 9.01E+01 | 9.59E+02 |
| 5/28/2006 | 16:00 | 970 | -1.53E+03 | 9.01E+02 |
| 5/28/2006 | 17:00 | 990 | -9.01E+02 | 8.90E+02 |
| 5/28/2006 | 18:00 | 1,010 | -8.11E+02 | 9.25E+02 |
| 5/28/2006 | 19:00 | 1,050 | -9.91E+02 | 9.15E+02 |
| 5/29/2006 | 7:00 | 1,075 | 4.51E+02 | 9.05E+02 |
| 5/29/2006 | 8:00 | 1,105 | 2.70E+02 | 8.80E+02 |
| 5/29/2006 | 9:00 | 1,130 | 6.31E+02 | 9.07E+02 |
| 5/29/2006 | 10:00 | 1,150 | 1.35E+03 | 9.23E+02 |
| 5/29/2006 | 13:00 | 1,170 | -1.98E+03 | 9.31E+02 |
| 5/29/2006 | 14:00 | 1,210 | -3.60E+02 | 9.80E+02 |
| 5/29/2006 | 15:00 | 1,260 | -7.21E+02 | 9.45E+02 |
| 5/29/2006 | 16:00 | 1,290 | -1.26E+03 | 9.39E+02 |
| 5/29/2006 | 17:00 | 1,310 | -1.62E+03 | 9.51E+02 |
| 5/29/2006 | 18:00 | 1,330 | -1.26E+03 | 9.55E+02 |
| 5/29/2006 | 19:00 | 1,350 | -1.89E+03 | 9.20E+02 |
| 5/29/2006 | 20:00 | 1,370 | -9.01E+02 | 9.83E+02 |
| 5/29/2006 | 21:00 | 1,390 | -1.62E+03 | 9.35E+02 |
| 5/29/2006 | 22:00 | 1,430 | -9.01E+02 | 9.59E+02 |
| 5/30/2006 | 0:00 | 1,470 | -2.34E+03 | 8.86E+02 |
| 5/30/2006 | 5:00 | 1,476 | -8.11E+02 | 9.33E+02 |
| 5/30/2006 | 6:00 | 1,504 | -3.24E+03 | 8.65E+02 |
| 5/30/2006 | 7:00 | 1,509 | -1.62E+03 | 9.19E+02 |
| 5/30/2006 | 8:00 | 1,529 | -2.43E+03 | 8.73E+02 |

# Table D.1-4
## Project Shoal Area MV-2 Tritium Results
(Page 4 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Drilling | | | | |
| 5/30/2006 | 8:30 | 1,530 | -2.52E+03 | 8.68E+02 |
| 5/30/2006 | 9:00 | 1,532 | -1.17E+03 | 9.45E+02 |
| 5/30/2006 | 10:00 | 1,550 | -2.88E+03 | 8.70E+02 |
| 5/30/2006 | 13:30 | 1,590 | -5.41E+02 | 9.24E+02 |
| 5/30/2006 | 14:00 | 1,610 | -6.31E+02 | 9.27E+02 |
| 5/30/2006 | 15:00 | 1,630 | 9.01E+01 | 9.50E+02 |
| 5/30/2006 | 16:45 | 1,650 | -6.31E+02 | 9.35E+02 |
| 6/1/2006 | 10:00 | 1,655 | -1.26E+03 | 9.09E+02 |
| 6/1/2006 | 11:08 | 1,672 | -5.41E+02 | 9.10E+02 |
| 6/1/2006 | 13:00 | 1,710 | 3.60E+02 | 9.24E+02 |
| 6/1/2006 | 14:30 | 1,730 | -5.41E+02 | 8.90E+02 |
| 6/1/2006 | 15:30 | 1,750 | -9.01E+02 | 9.01E+02 |
| 6/1/2006 | 17:00 | 1,770 | 1.26E+03 | 9.58E+02 |
| 6/1/2006 | 18:15 | 1,790 | 2.70E+02 | 9.27E+02 |
| 6/1/2006 | 20:00 | 1,810 | 4.51E+02 | 9.29E+02 |
| 6/1/2006 | 21:00 | 1,830 | 3.60E+02 | 9.09E+02 |
| 6/2/2006 | 0:00 | 1,889 | -7.21E+02 | 8.99E+02 |
| 6/2/2006 | 1:10 | 1,913 | 1.80E+02 | 9.34E+02 |
| 6/2/2006 | 2:00 | 1,928 | -1.35E+03 | 8.95E+02 |
| 6/2/2006 | 3:00 | 1,933 | -1.44E+03 | 8.81E+02 |
| 6/2/2006 | 4:00 | 1,953 | 1.44E+03 | 9.79E+02 |
| 6/2/2006 | 5:15 | 1,973 | -4.51E+02 | 9.31E+02 |
| 6/2/2006 | 6:00 | 1,976 | 9.01E+01 | 9.05E+02 |
| 6/2/2006 | 7:00 | 1,993 | -5.41E+02 | 9.09E+02 |
| 6/2/2006 | 8:00 | 2,011 | -1.17E+03 | 8.89E+02 |
| 6/2/2006 | 9:00 | 2,013 | -1.35E+03 | 8.86E+02 |
| 6/2/2006 | 10:00 | 2,023 | -2.16E+03 | 8.55E+02 |

**Table D.1-4**
**Project Shoal Area MV-2 Tritium Results**
(Page 5 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Airlift Development | | | | |
| 6/8/2006 | 9:10 | WD | 0.00E+00 | 9.91E+02 |
| 6/8/2006 | 10:10 | WD | 2.97E+03 | 1.11E+03 |
| 6/8/2006 | 12:30 | WD | -9.01E+01 | 9.27E+02 |
| 6/8/2006 | 13:00 | WD | -9.01E+01 | 9.67E+02 |
| 6/8/2006 | 14:00 | WD | -1.53E+03 | 9.09E+02 |
| 6/8/2006 | 15:00 | WD | 0.00E+00 | 9.47E+02 |
| 6/8/2006 | 16:00 | WD | -6.31E+02 | 9.28E+02 |
| 6/8/2006 | 17:00 | WD | 7.21E+02 | 9.63E+02 |
| 6/8/2006 | 18:00 | WD | 5.41E+02 | 9.45E+02 |
| 6/8/2006 | 19:00 | WD | -1.80E+02 | 9.22E+02 |
| 6/9/2006 | 0:30 | WD | -7.21E+02 | 9.18E+02 |
| 6/9/2006 | 1:30 | WD | -9.01E+02 | 9.32E+02 |
| 6/9/2006 | 2:30 | WD | -1.35E+03 | 9.15E+02 |
| 6/9/2006 | 3:25 | WD | 1.62E+03 | 9.82E+02 |
| 6/9/2006 | 4:30 | WD | 3.60E+02 | 9.54E+02 |
| 6/9/2006 | 5:30 | WD | 1.80E+03 | 9.91E+02 |
| 6/9/2006 | 6:30 | WD | -1.44E+03 | 8.70E+02 |
| 6/9/2006 | 7:30 | WD | 9.01E+02 | 9.37E+02 |
| 6/9/2006 | 8:30 | WD | -5.41E+02 | 9.20E+02 |
| 6/9/2006 | 9:15 | WD | -1.80E+02 | 9.09E+02 |
| 6/9/2006 | 10:20 | WD | -9.91E+02 | 9.11E+02 |
| 6/9/2006 | 12:00 | WD | -1.35E+03 | 9.44E+02 |
| 6/9/2006 | 13:00 | WD | -5.41E+02 | 9.49E+02 |
| 6/9/2006 | 14:00 | WD | -5.41E+02 | 9.57E+02 |
| 6/9/2006 | 15:00 | WD | -1.17E+03 | 9.46E+02 |
| 6/9/2006 | 16:00 | WD | -1.08E+03 | 9.59E+02 |
| 6/9/2006 | 17:00 | WD | -1.35E+03 | 9.36E+02 |

**Table D.1-4**
**Project Shoal Area MV-2 Tritium Results**
(Page 6 of 6)

| Date | Time | Depth (ft) | Tritium (pCi/L) | 2 Sigma Error (pCi/L) |
|---|---|---|---|---|
| Airlift Development | | | | |
| 6/9/2006 | 18:00 | WD | -1.80E+02 | 9.68E+02 |
| 6/9/2006 | 19:00 | WD | -6.31E+02 | 9.44E+02 |
| 6/9/2006 | 20:00 | WD | -8.11E+02 | 9.42E+02 |
| 6/9/2006 | 21:00 | WD | 0.00E+00 | 9.47E+02 |
| 6/9/2006 | 22:00 | WD | -9.01E+01 | 9.35E+02 |
| 6/9/2006 | 23:00 | WD | 4.51E+02 | 9.56E+02 |
| 6/10/2006 | 23:58 | WD | -7.21E+02 | 9.02E+02 |
| Pump Development | | | | |
| 6/15/2006 | 13:13 | WD | 3.69E+03 | 3.02E+02 |
| 6/15/2006 | 16:00 | WD | 3.76E+03 | 3.70E+02 |
| 6/16/2006 | 8:00 | WD | 3.98E+03 | 3.28E+02 |
| 6/16/2006 | 13:20 | WD | 4.04E+03 | 2.93E+02 |

ft = Foot
pCi/L = Picocuries per liter
WD = Well Development

# Table D.1-5
## Project Shoal Area MV-2 Water Quality Parameter Results
(Page 1 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Drilling | | | | | | |
| 5/24/2006 | 0:00 | 53 | 8.12 | 20.2 | 1,749.0 | 25.80 |
| 5/24/2006 | 12:00 | 61 | 9.47 | 21.2 | 1,603.0 | 16.90 |
| 5/25/2006 | 0:00 | 77 | 8.21 | 20.4 | 1,962.0 | 23.50 |
| 5/25/2006 | 12:00 | 93 | 9.14 | 19.9 | 1,506.0 | NA |
| 5/25/2006 | 14:00 | 96 | 6.36 | 23.6 | 1,680.0 | 22.00 |
| 5/26/2006 | 22:00 | 122 | 11.52 | 19.0 | 3,488.0 | 15.80 |
| 5/27/2006 | 0:00 | 170 | 11.28 | 24.2 | 2,376.0 | 21.90 |
| 5/27/2006 | 12:00 | 390 | 7.90 | 19.0 | 550.0 | 25.20 |
| 5/28/2006 | 0:00 | 670 | 8.30 | 20.4 | 519.0 | 28.40 |
| 5/28/2006 | 12:00 | 870 | 7.25 | 21.5 | 319.0 | 30.40 |
| 5/29/2006 | 7:00 | 1,075 | 8.23 | 18.2 | 313.4 | 29.20 |
| 5/30/2006 | 0:00 | 1,470 | 8.68 | 18.7 | 605.0 | 21.50 |
| 5/30/2006 | 5:00 | 1,476 | 7.85 | 21.5 | 598.0 | 18.10 |
| 5/30/2006 | 8:50 | 1,530 | 7.53 | 18.0 | 588.0 | 2.62 |
| 5/30/2006 | 9:00 | 1,532 | 6.35 | 18.3 | 132.5 | 14.20 |
| 5/30/2006 | 13:30 | 1,590 | 6.52 | 18.4 | 320.0 | 22.50 |
| 6/1/2006 | 10:00 | 1,655 | 7.05 | 20.6 | 717.0 | 16.60 |
| 6/1/2006 | 14:00 | 1,710 | 6.88 | 23.4 | 726.0 | NA |
| 6/2/2006 | 0:00 | 1,889 | 10.88 | 19.1 | 654.0 | 7.34 |
| 6/2/2006 | 2:00 | 1,928 | 8.10 | 18.0 | 536.0 | 7.40 |
| 6/2/2006 | 4:00 | 1,953 | 6.76 | 21.5 | 610.0 | 7.99 |
| 6/2/2006 | 6:00 | 1,976 | 7.35 | 18.7 | 559.0 | 9.94 |
| 6/2/2006 | 8:00 | 2,011 | 7.77 | 19.6 | 643.0 | 6.84 |
| 6/2/2006 | 10:00 | 2,023 | 7.26 | 19.6 | 564.0 | 11.30 |

**Table D.1-5**
**Project Shoal Area MV-2 Water Quality Parameter Results**
(Page 2 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Airlift Development | | | | | | |
| 6/8/2006 | 9:10 | WD | 7.96 | 20.5 | 517.0 | 52.60 |
| 6/8/2006 | 9:30 | Truck | 7.90 | 19.0 | 351.5 | 28.00 |
| 6/8/2006 | 10:10 | WD | 8.39 | 18.9 | 479.0 | 51.90 |
| 6/8/2006 | 12:30 | WD | 8.33 | 19.6 | 661.0 | 16.90 |
| 6/8/2006 | 13:00 | WD | 8.35 | 19.5 | 682.0 | 12.60 |
| 6/8/2006 | 14:00 | WD | 8.39 | 19.7 | 677.0 | 12.00 |
| 6/8/2006 | 15:00 | WD | 8.43 | 19.6 | 652.0 | 10.10 |
| 6/8/2006 | 16:00 | WD | 8.47 | 19.0 | 625.0 | 8.54 |
| 6/8/2006 | 17:00 | WD | 8.32 | 21.9 | 623.0 | 6.84 |
| 6/8/2006 | 18:00 | WD | 8.33 | 21.9 | 596.0 | 7.89 |
| 6/8/2006 | 19:00 | WD | 8.39 | 18.9 | 597.0 | 7.41 |
| 6/9/2006 | 0:30 | WD | 11.83 | 20.5 | 726.0 | 20.60 |
| 6/9/2006 | 1:30 | WD | 10.35 | 16.0 | 528.0 | 7.73 |
| 6/9/2006 | 2:30 | WD | 9.71 | 19.2 | 521.0 | 6.40 |
| 6/9/2006 | 3:25 | WD | 9.33 | 19.3 | 493.0 | 5.43 |
| 6/9/2006 | 4:30 | WD | 8.37 | 18.9 | 488.0 | 6.62 |
| 6/9/2006 | 5:30 | WD | 8.38 | 18.6 | 497.0 | 5.17 |
| 6/9/2006 | 6:30 | WD | 8.15 | 18.3 | 482.0 | 4.34 |
| 6/9/2006 | 7:30 | WD | 8.22 | 19.3 | 481.0 | 3.85 |
| 6/9/2006 | 8:30 | WD | 8.53 | 19.6 | 485.0 | 4.04 |
| 6/9/2006 | 9:15 | WD | 8.51 | 19.8 | 482.0 | 4.38 |
| 6/9/2006 | 10:20 | WD | 8.54 | 19.7 | 478.0 | 3.68 |
| 6/9/2006 | 12:00 | WD | 8.24 | 23.4 | 395.0 | 3.03 |
| 6/9/2006 | 13:00 | WD | 8.43 | 22.9 | 525.0 | 3.53 |
| 6/9/2006 | 14:00 | WD | 8.39 | 23.4 | 534.0 | 3.42 |
| 6/9/2006 | 15:00 | WD | 8.39 | 25.2 | 542.0 | 2.84 |
| 6/9/2006 | 16:00 | WD | 8.54 | 22.9 | 540.0 | 3.04 |

# Table D.1-5
## Project Shoal Area MV-2 Water Quality Parameter Results
(Page 3 of 3)

| Date | Time | Depth (ft) | pH (SU) | Temperature (°C) | Conductivity (µS/cm) | $Br^-$ (mg/L) |
|---|---|---|---|---|---|---|
| Airlift Development | | | | | | |
| 6/9/2006 | 17:00 | WD | 8.55 | 22.1 | 536.0 | 2.77 |
| 6/9/2006 | 18:00 | WD | 8.43 | 22.7 | 537.0 | 2.44 |
| 6/9/2006 | 19:00 | WD | 8.66 | 22.4 | 530.0 | 2.04 |
| 6/9/2006 | 20:00 | WD | 8.48 | 20.0 | 523.0 | 2.17 |
| 6/9/2006 | 21:00 | WD | 8.42 | 23.7 | 527.0 | 2.19 |
| 6/9/2006 | 22:00 | WD | 8.59 | 19.9 | 515.0 | 1.74 |
| 6/9/2006 | 23:00 | WD | 8.52 | 18.7 | 524.0 | 1.92 |
| 6/10/2006 | 23:58 | WD | 8.50 | 19.8 | 460.0 | 2.27 |
| Pump Development | | | | | | |
| 6/15/2006 | 13:13 | WD | 8.61 | NA | 322.0 | 3.53 |
| 6/15/2006 | 16:00 | WD | 8.50 | NA | 425.0 | 2.70 |
| 6/16/2006 | 8:00 | WD | 8.33 | NA | 308.0 | 2.57 |
| 6/16/2006 | 8:15* | WD | NA | NA | NA | 2.10 |
| 6/16/2006 | 13:20 | WD | 8.85 | NA | 390.0 | 1.77 |
| 6/19/2006 | 14:40* | WD | NA | NA | NA | 0.32 |

* = Analysis performed by Desert Research Institute
$Br^-$ = Bromide
°C = Degree Celsius
ft = Foot
mg/L = Milligrams per liter
NA = Not analyzed
SU = Standard unit
WD = Well Development
µS/cm = Microsiemens per centimeter

# *MV-2 Lithologic Log*

The following lithologic description for borehole MV-2 was produced using the geophysical logs and borehole cutting samples. The caliper log was used from the surface to 2,012 ft. The sonic velocity log was used from 1,720 to 2,008 ft. The acoustic televiewer log was used from 765 to 2,005 ft. The SP, resistivity, and natural gamma logs were used from the surface to 2,012 ft. The bottom 8 to 12 ft of the hole was not logged because of the way the configuration of the downhole geophysical tools. Depths are reported as ft because this is the standard used by the drillers and by the geophysical loggers. Colors were determined using the Munsell® Classification System.

| **Depth (ft)** | **Lithology** |
|---|---|
| 0 – 4 | Fill dirt from pad construction and alluvium from the surface weathering of porphyritic granite, very pale orange (10YR 8/2). |
| 4 – 50 | Porphyritic granite, yellowish gray (5YR 8/1); euhedral to subhedral phenocrysts of microcline from 1 to 2 cm in a groundmass of subhedral crystals of plagioclase and quartz from 1 to 6 mm, and euhedral biotite and hornblende from 1 to 3 mm; microcline = 35-40%, plagioclase = 35%, quartz = 20%, biotite = 5%, trace of hornblende; granite manifests near-surface weathering, including bronze colored oxidized biotite, iron oxide halos around biotite and hornblende crystals, local reddish brown hematite/limonite stains, and a trace of propylitic alteration (chlorite only at this depth) on fracture surfaces. |
| 50 – 80 | Porphyritic granite; very light gray (N8) to light gray (N7); mineralogy and texture as above, but without the near-surface weathering phenomena no oxidized biotite, no limonite stains, no hematite halos around biotite grains); trace of propylitic alteration (chlorite and minor epidote in groundmass, minor alteration of biotite to chlorite), very minor iron staining on fracture surfaces. |
| 80 - 90 | Porphyritic granite; with some clay-filled fractures and iron staining on fracture surfaces; only a trace of propylitic alteration.<br>**Note:** 29-in. diameter surface casing set to a depth of 90 ft. The drill cuttings from 90 to 120 are contaminated with cement from drilling out the plug at the base of the surface casing. |
| 90 – 120 | Porphyritic granite; sample is overwhelmed with cement chips. |
| 120 – 137 | Porphyritic granite with some iron oxide staining and very minor propylitic alteration. |
| 137 – 181 | Porphyritic granite, very pale orange (10YR 8/2); with some iron oxide staining and minor propylitic alteration. |

| | |
|---|---|
| 181 – 195 | Porphyritic granite, very light gray (N8) to light gray (N7); with no propylitic alteration and no iron oxide staining typically found above and below this interval. However, conspicuous small fractures are coated with bright red secondary mineral stains atypical of the iron oxide stains elsewhere in this borehole. Additionally, geophysical logs detected anomalously high natural gamma radiation, which typically indicates uranium- or thorium-bearing minerals such as monazite. The gamma spike in this interval is higher than any other interval within this borehole. |
| 195 – 210 | Porphyritic granite; with no alteration and no iron oxide staining. Natural gamma counts return to background levels. |
| 210 – 230 | Porphyritic granite, pinkish gray (5YR 8/1); with minor iron oxide staining. |
| 230 – 240 | Porphyritic granite, light greenish gray (5GY 8/1); with iron oxide staining and minor propylitic alteration. |
| 240 – 260 | Porphyritic granite, pinkish gray (5YR 8/1) to very light gray (N8); with minor iron oxide staining. |
| 260 – 270 | Porphyritic granite; light olive gray (5Y 5/2); with pervasive propylitic alteration, including chlorite-coated microfractures and biotite crystals altered to chlorite. |
| 270 – 285 | Porphyritic granite; yellowish gray (5Y 7/2); with propylitic alteration and minor iron oxide staining. |
| 285 – 300 | Porphyritic granite; with minor fractures and minor propylitic alteration. |
| 300 – 320 | Porphyritic granite; very light gray (N8) to light gray (N7) to pinkish gray (5YR 8/1); with very minor propylitic alteration and very minor iron oxide staining. |
| 320 – 374 | Porphyritic granite; no alteration. |
| 374 – 385 | Fracture zone, very light gray (N8) to light gray (N7) to light greenish gray (5GY 8/1); porphyritic granite with pervasive fractures, and with minor propylitic alteration and very minor iron oxide staining. |
| 385 – 410 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1); with few fractures, and very minor propylitic alteration. |
| 410 – 418 | Porphyritic granite, grayish yellow green (5GY 7/2) to pale yellowish green (10GY 7/2); fractured, with some propylitic alteration. |
| 418 – 442 | FAULT ZONE; brecciated, with subangular clasts of porphyritic granite, pale green (5G 7/2 to 10G 6/2) and clay fault gouge; extensive propylitic alteration. This small fault likely represents a minor splay of the main fault at 655 to 684 ft. |
| 442 – 468 | Porphyritic granite, light brown (5YR 6/4) to light olive gray (5Y 5/2) to pale yellowish green (10GY 7/2); fractured, with extensive propylitic alteration. |
| 468 – 490 | Porphyritic granite; with some propylitic alteration and some iron oxide staining. |

| | |
|---|---|
| 490 – 521 | Porphyritic granite, pale green (5G 7/2) to pale yellowish green (10GY 7/2) to pinkish gray (5YR 8/1); with minor fractures, and propylitic alteration. |
| 521 – 551 | FAULT ZONE; brecciated, with subangular clasts of porphyritic granite, greenish gray (5G 6/1) to pale red (10R 6/2), with pervasive propylitic alteration; and yellowish gray (5Y 8/1) clay fault gouge. This small fault likely represents another splay of the main fault at 655 to 684 ft. |
| 551 – 590 | Porphyritic granite, light greenish gray (5G 7/1) to light gray (N7); with minor fractures, and with propylitic alteration and minor iron oxide staining. |
| 590 – 610 | Porphyritic granite, light greenish gray (5G 7/1) to pinkish gray (5YR 8/1), with less propylitic alteration and some iron oxide staining. |
| 610 – 640 | Porphyritic granite pinkish gray (5YR 7/1) to greenish gray (5G 7/1) to light gray (N7); with minor propylitic and very minor iron oxide staining. |
| 640 – 650 | Fracture zone; porphyritic granite, greenish gray (5G 6/1) to light brownish gray (5YR 7/1) with pervasive fractures, and with propylitic alteration and minor iron oxide staining as limonite halos surrounding biotite and magnetite crystals. Geophysical logs indicate a drop in the background concentrations of natural gamma radiation at the top of this fracture zone. |
| 650 – 655 | Porphyritic granite; with fractures; and propylitic alteration and minor iron oxide staining. |
| 655 – 684 | FAULT ZONE; brecciated, with subangular to subrounded breccia clasts of porphyritic granite, pale green (5G 7/2) to greenish gray (5G 7/1), and thick zones of clay fault gouge, yellowish gray (5Y 7/2) to very light olive (5Y 6/2); with some propylitic alteration, some argillic alteration (eldspars altered to clay), and very minor iron oxide staining. Caliper log indicates the borehole diameter goes out of gage off the scale of the caliper log in this interval, and the samples are dominated by clay gouge. |
| 684 – 692 | Porphyritic granite, greenish gray (5G 7/1) to light gray (N7); fractured; with significant propylitic alteration. Fluid temperature log indicates a sudden increase in temperature that corresponds to lower part of the fault zone down through this fractured interval (from 674 to 700 ft). |
| 692 – 705 | Porphyritic granite; with some fractures; with a significant amount of propylitic alteration, and very minor iron oxide staining. |
| 705 – 738 | Porphyritic granite, light brownish gray (5YR 6/1) to greenish gray (5G 6/1) to light gray (N7); with fractures; and with propylitic alteration, some iron oxide staining, and locally some argillic alteration of feldspar crystals. |
| 738 – 765 | Porphyritic granite; with propylitic alteration, some iron oxide staining. |

| | |
|---|---|
| 765 – 770 | Porphyritic granite; fractured; with propylitic alteration and some iron oxide staining. |
| 770 – 782 | Porphyritic granite, light gray (N7) to pinkish gray (5YR 8/1) to light greenish gray (5GY 8/1); with minor propylitic alteration, and some iron oxide staining. |
| 782 – 805 | Porphyritic granite, very light gray (N8) to pinkish gray (5YR 8/1) to greenish gray (5G 7/1); with fractures; with iron oxide staining and very minor porphyritic alteration (partial alteration of biotite crystal to chlorite). |
| 805 – 870 | Porphyritic granite, light gray (N7) to grayish yellow green (5GY 7/2); with some fractures; with some propylitic alteration, including sparse pyrite, and minor iron oxide staining, including local hematite halos around pyrite crystals. |
| 870 – 878 | Porphyritic granite, light gray (N7) to very pale yellowish green (5GY 8/2); fractured; with some propylitic alteration, and minor iron oxide staining. |
| 878 – 907 | Porphyritic granite, light gray (N7) with moderate orange pink (5YR 8/4) stain; with minor fractures; with minor propylitic alteration, minor disseminated pyrite, and minor iron oxide staining. |
| 907 – 925 | Porphyritic granite, light gray (N7) to grayish yellow green (5YG 7/2); with some fractures and some scattered small pegmatite dikes; with some propylitic alteration, and minor iron oxide staining. |
| 925 – 950 | Porphyritic granite, light gray (N7) to grayish yellow green (5YG 7/2) with scattered moderate orange pink (5YR 8/4) stain; fractured; with some scattered small pegmatite dikes; minor propylitic alteration, and minor iron oxide attaining. |
| 950 – 975 | Porphyritic granite, light gray (N7) to grayish orange (10YR 7/4); with some fractures; with some iron oxide staining, and some minor propylitic alteration. |
| 975 – 1,010 | Porphyritic granite, light gray (N7) to light greenish gray (5GY 8/1) to greenish gray (5GY 6/1); with some fractures; with propylitic alteration and minor disseminated pyrite, and with minor iron oxide staining. |
| 1,010 – 1,034 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); no fractures; with some propylitic alteration and local disseminated pyrite, with argillic alteration of feldspars, and with very minor iron oxide staining. |
| 1,034 – 1,075 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1) to brownish gray (5YR 4/1); fractured; with some propylitic alteration with local disseminated pyrite, with argillic alteration of feldspars, and with minor iron oxide staining. The caliper log indicates an out-of-gage hole in this interval, the acoustic televiewer log indicates large aperture, high-angle fractures in this interval, and the resistivity logs indicate low resistance in this interval. |
| 1,075 – 1,125 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1); with minor fractures; with some propylitic alteration, and with some iron oxide staining. |

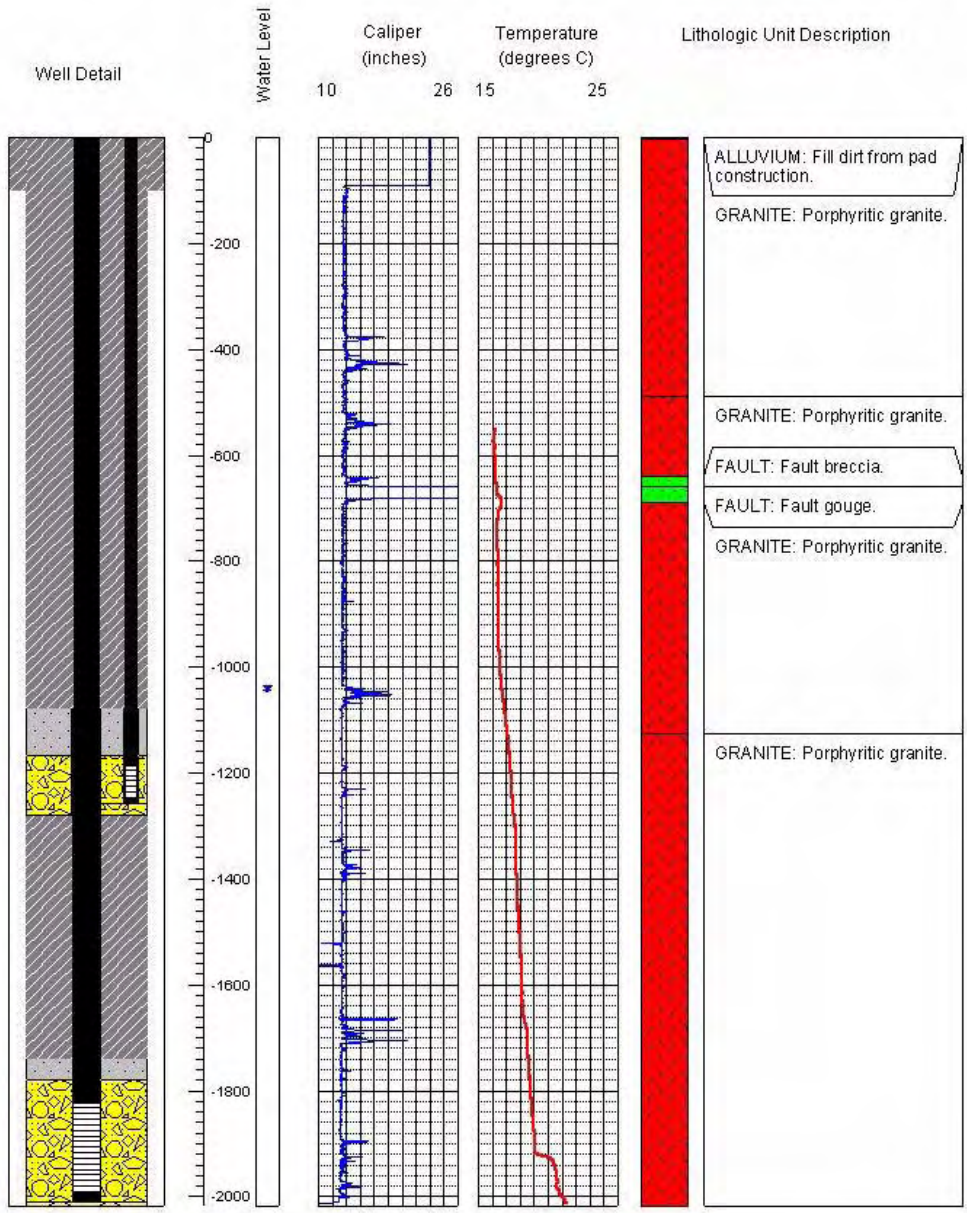
| | |
|---|---|
| 1,125 – 1,186 | Porphyritic granite, light gray (N7) to greenish gray (5G 6/1); with some fractures; some propylitic alteration with sparsely disseminated pyrite, some iron oxide staining. |
| 1,186 – 1,194 | Porphyritic granite; fractured; some propylitic alteration, minor iron oxide staining. The caliper log indicates an out-of-gage hole, accompanied by lower resistance on the resistivity log. |
| 1,194 – 1,225 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1); some fractures; minor propylitic alteration, minor iron oxide staining. |
| 1,225 – 1,244 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1) to dark yellowish orange (10YR 6/6); fractured, with clay (yellowish gray 5Y 8/1) in-filling; minor propylitic alteration, including epidote, very minor iron oxide staining. The caliper log indicates an out-of-gage hole in two distinct places within this interval, the acoustic televiewer log indicates two distinct major fractures with large apertures in this interval, and the resistivity logs indicate very low resistance in this interval. |
| 1,244 – 1,343 | Porphyritic granite, very light gray (N8) to grayish orange (10YR 7/4) to greenish gray (5G 6/1); some fractures; with iron oxide staining, and locally very minor propylitic alteration. |
| 1,343 – 1,352 | Porphyritic granite; fractured; with minor iron oxide staining, and very minor propylitic alteration. The caliper log indicates an out-of-gage hole in this interval, the acoustic televiewer log indicates a fractured interval with large apertures, and the resistivity logs indicate a drop in the resistance in this interval. |
| 1,352 – 1,372 | Porphyritic granite, very light gray (N8) to light greenish gray (5GY 8/1) to very pale orange (10 YR 8/2); possible small fractures; with minor iron oxide staining, and very minor propylitic alteration. |
| 1,372 – 1,402 | Porphyritic granite, greenish gray (5G 6/1) to light greenish gray (5G 8/1) to very pale orange (10 YR 8/2); fractured; extensive propylitic alteration, and minor iron oxide staining. The caliper log indicates an out-of-gage hole in three distinct locations within this interval, the acoustic televiewer log indicates a very fractured interval with large apertures, and the resistivity logs indicate very low resistance in this interval. |
| 1,402 – 1,461 | Porphyritic granite, pale greenish gray (5G 7/1) to light gray (N7); sparse fractures only; some propylitic alteration, minor iron oxide staining. |
| 1,461 - 1,465 | Porphyritic granite, light gray (N7) to greenish gray (5G6/1) to light greenish gray (5G 8/1); with prominent low-angle fractures with open apertures; propylitic alteration, minor iron oxide staining. |

| | |
|---|---|
| 1,465 – 1,490 | Porphyritic granite, light gray (N7) to greenish gray (5G6/1) to grayish orange (10YR 7/4); with some low-angle fractures and clay-filled fractures; propylitic alteration and minor iron oxide staining. |
| 1,490 – 1,515 | Porphyritic granite; with numerous low- and high-angle fractures; extensive propylitic alteration with very sparse disseminated sulfides, and some iron oxide staining. |
| 1,515 – 1,650 | Propylitic granite, very light gray (N8) to greenish gray (5G 6/1), some dark greenish gray (5G 4/1) and grayish orange (10YR 7/4); with scattered low- and high-angle fractures; with propylitic alteration and iron oxide staining. |
| 1,650 – 1,674 | Propylitic alteration, very light gray (N8) to greenish gray (5G 6/1) to light brownish gray (5YR 7/1); horizontal fractures with open apertures and some light greenish gray (5GY 8/1) clay filling; propylitic alteration and minor iron oxide staining. Caliper log indicates a significantly out-of-gage hole from 1,663 to 1,667 ft, and the resistivity log records the lowest resistivity in the entire well in this same interval. |
| 1,674 – 1,710 | Porphyritic granite; massive fracturing with open apertures on low-angle fractures; significant propylitic alteration, and some iron oxide staining. Caliper log indicates a significantly out-of-gage hole at numerous locations within this interval, and the geophysical logs record very low resistivity throughout this interval, and a spike in the natural gamma log in the lowest-most fracture within this interval. |
| 1,710 – 1,718 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to pinkish gray (5YR 8/1); with some vertical and low-angle fractures; with significant propylitic alteration, and some iron oxide staining. |
| 1,718 – 1,746 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to light greenish gray (5G 8/1); with sparse low-angle fractures; with significant propylitic alteration, and minor iron oxide staining. |
| 1,746 – 1,763 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) and dark greenish gray (5G 4/1) to grayish orange (10YR 7/4); with high- and low-angle fractures; with some propylitic alteration, and some iron oxide staining. Caliper log indicates an out-of-gage hole for portions of this interval, and the natural gamma log has gamma counts above background through most of this interval. |
| 1,763 – 1,795 | Porphyritic granite, grayish orange (10YR 7/4; with minor fractures; with propylitic alteration, and minor iron oxide staining. |
| 1,795 – 1,815 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to pinkish gray (5YR 8/1) to grayish orange (10YR 7/4); with numerous high- and low-angle fractures and some light greenish gray (5GY 8/1 to light gray (N7) clay-filled fractures; with propylitic alteration and iron oxide staining. |

| | |
|---|---|
| 1,815 – 1,880 | Porphyritic granite; with minor low-angle fractures; propylitic alteration, iron oxide staining, and a trace of argillic alteration (feldspars altering to clay). |
| 1,880 – 1,955 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) and dark greenish gray (5G 4/1) to pinkish gray (5YR 8/1) to grayish orange (10YR 7/4); with many low-angle fractures and some high-angle fractures, some fractures with open apertures; extensive propylitic alteration and widespread iron oxide staining. The caliper log shows out-of-gage hole at numerous locations throughout this interval, the geophysical logs record very low resistivity throughout this interval, and the sonic velocity log records significant volumes of fractured rock throughout this interval. The temperature log shows a sudden increase in water temperature from 1,920 to 1,928 ft, suggesting a potential inflow through open fractures at this depth of warmer groundwater from a deeper source. |
| 1,955 – 1,962 | Porphyritic granite, very light gray (N8) to light greenish gray (5G 8/1) to pinkish gray (5YR 8/1); with very few fractures; with propylitic alteration and some iron oxide staining. |
| 1,962 - 2,000 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to grayish orange (10YR 7/4 and light brown (5YR 6/4); with extensive high- and low-angle fracturing; with propylitic alteration and iron oxide staining. The caliper log indicates an out-of-gage hole for much of this interval, and the geophysical logs record very low resistivity and elevated natural gamma counts throughout this interval. The sonic velocity log indicates that the rock in this interval is extensively fractured. |
| 2,000 – 2,023 | Porphyritic granite, very light gray (N8) to greenish gray (5G 6/1) to dark yellowish orange (10YR 6/6); with minor high-angle fractures; with propylitic alteration and iron oxide staining. |

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Caliper/Temperature**
**Dates Logged: June 4 and June 5, 2006**

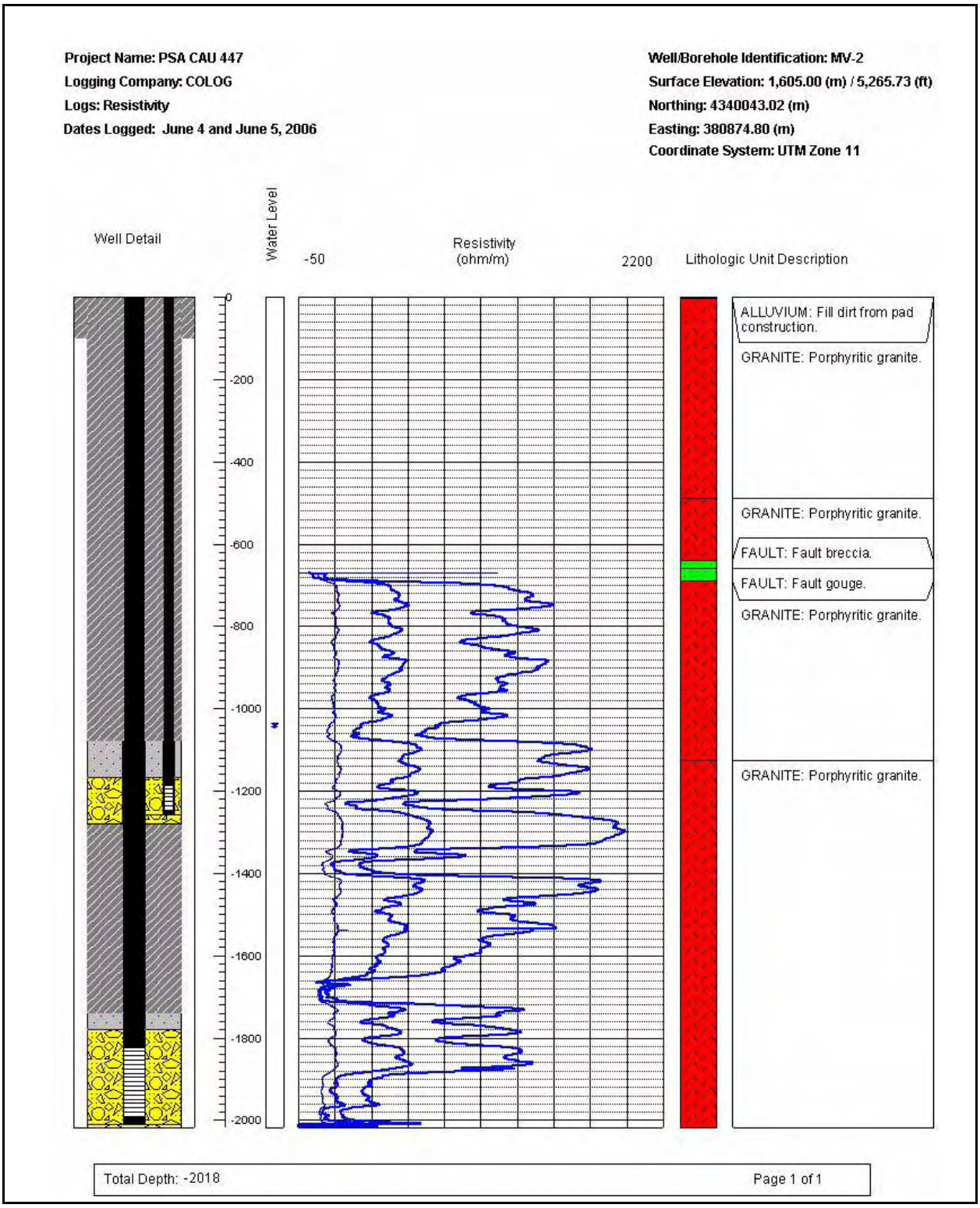
**Well/Borehole Identification: MV-2**
**Surface Elevation: 1,605.00 (m) / 5,265.73 (ft)**
**Northing: 4340043.02 (m)**
**Easting: 380874.80 (m)**
**Coordinate System: UTM Zone 11**




Total Depth: -2018

Page 1 of 1

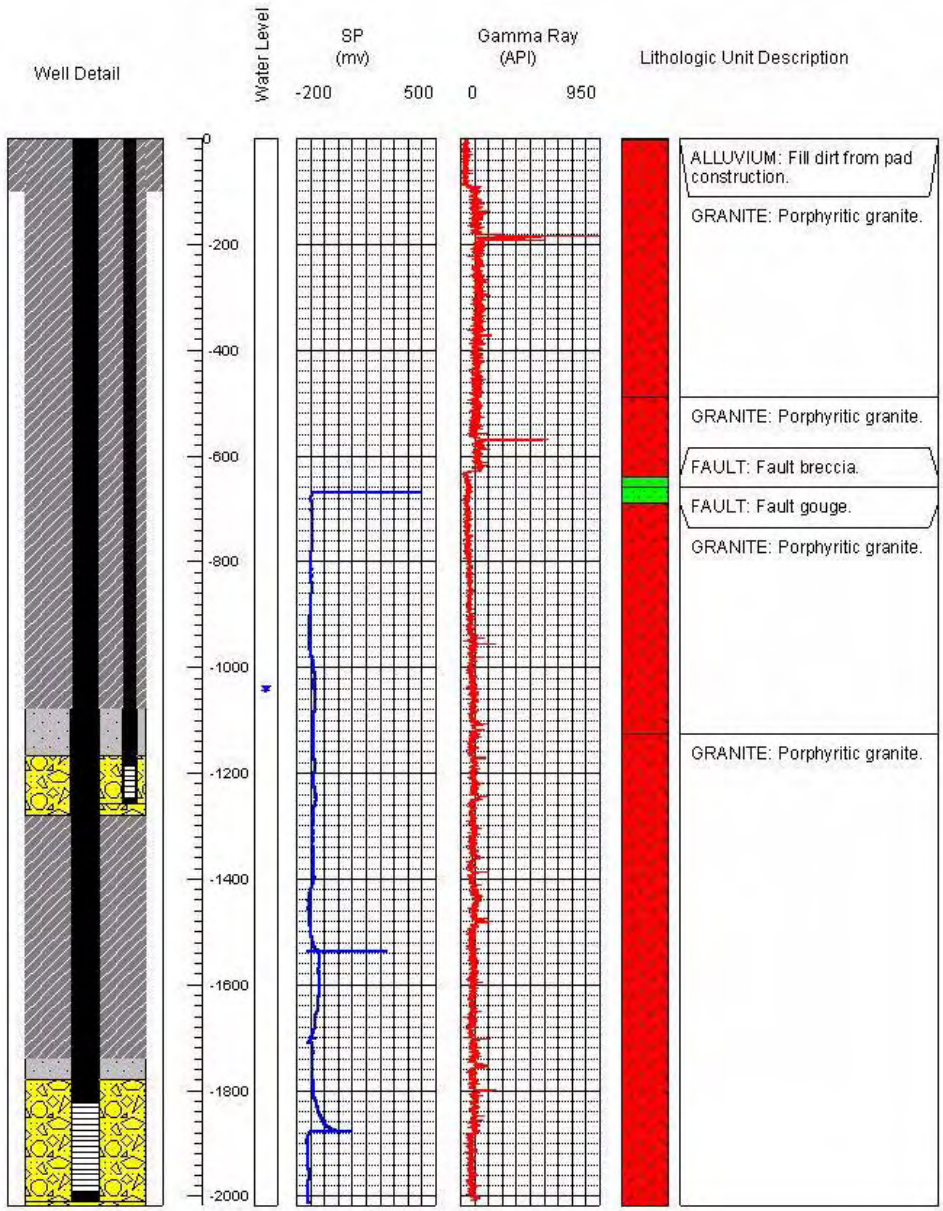
**Log Plot D.1-1**
**Geophysical Data**
**Project Shoal Area MV-2 Caliper and Temperature**




**Log Plot D.1-2**
**Geophysical Data**
**Project Shoal Area MV-2 Resistivity (Single-Point, 16-inch, and 64-inch)**

**Project Name: PSA CAU 447**
**Logging Company: COLOG**
**Logs: Spontaneous Potential/Gamma Ray**
**Dates Logged: June 4 and June 5, 2006**

**Well/Borehole Identification: MV-2**
**Surface Elevation: 1,605.00 (m) / 5,265.73 (ft)**
**Northing: 4340043.02 (m)**
**Easting: 380874.80 (m)**
**Coordinate System: UTM Zone 11**




Total Depth: -2018 Page 1 of 1

**Log Plot D.1-3**
**Geophysical Data**
**Project Shoal Area MV-2 Spontaneous Potential and Gamma Ray**

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