# Summary of Data Concerning Radiological Contamination at Well PM-2, Nevada Test Site, Nye County, Nevada

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U.S. GEOLOGICAL SURVEY

Open-File Report 96-599



Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY, under
Interagency Agreement DE-AI08-91NV11040

USGS-OFR--96-599

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*By* Gary M. Russell *and* Glenn L. Locke

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MASTER

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Carson City, Nevada
1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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## CONVERSION FACTORS AND VERTICAL DATUM

| Multiply | By | To obtain |
|---|---|---|
| becquerel (Bq) | 27.027 | picocurie |
| centimeter (cm) | 0.3937 | inch |
| gram (g) | 0.03527 | ounce avoirdupois |
| kilometer (km) | 0.62137 | mile |
| meter (m) | 3.281 | feet |
| square kilometer ($km^2$) | 0.3861 | square mile |

**Temperature:** Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula °F = [1.8(°C)]+32.

**Sea level:** In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

**Chemical symbols used in text:**

| | | | | | |
|---|---|---|---|---|---|
| Ag | silver | Fe | iron | Pb | lead |
| Al | aluminum | Ge | germanium | Pu | plutonium |
| Am | americium | He | helium | Ra | radium |
| B | boron | Hg | mercury | S | sulfur |
| Ba | barium | K | potassium | Sb | antimony |
| C | carbon | Kr | krypton | Se | selenium |
| Ca | calcium | Li | lithium | Si | silicon |
| Cl | chlorine | Mg | magnesium | Sr | strontium |
| Co | cobalt | Mn | manganese | Th | thorium |
| Cr | chromium | Mo | molybdenum | $^3H$ | tritium |
| Cs | cesium | Na | sodium | U | uranium |
| Cu | copper | Ni | nickel | Zn | zinc |
| Eu | europium | P | phosphorus | | |

# Summary of Data Concerning Radiological Contamination at Well PM-2, Nevada Test Site, Nye County, Nevada

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## ABSTRACT

Analysis of water from well Pahute Mesa No. 2 (PM-2), on Pahute Mesa in the extreme northwestern part of the Nevada Test Site, indicated tritium concentrations above background levels in August 1993. A coordinated investigation of the tritium occurrence in well PM-2 was undertaken by the Hydrologic Resources Management Program of the U.S. Department of Energy. Geologic and hydrologic properties of the hydrogeologic units were characterized using existing information. Soil around the well and water quality in the well were characterized during the investigation.

The nearest underground test in the immediate area of well PM-2 was the 1968 Schooner event (U-20u), detonated approximately 270 meters southeast of the well PM-2 at a depth of 108.2 meters. The crater created by the Schooner event is about 129.8 meters in radius and 63.4 meters in depth. The continuous-ejecta limit (the outermost limit of continuous deposits of earth materials thrown out and away from the explosion) was asymmetrical, ranging in radius from about 518 to 823 meters. The maximum extent of ejected earth materials exceeded 1,830 meters.

Results of soil sampling indicate that radioactivity of identifiable nonnaturally occurring fission and activation products (americium-241, cobalt-60, cesium-137, europium-150, europium-152, and europium-154) were the same order of magnitude as that of the natural radiation (krypton-40, radium-226, thorium-228, thorium-232). Gamma spectrum analysis of each soil sample had numerous unidentified peaks with high counting errors.

Close agreement between tritium analyses of water from well PM-2, at different times and at the same depths, confirms the elevated levels of tritium. The highest tritium values in the borehole were at 610 meters below land surface—above the shallowest perforations at 765 meters below land surface. These values were only slightly higher than values found at greater depth in the well.

Values for gamma spectral analysis of water samples were near or below detection limits with the exception of radium-226 at 305 and 823 meters below land surface. Radium-226 is probably a natural decay product from uranium-238. Laboratory analysis indicates that the gamma radiation in well PM-2 was minor.

## INTRODUCTION

The Nevada Test Site (NTS) includes about 3,600 $km^2$ in Nye County, southern Nevada, and is about 105 km northwest of Las Vegas (fig. 1). NTS is surrounded on the north, east, and west by Nellis Air Force Range (NAFR). This combination of federally owned lands constitutes the largest unpopulated area in the Nation, covering about 14,200 $km^2$. The NTS was established in December 1950 as the principal location for national testing of nuclear devices. The first nuclear test occurred on January 27, 1951. The first underground nuclear test occurred on November 29, 1951. Since July 11, 1962, all nuclear tests in the United States have been detonated underground; most of them at NTS. A total of 928 nuclear tests have been conducted at NTS—100 tests were atmospheric and 828 were underground (U.S. Department of Energy, 1994). Four major areas were used for testing: Frenchman Flat, Yucca Flat, Rainier Mesa, and Pahute Mesa (fig. 1).

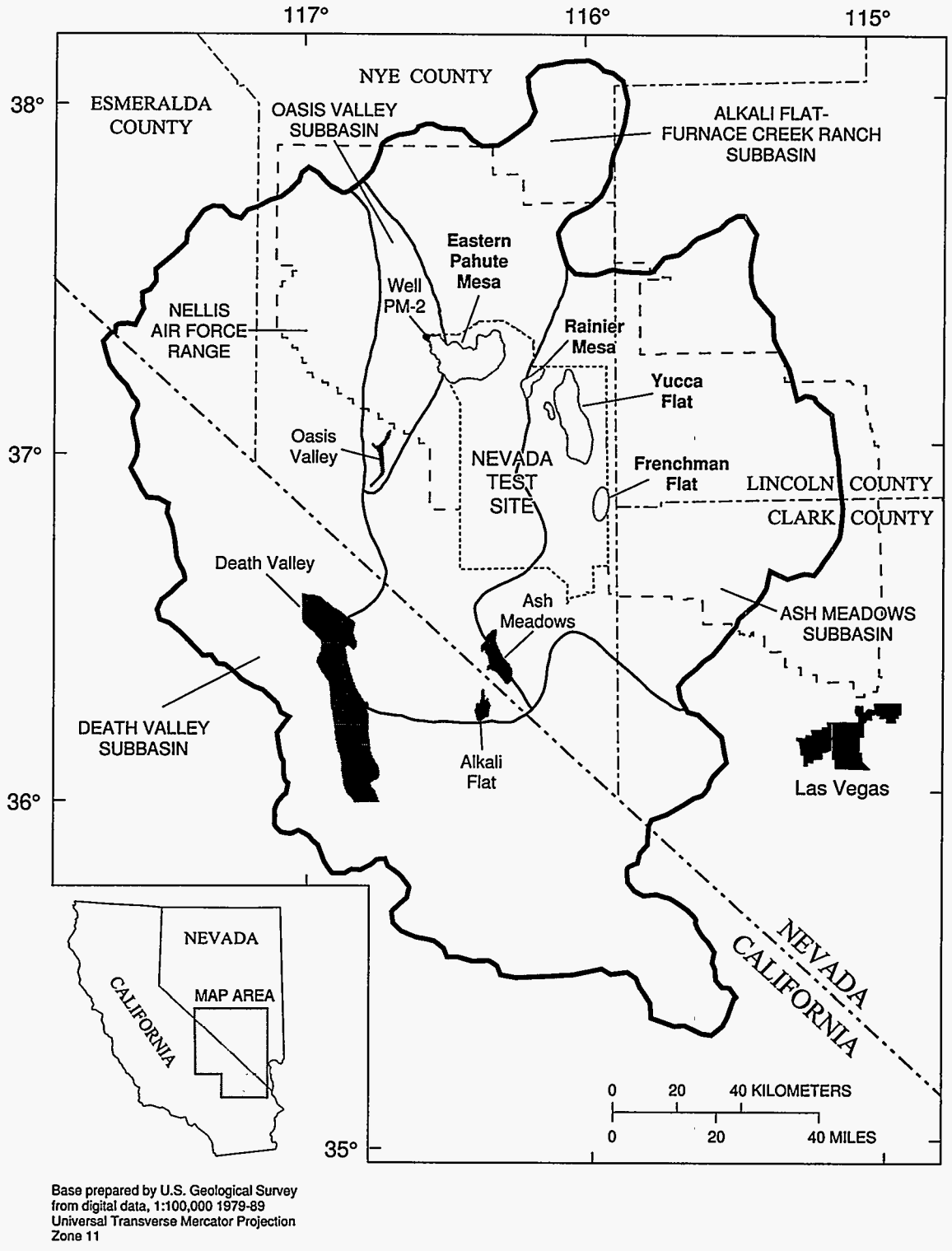


**Figure 1.** Death Valley ground-water-flow system and subbasins, southern Nevada and eastern California, showing location of Nevada Test Site and well PM-2 (compiled from Laczniak and others, 1996).

## Background

Well Pahute Mesa No. 2 (PM-2) is on eastern Pahute Mesa in the extreme northwestern corner of Area 20 approximately 105 m south of the northern NTS boundary and 275 m northeast of the western boundary (figs. 2 and 3). On May 20, 1993, the water level in well PM-2 was measured at 254.96 m below land surface, 4.77 m higher than a measurement 1 year earlier (fig. 4). During the 10 years prior to May 1993, the water level had not been detected to fluctuate more than 0.65 m. Projections of the rate of decline, following the high measurement, suggested the water level would return to pre-May 1993 levels in approximately 2 years.

The unexpected rise in water level and the ensuing, steady decline indicated that recharge may have taken place. In August 1993, the U.S. Geological Survey collected water samples for analysis of field characteristics, including specific conductance, to determine if the rise and subsequent decline in the water level might have been caused by recharge through the well bore rather than through the aquifer. Water samples were delivered to the Environmental Monitoring Systems Laboratory - Las Vegas (EMSL) of the U.S. Environmental Protection Agency (USEPA) for radiological testing. USEPA analysis indicated $^{3}H$ concentrations of 21,000 Bq/L. Possible sources of contamination of the water from well PM-2 include (1) prompt injection at the time of the Schooner event; (2) recharge from the Schooner crater; (3) water introduced during drilling and hydraulic testing of well PM-2; (4) migration of contamination from Schooner or other underground tests; (5) contaminated materials disposed of in the well; and (6) recharge through the borehole.

The U.S. Geological Survey (USGS) was directed by the U.S. Department of Energy (USDOE) under interagency agreement DE-AI08-91NV11040, as a part of the existing Hydrologic Resources Management Program (HRMP), to participate in investigating the occurrence of tritiated waters in well PM-2. Other HRMP member agencies involved with the investigation included Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Desert Research Institute (DRI), and Reynolds Electrical and Engineering Co. (REECo).

EXPLANATION

- Area used for nuclear testing
- Ground-water discharge area in Death Valley flow system
- Approximate boundary of Death Valley ground-water flow system—Subbasins within flow system are indicated

## Purpose and Scope

The purpose of this report is to present existing information and results from a coordinated investigation of $^{3}H$ occurrence in well PM-2 by the HRMP. The objectives of the overall investigation include (1) determination of the type and concentration of contamination, (2) identification of the source and mechanism of contamination, (3) estimation of the extent of radiological contamination, (4) initiation of appropriate monitoring of the contamination, and (5) reporting of investigation results. This report addresses objective five. Compiled and tabulated data of the area are presented. The report also includes characterization of geology, soil, hydrology, and water-quality data.

The six appendices herein, as well as tables 2 and 4-10, present data and information provided by several agencies. Nomenclature reproduced in the appendices does not necessarily conform to terminology used by the U.S. Geological Survey. Likewise, numerical data presented in the appendices and in tables 2 and 4-10 do not necessarily conform to U.S. Geological Survey guidelines with regard to the reporting of significant figures. Procedures used to collect, process, and analyze the samples for which data are listed in the appendices and in tables 2 and 4-10 do not necessarily conform to U.S. Geological Survey protocols and guidelines.

## Description of Study Area

The NTS lies in the Basin and Range physiographic province. The study area is in the northwest part of NTS, in eastern Pahute Mesa. The area consists of broad mesas and volcanic ranges where pre-shot topography was flat, reflecting the nearly flat-lying ash-fall tuffs that cover the area around PM-2. Altitudes range from less than 1,600 m to more than 2,200 m above sea level in Areas 19 and 20. Land-surface altitude at well PM-2 is 1,703.5 m. The well is located at Nevada State Plane coordinates N. 944,582 and E. 528,655. Mean annual precipitation on eastern

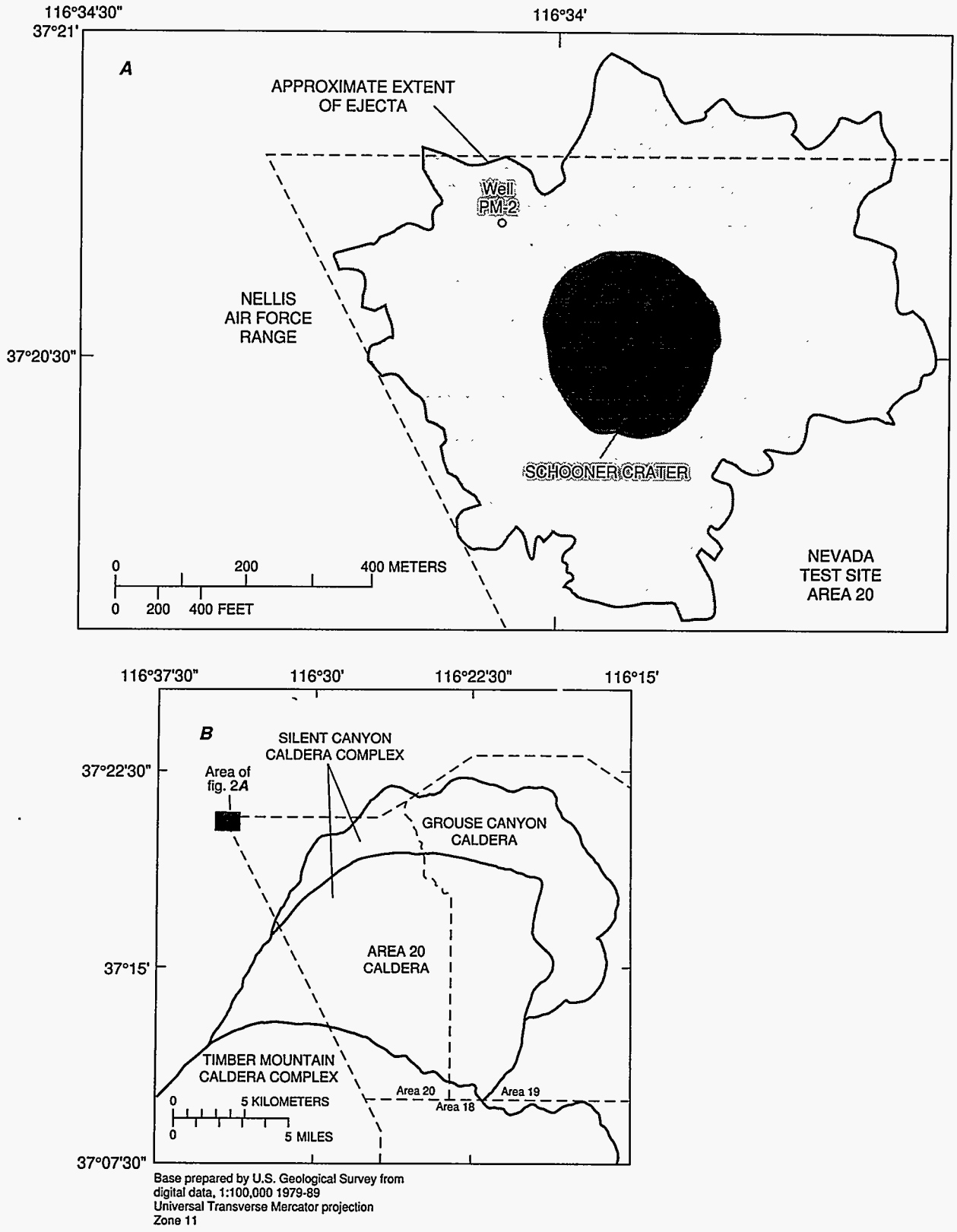


**Figure 2.** Location of well PM-2 and Schooner event. Extent of ejecta also is shown in figure 5.

**Figure 3.** Photograph of well PM-2 in 1993. Photograph by G.L. Otto, U.S. Geological Survey.

Pahute Mesa is variable, primarily due to altitude, and ranges from 20.3 to 30.5 cm (Winograd and Thordarson, 1975, p. C6).

## Geohydrologic Setting

On NTS, surface-water runoff usually occurs during March and April following spring snowmelt, and during July and August following infrequent but intense thunderstorms. In the eastern areas of NTS, surface water flows into playas (dry lake beds) in Yucca and Frenchman Flats. In the northwest part of NTS near well PM-2 (Areas 19 and 20), water may run off beyond the NTS boundaries onto NAFR. The southern and western parts of NTS also may channel waters off site toward Death Valley.

The NTS is in a geohydrologically complex area where alluvium of Quaternary age overlies volcanic rock of Tertiary age and complexly fractured clastic and carbonate rocks of Paleozoic and Precambrian age. The geohydrologic system consists of a valley-fill aquifer, the volcanic tuffs and lava flows that include several aquifers and confining units, and the carbonate aquifer and clastic confining units. Perched zones are common throughout the NTS (Laczniak and others, 1996).

### Geology

The NTS is in a structurally complex part of the southern Basin and Range physiographic province. The eastern part of Pahute Mesa (Areas 19 and 20) is part of the Southwest Nevada Volcanic Field. Well PM-2 is situated in a volcanic province of Tertiary age where ash-flow and ash-fall tuffs and rhyolitic lava flows more than 4,171 m thick were erupted from two calderas (fig. 2), the Area 20 and Grouse Canyon calderas, which together form the Silent Canyon caldera complex (Blankennagel and Weir, 1973, p. B3). Much of the area is covered by younger ash-flow and ash-fall tuff erupted from calderas to the south and west. Distribution of geologic units is extremely variable due to proximity to calderas, pre-depositional topography, and post-depositional faulting. The well penetrates a suite of volcanic rock—tuffs, rhyolites and lavas—overlying porphyritic granodiorite (table 1).

### Ground Water

Ground water beneath NTS is part of the Death Valley ground-water flow system, which consists of four subbasins: Oasis Valley, Ash Meadows, Alkali Flat-Furnace Creek Ranch, and Death Valley (fig. 1). Regional ground-water flow beneath NTS is in three

subbasins—Oasis Valley and Ash Meadows subbasins in Nevada and the Alkali Flat-Furnace Creek Ranch subbasin in Nevada and California. Well PM-2 is within the Oasis Valley flow system. Depth to ground water may range from about 156 m below land surface in Frenchman Flat to more than 600 m below land surface on Pahute Mesa (Winograd and Thordarson, 1975, p. C47).

The water-level altitude throughout the volcanic sequences within the Silent Canyon caldera complex on Pahute Mesa is from 1,268 m to 1,428 m above sea level (594 m to 716 m below land surface), according to Blankennagel and Weir (1973, pl. 1). Northwest of the caldera, near well PM-2, Blankennagel and Weir (1973, pl. 1) indicate that the altitude of the water table is about 1,432 m (260 m below land surface). In Area 20, thick layers of lower permeability ash-flow and ash-fall tuffs separate thinner and less extensive rhyolitic lava flows of higher permeability. Ground water moves primarily through interconnected fractures within the units. In general, zeolitized and nonwelded tuffs are less permeable and act as confining units, while the welded ash-flow tuffs and rhyolitic-lava flows form aquifers (Blankennagel and Weir, 1973, p. B7). Water-level contours in eastern Pahute Mesa are shown in figure 5 as reported by Blankennagel and Weir (1973, pl. 1). A recent water-level contour map by O'Hagan and Laczniak (1996) shows water levels in eastern Pahute Mesa that closely approximate those of Blankennagel and Weir (1973, pl. 1). Figure 5 indicates that well PM-2 lies upgradient from the Schooner event (assuming that ground-water flow is perpendicular to the contours shown on figure 5 and that ground water flows in the two dimensions shown on the map). A more thorough discussion on hydrogeologic units, ground-water occurrence, and ground-water flow is given by Laczniak and others (1996).

### The Schooner Event

The only test in the immediate area of well PM-2 was the Schooner event (U-20u), detonated approximately 270 m southeast of well PM-2 (fig. 2). The next closest test was more than 4 km east-southeast of well PM-2. Schooner was a 30-kiloton cratering demonstration in December 1968 detonated at a depth of 108.2 m (Henry, 1969, p. 1). The crater created by the Schooner event is about 129.8 m in radius and 63.4 m in depth. The continuous-ejecta limit (the outermost limit of continuous deposits of earth materials thrown out and away from the explosion) was asymmetrical

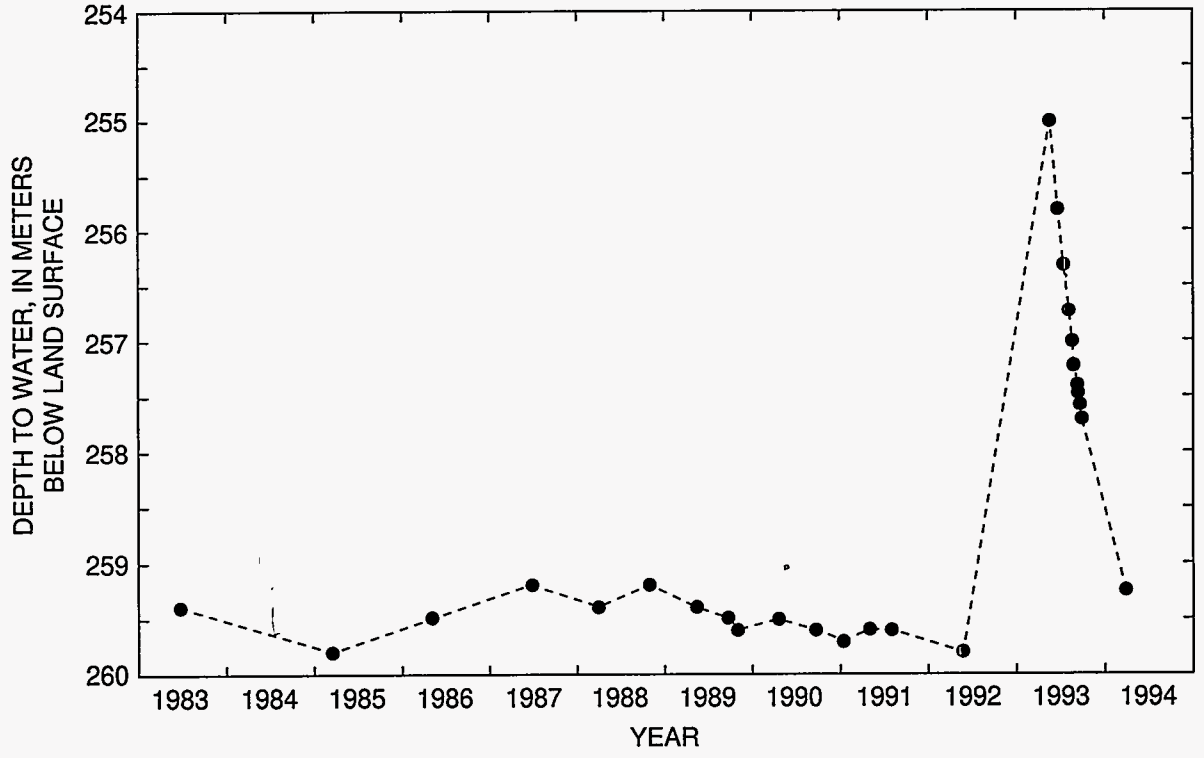


**Figure 4.** Measurements of depth to water in well PM-2, 1983-94.

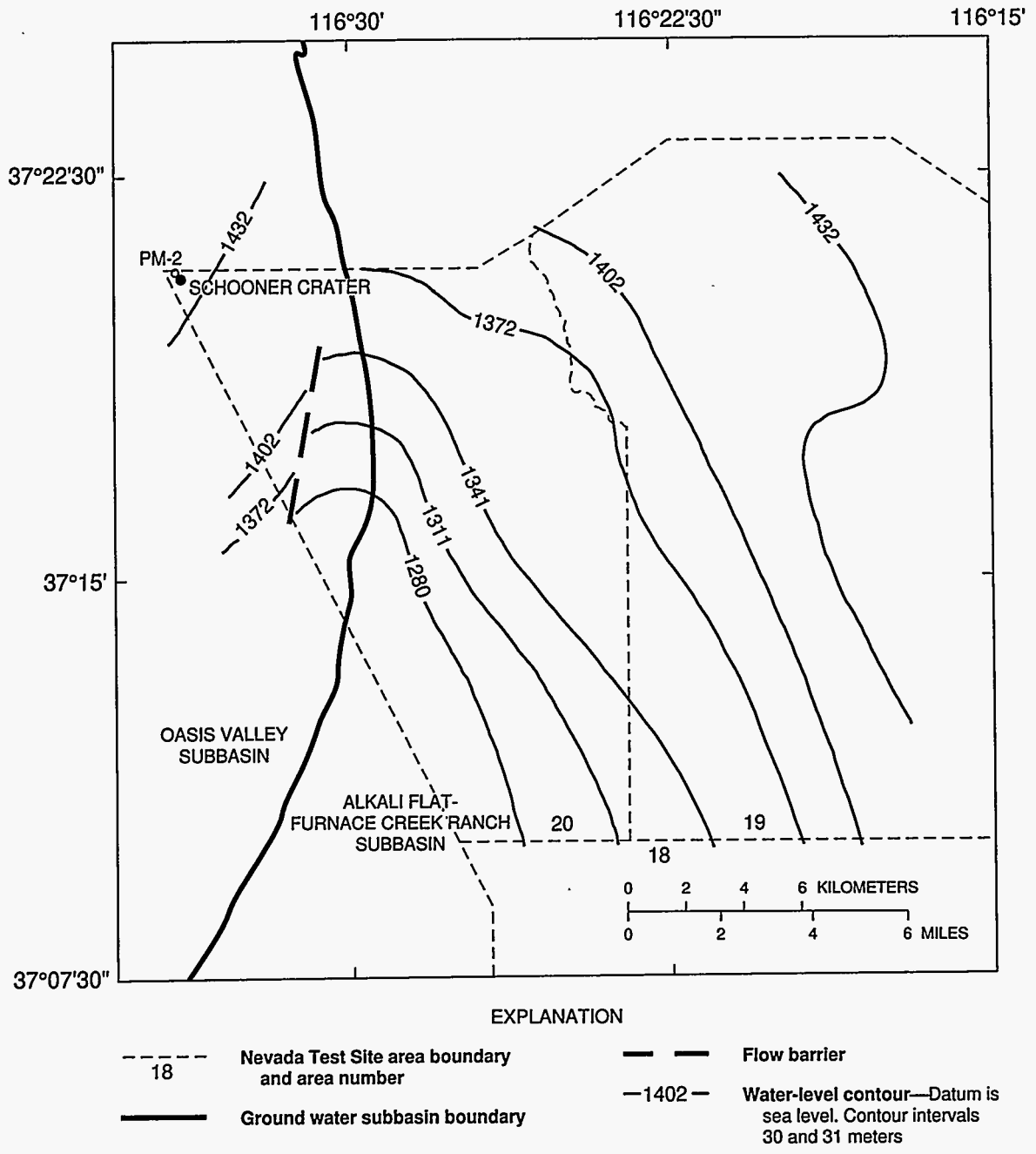


**Figure 5.** Water-level contours in eastern Pahute Mesa (modified from Blankennagel and Weir, 1973, where the contour interval is 100 feet).

(fig. 6), ranging from about 518 m to 823 m. The maximum extent ejected earth materials could be mapped exceeded 1,830 m (Henny, 1969, p. 53). Well PM-2 was completed in 1964 and buried beneath approximately 3 m of ejecta from the Schooner event in 1968. The crater and ejecta are shown in figure 6, which is an aerial photograph taken in 1989 by EG&G Energy Measurements, Inc. (EG&G). Also evident on the photograph is the access road to Schooner and well PM-2, north and west of the crater, clearly within the ejecta pattern (L. Tinney, EG&G, written commun., 1994). Additional information available from EG&G concerning the Schooner event includes enhanced Landsat imagery.

LLNL has compiled the radiochemical sources for the Schooner event (G.J. Nimz, LLNL, written commun., 1994). Because Schooner was a cratering event, less-than-typical amounts of fission products

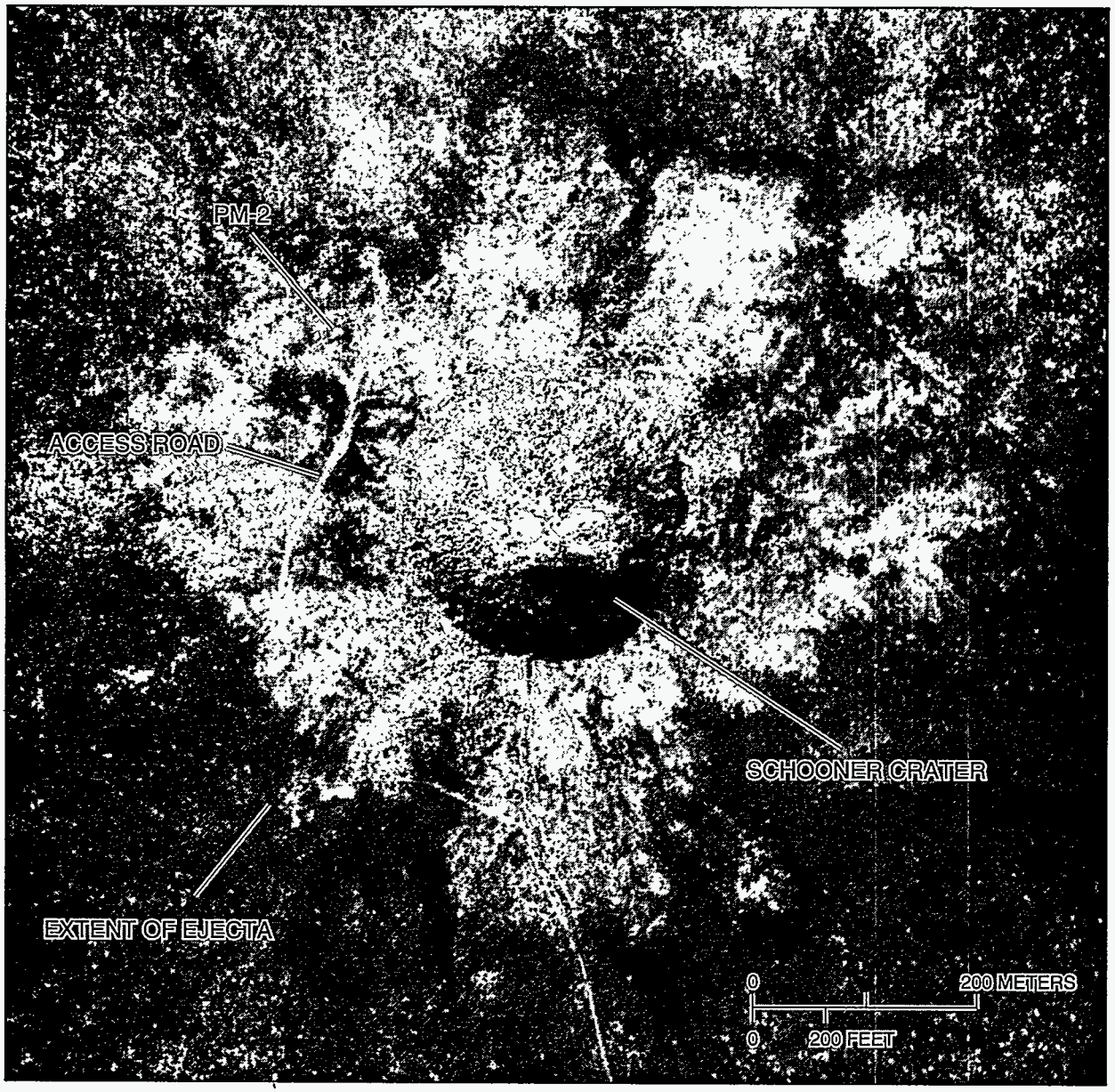


**Figure 6.** Aerial photograph of Schooner crater in 1989, showing extent of ejecta and location of well PM-2. Photograph by EG&G Energy Measurements, Inc.

were produced. At the same time, large amounts of activation products were produced in the surrounding soil and rock. A high ratio of activation products to fission products may help to identify Schooner as the source of contaminated water at well PM-2.

An aerial radiological survey of NTS and surrounding areas was made in 1970 and 1971 by EG&G. The primary objective of the survey was to determine exposure-rate contours in selected areas in and around NTS. Background exposure rates in the Pahute Mesa area ranged from 20 to 25 microRoentgens per hour (μR/hr). Exposure rates exceeded 200 μR/hr in the Schooner area. Background exposure rates north of NTS ranged from 20 to 30 μR/hr. Exposure rates near the NTS boundary exceeded 200 μR/hr as a result of the nearby NTS cratering event (Schooner) and other testing (EG&G Energy Measurements, Inc., 1972, p. 64).

An aerial radiological study was made in October 1992 to map possible contamination resulting from testing at NTS. The survey revealed a radioactive plume north of Schooner and on NAFR. The plume had a maximum anthropogenic gross count of 32,000 to 100,000 counts per second, of which 1,200 to

2,600 counts per second are due to $^{241}Am$, a beta-decay product of $^{241}Pu$. $^{241}Am$ count rate can be converted to surface activity, in units of becquerel per square meter ($Bq/m^2$), and to average activity in the top 1 cm, in units of becquerel per gram (Bq/g). The maximum anthropogenic count rate of 2,600 counts per second equates to a surface activity of 173.9 $Bq/m^2$ and an average activity in the top 1 cm of 11.8 Bq/g (EG&G Energy Measurements, Inc., 1992, p. 9).

The $^{241}Am$ activities of a material can be multiplied by the Pu-to-Am ratio of the material to obtain an estimate of Pu activity. For Schooner fallout, the Pu-to-Am ratio is approximately 0.7; therefore, the maximum surface activity of Pu in the top 1 cm is 8.3 Bq/g (EG&G Energy Measurements, Inc., 1992, p. 8).

### Previous Studies

Several U.S. Geological Survey reports detail activities concerning well PM-2. The lithology of rocks penetrated by well PM-2 is discussed by Hasler and Byers (1965). Well history, drilling data, and hydraulic testing at well PM-2 are discussed by Blankennagel and others (1964) and Blankennagel and Weir (1966). Geologic data at satellite holes for Schooner are discussed by Purtymun and others (1969). Other reports (Thordarson and others, 1967; Orkild, 1969; Orkild and Jenkins, 1970) summarize activities and data at the well PM-2 site. An Air Force report by Henny (1969) details observations concerning the Schooner event.

### Acknowledgments

The authors thank the participating agencies associated with the U.S. Department of Energy HRMP: Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Desert Research Institute, and Reynolds Electrical and Engineering Co. The authors express appreciation to Richard H. Pearl, Stephen H. Leedom, and Douglas W. Duncan of the U.S. Department of Energy for support during the compilation of the data. Special thanks to the HRMP members for the submission of materials for use in this report: Gregory J. Nimz, Lawrence Livermore National Laboratory, provided radionuclide and chemical analysis and radiochemical source terms for Schooner; Joseph L. Thompson, Los Alamos National Laboratory, provided water-quality-sampling data from well PM-2 and research into ejected materials at well PM-2; Paul R. Seaber and David Gillespie, Desert Research Institute, provided maps and assorted information; and Fred Ferate, Reynolds Electrical and Engineering Company, provided soil sample information and radionuclide and chemical analysis. Water-quality samples were analyzed by Terence M. Grady, Environmental Monitoring System Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nev. Raytheon Services Nevada provided information on hole histories and geophysical logs. Larry Tinney, EG&G Energy Measurements, Inc., provided maps, aerial photographs, and Landsat images of Pahute Mesa; and J.A. Zamudio, EG&G, provided Landsat analysis.

## SUMMARY OF DATA ON WELL PM-2

Summarized below are the construction and geophysical logging histories of well PM-2. Most of this information was obtained from records maintained by Raytheon Services Nevada (RSN). A report by Gillespie (1994) examined much of the available historical record on well PM-2 as part of the joint HRMP investigation into the radiological contamination of well PM-2. The summary description of the geologic and hydrologic properties of the units penetrated by well PM-2, as presented below, is from previously published reports. The soil chemistry around the wellhead and the water quality of samples from the well are characterized below from samples collected and analyzed as part of the joint HRMP investigation.

### Well Construction

Well PM-2 was constructed between May 20 and October 13, 1964, and completed as an open-hole well with a vertical depth of 2,676.6 m below land surface. The well was cased to a depth of 1,675.7 m. Gun-type perforations in the casing were added in May 1966 at depths between 762.0 and 1,612.3 m. Well-construction details of well PM-2 are shown in figure 7. Appendix A presents RSN hole-history data. The data include daily drilling activities, a hole-deviation survey, core sampling, and cementing records. The core samples obtained during drilling are archived at NTS in the USGS Core Library.

Well casings with outside diameters of 50.8 cm, 34.0 cm, and 24.4 cm were used in the construction of well PM-2 (fig. 7). All the casings were strung to land surface. The surface casing of 50.8-cm diameter was installed to a depth of 13.4 m. The 34.0-cm diameter casing was installed to a depth of 759.5 m. The casing

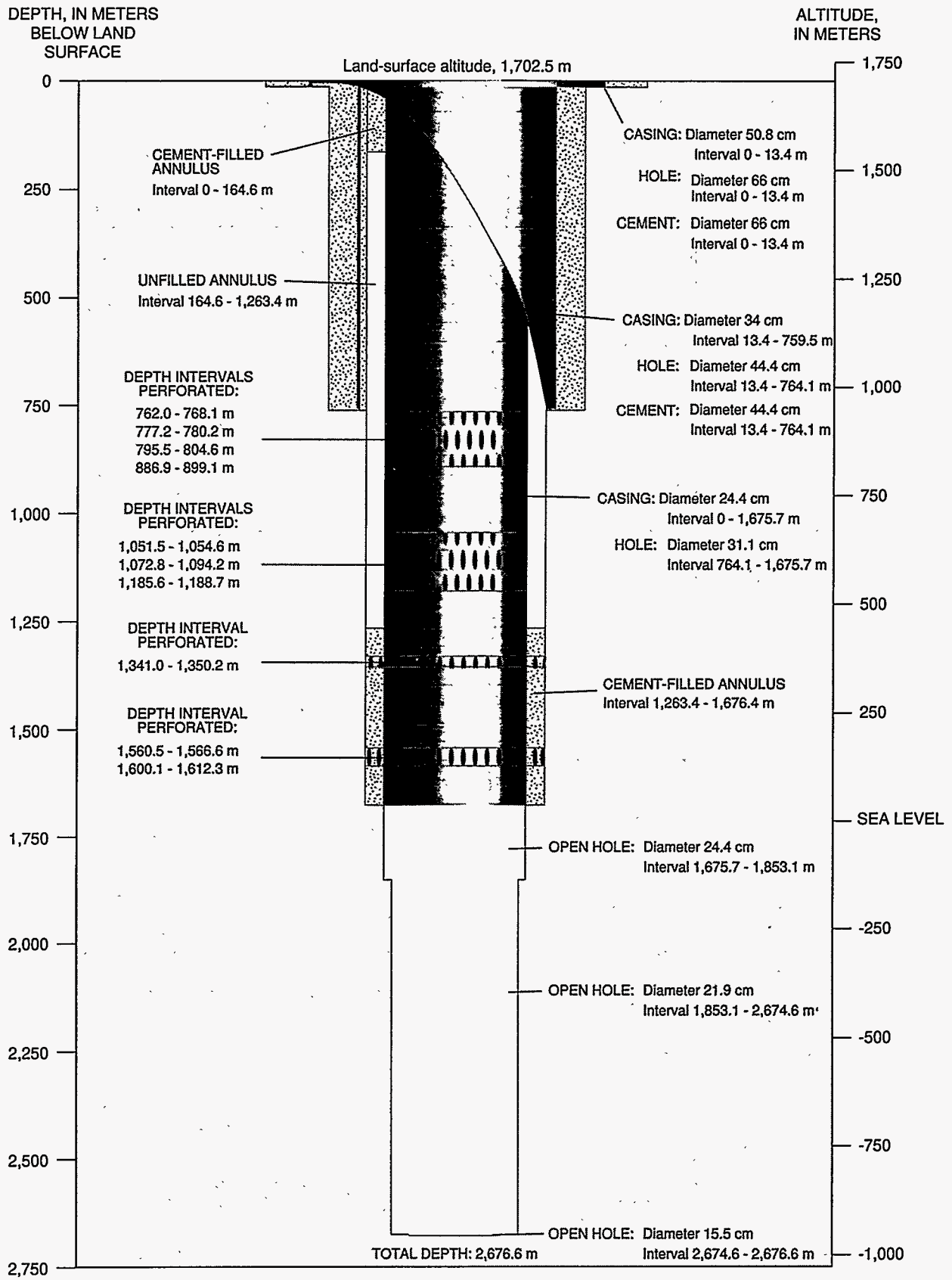


**Figure 7.** Construction details at well PM-2 from drillers' log. (Abbreviations: cm, centimeter; m, meter.)

of 24.4-cm diameter was installed to a depth of 1,675.7 m. Below the bottom of the 24.4-cm casing, from 1,675.7 to 2,676.6 m, well PM-2 was left as an open hole.

The annular spaces of the 50.8-cm and the 34.0-cm casings were cemented throughout the length of their casings. The annular space of only the uppermost part and the lowermost part of the 24.4-cm diameter casing was cemented. The annular space of the 24.4-cm casing was left open from 164.6 m to 1,263.4 m.

Filling, bridging, and caving of the drill hole were the main problems during the construction of PM-2. These problems first began to slow the drilling at about 1,265 m and continued to cause delays until drilling reached a depth of about 1,965 m. Of the 146 days the drill rig was at the site, 32 days were lost in washing and cleaning out bridges and fills in the hole and in attempts to prevent caving. One unsuccessful attempt involved setting packers between 1,664.2 m and 1,761.7 m and injecting 6,359.3 L of an "AM9" solution. AM-9 is an acrylamide, which polymerizes under the influence of ammonium persulfate and K ions (J.L. Thompson, LANL, written commun., 1994). However, replacing the circulation medium of the drill hole from an air-and-water mist to a bentonite-based mud mixed with diesel oil allowed drilling to continue from 1,965 m to the bottom of the hole at 2,676.6 m. To prevent further caving after total depth was reached, the drilling mud was left in the hole.

## Log Characteristics

RSN has about 70 geophysical logs on well PM-2. Information on the type of logs available, dates the logs were run, and the logged interval is presented in Appendix B. Most of the logs (43) were made during June-October 1964 as an aide in the drilling of well PM-2.

In April 1966, logs were run in preparation for the gun perforation of the well PM-2 casing. In November 1968, casing-collar-locator, caliper, and fluid-density logs were run prior to the December 1968 Schooner event. In June 1969, similar logs also were run to investigate the possible effect of the Schooner event on well PM-2. On June 20, 1983, a depth-check log was run and the USGS began periodic depth-to-water measurements in well PM-2. In October 1983, several geophysical logs were completed.

Caliper and casing collar locator logs made in November 1968 and in June 1969, before and after the Schooner event in December 1968, were compared by Gillespie (1994). Both sets of logs were completed in the interval from 0 to 304.8 m. Five possible breaks in the casing were identified at depths of 19.5, 37.5, 62.5, 144, and 151.5 m.

On July 11, 1994, a video camera was lowered into well PM-2 by LLNL to examine the casing for breaks. The camera was slowly run from the surface to the water table, passed the depths identified as suspect from the logs. No ruptures or tears in the casing were found. The video log of the well showed no evidence that ground water could have entered the well bore above the water level through casing breaks.

## Geologic Characteristics

Original lithology of well PM-2 is characterized by Hasler and Byers (1965). Geologic data for Schooner observation holes are discussed by Purtymun and others (1969). More recently, geologic nomenclature has been updated by Warren and others (1989). A summary of the geologic groups, units, lithologies, and depths at well PM-2 as described by Warren and others (1989) is in table 1. Results from cores that were analyzed immediately following drilling at well PM-2 show slightly welded tuffs down to 825.05 m with no fractures. Dacitic lavas and argillized lithic-rich tuffs between 874.8 m and 1,268 m were slightly to moderately fractured. The lava flows between 1,268 m and 2,520.7 m were moderately to highly fractured. The intrusive contact zone from 2,520.7 m to 2,554.1 m was moderately fractured whereas the granodiorite porphyry from 2,554.1 m to 2,676.8 m were extremely fractured (Hasler and Byers, 1965, p. 4).

## Soil Characteristics

Soil samples around the wellhead of well PM-2 were obtained on November 19, 1993, by REECo's Ramatrol Division for analysis by REECo Analytical Services Division. Summary results of soil moisture, $^{3}H$, and gamma spectroscopy on the soil around the wellhead are shown in table 2. A copy of REECo's analytical report on the soil samples is provided in Appendix C. Locations of six soil-sampling points around well PM-2 and the field descriptions of each site are in figure 8. Soil samples were obtained 5 or 5.6 m from the wellhead at the surface and from a depth of 30 cm at each site. Some of the samples represented undisturbed pre-event soil (virgin soil) and some samples represented ejecta from the Schooner event (throwout; F.D. Ferate, REECo Analytical Services, written

**Table 1.** Summary of lithologic log of well PM-2 (modified by Warren and others, 1989; R.G. Warren, Los Alamos National Laboratory, written commun., 1991)

| Depth (meters below land surface) | Stratigraphic unit | | Lithology |
|---|---|---|---|
| | Group | Member | |
| 0-15.2 | Thirsty Canyon Group | Trail Ridge Tuff | Densely welded ash-flow tuff |
| 15.2-91.4 | do. | Pahute Mesa Tuff | Partially welded and nonwelded ash-flow tuff |
| 91.4-109.7 | do. | Rocket Wash Tuff | Densely welded ash-flow tuff |
| 109.7-164.6 | Belted Range Group | Grouse Canyon Tuff | Densely welded ash-flow tuff |
| 164.6-298.7 | Tunnel Formation | Tunnel 3 member: Beds3bc | Bedded tuff: tuffaceous sandstone and interbedded nonwelded ash-flow tuff |
| 298.7-402.3 | Volcanics of Big Dome | Tub Spring Tuff | Nonwelded ash-flow tuff |
| 402.3-451.1 | Older volcanics | Rhyolite of Quartz Mountain | Zeolitized-bedded tuff |
| 451.1-719.3 | do. | Redrock Valley Tuff | Zeolitized nonwelded tuff |
| 719.3-755.9 | do. | Volcanics of Mount Helen: dacite-andesite | Dacite-andesite |
| 755.9-874.8 | do. | Upper "Fraction" Tuff | Zeoltized nonwelded tuff |
| 874.8-1,033.3 | do. | Volcanics of Mount Helen: dacite-andesite | Dacitic flow breccias and lava |
| 1,033.3-1,268.0 | do. | Volcanics of Mount Helen: Tuff of Wilsons Camp | Nonwelded zeolitized lithic tuffs, dacitic lava and flow breccias; zeolitized lithic nonwelded tuff; bedded tuffaceous mudstone |
| 1,268.0-2,554.1 | do. | Volcanics of Mount Helen: dacite-andesite | Dacitic lava flows; bedded tuff (zeolitized tuffaceous sandstone and mudstone); rhyodacitic lava flows; zeolitized nonwelded tuff; altered dacitic lava flow; silicified volcanic rock near basal contact |
| 2,554.1-2,633.3 | Brecciated aplite and granodiorite | | |
| 2,633.3-2,676.8 | Granodiorite | | |

commun., 1994). The soil around the wellhead was moved and graded after the Schooner test to uncover the well and to re-establish a dirt road to the well. As a result of these activities, the soil samples probably are a mix of undisturbed soil and ejecta material (F.D. Ferate, REECo Analytical Services, written commun., 1994).

Soil moisture was analyzed by measuring the mass of water in 10 g of each soil sample to determine the relation of the $^{3}H$ concentrations in the soil to $^{3}H$ concentrations in water (Appendix C). The $^{3}H$ concentration of the soil was determined by multiplying the $^{3}H$ concentration of the extracted water by the ratio of the soil-moisture mass to soil mass (F.D. Ferate, REECo, written commun., 1994).

Soil moistures ranged from 0.11 to 0.58 g of water per 10 g of soil, except for the sample at point C at 30 cm. The soil moisture of this sample was 2.5 g of water per 10 g of soil. The field description of this sample indicates that the sample was from the middle of the road leading to well PM-2 and that a layer of caliche was directly above the sample. The sample has a different physical appearance than all other samples. It is a fine, whitish, chalky-looking powder of low density and may be a powdered caliche (F.D. Ferate, REECo, written commun., 1994).

In general, results of $^{3}H$ analysis indicated a higher level of $^{3}H$ activity at a depth of 30 cm than samples from the surface (table 2). $^{3}H$ activity in the soil moisture ranged from 1,038 Bq/L to 33,105 Bq/L. Water samples from depth at well PM-2 had similar values. $^{3}H$ activities in the soil ranged from 0.019 to 1.62 Bq/g soil (table 2).

Gamma spectroscopy also was done on the samples by REECo Analytical Services for the detection of radionuclides and results are in Appendix C. Samples were normalized to weight and placed on the end of a high-purity Ge detector in a 500-mL bottle and counted for 20 minutes. Detection limits are from 0.004 to 0.001 Bq/g. Gamma spectroscopy of the soil samples identified six nonnaturally occurring radionuclides ($^{241}Am$, $^{60}Co$, $^{137}Cs$, $^{150}Eu$ $^{152}Eu$, $^{154}Eu$) and four naturally occurring radionuclides ($^{40}Kr$, $^{226}Ra$, $^{228}Th$, $^{232}Th$). The gamma spectrum of each soil sample had numerous unidentified peaks with high counting errors (Appendix C).

**Table 2.** Soil moisture, tritium, and gamma spectroscopy analysis of soil samples around PM-2, November 19, 1993

[Sampling and analysis by Reynolds Electrical & Engineering Company. Abbreviations: Bq/g soil, bequerel per gram of soil; Bq/L, becquerel per liter; cm, centimeter; n.d.; not detected]

| Sample point | Soil moisture (grams water per 10 grams soil) | Tritium in soil moisture (Bq/L) | Tritium (Bq/g soil) | Nonnaturally occurring | | | | | | Sum of nonnatural radionuclides (Bq/g soil) | Naturally occurring | | | | Sum of natural radionuclides (Bq/g soil) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Americium-241 (Bq/g soil) | Cobalt-60 (Bq/g soil) | Cesium-137 (Bq/g soil) | Europium-150 (Bq/g soil) | Europium-152 (Bq/g soil) | Europium-154 (Bq/g soil) | | Potassium-40 (Bq/g soil) | Radium-226 (Bq/g soil) | Thorium-228 (Bq/g soil) | Thorium-232 (Bq/g soil) | |
| A-Surface | 0.26 | 1,038 | 0.027 | 0.273 | 0.087 | 0.030 | 0.023 | 0.261 | 0.229 | 0.903 | 1.37 | 0.038 | 0.088 | 0.078 | 1.574 |
| A-30 cm | .49 | 2,102 | .103 | n.d. | n.d. | .004 | n.d. | n.d. | n.d. | .004 | 1.01 | .053 | .091 | .081 | 1.235 |
| B-Surface | .12 | 1,833 | .022 | .633 | .166 | .039 | .045 | .544 | .462 | 1.889 | 1.55 | .032 | .084 | .083 | 1.749 |
| B-30 cm | .13 | 19,385 | .252 | .023 | .009 | .043 | n.d. | .024 | .021 | .120 | 1.55 | .034 | .092 | .074 | 1.750 |
| C-Surface | .11 | 21,727 | .239 | .548 | .139 | .033 | .037 | .496 | .407 | 1.660 | 1.36 | .043 | .092 | .086 | 1.581 |
| C-30 cm | 2.5 | 3,524 | .881 | n.d. | n.d. | .002 | n.d. | n.d. | n.d. | .002 | .056 | .006 | .010 | .010 | .082 |
| D-Surface | .19 | 33,105 | .629 | .336 | .104 | .030 | .027 | .312 | .266 | 1.075 | 1.64 | .032 | .087 | .078 | 1.837 |
| D-30 cm | .17 | 1,118 | .019 | .142 | .044 | .028 | .012 | .128 | .110 | .464 | 1.56 | .031 | .080 | .077 | 1.748 |
| E-Surface | .29 | 6,690 | .194 | .514 | .094 | .039 | .026 | .370 | .288 | 1.331 | 1.38 | .033 | .077 | .067 | 1.557 |
| E-30 cm | .58 | 27,931 | 1.62 | n.d. | .003 | .017 | n.d. | .009 | .009 | .038 | .918 | .039 | .077 | .067 | 1.101 |
| F-Surface | .18 | 7,111 | .128 | .740 | .230 | .048 | .067 | .773 | .640 | 2.498 | 1.36 | .038 | .065 | .079 | 1.542 |
| F-30 cm | .45 | 4,267 | .192 | .022 | .006 | .010 | n.d. | .017 | .016 | .071 | .966 | .070 | .079 | .067 | 1.182 |
| Surface sample average | 0.192 | 11,917 | 0.206 | 0.507 | 0.137 | 0.036 | 0.038 | 0.459 | 0.382 | 1.559 | 1.44 | 0.036 | 0.082 | 0.078 | 1.64 |
| 30-cm sample average | [1]0.364 | 9,721 | 0.511 | 0.062 | 0.016 | 0.017 | 0.012 | 0.044 | 0.039 | 0.116 | 1.01 | 0.039 | 0.072 | 0.063 | 1.183 |

[1] Average value does not include sample at C-30 cm.

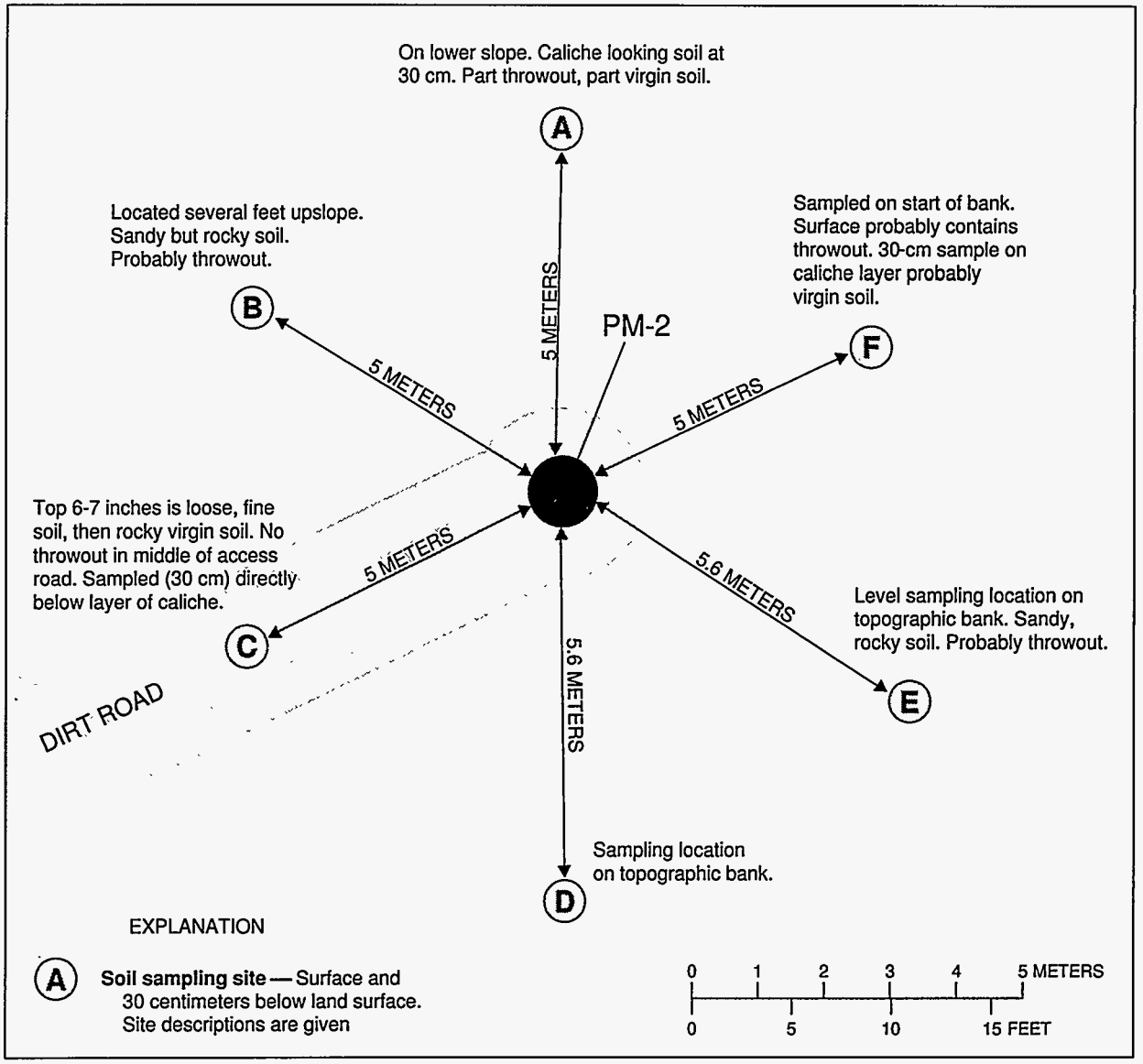


**Figure 8.** Soil-sampling sites adjacent to well PM-2 (from REECo field notes).

Results from previous soil-profile studies at other NTS areas showed that generally more than 95 percent of Am remained in the top 5 cm of surface soil after 10-20 years of residence time in undisturbed areas (Romney and others, 1987). At each of the six soil-sample sites near well PM-2, $^{241}$Am concentration was greater in soil collected from the surface than from 30 cm (table 2). $^{241}$Am was not detected in three of the soil samples at 30 cm, while the ratio of $^{241}$Am at surface to $^{241}$Am at 30 cm in the other three samples ranged from 2.36 to 33.6.

Activities of the six nonnaturally occurring radionuclides in the 12 soil samples ranged from not detected to 0.773 Bq/g of soil (table 2). The sum of the radioactivity of these six radionuclides at a given site ranged from 0.002 to 2.498 Bq/g of soil. At each of the six sites, the total activity of the surface samples was at least an order of magnitude greater than samples at 30 cm. At sample A at 30 cm and sample C at 30 cm, only trace amounts of $^{137}$Cs were found.

The four naturally occurring radionuclides were found in all 12 samples, ranging in value from 0.006 to 1.64 Bq/g of soil (table 2). The total activity of these four radionuclides at a given site ranged from 0.082 to 1.837 Bq/g of soil. The radionuclides were nearly equally distributed between the surface samples and samples at 30 cm for a given site, except at site C. The surface sample at site C had more than an order of

magnitude greater activity of natural radionuclides than the 30-cm sample. This is consistent with the interpretation that this sample is caliche (F.D. Ferate, REECo Analytical Services, written commun., 1994).

Relative to underground tests, cratering events, such as Schooner, typically produce more neutron-activation products than fission products. Of the six nonnaturally occurring isotopes, four are activation products ($^{60}$Co, $^{150}$Eu, $^{152}$Eu, $^{154}$Eu) and only $^{137}$Cs is a fission product. $^{241}$Am is a decay product of $^{241}$Pu, a common nuclear fuel (G.J. Nimz, LLNL, written commun., 1994).

## Hydrologic Characteristics

Hydraulic testing at well PM-2 in July 1964 is summarized in Appendix D. A detailed account of hydrologic testing at well PM-2 is given by Blankennagel and others (1964). Typically, hydraulic testing consisted of a suite of geophysical logs being run, followed by pumping tests, then a series of injection or swabbing tests. Injection tests indicated a low relative specific capacity for water flow. A swabbing test was run with the hole open from 759.5 m to 1,214.0 m (Blankennagel and others, 1964, p. 24). The water level was lowered 274.3 m below the static water level of approximately 394.4 m with little indication of water inflow. Recovery over the next 17 $^{1}/_{2}$ hours was 13.7 m.

Water-level measurements have been sporadic over the years and are available during drilling, testing, and logging activities at well PM-2. In 1969, water-level measurements were discontinued following the Schooner event, until 1983, when the U.S. Geological Survey began measurements on an intermittent basis (table 3). The water level had remained almost constant from 1983 through 1993 varying less than 0.65 m. In May 1993, a water-level measurement indicated that levels in the well had risen 4.77 m (fig. 4). Subsequent measurements show water levels declining to previous levels.

## Water-Quality Analyses

Water samples from the deep wells and holes at NTS are routinely collected with a wireline point sampler. The stainless-steel sampler is about 1.52 m long and 4.1 cm in diameter, and has a capacity of 2.2 L. The sample intake ports are about 1 m below a water-level sensor attached to the sampler. The ports are closed while the device is lowered and raised in the water column and are opened when the desired depth is reached. Prior to collecting a water sample, the standard U.S. Geological Survey procedure is to rinse the sampler with a 0.5 percent solution of hydrochloric acid, followed by rinsing with distilled water. Problems associated with collecting water samples with a point sampler include concerns about the representativeness of a sample of water from inside the casing to that of water in the aquifer; time delay in bringing a water sample to the surface; and mixing of the water column caused by lowering and raising the sampler.

### Field Water Quality, Tritium, and Krypton

Four water samples were collected on August 17, 1993, from well PM-2 as part of an investigation of the unexpected rise in the water level. Samples were collected with a point sampler at 258 m (water surface), 305 m, 610 m, and 765 m below land surface. The first open interval in the well casing is between 762 and 768 m. After the samples were brought up from depth, the temperature, specific conductance, and pH were determined in the field as soon as possible. $^{3}$H analysis were done later in the laboratory by the EMSL. No $^{3}$H analysis from well PM-2 prior to 1993 could be located. Field water-quality and $^{3}$H-analysis results are shown in figure 9. $^{3}$H levels in the two deepest samples (20,400 Bq/L at 610 m and 23,500 Bq/L at 765 m) exceeded proposed USEPA limits for $^{3}$H of 740 Bq/L by almost two orders of magnitude. Four additional samples at depths below land surface of 305 m, 610 m, 765 m, and 1,067 m were obtained from well PM-2 on September 27, 1993 (fig. 9), to confirm the elevated $^{3}$H levels.

**Table 3.** Summary of water-level measurements at well PM-2, 1983-94

| Date | Water level (meters below land surface) | Date | Water level (meters below land surface) |
|---|---|---|---|
| 06-20-83 | 259.38 | 09-30-91 | 259.67 |
| 03-13-85 | 259.85 | 05-20-92 | 259.74 |
| 05-01-86 | 259.53 | 05-20-93 | 254.97 |
| 06-16-87 | 259.20 | 06-18-93 | 255.86 |
| 03-13-88 | 259.44 | 07-12-93 | 256.30 |
| 10-17-88 | 259.22 | 08-02-93 | 256.72 |
| 05-09-89 | 259.43 | 08-17-93 | 257.01 |
| 09-20-89 | 259.50 | 08-24-93 | 257.22 |
| 10-27-89 | 259.56 | 09-07-93 | 257.41 |
| 04-11-90 | 259.48 | 09-14-93 | 257.47 |
| 09-13-90 | 259.59 | 09-23-93 | 257.58 |
| 01-15-91 | 259.68 | 09-27-93 | 257.70 |
| 04-24-91 | 259.56 | 03-28-94 | 259.24 |
| 07-25-91 | 259.61 | | |

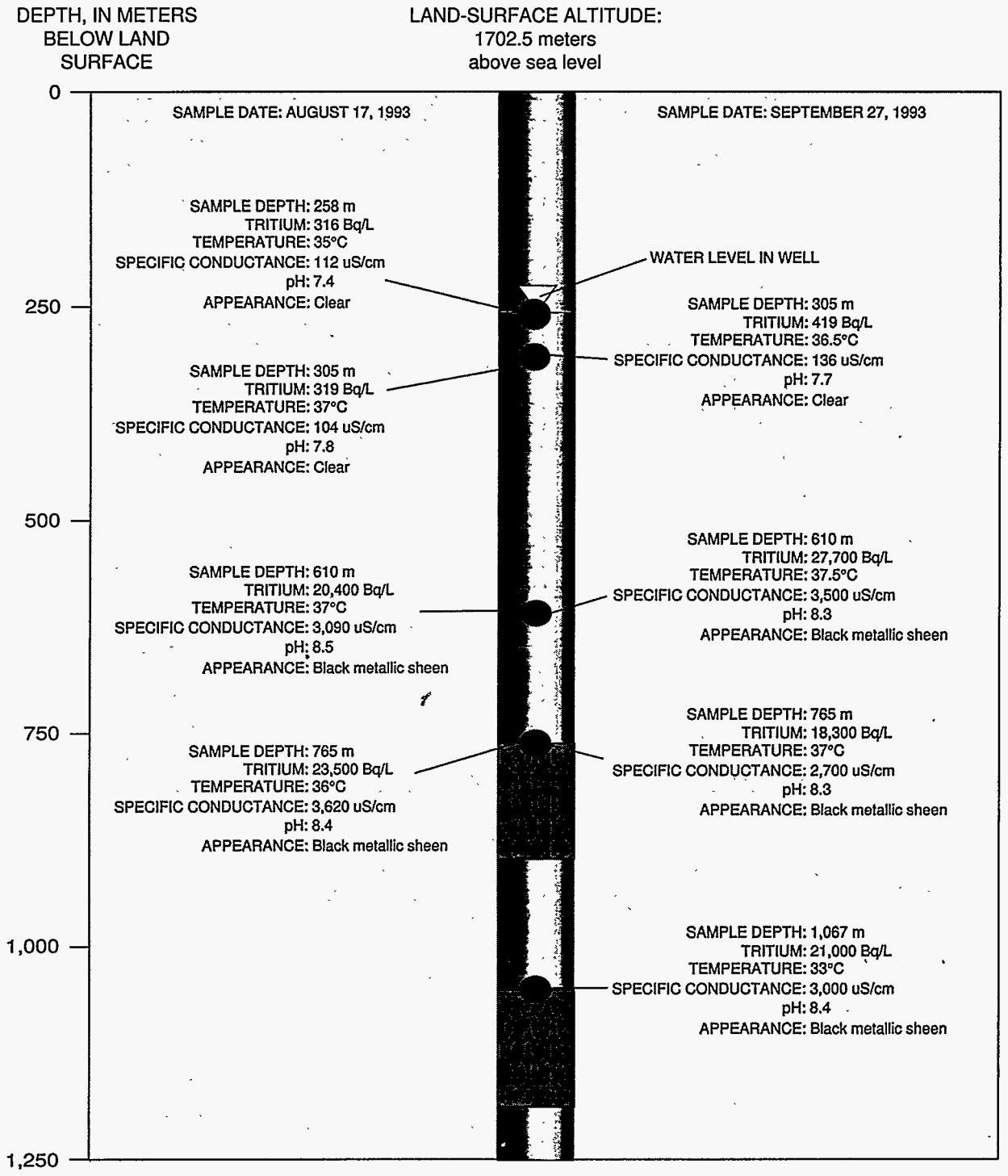


**Figure 9.** Water-quality data collected (by U.S. Geological Survey) at well PM-2, August 17, 1993, and September 27, 1993. Abbreviations: Bq/L, becquerel per liter; °C, degree Celsius; m, meter; µS/cm, microsiemens per centimeter.

The water samples from 258 m and 305 m were generally clear, while the deeper samples were black in color with a somewhat metallic sheen. These deeper samples also rapidly effervesced when poured out of the sampler, which could affect the laboratory and field measurements if the samples were changing chemically to a new equilibrium. The pH, specific conductance, and $^{3}H$ activity of the water samples at a depth of 610 m and below were about an order of magnitude greater than that of the samples at depths of 258 m and 305 m (fig. 9). The low specific conductance of these shallower samples (fig. 9) suggests that these waters could be classified as fresh (dissolved-solids concentration less than 1,000 mg/L). The $^{3}H$ activity of the samples at 258 m and 305 m (table 4) was almost an order of magnitude less than the activity of the soil-moisture samples (table 2) taken around well PM-2.

The confirmation of the elevated $^{3}H$ levels in the well led to additional sampling by LLNL and LANL during November 30-December 1, 1993, and May 3-4, 1994. Samples were collected using point samplers stacked in tandem. The samplers were rinsed with deionized water, then alcohol, and evacuated prior to being lowered into the hole. Samples were split between LANL, LLNL, REECo, and the State of Nevada (G.J. Nimz, LLNL, written commun., 1994). LANL analyzed the sample in detail (which required a large volume of sample water) for $^{3}H$, $^{85}Kr$, and gamma spectroscopy. LLNL was tasked with analysis for dissolved inorganic constituents, trace metals, volatile and semivolatile organic compounds, gross alpha and beta, and various radionuclides ($^{14}C$, $^{36}Cl$, $^{3}He$, $^{4}He$, $^{238}Pu$, $^{239}Pu$, $^{90}Sr$) in addition to $^{3}H$ analysis and gamma spectroscopy.

$^{3}H$ analyses from LANL (J.L. Thompson, LANL, written commun., 1994) and LLNL (G.J. Nimz, LLNL, written commun., 1994) are shown in table 4, along with results from previous analyses by EMSL (T.M. Grady, EMSL, written commun., 1993) and REECo (F.D. Ferate, REECo, written commun., 1994). The $^{3}H$ activity in water samples taken from 305 m and above was about two orders of magnitude less than water samples taken from 610 m and below. The average activity of $^{3}H$ from water samples from 258 m and 305 m was 515 Bq/L. The average activity of $^{3}H$ from 610 m and greater depths was 23,200 Bq/L. The variability of the $^{3}H$ analyses for a given depth may be due to movement into or out of the well or more likely a function of the mixing of the water column within the borehole as the sampling devices were lowered and raised. The highest $^{3}H$ values appear at 610 m, which is about 155 m above the first known open interval in the well. Further investigation might clarify whether contamination entered the casing about 600 m below land surface. These $^{3}H$ values, however, were only slightly higher than values found at greater depth in the well (table 4).

**Table 4.** Tritium analysis of water samples from PM-2, 1993-94

[*Tritium values in becquerels per liter.* Abbreviations: EMSL, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory; REECo, Reynolds Electrical Electrical & Engineering Co., Inc., Analytical Services; F.D., field data; L.D., laboratory data; LANL, Los Alamos National Laboratory; LLNL, Lawrence Livermore National Laboratory; n.d., not detected; n.m., not measured; n.s., not sampled]

| Analyzing laboratory | Date(s) sampled | Sample depth, below land surface | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 258 meters | 305 meters | 610 meters | 765 meters | 823 meters | 915 meters | 1,067 meters |
| EMSL | 08/17/93 | 316 | 319 | 20,400 | 23,500 | n.s. | n.s. | n.s. |
| REECo | 08/17/93 | 331 | 293 | 20,700 | 23,900 | n.s. | n.s. | n.s. |
| EMSL | 09/27/93 | n.s. | 419 | 27,700 | 18,300 | n.s. | n.s. | [1]21,000 |
| REECo | 09/27/93 | n.s. | 445 | 29,600 | 19,500 | n.s. | n.s. | [1]22,300 |
| LLNL - F.D. | 11/30-12/01/93 | n.s. | 537 | 27,200 | n.s. | 22,000 | 19,600 | n.s. |
| LLNL - L.D. | 11/30-12/01/93 | n.s. | 937 | 26,300 | n.s. | 22,900 | 21,400 | n.s. |
| LANL | 11/30-12/01/93 | n.s. | 541 | 27,000 | n.s. | 25,700 | n.s. | n.s. |
| LLNL - F.D. | 05/3-4/94 | n.s. | n.d. | n.s. | n.s. | 20,900 | n.m. | n.s. |
| LLNL - L.D. | 05/3-4/94 | n.s. | 756 | n.s. | n.s. | 24,600 | 21,600 | n.s. |
| LANL | 05/3-4/94 | n.s. | 770 | n.s. | n.s. | 25,100 | 23,300 | n.s. |
| AVERAGE CONCENTRATION | | 324 | 557 | 25,600 | 21,300 | 23,500 | 21,500 | 21,600 |

[1]Possible obstruction at 1,000 meters; depth may be less than 1,067 meters.

$^{85}Kr$ is a fission product of nuclear testing. Results of analyses by LANL for $^{85}Kr$ (J.L. Thompson, LANL, written commun., 1994) are given in table 5. The detection limit of the procedure used for $^{85}Kr$ analysis is 0.037 Bq/L. $^{85}Kr$ activity was low in all samples. $^{85}Kr$ was below the detection limit in samples from depths of 610 m and 823 m and only slightly above the limit in a sample from 915 m. The highest activity was found in the sample from 305 m, although the second time a sample was taken from this depth the value was just above the detection limit.

**Table 5.** Krypton-85 analysis of water samples from well PM-2, 1993-94

[Sampling and analysis by Los Alamos National Laboratory. Abbreviations: b.d.l., below detection limit; Bq/L, becquerels per liter; n.s., not sampled]

| Dates sampled | Sample depth, below land surface | | | |
|---|---|---|---|---|
| | 305 meters | 610 meters | 823 meters | 915 meters |
| 11/30/93-12/01/93 | 0.52 Bq/L | b.d.l. | b.d.l. | n.s. |
| 05/03/94-05/04/94 | 0.09 ± 0.04 Bq/L | n.s. | b.d.l. | 0.09 ± 0.03 Bq/L |

## Carbon-14, Chlorine-36, and Strontium-90

Results of analysis by LLNL for $^{14}C$, $^{36}Cl$ (both of which are activation products) and $^{90}Sr$ (a fission product) on water samples collected November 30-December 1, 1993, are presented in table 6. $^{14}C$ and $^{36}Cl$ were within expected activity levels. All $^{90}Sr$ samples were below detectable levels.

**Table 6.** Analysis of carbon-14, chloride-36, and strontium-90 in water samples from well PM-2, November 29-December 1, 1993

[Sampling and analysis by Lawrence Livermore National Laboratory. Abbreviations: b.d.l., below detection limit; Bq/L, becquerels per liter; n.s., not sampled]

| Sample depth (meters below land surface | Carbon-14 (Bq/L) | Chloride-36 (Bq/L) | Strontium-90 (Bq/L) |
|---|---|---|---|
| 305 | 250 | 0.000152 | b.d.l. |
| 610 | 200 | 0.0000222 | b.d.l. |
| 823 | 100 | n.s. | b.d.l. |
| 915 | 1,630 | 0.00002 | b.d.l. |

## Helium Age Dating

LLNL analyzed water samples collected at 610 and 910 m on November 29-December 1, 1993, for $^{3}He$ and $^{4}He$. The results of the analyses are presented in table 7. $^{3}H$ decays to He, and this ratio can be used as a dating tool. Analysis of the data by LLNL suggest that the water samples were about 9 years old. Limitations of the analysis include loss of He to the atmosphere, especially if the aquifer is not totally confined, contact of the sample with air during sampling, or mixing of waters with different He ratios.

**Table 7.** Helium-3 and helium-4 analyses used to determine age of water samples from well PM-2, November 29-December 1, 1993

[Analysis by Lawrence Livermore National Laboratory]

| Sample depth (meters below land surface) | Helium-3 atoms/L | Helium-4 atoms/L | Helium-3/ tritium age since May 1994 |
|---|---|---|---|
| 610 | $7.86 \times 10^{9}$ | $1.75 \times 10^{14}$ | 3,348 days |
| 915 | $5.36 \times 10^{9}$ | $1.43 \times 10^{14}$ | 3,162 days |

## Gamma Spectral

Both LLNL and LANL performed gamma spectral analyses on water samples collected from well PM-2 in November-December 1993 and in May 1994. Because LANL had a larger available sample size, a more sensitive gamma spectral analysis was done. In the procedure used by LLNL, a relatively small sample aliquot (0.5 L) was placed within an "uplooker" Ge detector and counted for 5 days. LLNL analyzed unfiltered samples, filtered samples, and the non-filterable residue. Complete results of LLNL analysis with the analytical detection limits are presented in Appendix E. LANL used an evaporation procedure appropriate for the larger volume (2.2 L) available to them. After evaporation, the sample residue was counted for 3,000 minutes (about 2 days) on a Ge counter. Summary analysis results from LLNL and LANL are given in table 8.

Both laboratory analyses show that the gamma radiation in well PM-2 was minor. Most of the water samples contain no gamma-emitting radionuclides. Of the three measurable radionuclides found—$^{137}Cs$, $^{226}Ra$, and $^{125}Sb$—none had an activity greater than 3 Bq/L. Most likely, the $^{226}Ra$ detected by LLNL is a natural decay from $^{238}U$ (G.J. Nimz, LLNL, written commun., 1994). Confirmation of this would require an analysis of the rocks adjacent to the well for their

**Table 8.** Gamma spectral analysis of water samples from well PM-2, 1993-94

[Abbreviations: b.d.l., below detection limit; Bq/L, becquerels per liter; n.d., not detected; m.w., molecular weight]

| Sample depth (meters below land surface) | Sampling and analysis by Lawrence Livermore National Laboratory | | | | | | Sampling and analysis by Los Alamos National Laboratory | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sampling of 11/29-12/01/93 | | Sampling of 05/3-4/94 | | | | Sampling of 11/29-12/01/93 | | Sampling of 05/3-4/94 |
| | Radium-226 (Bq/L) | | Radium-226 (Bq/L) | | Antimony-125 (Bq/L) | Cesium-137 (Bq/L) | Antimony-125 (Bq/L) | Cesium-137 (Bq/L) | Cesium-137 (Bq/L) |
| | Unfiltered water | 10,000 m.w. filter | Unfiltered water | 10,000 m.w. filter | Filtered water | Filtered water | | | |
| 305 | 0.615 | 0.0667 | 0.123 | 0.0378 | 0.0168 | 0.00881 | n.d. | n.d. | n.d. |
| 610 | b.d.l. | n.d. | (not sampled) | | | | (not sampled) | | |
| 823 | 0.0878 | n.d. | b.d.l. | n.d. | b.d.l. | 0.0349 | n.d. | trace | 0.01 |
| 915 | b.d.l. | n.d. | b.d.l. | 0.0256 | b.d.l. | b.d.l. | 0.02 | 2.4 | 0.096±0.054 |

U concentrations, and also would require U-series analysis for well PM-2 water (G.J. Nimz, LLNL, written commun., 1994).

The detection of $^{125}Sb$ is not an uncommon occurrence near cratering events. Substantial amounts of radioactive Sb have been detected in postshot debris (J.L. Thompson, LANL, written commun., 1994). Pb used as shielding for the Schooner event was "Sb hardened." When the event was detonated, the neutron activation would produce $^{125}Sb$. A substantial amount of Pb was used because Schooner was a cratering experiment (J.L. Thompson, LANL, written commun., 1994).

LANL also collected some of the sludge from well PM-2 at an approximate depth of 984 m. Two small cinders from the land surface, between well PM-2 and Schooner, were analyzed also. No gamma emitters were detected during laboratory analysis of the sludge; the cinders contained several becquerels of $^{60}Co$, $^{154}Eu$, $^{152}Eu$, $^{137}Cs$, and $^{133}Ba$, lesser amounts of $^{108}Ag$, and possibly $^{150}Eu$ and $^{155}Eu$ (J.L. Thompson, LANL, written commun., 1994).

## Gross Alpha and Gross Beta

Gross alpha and gross beta were analyzed by LLNL of the samples collected during November 29-December 1, 1993, and during May 3-4, 1994 (Appendix E). Water samples from depths of 305 m, 610 m, 823 m, and 915 m were analyzed. The gross alpha and beta counts of all the samples were below detection limits of about 3 Bq/L.

## Plutonium

Results of the analysis by LLNL of the combined activity of $^{238}Pu$ and $^{239}Pu$ are presented in table 9. No isotopes were detected at depths of 305 and 610 m. A small amount (average activity of 0.00444 Bq/L) of the Pu isotopes were present at a depth of 915 m and smaller amounts (0.00163 Bq/L) at a depth of 823 m. The measured Pu isotopic ratios suggest Schooner as a possible source of contamination and further support the belief that contamination was washed in from the surface (G.J. Nimz, LLNL, written commun., 1994).

**Table 9.** Analysis of combined plutonium-238 and plutonium-239 in raw water samples from well PM-2, May 3-4, 1994

[Sampling and analysis by Lawrence Livermore National Laboratory. Abbreviations: b.d.l., below detection limit; Bq/L, Bequerels per liter]

| Depth (meters) | Activity (Bq/L) | Error +2σ |
|---|---|---|
| 305 | <2.5E-04 | b.d.l. |
| 823 | 1.63E-03 | 4.15E-04 |
| 915 | 4.33E-03 | 6.85E-04 |

## Inorganic Constituents

During November 1993, REECo Analytical Services analyzed water collected by the USGS on September 27, 1993, from a depth of 610 m in well PM-2. Analytical results of inorganic constituents are shown in Appendix F. To obtain sufficient sample volume for analysis, the sample was diluted by a factor of 2.3, for

a final volume of 1,000 mL. During the preparation of the sample for metals analysis, 100 mL of the remaining 1,000 mL sample was digested and concentrated to a final volume of 50 mL, or a concentration factor of 2.0, to obtain as close a concentration as possible to the original sample (F.D. Ferate, REECo, written commun., 1994). Al (0.13 mg/L) exceeded the USEPA secondary maximum contaminant level (SMCL) of 0.05 to 0.2 mg/L. Mn (0.11 mg/L) and Fe (2.8 mg/L) also exceeded the SMCL's of 0.05 and 0.3 mg/L, respectively (U.S. Environmental Protection Agency, 1996).

LLNL analyzed for inorganic constituents in water samples collected from well PM-2 during November 29-December 1, 1993. The results of the analyses are presented in Appendix E. Except for Na, concentrations of constituents listed in Appendix E were relatively low. Five of the constituents (Al, B, Li, Mg, P) were present in concentrations of less than 1 mg/L. Six other constituents (Ca, Cl, Fe, K, S, Si) were present in concentrations of less than 20 mg/L in all the samples collected. Al exceeded USEPA SMCL (0.05-0.2 mg/L) at 915 m (0.14 mg/L). Fe also exceeded the SMCL (0.3 mg/L) at 610 m (1.29 mg/L), 823 m (1.22 mg/L), and 915 m (2.40 mg/L).

The concentrations of B, Fe, K, Na, Si and S more than doubled from the 305-m sample to the 610-m sample. Na increased in concentration from 26 mg/L in the shallowest sample to more than 1,000 mg/L in all the deeper samples. Differences in the concentrations of these six constituents in the samples taken at depths of 610 m, 823 m, and 915 m, were slight.

The largest increase in most trace constituents listed in Appendix E was between the samples taken at 305 m and 610 m below land surface. Eight of the constituents (Cr, Cu, Pb, Hg, Mo, Ni, Se, U) were at least an order of magnitude higher in concentration in the 610-m sample than the 305-m sample. The largest increase in concentration is present in five constituents (Cr, Cu, Mo, Se, Sr). Mn was the only constituent found higher in concentration (by an order of magnitude) in the 305-m sample than in the 610-m sample. Co, Hg, and U were found in concentrations of less than 10 µg/L in all the sample depths. Half of the constituents listed in Appendix E (Ba, Cr, Mn, Mo, Se, Sr, Zn) were found to exceed 100 µg/L in at least one sample depth.

Hg and Se exceeded the USEPA MCL's (2 µg/L and 50 µg/L, respectively) at depths of 610 m (7.9 µg/L and 127 µg/L, respectively), 823 m (7.9 µg/L and 71 µg/L, respectively), and 915 m (9.8 µg/L and 118.1 µg/L respectively). Mn exceeded the USEPA SMCL (50 µg/L) at 305 m (124.5 µg/L) and at 915 m (74.8 µg/L).

### Organic Compounds

During November 1993, REECo Analytical Services analyzed water collected by the USGS on September 27, 1993, from a depth of 610 m in well PM-2. Analytical results of semivolatile organics are shown in Appendix F. The 450-mL sample was diluted to obtain a sufficient volume for analysis. The sample was diluted by a factor of 2.3, for a final volume of 1,000 mL. Semi-volatile organic analyses detected only one compound, bis (2-ethylhexyl) phthalate. The phthalate detected may be due to contamination during the extensive handling of this sample (F.D. Ferate, REECo, written commun., 1994).

LLNL also analyzed for organic compounds in water samples collected from well PM-2 during November 29-December 1, 1993 (table 10). Samples for volatile and semivolatile organic compounds exceeded LLNL's recommended holding times, and results may not be representative of samples analyzed within recommended holding times. Low concentrations (less than 200 µg/L) of nine organic compounds were detected and no compounds were found in the water sample from 610 m. The only compound found in concentration greater than 100 µg/L was 4-methylphenol at depths of 823 m and 915 m. The total concentration of organic compounds did not exceed 300 µg/L in any sample.

Two compounds (1,1,2-trichloroethane, dimethyl ether) were found in samples from depths of 305 m and 823 m. Three compounds [4-methylphenol, bis(2-ethylhexyl)phthalate, di-n-butylphthalate] were found in samples from 823 m and 915 m. These three compounds were the only semivolatile compounds detected. All the other compounds are volatile.

## SUMMARY

Analysis of water collected during August and September 1993 from well PM-2, on Pahute Mesa at the Nevada Test Site, indicated $^{3}H$ concentrations of 21,000 Bq/L. The Schooner event (U-20u) was detonated in 1968 approximately 270 m southeast of well PM-2 at a working depth of 108.2 m. The crater created by the Schooner event was about 129.8 m in radius and 63.4 m in depth. The continuous ejecta limit was

**Table 10.** Volatile and semivolatile organic compounds in water samples from well PM-2, November 29-December 1, 1993

[Sampling and analysis by Lawrence Livermore National Laboratory]

| Organic compound | Concentration, in micrograms per liter |
|---|---|
| **Sample depth 305 meters below land surface** | |
| Benzene | 4.2 |
| Chloromethane | 2.0 |
| Methylchloride | 0.3 |
| 1,1,2-Trichloroethane | 0.5 |
| Dimethyl ether | 20.0 |
| **Sample depth 610 meters below land surface** | |
| No organic compounds detected | |
| **Sample depth 823 meters below land surface** | |
| Carbondisulfide | 1.0 |
| 1,1,2-Trichloroethane | 0.5 |
| Dimethyl ether | 20.0 |
| 4-methylphenol | 190.0 |
| Di-n-butylphthalate[1] | 21.0 |
| Bis(2-ethylhexyl)phthalate[1] | 35.0 |
| **Sample depth 915 meters below land surface** | |
| 4-methylphenol | 120.0 |
| Di-n-butylphthalate [1] | 18.0 |
| Bis (2-ethylhexyl) phthalate[1] | 25.0 |

[1] Concentration estimated.

asymmetrical, ranging from about 518 m to 823 m. The maximum extent to which earth materials were ejected exceeded 1,830 m.

Geologic and hydrologic properties of the stratigraphic units are summarized from historical data. The soil around the well and water in the well were analyzed for radionuclides and water in the well was also analyzed for inorganic constituents and organic (volatile and semivolatile) substances.

Results of soil sampling indicate that radioactivity of identifiable nonnaturally occurring radionuclides ($^{241}$Am, $^{60}$Co, $^{137}$Cs, $^{150}$Eu $^{150}$Eu, $^{154}$Eu) were the same order of magnitude as that of the natural radionuclides ($^{40}$Kr40, $^{226}$Ra, $^{228}$Th, $^{232}$Th). Gamma spectral analysis of each soil sample had numerous unidentified peaks with high counting errors.

$^{3}$H activity in water samples taken from depths of 258 and 305 m was about two orders of magnitude less than that in water samples taken from 610 m and below. The highest $^{3}$H values (greater than 27,000 Bq/L) were at 610 m below land surface, which is above the shallowest perforations at 765 m. These values are only slightly higher than values found at greater depth in the well. The lowest $^{3}$H values (316 and 319 Bq/L) were found near the water surface in the well, at 258 m and 305 m below land surface. The analysis of $^{3}$H activity in water samples appears consistent among samples collected at different times but at the same or similar depths. The variability of the analytical results may be a function of (1) the mixing of the water column within the borehole as the sampling device was lowered and raised, or, less likely, (2) movement of water into or out of the borehole.

Results for water samples collected from well PM-2 during November 1993 and May 1994 indicate that the concentration of gamma emitters was minor—most samples contain no gamma-emitting radionuclides. Of the three radionuclide detected—$^{137}$Cs, $^{226}$Ra, and $^{125}$Sb—none had an activity greater than 3 Bq/L. The $^{226}$Ra detected by LLNL may be natural decay from $^{238}$U. A small amount (average activity, 0.00433 Bq/L) of the Pu isotopes was present at a depth of 915 m and a smaller amount (0.00163 Bq/L) at a depth of 823 m.

Concentration of inorganic constituents increased with depth. The largest increase was between 305 and 610 m below land surface. Eight of the constituents (Cr, Cu, Pb, Hg, Mo, Ni, Se, U) were at least an order of magnitude higher in concentration in the 610-m sample. The largest increase in concentration is present in five of the constituents (Cr, Cu, Mo, Se, Sr).

Low concentrations (less than 200 µg/L) of nine organic compounds were detected. The only compound found in concentration greater than 100 µg/L was 4-methylphenol, detected by LLNL at depths of 825 m and 915 m. The total concentration of organic compounds did not exceed 300 µg/L in any sample.

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# APPENDIX A. Hole History, Well History, Core Samples, and Cementing Record for Well PM-2

The information contained in Appendix A was provided by Raytheon Services Nevada (formerly Fenix & Scisson). It is presented in the format provided to the USGS.

FENIX & SCISSON, INC.

Appendix B
Revision #1

Date 09-07-65 | HOLE HISTORY DATA | Approved: J. Walker

| HOLE No.: Pahute #2 | W.O. No.: 1160-36 | I.D. No.: 1131 |
|---|---|---|
| USER: LRL | TYPE HOLE: Exploratory | |
| LOCATION: NTS | COUNTY: Nye | AREA: 20 |
| SURFACE COORDINATES: N 944,581.79 E 528,655.28 | | GROUND ELEVATION: 5585.6′ |
| RIG ON LOCATION: 5-20-64 | SPUDDED: 5-20-64 | COMPLETED: 10-13-64 |
| REMARKS: Static water level approximately 1300′. | | |
| CIRCULATING MEDIA: Air, soap and water to 6450′ and mud to 8782′. | | |
| No. of COMPRESSORS & SIZE: 8 Gardner Denver (900 cfm) | | |
| TYPE DRILLING EQUIPMENT: Bethleham MA-10 | | |

| BORE HOLE RECORD | | | CASING RECORD | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FROM | TO | SIZE | I.D | WT/.FT. | WALL | GRADE | CPL'G. | FROM | TO | CU.FT.CMT |
| 0′<br>44′ | 44′<br>2507′ | 26″<br>17-1/2″ | 19.25″<br>12.615″ | 78.6#<br>54.5# | .375″<br>.380″ | H-40<br>J-55 | BW<br>8R | 0′<br>0′ | 44′<br>2492′ | 150**<br>3240 |
| 2507′ | 5498′ | 12-1/4″ | 8.921″<br>8.835″ | 36.0#<br>40.0# | .352″<br>.395″ | J-55<br>N-80 | ST&C | 0′<br>3674′ | 3674′<br>5498′ | 860 |
| 5498′<br>8775′ | 8775′<br>8782′ | 8-5/8″<br>6-1/8″ | | | | | | | | |
| TOTAL DEPTH: 8782′ | | | MANDREL DEPTH: NONE | | | | PLUGS: NONE | | | |
| JUNK: None | | | | | | | | | | |
| RIG DATA: See surveys, page 8 and a list of logs, page 10. | | | | | | | | | | |
| DEV. DATA M.D.: 6450′ | | | T.V.D.: 6446.19′ | | | | REFERENCE: 151-SH-267 In Run | | | |
| BOTTOM HOLE COORDINATES: N 944,581.15 E 528,655.45@6446.19′ | | | | | | | | | | |
| CORING DATA: See core Data, page 11. | | | | | | | | | | |

| NON-OPERATIONAL TIME | | OPERATIONAL DELAY TIME | | TIME SUMMARY | |
|---|---|---|---|---|---|
| Move Rig up & down | * days | Equipment | 9.5 days | Starting Date: | 05-20-64 |
| Secured | 1.9 days | Caving | 31.8 days | Completion Date: | 10-13-64 |
| Suspended | days | Lost Circ. | 5.2 days | Elapse Time | 145.87 days |
| Bail & Run Mandrel | days | Fishing | 2.2 days | Total N_O Time | 26.5 days |
| Logging | 7.7 days | Other | days | Total O_D Time | 48.7 days |
| Survey | 1.6 days | | | Working Time | 42.97 days |
| Casing | .6 days | | | Trips | 27.7 |
| Cement | 4.7 days | | | | |
| Coring | 4.3 days | | | | |
| Other | 5.7 days | | | | |
| TOTAL | 26.5 days | TOTAL | 48.7 days | | |

REMARKS: Prepared by G. Bruesch & N. Fowler: jc
* No rig-up or down time shown in this report.
**50 $ft^3$ inside casing.

WELL HISTORY

Pahute Mesa Exploratory Hole #2

| | |
|---|---|
| 5-20-64 | Bethleham MA-10 rig on location and rigged up at 0800 hours. Drilled 12 1/4" h ole from 0' to 44'. Reamed 12 1/4" hole to 26" hole. |
| 5-21-64 | Finished reaming 12 1/4" hole to 26" to 44'. Ran 20" O.D. casing to 44'. Cemented with 50 cu. ft. of 50-50 cal seal and neat cement inside the casing. |
| 5-22-64 | Finished cementing 20" casing with 100 cu. ft. of neat cement and 2% CaC12 down the annulus. |
| 5-23-64 | Drilled out cement and drilled 12 1/4" hole form 44' to 135'. Reamed 12 1/4" hole to 17 1/2" hole from 44' to 135. |
| 5-24-64 | Drilled 17 1/2" hole from 135' to 320'. |
| 5-25-64 | Cored from 320' to 327' with 5' of recovery. Drilled 17 1/2" hole from 320' to 445. |
| 5-26-64 | Drilled 17 1/2" hole from 446' to 512'. Left bit, bit sub, and bottom drill collar in hole. Fish for and recovered same with 10 1/4" overshot. Cored from 512' to 519 with no recovery. |
| 5-27-64 | Drilled 17 1/2" hole from 512' to 562. Cored from 521' to 536' with no recovery. Worked on equipment. |
| 5-28-64 | Drilled 17 1/2" hole from 550' to 887'. Cored from 550' to 566' with 90% recovery and from 887' to 895' with 100% recovery. |
| 5-29-64 | Drilled 17 1/2" hole from 887' to 1312'. Cored from 1085' to 1092' with 5' of recovery. |
| 5-30-64 | Drilled 17 1/2" hole from 1312' to 1510'. Cored from 1312' to 1319' with 6' recovery and from 1510' to 1517' with full recovery. |
| 5-31-64 | Drilled 17 1/2" hole from 1510' to 1800' |
| 6-1-64 | Drilled 17 1/2" hole from 1800' to 2056'. Cored from 1807' to 1819' with 7' of recovery. |
| 6-2-64 | Drilled 17 1/2" hole from 2056 to 2226'. Cored from 2100' to 2108' with 100% recovery. |
| 6-3-64 | Drilled 17 1.2" hole from 2226 to 2400'. |
| 6-4-64 | Drilled 17 1/2" hole from 2400' to 2500'. Cored from 2400' to 2407' with 100% recovery and from 2500' to 2407 with 90% recovery. |
| 6-5-64 | Drilled 14 1/2" hole from 2500' to 2507'. Prepared to log. |
| 6-6-64 | Ran Birdwell caliper, density, temperature and electric logs to 2470. |

6-7-64 Cleaned hole to run casing. Ran 13 3/8" O.D. Casing to 2492'. Cemented Stage @1 with 800 $ft^3$ of 1-1 neat cement and perlite with 4% dry gel, 2% CaC12 and 1% Halad-9; followed by 150 $ft^3$ of neat cement with 2% $CaCl_2$ added. Cemented stage #2 with 500 $ft^3$ of 1-1 neat cement and perlite with 2% $CaCl_2$ and 2% gel.

6-8-64 Cemented Stage #3 with 750 $ft^3$ of 1-1 neat cement and perlite, 2% CaC12 and 2% gel. Tagged top of cement with wire line at 330'. Cemented Stage #4 with 590 $ft^3$ of neat cement and 2% CaC12. Tagged top of cement at 230'. Cemented Stage #5 to surface with 450 $ft^3$ of 1-1 neat cement and perlite, 4% dry gel and 2% CaC12.

6-9-64 Nippled up. Drilled 9 5/8' hole through cement to 2495'.

6-10-64 Drilled cement from 2495' to 2507' with 9 5/8" bit. Drilled 9 5/8" hole from 2507' to 2700'. Prepared to core. Cleaned out 90' of fill on the bottom.

6-11-64 Drilled 9 5/8" hole from 2700' to 2952'. Cored from 2700' to 2707' with full recovery.

6-12-64 Drilled 9 5/8" hole from 2952' to 3190'. Cored from 2952' to 2959' and from 3190' to 3196' with full recovery.

6-13-64 Drilled 9 5/8" hole from 3190' to 3543'. Cored from 3447' to 3449' with full recovery.

6-14-64 Drilled 9 5/8" hole from 3543' to 3820'. Cored from 3680' to 3687' with full recovery.

6-15-64 Drilled 9 5/8" hole from 3820' to 4000'. Cored from 3900' to 3907' with full recovery.

6-16-64 Drilled 9 5/8" hole from 4000' to 4175'. Cored from 4100' to 4107' with 4' of recovery.

6-17-64 Made trip for core barrel. Cleaned out 70' of fill after trip. Cored from 4175' to 4182'. Found 32' of fill after coring. Washed out same.

6-18-64 Cleaned out and reamed hole from 4150' to 4182'. Hole kept caving in. Drilled 9 5/8" hole from 4182' to 4211'.

6-19-64 Drilled 9 5/8" hole from 4211' to 4292'. Cleaned hole with core barrel at 3942'. Made a trip for bit. Cleaned hole to 4292'.

6-20-64 Drilled 9 5/8" hole from 4292' to 4322'. Cleaned out hole for core. Cored from 4322' to 4329' with full recovery.

6-21-64 Drilled 9 5/8" hole form 4322' to 4515'.

6-22-64 Drilled 9 5/8" hole from 4515' to 4637'. Cored from 4532' to 4537' with full recovery.

6-23-64 Drilled 9 5/8" hole from 4637' to 4750'. Cored from 4750. Cored from 4750' to 4757' with 100% recovery. Hit bridge approximately 120' off bottom.

| | |
|---|---|
| 6-24-94 | Washed to bottom. Drilled 9 5/8" hole from 4750' to 4970'. |
| 6-25-64 | Cored from 4970' to 4975' with full recovery. Repaired equipment. |
| 6-26-64 | Repaired equipment. |
| 6-27-64 | Repaired equipment. Drilled 9 5/8" hole from 4970' to 5059'. |
| 6-28-64 | Drilled 9 5/8" hole from 5059' to 5202'. Cored from 5202' to 5204' with full recovery. |
| 6-29-64 | Drilled 9 5/8" hole from 5202' to 5534'. |
| 6-30-64 | Drilled 9 5/8" hole from 5534' to 5617'. Cored from 5550' to 5557' with 3' of recovery. |
| 7-1-64 | Drilled 9 5/8" hole from 5617' to 5786'. Cored from 5786' to 5792' with no recovery. |
| 7-2-64 | Drilled 9 5/8" hole from 5786' to 5892'. Cored from 5892' to 5899' with full recovery. |
| 7-3-64 | Drilled 9 5/8" hole from 5892' to 6037'. Stuck drill pipe. Left (11) drill collars and (8) stands of drill pipe in hole. Went in hole with overshot but hit bridge. Cleaned hole with bit. Top of fish at 4940'. |
| 7-4-64 | Cleaned hole to fish. Went in hole with overshot. |
| 7-5-64 | Recovered fish. Went in hole with bit and hit bridge at 4067'. Washed out bridges. |
| 7-6-64 | Washed out bridges to bottom. Drilled 9 5/8" hole from 6037' to 6080'. Made a short trip. Cleaned out 40' of fill. Conditioned hole for logs. |
| 7-7-64 | Cleaned hole for logs. Made a short trip to check for fill. Hit bridge at 4180'. Washed to bottom. Nippled up for aerated water. |
| 7-8-64 | Cleaned out bridges. |
| 7-9-64 | Pulled out of hole and W.O water. Ran in hole with 9 5/8" bit to a bridge at 4067'. Cleaned out bridges. |
| 7-10-64 | Cleaned out bridges. Ran electric log and temperature survey. |
| 7-11-64 | Ran 3-D and velocity log. Ran salinometer log. Ran caliper log to 3983'. |
| 7-12-64 | Ran water tests. |
| 7-13-64 | Ran water tests. Ran Birdwell tracer injector log. |
| 7-14-64 | Ran Birdwell tracer injector log. Ran water tests. |
| 7-15-64 | Ran water tests. |
| 7-16-94 | Prepared Davis mix and injected mix in hole. Made a trip in hole. Unloaded hole at 6 stand intervals, starting at approximately 2250'. Mixed and injected Davis mix. |
| 7-17-64 | Nippled up. Reamed 9 5/8" hole to 12 1/4" from 2507' to 3006. |

7-18-64 Reamed 9 5/8" hole to 12 1/4" from 3006' to 3476'.

7-19-64 Reamed 9 5/8" hole to 12 1/4" from 3476' to 3893'.

7-20-64 Reamed 9 5/8" hole to 12 1/4" from 3893' to 4045'.

7-21-64 Reamed 9 5/8" hole to 12 1/4" from 4045 'to 4152'. Mixed mud to use in hole instead of Davis mix.

7-22-64 Mixed mud and lost circulation material.

7-23-64 Mixed mud and lost circulation material. Washed to bottom with 9 5/8" bit. Reamed 9 5/8" hole to 12 1/4" from 4152' to 4169'.

7-24-64 Reamed 9 5/8" hole to 12 1/4" from 4169' to 4263'

7-25-64 Reamed 9 5/8" hole to 12 1/4" from 4263' to 4297'. Cleaned out 9 5/8" hole.

7-26-64 Cleaned out 9 5/8" hole. Reamed 9 5/8" hole to 12 1/4" from 4297' to 4398'.

7-27-64 Reamed out 9 5/8" hole to 12 1/4" from 4398' to 4497'. Cleaned out hole from 4447' to 4479' with 9 5/8" bit.

7-28-64 Cleaned out 9 5/8" hole from 4479' to 4578'.

7-29-64 Reamed 9 5/8" hole to 12 1/4" from 4447' to 4625'.

7-30-64 Reamed 9 5/8" hole to 12 1/4" from 4625' to 4750'.

7-31-64 Reamed 9 5/8" hole to 12 1/4" from 4750' to 4888'.

8-1-64 Reamed 9 5/8" hole to 12 1/4" from 4888' to 4970'.

8-2-64 Reamed 9 5/8" hole to 12 1/4" from 4970' to 5068'.

8-3-64 Reamed 9 5/8" hole to 12 1/4" from 5068' to 5163'.

8-4-64 Reamed 9 5/8" hole to 12 1/4" from 5163' to 5288'.

8-5-64 Reamed 9 5/8" hole to 12 1/4" from 5288' to 5359'.

8-6-64 Reamed 9 5/8" hole to 12 1/4" from 5359' to 5436'.

8-7-64 Reamed 9 5/8" hole to 12 1/4" from 5436' to 5500'. Ran Birdwell temperature log.

8-8-64 Ran Birdwell caliper, density and 3-D logs to 5500'.

8-9-64 Ran Birdwell continuous velocity and electric logs.

8-10-64 Ran 45 joints 40# N-80 (1823.62′) and 88 joints 36# J-55 (3676′) 9 5/8″ csg. with Baker guide shoe and float collar and D.V. tool with metal petal basket 30′ below D.V. tool. D.V. tool set at 510′. Set 9 5/8″ O.D. casing at 5498′. Cemented Stage #1 with 350 $ft^3$ neat cement with 12 1/4″ gilsonite/sack cement, 4% gel, 1% FLAC and 0.2% of D-8; followed by 150 $ft^3$ of neat cement, 1% FLAC and 0.2% of D-8. Checked cement top at 4145′. Cemented Stage #2 to surface with Halliburton D.V. tool with 360 $ft^3$ neat cement and 2% CaC12.

8-11-64 Unloaded hole. Drilled out cement and D.V. tool. Unloaded hole.

8-12-64 Drilled 8 5/8″ hole from 5498′ to 5627′.

8-13-64 Drilled 8 5/8″ hole from 5627′ to 5913′.

8-14-64 Drilled 8 5/8″ hole from 5913′ to 6272′. Went to mist drilling.

8-15-64 Drilled 8 5/8″ hole from 6272′ to 6450′. Attempted to core but plugged core barrel.

8-16-64 Attempted to core at 6450′ but again plugged core barrel. Went in hole with 8 5/8" bit and washed out a bridge at 5845′.

8-17-64 Washed out bridges and cleaned hole from 5825′ to 5860′.

8-18-64 Washed out bridge from 5845′ to 5860′. Attempted to dry up the hole.

8-19-64 Cleaned out hole to 6180′. Attempted to run Birdwell caliper log and hit bridge at 5817′. Cleaned out bridge from 5857′ to 5918′.

8-20-64 Ran Birdwell caliper log to 5801′. Secured rig on stand by ready.

8-21-64 Set Lynos Packers at 5780′ and 5460′ and squeezed 1680 gallons of AM9 into the formation.

8-22-94 Cleaned out hole to 6450′.

8-23-64 Attempted to core but hit bridge at 5845′. Cleaned out hole from 5845′ to 6430′.

8-24-64 Cleaned out hole. Waited on orders.

8-25-64 Cleaned out hole with aerated water. Mixed mud. Injected in the hole 500 bbls of mud.

8-26-64 Cleaned out hole with mud.

8-27-64 Cleaned out hole with mud.

8-28-64 Cleaned out hole with mud.

8-29-64 Cleaned out hole with mud. Stuck pipe at 6025′. Pumped pipe free. Stuck pipe at 6035′ and pulled loose. Added 500 bbls. diesel oil to mud.

8-30-64 Added 70 bbls. diesel oil to mud. Cleaned out hole to 6399′.

8-31-64 Cleaned out hole to 6450′.

9-1-64 Cleaned out hole. Drilled 8 5/8″ hole from 6450′ to 6525′.

| | |
|---|---|
| 9-2-64 | Drilled 8 5/8″ hole from 6525′ to 6550′. Cored, Core #28, from 6550′ to 6552′. |
| 9-3-64 | Finished coring Core #28 from 6552′ to 6558′. Recovered 1′ of core. Drilled 8 5/8″ hole from 6550′ to 6597′. |
| 9-4-64 | Drilled 8 5/8″ hole from 6597′ to 6650′. |
| 9-5-64 | Drilled 8 5/8″ hole from 6650′ to 6748′. |
| 9-6-64 | Cored from 6748′ to 6753′ with 4′ of recovery. Drilled 8 5/8″ hole from 6748′ to 6767′. |
| 9-7-64 | Drilled 8 5/8″ hole from 6767′ to 6839′. |
| 9-8-64 | Drilled 8 5/8″ hole from 6839′ to 6914′. |
| 9-9-64 | Drilled 8 5/8″ hole from 6914′ to 6980′. |
| 9-10-64 | Drilled 8 5/8″ hole from 6980′ to 7029′. |
| 9-11-64 | Drilled 8 5/8″ hole from 7029′ to 7129′. Cored from 7029′ to 7035′ with full recovery. |
| 9-12-64 | Drilled 8 5/8″ hole from 7129′ to 7196′. |
| 9-13-64 | Drilled 8 5/8″ hole from 7196′ to 7242′. |
| 9-14-64 | Drilled 8 5/8″ hole from 7242′ to 7305′. |
| 9-15-64 | Drilled 8 5/8″ hole from 7305′ to 7400′. Circulated for Core #32. |
| 9-16-64 | Cored from 7400′ to 7408′ with 8′ of recovery. Ran junk basket on top of bit and drilled from 7408′to 7428′. |
| 9-17-64 | Drilled 8 5/8″ hole from 7428′ to 7543′. |
| 9-18-64 | Made a trip for bit. Drilled 8 5/8″ hole from 7543′ to 7595′. |
| 9-19-64 | Drilled 8 5/8″ hole from 7595′ to 7674′. |
| 9-20-64 | Worked on draw works. Drilled 8 5/8″ hole form 7674′ to 7712′. |
| 9-21-64 | Drilled 8 5/8″ hole from 7712′ to 7800′. Circulated for core. |
| 9-22-64 | Cored from 7800′ to 7801.5′. Drilled 8 5/8″ hole form 7801.5′ to 7840′. |
| 9-23-64 | Drilled 8 5/8″ hole from 7840′ to 7926′. Made a trip for bit. |
| 9-24-64 | Finished trip for bit. Drilled 8 5/8″ hole from 7926′ to 7939′. Cored from 7939′ to 7942′ with 3′ recovery. |
| 9-25-64 | Ran temperature, continuous velocity log, electric log, density log. Had trouble with density log tool. Ran caliper lot to 7945′ Birdwell depth. |
| 9-26-64 | Ran density log. Ran Sperry Sun. |

9-27-64 Filled pipe with mud. Circulating same from bottom of casing to surface. No bridges or fill. Drilled 8 5/8″ hole form 7942′ to 8020′. Made trip for bit.

9-28-64 Drilled 8 5/8″ hole from 8020′ to 8045′. Cored from 8045′ to 8053′ with 8′ recovery. Pipe stuck while coring. Worked pipe loose.

9-29-64 Drilled 8 5/8″ hole from 8053′ to 8062′. Tripped for bit. Drilled 8 5/8″ hole from 8062′ to 8095′.

9-30-64 Drilled 8 5/8″ hole from 8095′ to 8151′. Made trip to change bits. Drilled from 8151′ to 8173′.

10-1-64 Drilled 8 5/8″ hole from 8173′ to 8273′.

10-2-64 Cored from 8273′ to 8281′ with 7′ of recovery. Drilled 8 5/8″ hole from 8281′ to 8300′.

10-3-64 Drilled 8 5/8″ hole from 8300′ to 8400′. Circulated for core.

10-4-64 Cored from 8400′ to 8408′ with 8′ recovery. Drilled 8 5/8″ hole from 8408′ to 8419′.

10-5-64 Drilled 8 5/8″ hole from 8419′ to 8505′.

10-6-64 Drilled 8 5/8″ hole from 8505′ to 8542′. Cored from 8542′ to 8545.5′ with 3.5′ recovery.

10-7-64 Laid down core barrel. Drilled 8 5/8″ hole from 8545′ to 8629′.

10-8-64 Drilled 8 5/8″ hole from 8629′ to 8728′.

10-9-64 Drilled 8 5/8″ hole from 8728′ to 8775′. Cored from 8775′ to 8782′ with 7′ recovery.

10-10-64 W.O.O. Ran temperature and electric logs.

10-11-64 Finished running electric log. Ran 3-D, velocity and density logs. Ran caliper log to 8776′.

10-12-64 Ran Sperry Sun Gyro Survey. Laid down drill collars and drill pipe.

10-13-64 Laid down drill pipe and drill collars. Jetted pits. Rig released at 0500 hrs. Hole completed 10-13-64.

The Sperry Sun tool could not get below 6450′. From this point to the T.D. recorded Totco Surveys show the deviation. The direction was not recorded.

TOTCO DEVIATION SURVEYS

| DEPTH | DEVIATION |
|---|---|
| 6800′ | 3 3/4° |
| 7029′ | 4 1/2° |
| 7129′ | 4° |
| 7228′ | 3 1/4° |
| 7400′ | 1 3/4° |
| 7543′ | 1 3/4° |
| 7650′ | 3° |

## TOTCO DEVIATION SURVEYS

| DEPTH | DEVIATION |
|---|---|
| 7800′ | 3 1/4° |
| 7926′ | 3 1/2° |
| 8020′ | 3 1/2° |
| 8150′ | 3° |
| 8542′ | 3° |

## SPERRY SUN MULTISHOT GYROSCOPIC SURVEYS

| Date | MD | TVD | Horizontal Displacement | Reference | Run |
|---|---|---|---|---|---|
| 9-28-64 | 4000′ | 3999.84′ | 16.73′ (S 35° 48′ W) | 151-SH-267 | In |
| 9-28-64 | 4000′ | 3999.85′ | 15.01′ (S 36° 34′ W) | 151-SH-267 | Out |
| 9-28-64 | 6450′ | 6446.19′ | 101.82′ (S 64° 17′ E) | 151-SH-267 | In |

In Run 151-SH-267

| MD | TVD | Latitude | Departure |
|---|---|---|---|
| 0′ | 100′ | 0° N | 0° E |
| 100′ | 100.00′ | 0.25°S | 0.15°W |
| 200′ | 199.99′ | 0.12°N | 0.30°W |
| 300′ | 299.99′ | 0.47° S | 0.26° W |
| 400′ | 399.98′ | 0.54° S | 0.20° E |
| 500′ | 499.98′ | 0.44° S | 0.77° E |
| 600′ | 599.98′ | 0.48° S | 1.06° E |
| 700′ | 699.98′ | 0.61° S | 1.31° S |
| 800′ | 799.98′ | 0.75° S | 1.41° E |
| 900′ | 899.98′ | 0.73° S | 1.21° E |
| 1000′ | 999.98′ | 0.64° S | 0.77° E |
| 1100′ | 1099.98′ | 0.45° S | 0.24° E |
| 1200′ | 1199.98′ | 0.70° S | 0.02° E |
| 1300′ | 1299.97′ | 0.81° S | 0.70° W |
| 1400′ | 1399.97′ | 0.74° S | 1.70° W |
| 1500′ | 1499.96′ | 0.75° S | 2.75° W |
| 1600′ | 1599.96′ | 1.23° S | 3.54° W |

In Run 151-SH-267

| MD | TVD | Latitude | Departure |
|---|---|---|---|
| 1700′ | 1699.95′ | 1.36° S | 4.39° W |
| 1800′ | 1799.95′ | 1.38° S | 5.32° W |
| 1900′ | 1899.95′ | 1.35° S | 6.30° W |
| 2000′ | 1999.94′ | 1.36° S | 7.24° W |
| 2100′ | 2099.93′ | 1.18° S | 8.37° W |
| 2200′ | 2199.93′ | 1.08° S | 9.05° W |
| 2300′ | 2299.93′ | 0.89° S | 9.26° W |
| 2400′ | 2399.93′ | 0.82° S | 9.15° W |
| 2500′ | 2499.93′ | 1.05° S | 9.03° W |
| 2600′ | 2599.93′ | 1.40° S | 9.12° W |
| 2700′ | 2699.93′ | 1.68° S | 9.25° W |
| 2800′ | 2799.93′ | 1.87° S | 9.24° W |
| 2900′ | 2899.93′ | 2.19° S | 9.13° W |
| 3000′ | 2999.93′ | 2.63° S | 9.11° W |
| 3100′ | 3099.93′ | 3.21° S | 8.98° W |
| 3200′ | 3199.92′ | 3.91° S | 8.77° W |
| 3300′ | 3299.92′ | 4.75° S | 8.41° W |
| 3400′ | 3399.92′ | 5.44° S | 8.01° W |
| 3500′ | 3499.91′ | 6.29° S | 7.53° W |
| 3600′ | 3599.90′ | 7.54° S | 7.03° W |
| 3700′ | 3699.89′ | 8.80° S | 6.92° W |
| 3800′ | 3799.88′ | 10.53° S | 7.17° W |
| 3900′ | 3899.86′ | 12.15° S | 8.19° W |
| 4000′ | 3999.84′ | 13.57° S | 9.79° W |
| 4100′ | 4099.83′ | 14.39° S | 11.18° W |
| 4200′ | 4199.82′ | 15.51° S | 12.15° W |
| 4300′ | 4299.81′ | 16.41° S | 12.81° W |
| 4400′ | 4399.79′ | 17.95° S | 12.01° W |
| 4500′ | 4499.73′ | 20.76° S | 10.19° W |
| 4600′ | 4599.67′ | 23.74° S | 8.15° W |
| 4700′ | 4699.56′ | 27.12° S | 4.95° W |

In Run 151-SH-267

| MD | TVD | Latitude | Departure |
|---|---|---|---|
| 4800′ | 4799.42′ | 27.54° S | 1.20° W |
| 4900′ | 4899.31′ | 30.92° S | 2.06° E |
| 5000′ | 4999.18′ | 34.37° S | 5.64° E |
| 5100′ | 5099.08′ | 37.51° S | 8.96° E |
| 5200′ | 5198.91′ | 40.68° S | 13.80° E |
| 5300′ | 5298.66′ | 44.03° S | 19.91° E |
| 5400′ | 5398.41′ | 45.98° S | 26.68° E |
| 5500′ | 5498.16′ | 48.53° S | 33.30° E |
| 5600′ | 5597.98′ | 49.68° S | 39.22° E |
| 5700′ | 5697.76′ | 49.56° S | 45.78° E |
| 5800′ | 5797.47′ | 48.25° S | 53.29° E |
| 5900′ | 5897.27′ | 48.12° S | 59.24° E |
| 6000′ | 5996.96′ | 46.48° S | 66.56° E |
| 6100′ | 6096.75′ | 45.11° S | 72.89° E |
| 6200′ | 6196.51′ | 43.86° S | 79.77° E |
| 6300′ | 6296.35′ | 42.83° S | 85.16° E |
| 6400′ | 6396.25′ | 43.42° S | 89.40° E |

Well History Pahute Mesa Exploratory Hole #2

## Core Data

| Core # | Date | Interval | Recovery | Formation & Remarks |
|---|---|---|---|---|
| 1 | 5-25-64 | 320′-327′ | 5′ | Welded tuff |
| 2 | 5-26-64 | 512′-519′ | 0′ | |
| 3 | 5-27-64 | 521′-536′ | 0′ | |
| 4 | 5-28-64 | 562′-572′ | 9′ | Bedded tuff |
| 5 | 5-28-64 | 875′-883′ | 8′ | Bedded tuff |
| 6 | 5-29-64 | 1085′-1092′ | 5′ | Tuff -slightly broken |
| 7 | 5-30-64 | 1300′-1307′ | 6′ | Tuff |
| 8 | 5-30-64 | 1510′-1517′ | 7′ | Zeolitized tuff |
| 9 | 6-1-64 | 1800′-1807′ | 7′ | Zeolitized tuff |
| 10 | 6-2-64 | 2100′-2108′ | 8′ | Zeolitized tuff |
| 11 | 6-3-64 | 2400′-2407′ | 7′ | Zeolitized tuff |
| 12 | 6-4-64 | 2500′-2507′ | 6′ | Welded tuff |
| 13 | 6-11-64 | 2700′-2707′ | 7′ | Tuff breccia - fractured |
| 14 | 6-11-64 | 2952′-2959′ | 7′ | Dacite |
| 15 | 6-12-64 | 3190′-3196′ | 6′ | Dacite - fractured |
| 16 | 6-13-64 | 3447′-3449′ | 2′ | Tuff breccia -fractured |
| 17 | 6-14-64 | 3680′-3687′ | 7′ | Tuff |
| 18 | 6-15-64 | 3900′-3907′ | 7′ | Tuff breccia - alight fractures |
| 19 | 6-16-64 | 4100′-4107′ | 4′ | Tuffaceous mudstone - very broken |
| 20 | 6-17-64 | 4175′-4282′ | 7′ | Tuffaceous mudstone |
| 21 | 6-20-64 | 4322′-4329′ | 7′ | Dacite - fractured |
| 22 | 6-22-64 | 4530′-4537′ | 7′ | Dacite - fractured |
| 23 | 6-23-64 | 4750′-4757′ | 7′ | Dacite - fractured |
| 24 | 6-25-64 | 4970′-4975′ | 5′ | Rhyodacite - slight fractures |
| 25 | 6-28-64 | 5202′-5204′ | 2′ | Rhyodacite - highly fractured |
| 26 | 6-30-64 | 5550′-5557′ | 5′ | Rhyodacite - highly fractured |
| 27 | 7-1-64 | 5786′-5792′ | 5′ | Rhyodacite - highly fractured |
| 28 | 7-2-64 | 5892′-5899′ | 7′ | Latite - highly fractured |
| 29 | 9-2-64 | 6550′-6558′ | 1′ | Dacite - fractured |

## Core Data

| Core # | Date | Interval | Recovery | Formation & Remarks |
|---|---|---|---|---|
| 30 | 9-6-64 | 6748′-6753′ | 4′ | Dacite - fractured |
| 31 | 9-11-64 | 7029′-7035′ | 6′ | Dacite - highly fractured |
| 32 | 9-16-64 | 7400′-7408′ | 8′ | Dacite - fractured |
| 33 | 9-22-64 | 7800′-9801.5′ | 1.5′ | Dacite - highly fractured |
| 34 | 9-24-64 | 7939′-7942′ | 3′ | Dacite - fractured |
| 35 | 9-28-64 | 8045′-8053′ | 8′ | Dacite - fractures |
| 36 | 10-2-64 | 8273′-8281′ | 7′ | Dacite - fractures |
| 37 | 10-4-64 | 8400′-8408′ | 8′ | Aplite breccia |
| 38 | 10-7-64 | 8542′-8545.5′ | 3.5′ | Granodiorite |
| 39 | 10-9-64 | 8775′-8782′ | 7′ | Granodiorite |

# CEMENTING RECORD

USER:
HOLE NO: PM Ex. #2
DATE PREPARED: 09-19-90 By JEC

CEMENTING RECORD FOR: 13-3/8" O.D.,54.5#, 0.38" wall casing at 2492' in 17-1/2" hole to 2507'. 20" O.D., 78.6#, 0.375" wall casing cemented at 44'. Information taken from Hole History.

| DATE | CMT STAGE | TOP OF CMT W/SLM (FT) | VOL OF CMT SLRY USED (FT3) | VOL OF CMT SLRY CAL (FT3) | DIFF IN SLRY VOL (FT3) | REMARKS |
|---|---|---|---|---|---|---|
| 06-07-64 | 1 | | 800 | | | 50% neat & 50% perlite + 4% gel, 2% $CaCl_2$, & 1% Halad-9 |
| " | | | 150 | | | Neat + 2% $CaCl_2$ |
| " | 2 | | 500 | | | 50% neat & 50% perlite + 2% $CaCl_2$ & 2% gel |
| 06-08-64 | 3 | 330 | 750 | | | " |
| " | 4 | 230 | 590 | | | Neat + 2% $CaCl_2$ |
| " | 5 | Surf | 450 | | | 50% neat & 50% perlite + 4% gel & 2% $CaCl_2$ |
| | | | 3240 | 3225 | +15 | |

NOTE: Birdwell caliper log run 06-06-64 (NA).

Calculation total pre-figured.

$$\frac{+15 \times 100\%}{3225} = 0.5\%\text{excess}$$

SIGNED_____

# CEMENTING RECORD

USER:
HOLE NO: PM Ex. #2
DATE PREPARED: 09-19-90 By JEC

CEMENTING RECORD FOR: 9-5/8" O.D., 36# Casing at 3676' and 40# casing to 5498' and DV tool at 510' with metal petal at 540' IN 12-1/4" HOLE TO 5500'.12.615" I.D. casing cemented at 2492'.
Information taken from hole history.

| DATE | CMT STAGE | TOP OF CMT W/___ (FT) | CMT RISE (FT) | VOL OF CMT SLRY USED (FT3) | VOL OF CMT SLRY CAL (FT3) | DIFF IN SLRY VOL (FT3) | REMARKS |
|---|---|---|---|---|---|---|---|
| 08-10-64 | 1 | | | 350 | | | Neat + 12-1/4# gilsonite/5x, 4% gel, 1% FLAC, & 0.2% D-8 |
| " | | 4145 | 1355 | 150 | 470 | +30 | Neat + 1% FLAC & 0.2% D-8 |
| " | 2 | Surf | 540' | 360 | 197 | +163 | Neat + 2% $CaCl_2$ |
| | | | | 860 | 667 | +193 | |

NOTE: Birdwell caliper log run 08-08-64 (NA).

$$\frac{+193 \times 100\%}{667} = 29\%\text{excess}$$

Calculations based on 12.5" gauge hole
12.5" O.H. = 0.8522 $ft^2$
12.615" I.D = 0.8694 $ft^2$
9-5/8" O.D. = 0.5053 $ft^2$

SIGNED_____

# APPENDIX B. Geophysical Logs Available for Well PM-2

The information contained in Appendix B was provided by Raytheon Services Nevada (formerly Fenix & Scisson). It is presented in the format provided to the USGS .

Original 6-30-65
Revision 9-30-66
Revision #2 8-18-67

HOLE No.
USGS Exploratory
Pahute Mesa #2

| TYPE | DATE | RUN NO. | TOTAL DEPTH | | LOGGED INTERVAL | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | DRILLERS | LOGGERS | FROM | TO | |
| Caliper | 6-6-64 | 1 | 2496′ | 2470′ | 64′ | 2469′ | |
| Caliper | 7-11-64 | 2 | 6080′ | 3983′ | 2400′ | 3983′ | |
| Caliper | 8-8-64 | 3 | 5500′ | 5500′ | 2450′ | 5499′ | |
| Caliper | 8-19-64 | 4 | 6180′ | 5817′ | 5450′ | 5816′ | |
| Caliper | 8-20-64 | 5 | 6180′ | 5801′ | 5450′ | 5800′ | |
| Caliper | 9-25-64 | | 7942′ | 7945′ | 5490′ | 7940′ | |
| Caliper | 10-11-64 | 2 | 8781′ | 8776′ | 7000′ | 8775′ | |
| Electric | 6-6-64 | 1 | 2496′ | 2453′ | 1060′ | 2453′ | |
| Electric | 7-10-64 | 2 | 6080′ | 4074′ | 2484′ | 4074′ | |
| Electric | 7-10-64 | 3 | 6080′ | 4074′ | 2484′ | 4074′ | |
| Electric | 8-9-64 | 4 | 5500′ | 5500′ | 2484′ | 5498′ | |
| Electric | 8-9-64 | 5 | 5500′ | 5500′ | 2484′ | 5498′ | |
| Electric | 9-25-64 | 1 | 7942′ | 7945′ | 5500′ | 7945′ | |
| Electric | 10-11-64 | 2 | 8781′ | 8775′ | 7000′ | 8775′ | |
| Radio Active | 7-11-64 | 1 | 6080′ | | 2300′ | 3980′ | |
| Radio Active | 9-25-64 | 1 | 7942′ | 7945′ | 5500′ | 7945′ | |
| Salinometer | 7-11-64 | 1&2 | 6080′ | 4074′ | 850′ | 4074′ | |
| Salinometer | 7-11-64 | 3 | 6080′ | 3983′ | 850′ | 3983′ | |
| Density | 6-5-64 | 1 | 2496′ | 2473′ | 0′ | 2470′ | |
| Density | 7-11-64 | 2 | 6080′ | 3983′ | 2450′ | 3983′ | |
| Density | 8-8-64 | 3 | 5500′ | 5497′ | 3800′ | 5492′ | |
| Density | 9-25-64 | 1 | 7942′ | 7945′ | 5500′ | 7945′ | |
| Density | 10-10-64 | 2 | 8781′ | 8778′ | 7000′ | 8775′ | |
| Pressure Finder | 9-25-64 | 1 | 7942′ | 7945′ | 5400′ | 7940′ | MSG |
| 3-D | 7-10-64 | 1 | 6080′ | 4076′ | 2450′ | 4072′ | |
| 3-D | 7-10-64 | 2 | 6080′ | 4076′ | 2450′ | 4068′ | |
| 3-D | 8-8-64 | 3 | 5500′ | 5490′ | 3800′ | 5488′ | |
| 3-D | 8-8-64 | 4 | 5500′ | 5500′ | 3800′ | 5490′ | |
| Velocity | 7-11-64 | 2 | 6080′ | 4074′ | 2450′ | 4070′ | |

| TYPE | DATE | RUN NO. | TOTAL DEPTH | | LOGGED INTERVAL | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | DRILLERS | LOGGERS | FROM | TO | |
| Velocity | 8-9-64 | 2 | 5500′ | 5500′ | 3100′ | 5495′ | |
| Velocity | 9-25-64 | 1 | 7942′ | 7945′ | 5470′ | 7938′ | |
| Velocity | 10-11-64 | 2 | 8781′ | 8777′ | 7000′ | 8772′ | |
| Temp | 6-6-64 | 1 | 2496′ | 2470′ | 0′ | 2470′ | |
| Temp | 6-7-64 | 2 | 2473′ | | 0′ | 2150′ | |
| Temp | 7-10-64 | 3 | 6080′ | 4076′ | 0′ | 4076′ | |
| Temp | 7-11-64 | 4 | 6080′ | 3983′ | 0′ | 3983′ | |
| Temp | 8-2-64 | 1 | 5500′ | 5498′ | 3800′ | 5498′ | |
| Temp | 8-7-64 | 5 | 5500′ | 5498′ | 3800′ | 5498′ | |
| Temp | 8-10-64 | 6 | 5500′ | 5438′ | 0′ | 5438′ | |
| Temp | 9-25-64 | | 7942′ | 7950′ | 0′ | 7950′ | |
| Temp | 10-10-64 | 2 | 8781′ | 8780′ | 7000′ | 8780′ | |
| E.C.C. | 5-29-65 | | | | 5492′ | 8768′ | |
| Gamma Ray Neutron | 4-27-66 | 1 | N/A | N/A | 3150′ | 3650′ | |
| Water Locator | 6-6-66 | 1 | N/A | N/A | 1010′ | 1066′ | |
| Water Locator | 8-16-66 | 2 | N/A | N/A | 900′ | 974′ | 961′ |
| Water Locator | 4-12-67 | 3 | N/A | Not Reached | 850′ | 950′ | Fluid Level 895′ |
| Gyro | 9-26-64 | | | | 0′ | 6450′ | 151-SH-267 |
| WL | 11-21-67 | 4 | NA | Not Reached | 850′ | 896 | |
| Caliper | 11-5-68 | 6 | 8775′ | Ditto | 0′ | 1000′ | |
| CCL | 11-5-68 | 1 | 8775′ | Ditto | 0′ | 1000′ | |
| FLD | 11-5-68 | 1 | 8775′ | Ditto | 864′ | 2000′ | |
| Caliper | 11-8-68 | 7 | 8782′ | Ditto | 0′ | 1000′ | |
| CCL | 11-8-68 | 2 | 8782′ | Ditto | 0′ | 1000′ | |
| Caliper | 6-6-69 | 8 | 8782′ | Ditto | 0′ | 1000′ | |
| CCL | 6-6-69 | 3 | 8782′ | Ditto | 0′ | 1000′ | |
| WL | 6-6-69 | 5 | 8782′ | Ditto | 850′ | 900′ | |
| FF | 10-11-64 | 2 | 8782′ | 8775′ | 7000′ | 8770′ | Welex |
| Depth Ck | 6-20-83 | | 8781′ | 3066′ | | 3066′ | |
| Thermal | 10-19-83 | | 8782′ | 2721′ | 0′ | 2721′ | |

| TYPE | DATE | RUN NO. | TOTAL DEPTH | | LOGGED INTERVAL | | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | DRILLERS | LOGGERS | FROM | TO | |
| Neutron | 10-19-83 | | 8782′ | 2721′ | 0′ | 2721′ | |
| Temp | 10-19-83 | | 8782′ | 2721′ | 0′ | 2721′ | |
| Gamma | 10-19-83 | | 8782′ | 2721′ | 0′ | 2721′ | |
| K.U.T. | 10-20-83 | | 8782′ | 3066′ | 0′ | 3066′ | |
| Gamma Ray | 10-20-83 | | 8782′ | 3066′ | 0′ | 3059′ | |
| K.U.T. | 10-21-83 | | 8782′ | 3062′ | 1600′ | 3059′ | Fluid Level 2215′ |
| T. L. | 10-21-83 | | 8782′ | 3062′ | 1600′ | 3059′ | |
| Caliper | 10-21-83 | | 8782′ | 3062′ | 1600′ | 3059′ | |
| E.P.N. | 10-21-83 | | 8782′ | 3065′ | 8′ | 3059′ | |
| Gamma Ray | 10-21-83 | | 8782′ | 3065′ | 8′ | 3059′ | |

# APPENDIX C. Summary of Soil-Sampling Surveys at Well PM-2

The information contained in Appendix C was provided by Reynolds Electrical & Engineering Co., Inc. It is presented in the format provided to the USGS.

# Reynolds Electrical & Engineering Co., Inc.

## MEMORANDUM

To F. D. Ferate

From A. R. Latham

Date January 13, 1994

Subject ANALYTICAL REPORT ON TRITIUM, SOIL MOISTURE, AND GAMMA ANALYSES OF THE PM-2 WELLHEAD SOIL SAMPLES

Enclosed are Analytical Services Department's results for tritium, moisture content, and gamma analyses of 12 PM-2 wellhead soil samples submitted for analysis on November 22, 1993. Tritium and gamma results are in the units of micro-Curies per gram of soil as submitted (i.e. wet weight).

This report contains results for the following samples:

| Client Sample ID | Lab ID | Client Sample ID | Lab ID |
|---|---|---|---|
| WELL PM-2 A-SURFACE | 80227 | WELL PM-2 D-SURFACE | 80990 |
| WELL PM-2 A-30-CM | 80980 | WELL PM-2 D-30-CM | 80992 |
| WELL PM-2 B-SURFACE | 80982 | WELL PM-2 E-SURFACE | 80994 |
| WELL PM-2 B-30-CM | 80984 | WELL PM-2 E-30-CM | 80996 |
| WELL PM-2 C-SURFACE | 80986 | WELL PM-2 F-SURFACE | 80998 |
| WELL PM-2 C-30-CM | 80988 | WELL PM-2 F-30-CM | 81000 |

QUALITY CONTROL

Background and laboratory control samples were analyzed for tritium and gamma with the samples listed above. Results are included in this report.

Please direct any questions you may have to Y. K. Lee at 295-7075.

Enclosures
As stated

ARL:YKL:181:VB

cy: Central Files, w/encls., M/S 530
L. S. Sygitowicz w/o encls., M/S 708

ANALYTICAL SERVICES DEPARTMENT

SOIL MOISTURE OF PM-2 WELLHEAD SOIL SAMPLES

Reported to: F. D. Ferate

Program No: 113

Packet Nos: D5089 & D5090

Analysis Date: Nov. 25, 1993

Report Date: Jan. 12, 1994

| Client Sample ID | Lab ID | MOISTURE BY WT.[a] |
|---|---|---|
| WELL PM-2 A-SURFACE | 80979 | 2.6 |
| WELL PM-2 A-30-CM | 80981 | 4.9 |
| WELL PM-2 B-SURFACE | 80983 | 1.2 |
| WELL PM-2 B-30-CM | 80985 | 1.3 |
| WELL PM-2 C-SURFACE | 80987 | 1.1 |
| WELL PM-2 C-30-CM[b] | 80989 | 25.0 |
| WELL PM-2 D-SURFACE | 80991 | 1.9 |
| WELL PM-2 D-30-CM | 80993 | 1.7 |
| WELL PM-2 E-SURFACE | 80995 | 2.9 |
| WELL PM-2 E-30-CM | 80997 | 5.8 |
| WELL PM-2 F-SURFACE | 80999 | 1.8 |
| WELL PM-2 F-30-CM | 81001 | 4.5 |

[a] In units of grams of moisture per 100 grams of soil as submitted.

[b] The physical appearance of Sample WELL PM-2 C-30-CM is quite difference as compared with other soil samples in this batch. It has a much lighter color and much lower density. Reanalysis of the sample on January 12, 1993 confirmed the relatively high amount of moisture content.

Report Prepared by: Yuanbo Lee Date: Jan 12, 1994

Report Reviewed and Approved by: Lynn Jones Date: 1/12/94

**ANALYTICAL SERVICES REPORT**



RADIOANALYTICAL QUALITY CONTROL RESULTS

Date: 01/12/94

Reported to: F. D. Ferate

Program Code: 113

Packet Nos.: D5089 to D5090

| QC SAMP ID | REFERENCE PACKET NO. | SAMP TYPE | ANALYSIS TYPE | SAMPLE VALUE | SAMPLE ERROR | KNOWN VALUE | KNOWN ERROR | UNITS | SPIKE YIELD | ANAL DATE | DET ID |
|---|---|---|---|---|---|---|---|---|---|---|---|
| QA Blank 00316 | C6368 | Empty Bottle | Gamma | No radionuclide detected | N/A | Blank | N/A | N/A | N/A | 11/30/93 | 08 |
| QA Spike 06390 | C5778 | Water | Tritium | 2.88E-05 | 3.2% | 2.99E-05 | 7.0% | µCi/g | 96.3% | 12/14/93 | 25 |
| QA Blank 06389 | C5778 | Water | Tritium | 9.09E-08 | 480% | Blank | N/A | µCi/g | N/A | 12/14/93 | 25 |
| QASpike 12750 | C6359 | Soil | Gamam | | | | | µCi/g | | 11/30/93 | 08 |
| | | | Am-241 | 1.85E-04 | 9.2% | 1.76E-04 | 3.5% | | 105% | | |
| | | | Co-60 | 3.38E-04 | 8.2% | 3.33E-04 | 2.3% | | 102% | | |
| | | | Cs-137 | 2.27E-04 | 8.2% | 2.24E-04 | 2.1% | | 101% | | |

Comment: Sample error is 2 sigma counting error.

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 0
SAMPLE 80227 ID= WELL PM-2 A-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 7.31E-07 | 3.37E+01 | 2.34E-07 | uCi/g |

PACKET D5089 ITEM 0
SAMPLE 80227 ID= WELL PM-2 A-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.93E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 7.38E-06 | 1.13E+01 | 2.40E-07 | uCi/g |
| CO60 | 2.36E-06 | 1.15E+01 | 5.07E-08 | uCi/g |
| CS137 | 8.17E-07 | 1.82E+01 | 7.06E-08 | uCi/g |
| EU150 | 6.18E-07 | 1.86E+01 | 5.84E-08 | uCi/g |
| EU152 | 7.06E-06 | 1.12E+01 | 2.03E-07 | uCi/g |
| EU154 | 6.20E-06 | 1.19E+01 | 1.70E-07 | uCi/g |
| K 40 | 3.71E-05 | 1.02E+01 | 3.05E-07 | uCi/g |
| RA226 | 1.02E-06 | 2.24E+01 | 1.23E-07 | uCi/g |
| TH228 | 2.38E-06 | 1.42E+01 | 1.31E-07 | uCi/g |
| TH232 | 2.10E-06 | 2.21E+01 | 2.56E-07 | uCi/g |
| XPEAK 150.8 Kev | 2.04E+00 | 7.21E+01 | 0.00E+00 | cpm |
| XPEAK 209.4 Kev | 1.82E+00 | 7.19E+01 | 0.00E+00 | cpm |
| XPEAK 270.5 Kev | 1.49E+00 | 6.27E+01 | 0.00E+00 | cpm |
| XPEAK 328.3 Kev | 1.10E+00 | 8.58E+01 | 0.00E+00 | cpm |
| XPEAK 367.6 Kev | 1.05E+00 | 7.98E+01 | 0.00E+00 | cpm |
| XPEAK 488.6 Kev | 5.00E-01 | 1.18E+02 | 0.00E+00 | cpm |
| XPEAK 624.4 Kev | 5.45E-01 | 1.30E+02 | 0.00E+00 | cpm |
| XPEAK 766.3 Kev | 9.90E-01 | 6.68E+01 | 0.00E+00 | cpm |
| XPEAK 846.2 Kev | 6.35E-01 | 9.70E+01 | 0.00E+00 | cpm |
| XPEAK 904.6 Kev | 6.05E-01 | 9.85E+01 | 0.00E+00 | cpm |
| XPEAK 934.1 Kev | 4.05E-01 | 1.10E+02 | 0.00E+00 | cpm |
| XPEAK 989.2 Kev | 4.60E-01 | 1.04E+02 | 0.00E+00 | cpm |
| XPEAK 1016.1 Kev | 6.00E-01 | 8.79E+01 | 0.00E+00 | cpm |
| XPEAK 1128.7 Kev | 8.60E-01 | 6.03E+01 | 0.00E+00 | cpm |
| XPEAK 1236.6 Kev | 7.25E-01 | 6.77E+01 | 0.00E+00 | cpm |
| XPEAK 1378.3 Kev | 4.60E-01 | 5.07E+01 | 0.00E+00 | cpm |
| XPEAK 1399.7 Kev | 5.75E-01 | 4.17E+01 | 0.00E+00 | cpm |
| XPEAK 1494.6 Kev | 2.80E-01 | 6.58E+01 | 0.00E+00 | cpm |
| XPEAK 1510.2 Kev | 2.10E-01 | 9.55E+01 | 0.00E+00 | cpm |
| XPEAK 1529.9 Kev | 3.85E-01 | 5.03E+01 | 0.00E+00 | cpm |
| XPEAK 1540.4 Kev | 2.45E-01 | 6.38E+01 | 0.00E+00 | cpm |
| XPEAK 1588.5 Kev | 3.30E-01 | 5.75E+01 | 0.00E+00 | cpm |
| XPEAK 1597.3 Kev | 5.95E-01 | 4.29E+01 | 0.00E+00 | cpm |

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 0
SAMPLE 80227 ID= WELL PM-2 A-SURFACE SAMPLING DATE 111993 -

| | | | | |
|---|---|---|---|---|
| XPEAK 1731.0 Kev | 2.85E-01 | 4.60E+01 | 0.00E+00 | cpm |
| XPEAK 1848.3 Kev | 1.45E-01 | 8.59E+01 | 0.00E+00 | cpm |
| XPEAK 1861.7 Kev | 8.00E-02 | 9.41E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PACKET D5089 ITEM 1
SAMPLE 80980 ID= WELL PM-2 A-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| H-3 TRITIUM 2.79E-06 | 1.88E+01 | 4.67E-07 | uCi/g |

PACKET D5089 ITEM 1
SAMPLE 80980 ID= WELL PM-2 A-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.30E+02 PROCESSED ON 113093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| CS137 1.17E-07 | 4.05E+01 | 3.47E-08 | uCi/g |
| K 40 2.74E-05 | 1.08E+01 | 3.13E-07 | uCi/g |
| RA226 1.43E-06 | 1.48E+01 | 6.85E-08 | uCi/g |
| TH228 2.47E-06 | 1.19E+01 | 7.56E-08 | uCi/g |
| TH232 2.18E-06 | 1.61E+01 | 1.26E-07 | uCi/g |
| XPEAK 62.7 Kev 2.57E+00 | 4.68E+01 | 0.00E+00 | cpm |
| XPEAK 837.7 Kev 6.05E-01 | 6.16E+01 | 0.00E+00 | cpm |
| XPEAK 949.4 Kev 3.95E-01 | 5.78E+01 | 0.00E+00 | cpm |
| XPEAK 987.8 Kev 3.25E-01 | 9.34E+01 | 0.00E+00 | cpm |
| XPEAK 1364.5 Kev 3.05E-01 | 6.05E+01 | 0.00E+00 | cpm |
| XPEAK 1421.3 Kev 1.65E-01 | 8.26E+01 | 0.00E+00 | cpm |
| XPEAK 1510.5 Kev 2.10E-01 | 6.28E+01 | 0.00E+00 | cpm |
| XPEAK 1712.2 Kev 1.40E-01 | 7.42E+01 | 0.00E+00 | cpm |
| XPEAK 1731.2 Kev 3.00E-01 | 5.12E+01 | 0.00E+00 | cpm |
| XPEAK 1956.5 Kev 5.50E-02 | 2.30E+02 | 0.00E+00 | cpm |
| XPEAK 1973.6 Kev 1.75E-01 | 5.94E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 2
SAMPLE 80982 ID= WELL PM-2 B-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 5.85E-07 | 7.67E+01 | 4.45E-07 | uCi/g |

PACKET D5089 ITEM 2
SAMPLE 80982 ID= WELL PM-2 B-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.82E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 1.71E-05 | 9.50E+00 | 3.07E-07 | uCi/g |
| CO60 | 4.50E-06 | 1.01E+01 | 5.91E-08 | uCi/g |
| CS137 | 1.05E-06 | 1.71E+01 | 8.68E-08 | uCi/g |
| EU150 | 1.21E-06 | 1.49E+01 | 7.63E-08 | uCi/g |
| EU152 | 1.47E-05 | 9.72E+00 | 2.59E-07 | uCi/g |
| EU154 | 1.25E-05 | 1.03E+01 | 1.96E-07 | uCi/g |
| K 40 | 4.20E-05 | 1.00E+01 | 3.92E-07 | uCi/g |
| RA226 | 8.60E-07 | 2.69E+01 | 1.46E-07 | uCi/g |
| TH228 | 2.28E-06 | 1.63E+01 | 1.70E-07 | uCi/g |
| TH232 | 2.24E-06 | 2.52E+01 | 3.41E-07 | uCi/g |
| XPEAK 48.8 Kev | 4.18E+00 | 5.15E+01 | 0.00E+00 | cpm |
| XPEAK 93.3 Kev | 2.26E+00 | 9.70E+01 | 0.00E+00 | cpm |
| XPEAK 129.4 Kev | 1.29E+00 | 1.28E+02 | 0.00E+00 | cpm |
| XPEAK 209.2 Kev | 2.04E+00 | 8.09E+01 | 0.00E+00 | cpm |
| XPEAK 232.6 Kev | 2.43E+00 | 6.33E+01 | 0.00E+00 | cpm |
| XPEAK 270.1 Kev | 2.51E+00 | 6.16E+01 | 0.00E+00 | cpm |
| XPEAK 328.4 Kev | 1.27E+00 | 9.54E+01 | 0.00E+00 | cpm |
| XPEAK 367.7 Kev | 1.33E+00 | 7.09E+01 | 0.00E+00 | cpm |
| XPEAK 434.1 Kev | 1.62E+00 | 5.27E+01 | 0.00E+00 | cpm |
| XPEAK 489.1 Kev | 9.70E-01 | 9.50E+01 | 0.00E+00 | cpm |
| XPEAK 564.5 Kev | 1.23E+00 | 7.21E+01 | 0.00E+00 | cpm |
| XPEAK 614.4 Kev | 1.69E+00 | 4.91E+01 | 0.00E+00 | cpm |
| XPEAK 625.3 Kev | 5.80E-01 | 1.42E+02 | 0.00E+00 | cpm |
| XPEAK 649.8 Kev | 8.85E-01 | 8.95E+01 | 0.00E+00 | cpm |
| XPEAK 692.5 Kev | 1.65E+00 | 5.08E+01 | 0.00E+00 | cpm |
| XPEAK 860.7 Kev | 1.29E+00 | 6.37E+01 | 0.00E+00 | cpm |
| XPEAK 892.8 Kev | 9.90E-01 | 8.92E+01 | 0.00E+00 | cpm |
| XPEAK 1102.8 Kev | 7.95E-01 | 9.02E+01 | 0.00E+00 | cpm |
| XPEAK 1140.3 Kev | 6.55E-01 | 8.97E+01 | 0.00E+00 | cpm |
| XPEAK 1233.9 Kev | 5.70E-01 | 7.87E+01 | 0.00E+00 | cpm |
| XPEAK 1246.4 Kev | 6.10E-01 | 8.33E+01 | 0.00E+00 | cpm |
| XPEAK 1378.1 Kev | 3.60E-01 | 6.80E+01 | 0.00E+00 | cpm |
| XPEAK 1509.6 Kev | 1.45E-01 | 1.13E+02 | 0.00E+00 | cpm |

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 2
SAMPLE 80982 ID= WELL PM-2 B-SURFACE SAMPLING DATE 111993 -

| | | | | |
|---|---|---|---|---|
| XPEAK 1519.5 Kev | 2.30E-01 | 8.09E+01 | 0.00E+00 | cpm |
| XPEAK 1588.9 Kev | 2.90E-01 | 7.27E+01 | 0.00E+00 | cpm |
| XPEAK 1621.0 Kev | 3.30E-01 | 5.30E+01 | 0.00E+00 | cpm |
| XPEAK 1631.4 Kev | 2.80E-01 | 4.51E+01 | 0.00E+00 | cpm |
| XPEAK 1638.2 Kev | 2.60E-01 | 5.60E+01 | 0.00E+00 | cpm |
| XPEAK 1720.2 Kev | 2.10E-01 | 8.10E+01 | 0.00E+00 | cpm |
| XPEAK 1730.5 Kev | 2.40E-01 | 6.56E+01 | 0.00E+00 | cpm |
| XPEAK 1742.7 Kev | 1.15E-01 | 1.11E+02 | 0.00E+00 | cpm |
| XPEAK 1749.3 Kev | 8.50E-02 | 1.44E+02 | 0.00E+00 | cpm |
| XPEAK 1847.8 Kev | 1.65E-01 | 6.56E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PACKET D5089 ITEM 3
SAMPLE 80984 ID= WELL PM-2 B-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 6.80E-06 | 5.36E+00 | 2.34E-07 | uCi/g |

PACKET D5089 ITEM 3
SAMPLE 80984 ID= WELL PM-2 B-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.85E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 6.16E-07 | 3.38E+01 | 1.47E-07 | uCi/g |
| CO60 | 2.54E-07 | 2.75E+01 | 3.86E-08 | uCi/g |
| CS137 | 1.16E-06 | 1.34E+01 | 4.71E-08 | uCi/g |
| EU152 | 6.36E-07 | 3.14E+01 | 1.31E-07 | uCi/g |
| EU154 | 5.73E-07 | 3.86E+01 | 1.52E-07 | uCi/g |
| K 40 | 4.20E-05 | 9.96E+00 | 2.97E-07 | uCi/g |
| RA226 | 9.09E-07 | 1.90E+01 | 7.66E-08 | uCi/g |
| TH228 | 2.48E-06 | 1.23E+01 | 8.58E-08 | uCi/g |
| TH232 | 2.00E-06 | 1.77E+01 | 1.51E-07 | uCi/g |
| XPEAK 651.4 Kev | 4.10E-01 | 9.13E+01 | 0.00E+00 | cpm |
| XPEAK 770.3 Kev | 8.75E-01 | 4.54E+01 | 0.00E+00 | cpm |
| XPEAK 1027.9 Kev | 2.60E-01 | 1.03E+02 | 0.00E+00 | cpm |
| XPEAK 1523.0 Kev | 1.10E-01 | 1.12E+02 | 0.00E+00 | cpm |
| XPEAK 1638.7 Kev | 1.60E-01 | 7.83E+01 | 0.00E+00 | cpm |
| XPEAK 1749.0 Kev | 1.50E-01 | 5.23E+01 | 0.00E+00 | cpm |
| XPEAK 1757.0 Kev | 8.50E-02 | 9.20E+01 | 0.00E+00 | cpm |
| XPEAK 1951.8 Kev | 1.45E-01 | 7.05E+01 | 0.00E+00 | cpm |
| XPEAK 1960.4 Kev | 1.65E-01 | 6.30E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 4
SAMPLE 80986 ID= WELL PM-2 C-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 6.45E-06 | 5.38E+00 | 2.23E-07 | uCi/g |

PACKET D5089 ITEM 4
SAMPLE 80986 ID= WELL PM-2 C-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.86E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 1.48E-05 | 9.74E+00 | 2.95E-07 | uCi/g |
| CO60 | 3.76E-06 | 1.05E+01 | 5.78E-08 | uCi/g |
| CS137 | 8.87E-07 | 1.81E+01 | 8.15E-08 | uCi/g |
| EU150 | 9.89E-07 | 1.50E+01 | 6.57E-08 | uCi/g |
| EU152 | 1.34E-05 | 9.84E+00 | 2.45E-07 | uCi/g |
| EU154 | 1.10E-05 | 1.06E+01 | 1.98E-07 | uCi/g |
| K 40 | 3.67E-05 | 1.03E+01 | 3.86E-07 | uCi/g |
| RA226 | 1.16E-06 | 2.33E+01 | 1.50E-07 | uCi/g |
| TH228 | 2.48E-06 | 1.51E+01 | 1.58E-07 | uCi/g |
| TH232 | 2.31E-06 | 2.38E+01 | 3.21E-07 | uCi/g |
| XPEAK 92.9 Kev | 2.97E+00 | 6.85E+01 | 0.00E+00 | cpm |
| XPEAK 146.2 Kev | 1.12E+00 | 1.12E+02 | 0.00E+00 | cpm |
| XPEAK 209.6 Kev | 3.03E+00 | 5.15E+01 | 0.00E+00 | cpm |
| XPEAK 270.3 Kev | 2.19E+00 | 6.65E+01 | 0.00E+00 | cpm |
| XPEAK 328.4 Kev | 1.32E+00 | 8.57E+01 | 0.00E+00 | cpm |
| XPEAK 367.5 Kev | 1.56E+00 | 5.69E+01 | 0.00E+00 | cpm |
| XPEAK 433.9 Kev | 1.13E+00 | 8.39E+01 | 0.00E+00 | cpm |
| XPEAK 503.9 Kev | 7.85E-01 | 1.12E+02 | 0.00E+00 | cpm |
| XPEAK 845.6 Kev | 1.20E+00 | 6.54E+01 | 0.00E+00 | cpm |
| XPEAK 933.9 Kev | 8.10E-01 | 8.82E+01 | 0.00E+00 | cpm |
| XPEAK 1046.7 Kev | 1.18E+00 | 6.17E+01 | 0.00E+00 | cpm |
| XPEAK 1128.5 Kev | 9.55E-01 | 6.44E+01 | 0.00E+00 | cpm |
| XPEAK 1236.6 Kev | 8.75E-01 | 6.33E+01 | 0.00E+00 | cpm |
| XPEAK 1246.5 Kev | 5.25E-01 | 7.57E+01 | 0.00E+00 | cpm |
| XPEAK 1378.4 Kev | 5.45E-01 | 4.95E+01 | 0.00E+00 | cpm |
| XPEAK 1494.6 Kev | 6.20E-01 | 3.96E+01 | 0.00E+00 | cpm |
| XPEAK 1588.5 Kev | 1.95E-01 | 9.44E+01 | 0.00E+00 | cpm |
| XPEAK 1638.0 Kev | 2.55E-01 | 5.42E+01 | 0.00E+00 | cpm |
| XPEAK 1650.6 Kev | 1.05E-01 | 9.18E+01 | 0.00E+00 | cpm |
| XPEAK 1691.4 Kev | 1.25E-01 | 1.12E+02 | 0.00E+00 | cpm |
| XPEAK 1720.4 Kev | 3.30E-01 | 4.94E+01 | 0.00E+00 | cpm |
| XPEAK 1730.8 Kev | 2.45E-01 | 6.94E+01 | 0.00E+00 | cpm |
| XPEAK 1803.1 Kev | 2.25E-01 | 5.33E+01 | 0.00E+00 | cpm |

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5089 ITEM 4
SAMPLE 80986 ID= WELL PM-2 C-SURFACE SAMPLING DATE 111993 -

| | | | | |
|---|---|---|---|---|
| XPEAK 1840.3 Kev | 1.75E-01 | 5.57E+01 | 0.00E+00 | cpm |
| XPEAK 1848.3 Kev | 1.80E-01 | 6.94E+01 | 0.00E+00 | cpm |
| XPEAK 1868.5 Kev | 1.20E-01 | 9.13E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PACKET D5089 ITEM 5
SAMPLE 80988 ID= WELL PM-2 C-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| H-3 TRITIUM 2.38E-05 | 3.01E+00 | 3.34E-07 | uCi/g |

PACKET D5089 ITEM 5
SAMPLE 80988 ID= WELL PM-2 C-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 2.08E+02 PROCESSED ON 113093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| CS137 6.14E-08 | 5.10E+01 | 2.42E-08 | uCi/g |
| K 40 1.51E-06 | 3.65E+01 | 2.68E-07 | uCi/g |
| RA226 1.69E-07 | 4.65E+01 | 4.61E-08 | uCi/g |
| TH228 2.64E-07 | 3.29E+01 | 4.12E-08 | uCi/g |
| TH232 2.76E-07 | 4.37E+01 | 8.56E-08 | uCi/g |
| XPEAK 92.5 Kev 6.55E-01 | 9.09E+01 | 0.00E+00 | cpm |
| XPEAK 151.2 Kev 5.45E-01 | 8.33E+01 | 0.00E+00 | cpm |
| XPEAK 631.8 Kev 2.05E-01 | 7.56E+01 | 0.00E+00 | cpm |
| XPEAK 652.6 Kev 1.60E-01 | 1.16E+02 | 0.00E+00 | cpm |
| XPEAK 684.2 Kev 1.15E-01 | 1.17E+02 | 0.00E+00 | cpm |
| XPEAK 787.1 Kev 2.35E-01 | 9.31E+01 | 0.00E+00 | cpm |
| XPEAK 1003.4 Kev 2.15E-01 | 6.24E+01 | 0.00E+00 | cpm |
| XPEAK 1064.0 Kev 1.05E-01 | 1.19E+02 | 0.00E+00 | cpm |
| XPEAK 1238.7 Kev 1.35E-01 | 7.80E+01 | 0.00E+00 | cpm |
| XPEAK 1409.9 Kev 9.00E-02 | 1.21E+02 | 0.00E+00 | cpm |
| XPEAK 1485.7 Kev 8.50E-02 | 7.53E+01 | 0.00E+00 | cpm |
| XPEAK 1731.2 Kev 6.00E-02 | 9.05E+01 | 0.00E+00 | cpm |
| XPEAK 1747.9 Kev 1.10E-01 | 7.16E+01 | 0.00E+00 | cpm |
| XPEAK 1951.8 Kev 7.50E-02 | 9.43E+01 | 0.00E+00 | cpm |
| XPEAK 1960.9 Kev 7.50E-02 | 8.34E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 0
SAMPLE 80990 ID= WELL PM-2 D-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 1.70E-05 | 2.96E+00 | 2.34E-07 | uCi/g |

PACKET D5090 ITEM 0
SAMPLE 80990 ID= WELL PM-2 D-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 7.87E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 9.09E-06 | 1.09E+01 | 2.67E-07 | uCi/g |
| CO60 | 2.80E-06 | 1.10E+01 | 4.83E-08 | uCi/g |
| CS137 | 8.01E-07 | 1.94E+01 | 7.87E-08 | uCi/g |
| EU150 | 7.31E-07 | 1.78E+01 | 6.38E-08 | uCi/g |
| EU152 | 8.42E-06 | 1.08E+01 | 2.19E-07 | uCi/g |
| EU154 | 7.18E-06 | 1.15E+01 | 1.72E-07 | uCi/g |
| K 40 | 4.44E-05 | 9.90E+00 | 3.70E-07 | uCi/g |
| RA226 | 8.71E-07 | 2.61E+01 | 1.33E-07 | uCi/g |
| TH228 | 2.35E-06 | 1.49E+01 | 1.44E-07 | uCi/g |
| TH232 | 2.10E-06 | 2.48E+01 | 2.95E-07 | uCi/g |
| XPEAK 145.4 Kev | 7.65E-01 | 1.78E+02 | 0.00E+00 | cpm |
| XPEAK 175.2 Kev | 1.22E+00 | 1.21E+02 | 0.00E+00 | cpm |
| XPEAK 209.0 Kev | 2.10E+00 | 6.74E+01 | 0.00E+00 | cpm |
| XPEAK 258.5 Kev | 1.54E+00 | 7.45E+01 | 0.00E+00 | cpm |
| XPEAK 270.3 Kev | 2.77E+00 | 4.66E+01 | 0.00E+00 | cpm |
| XPEAK 327.5 Kev | 8.55E-01 | 1.02E+02 | 0.00E+00 | cpm |
| XPEAK 367.6 Kev | 1.11E+00 | 7.07E+01 | 0.00E+00 | cpm |
| XPEAK 433.9 Kev | 1.72E+00 | 4.79E+01 | 0.00E+00 | cpm |
| XPEAK 454.1 Kev | 1.48E+00 | 6.01E+01 | 0.00E+00 | cpm |
| XPEAK 546.6 Kev | 6.40E-01 | 1.30E+02 | 0.00E+00 | cpm |
| XPEAK 713.7 Kev | 1.12E+00 | 6.51E+01 | 0.00E+00 | cpm |
| XPEAK 904.0 Kev | 8.15E-01 | 7.91E+01 | 0.00E+00 | cpm |
| XPEAK 989.9 Kev | 3.65E-01 | 1.22E+02 | 0.00E+00 | cpm |
| XPEAK 1128.8 Kev | 8.20E-01 | 7.31E+01 | 0.00E+00 | cpm |
| XPEAK 1246.4 Kev | 5.40E-01 | 8.08E+01 | 0.00E+00 | cpm |
| XPEAK 1378.3 Kev | 3.40E-01 | 5.94E+01 | 0.00E+00 | cpm |
| XPEAK 1397.8 Kev | 5.10E-01 | 4.27E+01 | 0.00E+00 | cpm |
| XPEAK 1495.3 Kev | 5.15E-01 | 4.10E+01 | 0.00E+00 | cpm |
| XPEAK 1529.5 Kev | 4.05E-01 | 4.55E+01 | 0.00E+00 | cpm |
| XPEAK 1631.7 Kev | 3.05E-01 | 4.93E+01 | 0.00E+00 | cpm |
| XPEAK 1639.9 Kev | 1.55E-01 | 9.81E+01 | 0.00E+00 | cpm |
| XPEAK 1680.4 Kev | 1.10E-01 | 8.23E+01 | 0.00E+00 | cpm |
| XPEAK 1720.6 Kev | 1.70E-01 | 9.20E+01 | 0.00E+00 | cpm |

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 0
SAMPLE 80990 ID= WELL PM-2 D-SURFACE SAMPLING DATE 111993 -

| | | | | |
|---|---|---|---|---|
| XPEAK 1848.6 Kev | 2.40E-01 | 4.90E+01 | 0.00E+00 | cpm |
| XPEAK 1952.3 Kev | 1.05E-01 | 8.57E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PACKET D5090 ITEM 1
SAMPLE 80992 ID= WELL PM-2 D-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| H-3 TRITIUM 5.07E-07 | 9.03E+01 | 4.56E-07 | uCi/g |

PACKET D5090 ITEM 1
SAMPLE 80992 ID= WELL PM-2 D-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 7.49E+02 PROCESSED ON 113093

| ********** RESULT ********** | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|
| AM241 3.83E-06 | 1.29E+01 | 1.81E-07 | uCi/g |
| CO60 1.18E-06 | 1.40E+01 | 4.77E-08 | uCi/g |
| CS137 7.47E-07 | 1.73E+01 | 5.74E-08 | uCi/g |
| EU150 3.13E-07 | 2.50E+01 | 4.71E-08 | uCi/g |
| EU152 3.45E-06 | 1.36E+01 | 1.65E-07 | uCi/g |
| EU154 2.97E-06 | 1.51E+01 | 1.59E-07 | uCi/g |
| K 40 4.22E-05 | 9.95E+00 | 3.15E-07 | uCi/g |
| RA226 8.28E-07 | 2.31E+01 | 1.02E-07 | uCi/g |
| TH228 2.17E-06 | 1.42E+01 | 1.18E-07 | uCi/g |
| TH232 2.09E-06 | 1.84E+01 | 1.85E-07 | uCi/g |
| XPEAK 92.8 Kev 1.52E+00 | 8.87E+01 | 0.00E+00 | cpm |
| XPEAK 517.6 Kev 7.05E-01 | 7.79E+01 | 0.00E+00 | cpm |
| XPEAK 737.4 Kev 6.15E-01 | 8.59E+01 | 0.00E+00 | cpm |
| XPEAK 770.7 Kev 1.14E+00 | 5.28E+01 | 0.00E+00 | cpm |
| XPEAK 930.3 Kev 7.30E-01 | 5.96E+01 | 0.00E+00 | cpm |
| XPEAK 1067.2 Kev 4.55E-01 | 7.79E+01 | 0.00E+00 | cpm |
| XPEAK 1197.6 Kev 4.00E-01 | 8.38E+01 | 0.00E+00 | cpm |
| XPEAK 1377.9 Kev 3.00E-01 | 7.74E+01 | 0.00E+00 | cpm |
| XPEAK 1398.5 Kev 3.35E-01 | 6.59E+01 | 0.00E+00 | cpm |
| XPEAK 1449.2 Kev 2.10E-01 | 9.59E+01 | 0.00E+00 | cpm |
| XPEAK 1544.8 Kev 1.65E-01 | 5.46E+01 | 0.00E+00 | cpm |
| XPEAK 1609.1 Kev 8.00E-02 | 1.23E+02 | 0.00E+00 | cpm |
| XPEAK 1730.7 Kev 2.40E-01 | 4.97E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 2
SAMPLE 80994 ID= WELL PM-2 E-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 5.25E-06 | 6.44E+00 | 2.34E-07 | uCi/g |

PACKET D5090 ITEM 2
SAMPLE 80994 ID= WELL PM-2 E-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 5.90E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 1.39E-05 | 9.49E+00 | 2.37E-07 | uCi/g |
| CO60 | 2.55E-06 | 1.12E+01 | 4.52E-08 | uCi/g |
| CS137 | 1.06E-06 | 1.62E+01 | 7.36E-08 | uCi/g |
| EU150 | 7.17E-07 | 1.72E+01 | 5.88E-08 | uCi/g |
| EU152 | 1.00E-05 | 1.02E+01 | 2.04E-07 | uCi/g |
| EU154 | 7.77E-06 | 1.14E+01 | 1.82E-07 | uCi/g |
| K 40 | 3.74E-05 | 1.03E+01 | 3.63E-07 | uCi/g |
| RA226 | 8.81E-07 | 2.45E+01 | 1.22E-07 | uCi/g |
| TH228 | 2.07E-06 | 1.51E+01 | 1.29E-07 | uCi/g |
| TH232 | 1.81E-06 | 2.34E+01 | 2.55E-07 | uCi/g |
| XPEAK 161.6 Kev | 2.24E+00 | 6.08E+01 | 0.00E+00 | cpm |
| XPEAK 209.1 Kev | 2.17E+00 | 4.89E+01 | 0.00E+00 | cpm |
| XPEAK 270.4 Kev | 1.60E+00 | 6.49E+01 | 0.00E+00 | cpm |
| XPEAK 327.9 Kev | 1.44E+00 | 7.34E+01 | 0.00E+00 | cpm |
| XPEAK 433.9 Kev | 1.72E+00 | 5.02E+01 | 0.00E+00 | cpm |
| XPEAK 626.0 Kev | 6.40E-01 | 9.92E+01 | 0.00E+00 | cpm |
| XPEAK 846.2 Kev | 8.15E-01 | 8.15E+01 | 0.00E+00 | cpm |
| XPEAK 880.8 Kev | 6.20E-01 | 1.14E+02 | 0.00E+00 | cpm |
| XPEAK 893.6 Kev | 6.10E-01 | 1.03E+02 | 0.00E+00 | cpm |
| XPEAK 904.2 Kev | 6.70E-01 | 8.45E+01 | 0.00E+00 | cpm |
| XPEAK 948.2 Kev | 8.90E-01 | 6.64E+01 | 0.00E+00 | cpm |
| XPEAK 1122.4 Kev | 1.35E+00 | 4.35E+01 | 0.00E+00 | cpm |
| XPEAK 1222.3 Kev | 6.65E-01 | 6.16E+01 | 0.00E+00 | cpm |
| XPEAK 1246.5 Kev | 4.30E-01 | 1.02E+02 | 0.00E+00 | cpm |
| XPEAK 1317.2 Kev | 5.45E-01 | 5.35E+01 | 0.00E+00 | cpm |
| XPEAK 1428.1 Kev | 3.30E-01 | 6.40E+01 | 0.00E+00 | cpm |
| XPEAK 1446.2 Kev | 4.60E-01 | 4.82E+01 | 0.00E+00 | cpm |
| XPEAK 1609.3 Kev | 1.20E-01 | 1.02E+02 | 0.00E+00 | cpm |
| XPEAK 1631.2 Kev | 2.35E-01 | 5.50E+01 | 0.00E+00 | cpm |
| XPEAK 1644.4 Kev | 1.10E-01 | 1.08E+02 | 0.00E+00 | cpm |
| XPEAK 1720.5 Kev | 2.75E-01 | 5.33E+01 | 0.00E+00 | cpm |
| XPEAK 1758.1 Kev | 8.00E-02 | 1.31E+02 | 0.00E+00 | cpm |
| XPEAK 1984.5 Kev | 1.20E-01 | 7.07E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 3
SAMPLE 80996 ID= WELL PM-2 E-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 4.38E-05 | 1.77E+00 | 2.45E-07 | uCi/g |

PACKET D5090 ITEM 3
SAMPLE 80996 ID= WELL PM-2 E-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 5.69E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| CO60 | 8.23E-08 | 5.79E+01 | 3.79E-08 | uCi/g |
| CS137 | 4.49E-07 | 1.81E+01 | 3.65E-08 | uCi/g |
| EU152 | 2.54E-07 | 5.97E+01 | 1.18E-07 | uCi/g |
| EU154 | 2.47E-07 | 5.78E+01 | 1.15E-07 | uCi/g |
| K 40 | 2.48E-05 | 1.10E+01 | 2.84E-07 | uCi/g |
| RA226 | 1.05E-06 | 1.68E+01 | 6.54E-08 | uCi/g |
| TH228 | 2.07E-06 | 1.26E+01 | 7.21E-08 | uCi/g |
| TH232 | 1.80E-06 | 1.83E+01 | 1.37E-07 | uCi/g |
| XPEAK 106.8 Kev | 1.46E+00 | 6.05E+01 | 0.00E+00 | cpm |
| XPEAK 517.9 Kev | 3.70E-01 | 1.01E+02 | 0.00E+00 | cpm |
| XPEAK 677.3 Kev | 4.65E-01 | 5.63E+01 | 0.00E+00 | cpm |
| XPEAK 783.7 Kev | 6.23E-01 | 5.70E+01 | 0.00E+00 | cpm |
| XPEAK 932.5 Kev | 4.65E-01 | 6.15E+01 | 0.00E+00 | cpm |
| XPEAK 1086.8 Kev | 1.90E-01 | 1.06E+02 | 0.00E+00 | cpm |
| XPEAK 1111.7 Kev | 3.75E-01 | 8.15E+01 | 0.00E+00 | cpm |
| XPEAK 1343.9 Kev | 3.70E-01 | 4.67E+01 | 0.00E+00 | cpm |
| XPEAK 1497.0 Kev | 1.45E-01 | 7.66E+01 | 0.00E+00 | cpm |
| XPEAK 1510.4 Kev | 3.20E-01 | 4.00E+01 | 0.00E+00 | cpm |
| XPEAK 1558.4 Kev | 7.50E-02 | 1.25E+02 | 0.00E+00 | cpm |
| XPEAK 1570.0 Kev | 1.50E-01 | 7.60E+01 | 0.00E+00 | cpm |
| XPEAK 1662.7 Kev | 1.15E-01 | 8.61E+01 | 0.00E+00 | cpm |
| XPEAK 1682.8 Kev | 1.60E-01 | 6.66E+01 | 0.00E+00 | cpm |
| XPEAK 1694.2 Kev | 1.05E-01 | 8.57E+01 | 0.00E+00 | cpm |
| XPEAK 1742.4 Kev | 6.00E-02 | 9.13E+01 | 0.00E+00 | cpm |
| XPEAK 1878.8 Kev | 1.60E-01 | 5.30E+01 | 0.00E+00 | cpm |
| XPEAK 1893.2 Kev | 9.50E-02 | 6.94E+01 | 0.00E+00 | cpm |
| XPEAK 1900.5 Kev | 1.60E-01 | 5.64E+01 | 0.00E+00 | cpm |
| XPEAK 1952.6 Kev | 1.45E-01 | 7.30E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 4
SAMPLE 80998 ID= WELL PM-2 F-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 3.47E-06 | 8.81E+00 | 2.34E-07 | uCi/g |

PACKET D5090 ITEM 4
SAMPLE 80998 ID= WELL PM-2 F-SURFACE SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 5.68E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 2.00E-05 | 9.36E+00 | 3.41E-07 | uCi/g |
| CO60 | 6.23E-06 | 9.64E+00 | 5.85E-08 | uCi/g |
| CS137 | 1.31E-06 | 1.72E+01 | 1.06E-07 | uCi/g |
| EU150 | 1.81E-06 | 1.30E+01 | 8.50E-08 | uCi/g |
| EU152 | 2.09E-05 | 9.23E+00 | 2.92E-07 | uCi/g |
| EU154 | 1.73E-05 | 9.74E+00 | 2.08E-07 | uCi/g |
| K 40 | 3.68E-05 | 1.03E+01 | 4.03E-07 | uCi/g |
| RA226 | 1.02E-06 | 2.95E+01 | 1.88E-07 | uCi/g |
| TH228 | 1.77E-06 | 2.04E+01 | 1.95E-07 | uCi/g |
| TH232 | 2.14E-06 | 2.83E+01 | 3.86E-07 | uCi/g |
| XPEAK 92.5 Kev | 3.49E+00 | 6.82E+01 | 0.00E+00 | cpm |
| XPEAK 176.5 Kev | 1.42E+00 | 9.34E+01 | 0.00E+00 | cpm |
| XPEAK 269.8 Kev | 2.06E+00 | 7.26E+01 | 0.00E+00 | cpm |
| XPEAK 306.1 Kev | 1.79E+00 | 8.50E+01 | 0.00E+00 | cpm |
| XPEAK 422.9 Kev | 6.60E-01 | 1.40E+02 | 0.00E+00 | cpm |
| XPEAK 565.0 Kev | 2.06E+00 | 5.58E+01 | 0.00E+00 | cpm |
| XPEAK 714.5 Kev | 1.03E+00 | 8.59E+01 | 0.00E+00 | cpm |
| XPEAK 816.6 Kev | 9.35E-01 | 8.76E+01 | 0.00E+00 | cpm |
| XPEAK 839.9 Kev | 9.05E-01 | 8.91E+01 | 0.00E+00 | cpm |
| XPEAK 919.8 Kev | 1.04E+00 | 8.37E+01 | 0.00E+00 | cpm |
| XPEAK 1153.9 Kev | 7.25E-01 | 8.66E+01 | 0.00E+00 | cpm |
| XPEAK 1233.9 Kev | 5.75E-01 | 9.38E+01 | 0.00E+00 | cpm |
| XPEAK 1378.4 Kev | 3.80E-01 | 7.59E+01 | 0.00E+00 | cpm |
| XPEAK 1448.2 Kev | 3.50E-01 | 5.92E+01 | 0.00E+00 | cpm |
| XPEAK 1538.9 Kev | 2.85E-01 | 5.98E+01 | 0.00E+00 | cpm |
| XPEAK 1619.0 Kev | 3.05E-01 | 5.40E+01 | 0.00E+00 | cpm |
| XPEAK 1692.3 Kev | 1.10E-01 | 1.02E+02 | 0.00E+00 | cpm |
| XPEAK 1730.8 Kev | 1.70E-01 | 7.58E+01 | 0.00E+00 | cpm |
| XPEAK 1798.3 Kev | 7.50E-02 | 1.10E+02 | 0.00E+00 | cpm |
| XPEAK 1821.1 Kev | 2.15E-01 | 5.54E+01 | 0.00E+00 | cpm |
| XPEAK 1839.5 Kev | 2.30E-01 | 5.61E+01 | 0.00E+00 | cpm |
| XPEAK 1848.8 Kev | 2.45E-01 | 5.31E+01 | 0.00E+00 | cpm |
| XPEAK 1951.8 Kev | 1.55E-01 | 8.44E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

PROJECT: RES EVENT/PROGRAM: ENVIRONMENTAL SURVEILLANCE SPECIAL STUDIES
TYPE: SOIL GROSS (500 ML BOTTLE)

PACKET D5090 ITEM 5
SAMPLE 81000 ID= WELL PM-2 F-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= H-3 TRITIUM
PARAMETER= 67861 SIGMA= 2.0 SIZE= 1.00E+01 PROCESSED ON 122093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| H-3 TRITIUM | 5.18E-06 | 6.74E+00 | 2.45E-07 | uCi/g |

PACKET D5090 ITEM 5
SAMPLE 81000 ID= WELL PM-2 F-30-CM SAMPLING DATE 111993 -
COMMENT -- H-3 MDA SHOULD BE 3.E-7 uCi/ml
ANALYSIS= GAMMA
PARAMETER= 00816 SIGMA= 2.0 SIZE= 6.20E+02 PROCESSED ON 113093

| ********** RESULT ********** | | % ERROR | DET LIMIT | UNITS |
|---|---|---|---|---|
| AM241 | 6.05E-07 | 3.30E+01 | 1.40E-07 | uCi/g |
| CO60 | 1.71E-07 | 3.45E+01 | 3.78E-08 | uCi/g |
| CS137 | 2.84E-07 | 2.46E+01 | 3.88E-08 | uCi/g |
| EU152 | 4.63E-07 | 3.98E+01 | 1.31E-07 | uCi/g |
| EU154 | 4.37E-07 | 4.13E+01 | 1.25E-07 | uCi/g |
| K 40 | 2.61E-05 | 1.09E+01 | 2.82E-07 | uCi/g |
| RA226 | 1.90E-06 | 1.31E+01 | 6.28E-08 | uCi/g |
| TH228 | 2.14E-06 | 1.27E+01 | 7.93E-08 | uCi/g |
| TH232 | 1.80E-06 | 1.92E+01 | 1.52E-07 | uCi/g |
| XPEAK 105.4 Kev | 1.49E+00 | 6.81E+01 | 0.00E+00 | cpm |
| XPEAK 372.8 Kev | 4.40E-01 | 1.12E+02 | 0.00E+00 | cpm |
| XPEAK 395.5 Kev | 7.20E-01 | 6.27E+01 | 0.00E+00 | cpm |
| XPEAK 433.8 Kev | 4.35E-01 | 8.53E+01 | 0.00E+00 | cpm |
| XPEAK 639.1 Kev | 4.75E-01 | 7.34E+01 | 0.00E+00 | cpm |
| XPEAK 806.0 Kev | 4.90E-01 | 5.66E+01 | 0.00E+00 | cpm |
| XPEAK 837.9 Kev | 5.20E-01 | 6.68E+01 | 0.00E+00 | cpm |
| XPEAK 981.0 Kev | 3.10E-01 | 7.99E+01 | 0.00E+00 | cpm |
| XPEAK 1064.7 Kev | 2.50E-01 | 1.02E+02 | 0.00E+00 | cpm |
| XPEAK 1155.9 Kev | 5.85E-01 | 5.50E+01 | 0.00E+00 | cpm |
| XPEAK 1185.5 Kev | 4.05E-01 | 7.97E+01 | 0.00E+00 | cpm |
| XPEAK 1402.0 Kev | 2.00E-01 | 8.19E+01 | 0.00E+00 | cpm |
| XPEAK 1510.1 Kev | 2.40E-01 | 6.83E+01 | 0.00E+00 | cpm |
| XPEAK 1554.3 Kev | 1.25E-01 | 9.83E+01 | 0.00E+00 | cpm |
| XPEAK 1622.0 Kev | 1.35E-01 | 9.34E+01 | 0.00E+00 | cpm |
| XPEAK 1730.5 Kev | 3.30E-01 | 4.56E+01 | 0.00E+00 | cpm |
| XPEAK 1848.4 Kev | 2.65E-01 | 6.00E+01 | 0.00E+00 | cpm |

** ANALYSIS: H2O_SOIL H2O IN SOIL IN PROCESS **

****** End of Report ******

# APPENDIX D. Summary of Hydrologic Testing at Well PM-2

The information contained in Appendix D was provided from original field notes (R.K. Blankennagel, written commun., 1964).

## SALINOMETER TEST 7/11/64

Original depth to water: 1,260'
Depth to bridge: 4,070'
Added 125 lbs. salt /40 bbl water

| | |
|---|---|
| Run #1 Brine in at 0615 | SWL = 1,260' |
| Salinometer run at 0800 | WL = 905' |
| Salt/fresh Interface | reversal at 1800' from fresh to salt |
| | back to fresh at 2,330' |
| | back to salt at 3,630' |
| Run #2 Brine in | SWL =1,260' |
| after brine injection: | WL =910' (0800) |
| WL 1 1/4 hours after injection | WL =920' (0915) |

## SWABBING TESTS 07/12/64

Specific capacity (gpm/foot of drawdown) not determined because water level continued to decline throughout swabbing period. Swabbing tests proved unnecessary and undesirable

## INJECTION TESTS

Injection test were run on 5 zones believed to be most permeable.

| Interval injected, in feet | Relative Specific Capacity |
|---|---|
| 2,528-2,726 | .01 |
| 2,818-3,016 | 0.00 |
| 3,168-3,366 | .00 |
| 3,441-3,639 | .02 |
| 3,720-3,918 | .00 |

## TRACEJECTOR TESTS 07/13/64

Tracejector test included the use of Iodine 131 at a concentration of 5 millicuries per 7 milliliters. Records indicate nuclide was emptied from casing at end of test.

| Depth, in feet | 2,450 | 2,574 | 2,896 | 3,190 | 3,336 | 3,560 | 3,650 | 3,760 | 3,896 | 3,950 |
|---|---|---|---|---|---|---|---|---|---|---|
| Flow rate, in gpm | 1.3 | 0.5 | 1.26 | 0.9 | 1.7 | 0.97 | 1.1 | 1.6 | 1.3 | 2.3 |

# APPENDIX E. Summary of Water-Quality Data for Well PM-2 from Lawrence Livermore National Laboratory

The information contained in Appendix E was provided by Lawrence Livermore National Laboratory. It is presented in the format provided to the USGS.

**PRELIMINARY DATA**
**SUBJECT TO REVISION**

**Well PM-2**
**Nevada Test Site**
**LLNL-HRMP Data**

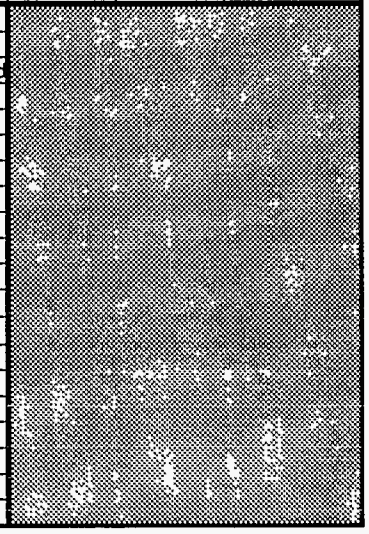
**SAMPLE DATES: November 29th-December 1st, 1993**

| SAMPLE DEPTH | | Tritium (Bq/L) | | GAMMA SPECTRAL (Bq/L) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 60Co | | 125Sb | | 137Cs | | 226Ra | |
| | | | | Unfiltered | 10000 M.W. | Unfiltered | 10000 M.W. | Unfiltered | 10000 M.W. | Unfiltered | 10000 M.W. |
| Feet | Meters | Field | Laboratory | Water | Filter | Water | Filter | Water | Filter | Water | Filter |
| 1000 | 305 | 5.37E+02 | 9.37E+02 | <1.10E-02 | not detected | <3.18E-02 | not detected | <1.10E-02 | not detected | 6.15E-01 | 6.67E-02 |
| 2000 | 610 | 2.72E+04 | 2.63E+04 | <1.67E-02 | not detected | <4.48E-02 | not detected | <1.77E-02 | not detected | <3.78E-02 | not detected |
| 2700 | 823 | 2.20E+04 | 2.29E+04 | <1.43E-02 | not detected | <3.69E-02 | not detected | <1.45E-02 | not detected | 8.78E-02 | not detected |
| 3000 | 915 | 1.96E+04 | 2.14E+04 | <1.25E-02 | not detected | <3.81E-02 | not detected | <1.59E-02 | not detected | <3.07E-02 | not detected |

| SAMPLE DEPTH | | 14C (Bq/L) | 36Cl (Bq/L) | 90Sr (Bq/L) | 3He atoms | 4He atoms | 3He/3H Age (days) | Gross Alpha (Bq/L) | Gross Beta (Bq/L) | 238Pu (Bq/L) | 239Pu (Bq/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feet | Meters | | | | | | | | | | |
| 1000 | 305 | 2.50E+02 | 1.52E-04 | <1.9E-02 | -- | -- | -- | <1.3 | <2.6 | <2.0E-03 | <2.0E-03 |
| 2000 | 610 | 2.00E+02 | 2.22E-05 | <2.6E-02 | 7.86E+09 | 1.75E+14 | 3348 | <1.3 | <2.6 | <2.8E-03 | <1.4E-03 |
| 2700 | 823 | 1.00E+02 | -- | <2.3E-01 | -- | -- | -- | <1.3 | <2.6 | <3.9E-03 | <2.1E-03 |
| 3000 | 915 | 1.63E+03 | 2.00E-05 | <1.4E-01 | 5.36E+09 | 1.43E+14 | 3162 | <1.3 | <2.6 | 4.56E-03 | <2.4E-03 |

**Detectable Volatile and Semi-volatile Organic Compounds (ug/L)**

| | | | |
|---|---|---|---|
| 1000 ft (305 m) | | 2000 ft (610 m) | |
| Benzene | 4.2 | VOC's and Semi's not detected | |
| Chloromethane | 2 | | |
| Methyl chloride | 0.3 | | |
| TCE 1,1,2 | 0.5 | | |
| Dimethyl ether | 20 | | |
| | | | |
| 2700 ft (823 m) | | | |
| Carbon disulfide | 1 | | |
| TCE 1,1,2 | 0.5 | | |
| Dimethyl ether | 20 | | |
| 4 Methylphenol | 190 | | |
| Di-n-butyl phthalate | 21 | (detection confirmed, value estimated) | |
| Bis (2-ethylhexylphthalate) | 35 | (detection confirmed, value estimated) | |
| | | | |
| 3000 ft (915 m) | | | |
| 4 Methylphenol | 120 | | |
| Di-n-butyl phthalate | 18 | (detection confirmed, value estimated) | |
| Bis (2-ethylhexylphthalate) | 25 | (detection confirmed, value estimated) | |



**PRELIMINARY DATA**
**SUBJECT TO REVISION**

**Well PM-2**
**Nevada Test Site**
**LLNL-HRMP Data**

**SAMPLE DATES: May 3-4, 1994**

| SAMPLE DEPTH | | Tritium (Bq/L) | | GAMMA SPECTRAL (Bq/L) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 60Co | | | 125Sb | | | 137Cs | | | 226Ra | | | 238+239Pu |
| | | | | Unfiltered | Filtered | 10000 M.W. | Unfiltered | Filtered | 10000 M.W. | Unfiltered | Filtered | 10000 M.W. | Unfiltered | Filtered | 10000 M.W. | Unfiltered |
| Feet | Meters | Field | Laboratory | Water | Water | Filter | Water | Water | Filter | Water | Water | Filter | Water | Water | Filter | Water |
| 1000 | 305 | not detected | 7.56E+02 | <8.93E-03 | <1.21E-03 | not detected | <2.75E-02 | (0.0168) | not detected | <1.00E-02 | (0.00881) | not detected | 1.23E-01 | <2.48E-03 | 3.78E-02 | <2.5E-04 |
| 2700 | 823 | 2.09E+04 | 2.46E+04 | <9.00E-03 | <1.48<-03 | not detected | <2.26E-02 | <3.70E-03 | not detected | <9.56E-03 | 3.49E-02 | not detected | <1.87E-02 | <2.81E-03 | not detected | 1.63E-03 |
| 3000 | 915 | not measured | 2.16E+04 | <1.47E-02 | <2.06E-03 | not detected | <4.11E-02 | <4.47E-03 | not detected | <1.56E-02 | <2.07E-03 | not detected | <3.15E-02 | <3.78E-03 | 2.56E-02 | 4.33E-03 |

The analyses for 125Sb and 137Cs for the 1000 foot sample are presently suspect, and should be regarded as very preliminary. Verification of the findings is currently being conducted.

**PRELIMINARY DATA**
**SUBJECT TO REVISION**

**Well PM-2**
**Nevada Test Site**
**LLNL-HRMP Data**

| SAMPLE DATES: November 29th-December 1st, 1993 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Depth | | MAJOR CATIONS AND ANIONS (mg/L) | | | | | | | | | | | | | |
| Feet | Meters | Al | B | Ca | Mg | Na | Fe | P | Si | K | S | Li | Cl | | |
| 1000 | 305 | <0.06 | <0.06 | 6.0 | 0.91 | 26 | 0.19 | 0.2 | 2.8 | 5.2 | 0.3 | <0.1 | 2.30 | | |
| 2000 | 610 | <0.06 | 0.73 | 2.1 | 0.50 | 1161 | 1.29 | <0.1 | 17.6 | 10.5 | 5.6 | 0.1 | ??? | | |
| 2700 | 823 | <0.06 | 0.72 | 4.4 | 0.97 | 1114 | 1.22 | 0.3 | 19.1 | 10.4 | 5.7 | 0.1 | ??? | | |
| 3000 | 915 | 0.14 | 0.73 | 4.0 | 0.81 | 1557 | 2.40 | 0.3 | 17.3 | 10.7 | 6.1 | <0.1 | ??? | | |
| Sample Depth | | TRACE METALS (ug/L) | | | | | | | | | | | | | |
| Feet | Meters | Cr | Mn | Ni | Co | Cu | Zn | As | Se | Sr | Mo | Ba | Hg | Pb | U |
| 1000 | 305 | 0.2 | 124.5 | <0.1 | <0.1 | 5.4 | 75.9 | 2.9 | 7.9 | 208.7 | 10.6 | 249.7 | <0.5 | 0.6 | <0.1 |
| 2000 | 610 | 109.1 | 16.1 | 7.1 | 0.5 | 94.2 | 105.8 | 11.2 | 127.0 | 353.2 | 266.5 | 297.8 | 7.9 | 16.2 | 2.4 |
| 2700 | 823 | 107.3 | 35.0 | 6.2 | 0.5 | 90.5 | 48.8 | 7.2 | 71.0 | 516.0 | 258.6 | 390.5 | 7.9 | 10.5 | 2.5 |
| 3000 | 915 | 93.9 | 74.8 | 18.0 | 0.9 | 54.3 | 132.1 | 11.0 | 118.1 | 681.2 | 264.8 | 462.1 | 9.8 | 23.7 | 2.5 |

| | | PM-2 Soils Samples: REECo Sampling Locations (pCi/g ± % error) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | Depth | K-40 | Co-60 | Ag-108m | Cs-137 | Eu-152 | Eu-154 | Eu-155 | Ra-226 | Ra-228 | Th-228 | U-235 | U-238 | Am-241 |
| A | Surface | 28.7±2 | 2.46±1 | 0.12±9 | 0.852±2 | 7.56±1 | 7.02±1 | 1.09±6 | 1.51±4 | 1.51±4 | 1.76±7 | 0.6±29 | 1.51±20 | 10.7±4 |
| A#2 | Surface | 24.8±2 | 2.30±1 | 0.12±9 | 0.753±2 | 6.92±1 | 6.52±1 | 0.52±10 | 1.22±4 | 1.22±4 | 1.44±2 | -- | -- | 0.47±22 |
| A | 30cm | 19.4±3 | <0.018 | -- | 0.07±27 | <0.05 | <0.03 | <0.05 | 1.43±4 | 1.43±4 | 1.68±2 | -- | <2.2 | <0.08 |
| B | Surface | 31.5±3 | 3.86±1 | 0.18±16 | 0.94±4 | 12.0±1 | 11.2±1 | 1.76±7 | 0.77±6 | 1.60±7 | 2.03±4 | -- | <0.87 | 16.4±4 |
| B | 30cm | 31.9±1 | 0.11±7 | 0.073±6 | 1.23±1 | 0.22±7 | 0.22±4 | 0.04±54 | 0.79±4 | 1.55±2 | 1.88±1 | 0.7±14 | 1.32±16 | 0.36±12 |
| B#2 | 30cm | 27.5±2 | 0.13±4 | -- | 1.06±1 | 0.23±6 | 0.23±6 | 0.10±34 | 0.67±2 | 1.31±2 | 1.59±2 | -- | <0.50 | 0.52±8 |

# LIST OF VOC and SEMI-VOC ANALYTES
## NTS WATER SAMPLES
## LLNL-HRMP 1993-1994

| VOLATILE ORGANICS | | | | SEMIVOLATILE ORGANICS | | | |
|---|---|---|---|---|---|---|---|
| COMPOUND | MDL (ug/L) | COMPOUND | MDL (ug/L) | COMPOUND | MDL (ug/L) | COMPOUND | MDL (ug/L) |
| Acetone | 10 | 1,2-Dichloropropane | 0.3 | Phenol | 37 | 2,4-Dinitrophenol | 190 |
| Benzene | 0.3 | 1,3-Dichloropropane | 0.3 | Bis(2-choloethyl) ether | 37 | 4-Nitrophenol | 190 |
| Bromobenzene | 0.3 | 12,2-Dichloropropane | 0.2 | 2-Chlorophenol | 37 | Dibenzofuran | 37 |
| Bromodichloromethane | 0.3 | 1,1-Dichloropropene | 0.2 | 1,3-dichlorobenzene | 37 | 2,4-Dinitrotoluene | 37 |
| Bormoform | 0.4 | Ethyl benzene | 0.3 | 1,4-dichlorobenzene | 37 | Diethyl phthalate | 37 |
| Bromomethan | 0.8 | Freon 113 | 0.3 | Benzyl alcohol | 37 | 4-chlorophenyl phenyl ether | 37 |
| 2-Butanone | 4 | Hexachlorobutadiene | 0.3 | 1,2-Dichlorobenzene | 37 | Fluorene | 37 |
| n-Butylbenzene | 0.3 | 2-Hexanone | 3 | 2-Methylphenol | 37 | 4-Nitroaniline | 190 |
| sec-Butylbenzene | 0.3 | Isopropylbenzene | 0.3 | n-nitrosodi-n-propylamine | 37 | 4,6-Dinitro-2Methylphenol | 190 |
| tert-Butylbenzene | 0.3 | p-Isopropyltoluene | 0.3 | Hexachloroethane | 37 | 4-Bromophenyl phenyl ether | 37 |
| Carbon disulfide | 0.2 | Methylene chloride | 0.3 | Nitrobenzene | 37 | Hexachlorobenzene | 37 |
| Carbon tetrachloride | 0.2 | 4-Methyl-2-pentanone | 6 | Isophorone | 37 | Pentachlorophenol | 190 |
| Chlorobenzene | 0.3 | Naphthalene | 0.4 | 2-Nitrophenol | 37 | Phenanthrene | 37 |
| Chloroethane | 0.3 | n-Propylbenzene | 1 | 2,4-Dimethylphenol | 37 | Anthracene | 37 |
| 2-Chloroethyl vinyl ether | 0.2 | Styrene | 0.3 | Benzoic acid | 190 | Di-n-butyl phthalate | 37 |
| Chloroform | 0.3 | 1,1,1,2-Tetrachloroethane | 0.3 | Bis-(2-chloroethoxy) methane | 37 | Fluoranthene | 37 |
| Chloromethane | 1 | 1,1,2,2-Tetrachloroethane | 0.4 | 2,4-Dichlorophenol | 37 | Pyrene | 37 |
| 2-Chlorotoluene | 0.3 | Tetrachloroethane | 0.2 | 1,2,4-Trichlorobenzene | 37 | Butyl benzyl phthalate | 37 |
| 4-Chlorotoluene | 0.3 | Toluene | 0.3 | Naphalene | 37 | 3,3'-Dichlorobenzidine | 74 |
| Dibromochloromethane | 0.4 | 1,2,3-Trichlorobenzene | 0.3 | 4-Chloroaniline | 37 | Benzo(a)anthrcene | 37 |
| 1,2-Dibromo-3-chloropropane | 0.5 | 1,2,4-Trichlorobenzene | 0.4 | Hexachlorobutadiene | 37 | Chrysene | 37 |
| 1,2-Dibromoethane | 0.3 | 1,1,1-Trichloroethane | 1 | 4-Chloro-3-methylphenol | 37 | Bis(2-ethylhexyl) phthalate | 37 |
| Dibromoethane | 0.3 | 1,1,2-Trichloroethane | 0.4 | 2-Methylnaphthalene | 37 | Benzo(b)fluoranthene | 37 |
| 1,2-Dichlorobenzene | 0.4 | Trichloroethane | 0.5 | 2-Nitroaniline | 190 | Benzo(k)fluoranthene | 37 |
| 1,3-Dichlorobenzene | 0.3 | Trichlorofluoromethane | 0.5 | Dimethyl phthalate | 37 | Benzo(a)pyrene | 37 |
| 1,4-Dichlorobenzene | 0.3 | 1,2,3-Trichloropropane | 0.5 | Acenaphthylene | 37 | Indeno(1,2,3-cd)pyrene | 37 |
| Dichlorodifluoromethane | 1 | 1,2,4-Trimethylbenzene | 0.3 | 2,6-Dinitrotoluene | 37 | Dibenzo(a,h)anthracene | 37 |
| 1,1-Dichloroethane | 0.3 | 1,3,5-Trimethylbenzene | 0.3 | 3-Nitroaniline | 190 | Benzo(g,h,i)perylene | 37 |
| 1,2-Dichloroethane | 0.3 | Vinyl Acetate | 0.1 | Acenaphthene | 37 | | |
| 1,3-Dichloroethane | 0.2 | Vinyl chloride | 2 | | | | |
| cis-1,2-Dichloroethane | 0.3 | m-Xylene and p-Xylene | 0.2 | | | | |
| trans-1,2-Dichloroethane | 0.2 | | | | | | |

# APPENDIX F. Summary of Water-Quality Data for Well PM-2 from Reynolds Electrical & Engineering Company

The information contained in Appendix F was provided by Reynold Electrical & Engineering Co., Inc. It is presented in the format provided to the USGS.

# Reynolds Electrical & Engineering Co., Inc.

## MEMORANDUM

To F. D. Ferate

From G. A. Clark GAC

Date November 18, 1993

Subject SAMPLE ANALYTICAL RESULTS

Enclosed are Analytical Services Department's results for the semivolatile organics and total metals analyses of one water sample collected on September 27, 1993, at Well PM-2 in Area 20.

Please direct any questions you may have about these results to Roger Mitchell (295-7220) or Jerry Dugas (295-7997).

GAC:RNL1282:rn

Enclosures
As stated

cy: Central Files, w/o encls.
A. R. Latham, w/o encls.
L. S. Sygitowicz, w/o encls.
ACS Packet No. 93-11-001, w/o encls.

REECO ASD/ACS

REECO
MISC
REECO

Attn: FRED FERATE

Purchase Order: 1125-022
Invoice Number:

Order #: 93-11-001
Date: 11/18/93 15:18
Work ID: MTLS,BNA/LIQ; A20, RUSH!
Date Received: 10/28/93
Date Completed: 11/18/93

Client Code: REECO

REPORT TO FRED FERATE, REECO ASD.

SAMPLE IDENTIFICATION

| Sample Number | Sample Description |
|---|---|
| 01 | C5682-3 |
| 02 | 93-11-001-QC1 METHOD BLANK |
| 03 | 93-11-001-QC2 INFO_I |
| 04 | 93-11-001-QC3 DETEC. LIMIT |
| 05 | 93-11-001-CV INST CHK SPK |

Certified By

Sample Description: C5682-3 Lab No: 01B
Test Description: ICP SCAN Method: ICP Test Code: ICPSCN
Collected: 09/27/93 Category: ICPSCN

| PARAMETER | RESULT |
|---|---|
| LITHIUM | 0.15 |
| BERYLLIUM | ND |
| BORON | 0.51 |
| SODIUM | 1100 |
| MAGNESIUM | 0.35 |
| ALUMINUM | 0.13 |
| PHOSPHORUS | 0.26 |
| TITANIUM | 0.11 |
| VANADIUM | 0.017 |
| CHROMIUM | 0.069 |
| MANGANESE | 0.11 |
| IRON | 2.8 |
| COBALT | ND |
| NICKEL | ND |
| COPPER | 0.023 |
| ZINC | 0.14 |
| ARSENIC | ND |
| SELENIUM | ND |
| STRONTIUM | 0.22 |
| MOLYBDENUM | 0.17 |
| SILVER | ND |
| CADMIUM | ND |
| TIN | ND |
| ANTIMONY | ND |
| BARIUM | 0.17 |
| CERIUM | ND |
| TANTALUM | ND |
| TUNGSTEN | 0.38 |
| THALLIUM | ND |
| LEAD | ND |
| SILICON | 0.94 |
| SULFUR | 5.0 |
| POTASSIUM | 7.8 |
| CALCIUM | 1.3 |
| BISMUTH | ND |

Notes and Definitions for this Report:

ANALYST AJK
UNITS mg/L

Sample Description: 93-11-001-QC2 INFO_I Lab No: 03A
Test Description: INFORMATION FOR INORGANIC Category: ICPSCN_QC Test Code: INFO_I

| PARAMETER | PREP_DATE | RUN_DATE | ANALYSTS |
|---|---|---|---|
| ICP | 11/03/93 | 11/04/93 | AJK |
| GFAA | | | |
| HG (CV) | | | |

Sample Description: 93-11-001-QC3 DETEC. LIMIT Lab No: 04A
Test Description: ICP SCAN Category: ICPSCN_QC Test Code: ICPSCN

| PARAMETER | RESULT |
|---|---|
| LITHIUM | 0.0033 |
| BERYLLIUM | 0.0018 |
| BORON | 0.0033 |
| SODIUM | 0.087 |
| MAGNESIUM | 0.048 |
| ALUMINUM | 0.028 |
| PHOSPHORUS | 0.066 |
| TITANIUM | 0.0030 |
| VANADIUM | 0.0078 |
| CHROMIUM | 0.0048 |
| MANGANESE | 0.0012 |
| IRON | 0.0027 |
| COBALT | 0.012 |
| NICKEL | 0.032 |
| COPPER | 0.0027 |
| ZINC | 0.0015 |
| ARSENIC | 0.042 |
| SELENIUM | 0.048 |
| STRONTIUM | 0.0018 |
| MOLYBDENUM | 0.0027 |
| SILVER | 0.020 |
| CADMIUM | 0.0042 |
| TIN | 0.021 |
| ANTIMONY | 0.015 |
| BARIUM | 0.0018 |
| CERIUM | 0.095 |
| TANTALUM | 0.039 |
| TUNGSTEN | 0.042 |
| THALLIUM | 0.016 |
| LEAD | 0.035 |
| SILICON | 0.041 |
| SULFUR | 0.051 |
| POTASSIUM | 0.438 |
| CALCIUM | 0.010 |
| BISMUTH | 0.21 |

Notes and Definitions for this Report:

ANALYST AJK
UNITS mg/L

Sample Description: 93-11-001-CV INST CHK SPK Lab No: 05A
Test Description: ICP SCAN Category: ICPSCN_QC Test Code: ICPSCN

| PARAMETER | RESULT |
|---|---|
| LITHIUM | 98 |
| BERYLLIUM | 96 |
| BORON | 100 |
| SODIUM | 100 |
| MAGNESIUM | 97 |
| ALUMINUM | 101 |
| PHOSPHORUS | 105 |
| TITANIUM | 99 |
| VANADIUM | 98 |
| CHROMIUM | 102 |
| MANGANESE | 103 |
| IRON | 100 |
| COBALT | N/A |
| NICKEL | N/A |
| COPPER | 99 |
| ZINC | 102 |
| ARSENIC | N/A |
| SELENIUM | N/A |
| STRONTIUM | 99 |
| MOLYBDENUM | 100 |
| SILVER | N/A |
| CADMIUM | N/A |
| TIN | N/A |
| ANTIMONY | N/A |
| BARIUM | 100 |
| CERIUM | N/A |
| TANTALUM | N/A |
| TUNGSTEN | 96 |
| THALLIUM | N/A |
| LEAD | N/A |
| SILICON | 140 |
| SULFUR | 100 |
| POTASSIUM | 96 |
| CALCIUM | 100 |
| BISMUTH | N/A |

Notes and Definitions for this Report:

ANALYST AJK
UNITS % RECOVERY

BNA ORGANICS (EPA 8270) Minimum: Maximum:
Method: SW846 8270

| Samp | Sample Description | Result | Units | Limit | Prepared | Analyzed | By |
|---|---|---|---|---|---|---|---|
| 01A | C5682-3 | SEE DATA | PACKAGE | | | | |
| 02A | 93-11-001-QC1 METHOD BLANK | SEE DATA | PACKAGE | | | | |

INORGANIC ANALYST'S NOTES:

Sample number C5682-3 was diluted by the organic branch in order to get enough sample to extract. This diluted sample was given to the inorganic branch to run an ICP metals scan. The sample was diluted by a factor of 2.3, 430 ml of sample diluted to a final volume of 1000 ml. During the preparation of the sample for metals analysis, 100 ml of sample was digested and concentrated down to a final volume of 50 ml, or a concentration factor of 2.0. This was done in order to get the sample as close to the original sample concentration as possible.

**ANALYST NOTES: BNAs**

**Date:** November 15,1993

**Lab Work Order No.:** 93-11-001

**Client Sample ID.:** SBLK1101W (Extraction Blank)
C5682-3

**Analyst:** Phil Briggs

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The samples were analyzed on a Hewlett Packard 5890 GC/5970 MSD. Data were collected on an HP 1000/RTE-A data system. Instrumental parameters used are those specified in **SW-846** 3rd edition, September, 1986, METHOD 8270 (for capillary column GC).

The target analytes are listed with their CAS numbers, and the amount of the target compound found in ug/L or ug/kg, depending on the matrix (water or soil, respectively). If the analyte was not found in the sample, the quantitation limit is reported preceded by an n.d. qualifier in the "result" column. The qualifiers used in this reporting format are:

**n.d.-** Indicates compound was analyzed for but not detected.

**J-** Indicates an estimated value. Indicates the presence of a compound that meets the identification criteria, but the result is less than the sample quantitation limit but greater than zero.

**B-** This flag is used when the analyte is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination.

**E-** This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.

**D-** This flag identifies all compounds identified in an analysis at a secondary dilution factor.

**Case Narrative:**

Only 430 mls water were available for extraction instead of the prerequisite liter. The phthalate detected in the sample should probably be considered contamination of it during handling.

EPA 625/8270 Semivolatile Organics Test Results


Name Field: C5682-3 Blank:>SD164:PASS QaQc File: QSEMWM
Misc Field: 93-11-001-02A 430 ML/TO 1 LITER//EXTR. (DF=2.33)
Instrument: BNA1 Datafile: >SD153 Idfile: ID_B1X Quantfile: ^SD153

Injection time: 16:00 on 11-04-93 Quant Time: 16:43 on 11-04-93
Continuing calibration time : 08:59 on 11-04-93 using the file: ^SC150::D5
User dilfac:2.33 Quant dilfac: 1. Multi-calibration: 09:25 on 10-13-93

| Compound Name | CAS Number | Result | Units | Detection Limit |
|---|---|---|---|---|
| Phenol | 108-95-2 | n.d. | uG/L | 23. |
| bis(2-Chloroethyl)ether | 111-44-4 | n.d. | uG/L | 23. |
| 2-Chlorophenol | 95-57-8 | n.d. | uG/L | 23. |
| 1,3-Dichlorobenzene | 541-73-1 | n.d. | uG/L | 23. |
| 1,4-Dichlorobenzene | 106-46-7 | n.d. | uG/L | 23. |
| Benzyl alcohol | 100-51-6 | n.d. | uG/L | 23. |
| 1,2-Dichlorobenzene | 95-50-1 | n.d. | uG/L | 23. |
| 2-Methylphenol | 95-48-7 | n.d. | uG/L | 23. |
| 2,2'-oxybis(1-Chloropropane) | 108-60-1 | n.d. | uG/L | 23. |
| bis(2-Chloroisopropyl)ether | 39638-32-9 | n.d. | uG/L | 23. |
| 4-Methylphenol | 106-44-5 | n.d. | uG/L | 23. |
| N-Nitroso-di-n-propylamine | 621-64-7 | n.d. | uG/L | 23. |
| Hexachloroethane | 67-72-1 | n.d. | uG/L | 23. |
| Nitrobenzene | 98-95-3 | n.d. | uG/L | 23. |
| Isophorone | 78-59-1 | n.d. | uG/L | 23. |
| 2-Nitrophenol | 88-75-5 | n.d. | uG/L | 23. |
| 2,4-Dimethylphenol | 105-67-9 | n.d. | uG/L | 23. |
| Benzoic acid | 65-85-0 | n.d. | uG/L | 120. |
| bis(2-Chloroethoxy)methane | 111-91-1 | n.d. | uG/L | 23. |
| 2,4-Dichlorophenol | 120-83-2 | n.d. | uG/L | 23. |
| 1,2,4-Trichlorobenzene | 120-82-1 | n.d. | uG/L | 23. |
| Naphthalene | 91-20-3 | n.d. | uG/L | 23. |
| 4-Chloroaniline | 106-47-8 | n.d. | uG/L | 23. |
| Hexachlorobutadiene | 87-68-3 | n.d. | uG/L | 23. |
| 4-Chloro-3-methylphenol | 59-50-7 | n.d. | uG/L | 23. |
| 2-Methylnaphthalene | 91-57-6 | n.d. | uG/L | 23. |
| Hexachlorocyclopentadiene | 77-47-4 | n.d. | uG/L | 23. |
| 2,4,6-Trichlorophenol | 88-06-2 | n.d. | uG/L | 23. |
| 2,4,5-Trichlorophenol | 95-95-4 | n.d. | uG/L | 120. |
| 2-Chloronaphthalene | 91-58-7 | n.d. | uG/L | 23. |
| 2-Nitroaniline | 88-74-4 | n.d. | uG/L | 120. |
| Dimethylphthalate | 131-11-3 | n.d. | uG/L | 23. |
| Acenaphthylene | 208-96-8 | n.d. | uG/L | 23. |
| 2,6-Dinitrotoluene | 606-20-2 | n.d. | uG/L | 23. |
| 3-Nitroaniline | 99-09-2 | n.d. | uG/L | 120. |
| Acenaphthene | 83-32-9 | n.d. | uG/L | 23. |
| 2,4-Dinitrophenol | 51-28-5 | n.d. | uG/L | 120. |
| 4-Nitrophenol | 100-02-7 | n.d. | uG/L | 120. |
| Dibenzofuran | 132-64-9 | n.d. | uG/L | 23. |
| 2,4-Dinitrotoluene | 121-14-2 | n.d. | uG/L | 23. |
| Diethylphthalate | 84-66-2 | n.d. | uG/L | 23. |
| 4-Chlorophenyl-phenylether | 7005-72-3 | n.d. | uG/L | 23. |
| Fluorene | 86-73-7 | n.d. | uG/L | 23. |
| 4-Nitroaniline | 100-01-6 | n.d. | uG/L | 120. |

EPA 625/8270 Semivolatile Organics Test Results
- Page - 2

Name Field: C5682-3 Blank:>SD164:PASS QaQc File: QSEMWM
Misc Field: 93-11-001-02A 430 ML/TO 1 LITER//EXTR. (DF=2.33)
Instrument: BNA1 Datafile: >SD153 Idfile: ID_B1X Quantfile: ^SD153

| Compound Name | CAS Number | Result | Units | Detection Limit |
|---|---|---|---|---|
| 4,6-Dinitro-2-methylphenol | 534-52-1 | n.d. | uG/L | 120. |
| N-Nitrosodiphenylamine | 86-30-6 | n.d. | uG/L | 23. |
| 4-Bromophenyl-phenylether | 101-55-3 | n.d. | uG/L | 23. |
| Hexachlorobenzene | 118-74-1 | n.d. | uG/L | 23. |
| Pentachlorophenol | 87-86-5 | n.d. | uG/L | 120. |
| Phenanthrene | 85-01-8 | n.d. | uG/L | 23. |
| Anthracene | 120-12-7 | n.d. | uG/L | 23. |
| Carbazole | 86-74-8 | n.d. | uG/L | 23. |
| Di-n-butylphthalate | 84-74-2 | n.d. | uG/L | 23. |
| Fluoranthene | 206-44-0 | n.d. | uG/L | 23. |
| Pyrene | 129-00-0 | n.d. | uG/L | 23. |
| Butylbenzylphthalate | 85-68-7 | n.d. | uG/L | 23. |
| 3,3'-Dichlorobenzidine | 91-94-1 | n.d. | uG/L | 47. |
| Benzo(a)anthracene | 56-55-3 | n.d. | uG/L | 23. |
| Chrysene | 218-01-9 | n.d. | uG/L | 23. |
| bis(2-Ethylhexyl)phthalate | 117-81-7 | 54. | uG/L | 23. |
| Di-n-octylphthalate | 117-84-0 | n.d. | uG/L | 23. |
| Benzo(b)fluoranthene | 205-99-2 | n.d. | uG/L | 23. |
| Benzo(k)fluoranthene | 207-08-9 | n.d. | uG/L | 23. |
| Benzo(a)pyrene | 50-32-8 | n.d. | uG/L | 23. |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | n.d. | uG/L | 23. |
| Dibenzo(a,h)anthracene | 53-70-3 | n.d. | uG/L | 23. |
| Benzo(g,h,i)perylene | 191-24-2 | n.d. | uG/L | 23. |

n.d. - not detected

Approved by:_____

EPA 625/8270 Semivolatile Organics Test Results


Name Field: SBLK1101W QaQc File: QSEMWM
Misc Field: 93-11-001-02A
Instrument: BNA1 Datafile: >SD164 Idfile: ID_B1X Quantfile: ^SD164

Injection time: 18:29 on 11-10-93 Quant Time: 19:12 on 11-10-93
Continuing calibration time : 13:08 on 11-10-93 using the file: ^SC158::D3
User dilfac:1.00 Quant dilfac: 1. Multi-calibration: 11:06 on 11-10-93

| Compound Name | CAS Number | Result | Units | Detection Limit |
|---|---|---|---|---|
| Phenol | 108-95-2 | n.d. | uG/L | 10. |
| bis(2-Chloroethyl)ether | 111-44-4 | n.d. | uG/L | 10. |
| 2-Chlorophenol | 95-57-8 | n.d. | uG/L | 10. |
| 1,3-Dichlorobenzene | 541-73-1 | n.d. | uG/L | 10. |
| 1,4-Dichlorobenzene | 106-46-7 | n.d. | uG/L | 10. |
| Benzyl alcohol | 100-51-6 | n.d. | uG/L | 10. |
| 1,2-Dichlorobenzene | 95-50-1 | n.d. | uG/L | 10. |
| 2-Methylphenol | 95-48-7 | n.d. | uG/L | 10. |
| 2,2'-oxybis(1-Chloropropane) | 108-60-1 | n.d. | uG/L | 10. |
| bis(2-Chloroisopropyl)ether | 39638-32-9 | n.d. | uG/L | 10. |
| 4-Methylphenol | 106-44-5 | n.d. | uG/L | 10. |
| N-Nitroso-di-n-propylamine | 621-64-7 | n.d. | uG/L | 10. |
| Hexachloroethane | 67-72-1 | n.d. | uG/L | 10. |
| Nitrobenzene | 98-95-3 | n.d. | uG/L | 10. |
| Isophorone | 78-59-1 | n.d. | uG/L | 10. |
| 2-Nitrophenol | 88-75-5 | n.d. | uG/L | 10. |
| 2,4-Dimethylphenol | 105-67-9 | n.d. | uG/L | 10. |
| Benzoic acid | 65-85-0 | n.d. | uG/L | 50. |
| bis(2-Chloroethoxy)methane | 111-91-1 | n.d. | uG/L | 10. |
| 2,4-Dichlorophenol | 120-83-2 | n.d. | uG/L | 10. |
| 1,2,4-Trichlorobenzene | 120-82-1 | n.d. | uG/L | 10. |
| Naphthalene | 91-20-3 | n.d. | uG/L | 10. |
| 4-Chloroaniline | 106-47-8 | n.d. | uG/L | 10. |
| Hexachlorobutadiene | 87-68-3 | n.d. | uG/L | 10. |
| 4-Chloro-3-methylphenol | 59-50-7 | n.d. | uG/L | 10. |
| 2-Methylnaphthalene | 91-57-6 | n.d. | uG/L | 10. |
| Hexachlorocyclopentadiene | 77-47-4 | n.d. | uG/L | 10. |
| 2,4,6-Trichlorophenol | 88-06-2 | n.d. | uG/L | 10. |
| 2,4,5-Trichlorophenol | 95-95-4 | n.d. | uG/L | 50. |
| 2-Chloronaphthalene | 91-58-7 | n.d. | uG/L | 10. |
| 2-Nitroaniline | 88-74-4 | n.d. | uG/L | 50. |
| Dimethylphthalate | 131-11-3 | n.d. | uG/L | 10. |
| Acenaphthylene | 208-96-8 | n.d. | uG/L | 10. |
| 2,6-Dinitrotoluene | 606-20-2 | n.d. | uG/L | 10. |
| 3-Nitroaniline | 99-09-2 | n.d. | uG/L | 50. |
| Acenaphthene | 83-32-9 | n.d. | uG/L | 10. |
| 2,4-Dinitrophenol | 51-28-5 | n.d. | uG/L | 50. |
| 4-Nitrophenol | 100-02-7 | n.d. | uG/L | 50. |
| Dibenzofuran | 132-64-9 | n.d. | uG/L | 10. |
| 2,4-Dinitrotoluene | 121-14-2 | n.d. | uG/L | 10. |
| Diethylphthalate | 84-66-2 | n.d. | uG/L | 10. |
| 4-Chlorophenyl-phenylether | 7005-72-3 | n.d. | uG/L | 10. |
| Fluorene | 86-73-7 | n.d. | uG/L | 10. |
| 4-Nitroaniline | 100-01-6 | n.d. | uG/L | 50. |

EPA 625/8270 Semivolatile Organics Test Results


Name Field: SBLK1101W QaQc File: QSEMWM
Misc Field: 93-11-001-02A
Instrument: BNA1 Datafile: >SD164 Idfile: ID_B1X Quantfile: ^SD164

| Compound Name | CAS Number | Result | Units | Detection Limit |
|---|---|---|---|---|
| 4,6-Dinitro-2-methylphenol | 534-52-1 | n.d. | uG/L | 50. |
| N-Nitrosodiphenylamine | 86-30-6 | n.d. | uG/L | 10. |
| 4-Bromophenyl-phenylether | 101-55-3 | n.d. | uG/L | 10. |
| Hexachlorobenzene | 118-74-1 | n.d. | uG/L | 10. |
| Pentachlorophenol | 87-86-5 | n.d. | uG/L | 50. |
| Phenanthrene | 85-01-8 | n.d. | uG/L | 10. |
| Anthracene | 120-12-7 | n.d. | uG/L | 10. |
| Carbazole | 86-74-8 | n.d. | uG/L | 10. |
| Di-n-butylphthalate | 84-74-2 | n.d. | uG/L | 10. |
| Fluoranthene | 206-44-0 | n.d. | uG/L | 10. |
| Pyrene | 129-00-0 | n.d. | uG/L | 10. |
| Butylbenzylphthalate | 85-68-7 | n.d. | uG/L | 10. |
| 3,3'-Dichlorobenzidine | 91-94-1 | n.d. | uG/L | 20. |
| Benzo(a)anthracene | 56-55-3 | n.d. | uG/L | 10. |
| Chrysene | 218-01-9 | n.d. | uG/L | 10. |
| bis(2-Ethylhexyl)phthalate | 117-81-7 | n.d. | uG/L | 10. |
| Di-n-octylphthalate | 117-84-0 | n.d. | uG/L | 10. |
| Benzo(b)fluoranthene | 205-99-2 | n.d. | uG/L | 10. |
| Benzo(k)fluoranthene | 207-08-9 | n.d. | uG/L | 10. |
| Benzo(a)pyrene | 50-32-8 | n.d. | uG/L | 10. |
| Indeno(1,2,3-cd)pyrene | 193-39-5 | n.d. | uG/L | 10. |
| Dibenzo(a,h)anthracene | 53-70-3 | n.d. | uG/L | 10. |
| Benzo(g,h,i)perylene | 191-24-2 | n.d. | uG/L | 10. |

n.d. - not detected

Approved by:_____

# DATA PACKAGE REVIEW

ACS PACKET NUMBER: 93-11-001 CLIENT: FRED FERATE

LABORATORY: REECO-ASD

DATE REVIEWED: 11-18-93 REVIEWED BY:

BNA:

MATRIX: WATER ARE BNA DATA ACCEPTABLE: YES

| | SAMPLE NO. | DATE/TIME | CRITERIA ACCEPTABLE |
|---|---|---|---|
| 1. TUNE | DFTPP | 10-27-93/0735 | YES |
| | DFTPP | 11-4-93/0821 | YES |
| | DFTPP | 11-10-93/0924 | YES |
| 2. CALIBRATION | INITIAL | 10-27-93 | YES |
| | SSTD050 | 11-4-93/0859 | YES |
| | SSTD050 | 11-10-93/1308 | YES |
| 3. METHOD BLANK | SBLK1101W | 11-10-93/1829 | YES |
| 4. SAMPLES | C5682-3 | 11-4-93/1600 | YES |

5. SURROGATE RECOVERY ACCEPTABLE: YES
6. MS/MSD RECOVERY ACCEPTABLE: N/A
7. METHOD BLANK ACCEPTABLE: YES
8. HOLDING TIMES ACCEPTABLE: YES

| | | #DAYS | ACCEPTABLE |
|---|---|---|---|
| a. Date Sampled: | 9-27-93 | 0 | 0 |
| b. Date ACS Received: | 10-28-93 | 31 | YES |
| c. Date Contract Lab Received: | N/A | N/A | N/A |
| d. Date Extracted: | 11-1-93 | 35 | 7 * |
| e. Date Analyzed: | 11-10-93 | 9 | 40 |

9. Correct conc units used: YES
10. CALCULATIONS ACCEPTABLE: YES
11. IS AREAS ACCEPTABLE: YES
12. RRT IS ACCEPTABLE: YES
13. FORMS ACCEPTABLE: YES
14. Chain-of-Custody agrees: YES

COMMENTS: HOLD TIME TO EXTRACTION WAS EXCEEDED DUE TO THE LATE DELIVERY OF THE SAMPLE.

EFRE-2260 (03/93)

## DATA PACKAGE REVIEW

ACS PACKET NUMBER: 93-11-001 CLIENT: FRED FERATE

LABORATORY: REECO-ASD

DATE REVIEWED: 11-8-93 REVIEWED BY: [signature]

**TOTAL METALS**

MATRIX: WATERO ARE METALS DATA ACCEPTABLE: YES

1. Are Method Blanks Acceptable: YES
2. Are Matrix Spikes Acceptable: YES
3. Are QC Samples Acceptable: YES
4. Are Holding Times Acceptable: YES

| | | # DAYS | ACCEPTABLE |
|---|---|---|---|
| a. Sample Date: | 9-27-93 | 0 | 0 |
| b. Date ACS Received: | 10-28-93 | N/A | YES |
| c. Date Contract Lab Received: | N/A | N/A | N/A |
| d. Date Hg Extracted: | N/A | N/A | N/A |
| e. Date Hg Analyzed: | N/A | N/A | N/A |
| f. Date Others Extracted: | N/A | N/A | N/A |
| g. Date Others Analyzed: | 11-4-93 | 38 | 180 |

5. Are Forms correct: YES
6. Are correct conc. units used: YES
7. Are analyses completed: YES
8. Chain-of-Custody agrees: YES

COMMENTS:

EFRE-2262 (03/93)

# Reynolds Electrical & Engineering Co., Inc.

## SAMPLE CHAIN-OF-CUSTODY RECORD

LOCATION OF SAMPLING: AREA 20, WELL PM-2 | WORK ORDER No.: 1125-022 | PACKET No.: 93-10-001

| ITEM No. | DATE/TIME SAMPLED | FIELD SAMPLE I.D. | LABORATORY SAMPLE I.D. | ANALYSIS REQUESTED | COMMENTS |
|---|---|---|---|---|---|
| 1 | 9/27/93 | C5682-3 | -01A | BNA | See Special Instructions |
| 2 | | Last Item | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | Rad Survey |
| 10 | | | | | See Attached. |

SAMPLER: NA (SIGNATURE) NA (PRINT NAME)

ORGANIZATION (PRINT): REECo

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME RELINQUISHED | DATE/TIME RECEIVED | RECEIVED BY: (SIGN, PRINT NAME AND ORGANIZATION) |
|---|---|---|---|
| Fred Ferate | 10/28/93 1610 | 10/28/93 1610 | Catherine D. Castaneda Catherine D. Castaneda ACS |
| Catherine D. Castaneda | 11/01/93 1000 | 11/01/93 1000 | Barbara A. Hommel Barbara A. Hommel ACS |
| Barbara A. Hommel | 11/02/93 0930 | 11/02/93 0930 | Al Karns Al KARNS ACS |
| | / / | / / | |
| | / / | / / | |
| | / / | / / | |
| | / / | / / | |
| | / / | / / | |

| Y | N | FOR LAB USE ONLY |
|---|---|---|
| N | R | PACKAGES REC'D W/CUSTODY SEAL INTACT? |
| Y | | SAMPLE LABELS AND C-O-C AGREE? |

FINAL DISPOSITION: _____

SIGNATURE: _____ DATE: / /

DISTRIBUTION: White (Original) - retained by laboratory performing final analysis

# REYNOLDS ELECTRICAL & ENGINEERING CO., INC.
## SAMPLING AND ANALYSIS INFORMATION FORM

### PROJECT DESCRIPTION

WORK ORDER No: 1125-022 | PROJECT MANAGER: FRED FERATE | PROJECT I.D.: WELL PM-2

DATE SAMPLING NEEDED: | TELEPHONE: 5-7102 | DEPARTMENT: ASD | M/S: 776

SAMPLING LOCATION: WELL PM-2, AREA 20 | ON-SITE CONTACT: FRED FERATE

OFFICE LOCATION: MERCURY, BLDG 650, RM. 142 | CONTACT TELEPHONE: 295-7102

DETAILED SITE DESCRIPTION: WELL PM-2. ON PAHUTE MESA, 270 M. FROM SCHOONER CRATER. SAMPLE TAKEN AT DEPTH OF 2,000 FT. BELOW TOP OF CASING, ON 9/27/93.

### SITE SAFETY, HEALTH, AND RADIOLOGICAL EVALUATION

| | NO HAZARD | HAZARDOUS CONDITION EXISTS |
|---|---|---|
| RADIOLOGICAL HAZARDS | – | X TRITIUM, CONCENTRATION 748 pCi/mL |
| SAFETY HAZARDS | – | – (SEE REVERSE SIDE OF FORM FOR APPROPRIATE ACTION IF POTENTIAL |
| I. H. HAZARDS | – | – HAZARDOUS CONDITION EXISTS) |

### ANALYSIS DESCRIPTION

SPECIAL INSTRUCTIONS (NUMBER OF SAMPLES, SPECIFIC LOCATIONS, COMPOSITING REQUIREMENTS, ETC): One Sample. Perform CLP-type BNA analysis to determine composition of dark matter. (if petroleum, whether crude or refined). If liquid not clear after extraction, simultaneously initiate ICP metals scan. Try to have results to me by Thurs. Nov. 4, 1993.

### REPORT REQUIREMENTS

DATE FINAL REPORT REQUIRED: 11/4/93 | PRELIMINARY REPORT REQUIRED? Y / N

REPORT TYPE:
1. TARGET COMPOUND (TC) RESULTS ONLY
2. TC AND QC RESULTS
(3.) TC AND TENTATIVELY IDENTIFIED COMPOUND (TIC) RESULTS
4. TCL, TIC AND QC RESULTS
5. CLP FORMAT REPORT

PROJECT MANAGER SIGNATURE: Fred Ferate DATE 10/28/93

ASD MANAGEMENT CONCURRENCE: Fred Ferate, for L.S. Sygitowicz DATE 10/28/93

| LAB ID # | FIELD SAMPLE # | MATRIX | SAMPLE SIZE | ANALYSES REQUESTED (METHOD # REQUIRED) |
|---|---|---|---|---|
| | Ref. Packet/Item C5682/3 | Unknown substance in Water | ~450mL | BNA, possibly ICP also |
| | | | | |
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