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Date: September 17, 1997
Refer to: EM/ER:97-381

97 SEP 26 AM 11:58
RCRA PERMITS PROGRAM

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87502

SUBJECT: FIELD IMPLEMENTATION PLAN FOR THE DRILLING AND TESTING OF LANL REGIONAL CHARACTERIZATION WELL R-9

Dear Mr. Garcia:

The Environmental Restoration (ER) Project's Field Unit 4 will begin drilling activities for characterization well R-9 on September 22, 1997. Well R-9 is located in Los Alamos Canyon just west of State Road 4. This well has a planned depth of 750 ft. and will provide water quality, hydrologic, and geologic data for groundwater near the eastern boundary of Los Alamos National Laboratory. R-9 is the first regional aquifer well that will be drilled as part of the Hydrogeologic Workplan.

The Laboratory and the New Mexico Environmental Environment Department (NMED) agreed to consult with each other on the issue of well screen length as part of the Notice of Deficiency (NOD) comment resolution for the Los Alamos and Pueblo Canyons Workplan. As presently planned, R-9 will be completed with a 60 ft. screen (5 ft. above the water table and 55 ft below the water table) in the regional aquifer rather than with a 10 ft. or less screen as specified by the Hazardous and Solid Waste Amendments of 1984 (HSWA) permit. The additional screen length will ensure that the well will have a potential useful lifetime of 40 to 50 years in an area where pumping of surrounding water supply wells may result in significant water table decline. The screen length will be re-evaluated once the hole is completed and the depth of key hydrogeologic contacts is known. This approach will ensure that the well screen is located in only the uppermost water-producing zone of the regional aquifer. We request that you provide us with feedback on the proposed approach for determining well screen length for R-9.

The well design deviates in two minor ways from the Hydrogeologic Workplan. First, the Workplan states that regional aquifer wells will penetrate 500 ft into the regional aquifer. R-9 will accomplish our hydrologic and geologic characterization goals by penetrating 100 ft into the regional aquifer at this location. Secondly, for the sake of drilling efficiency we will complete the well with 5 in. I.D. stainless steel casing above and below the screen interval rather than using 6 in. I.D. casing as stated in the Workplan. Neither of these changes will adversely affect the performance or characterization goals of this well.

6930

Although R-9 is primarily a characterization well, its design is such that it substantially meets the requirements of a monitor well as defined in the HSWA permit. Incorporation of this well into a Laboratory-wide groundwater monitoring program will be evaluated at a later date when the results of this characterization activity are integrated with other groundwater investigations of the Hydrogeologic Workplan.

We are enclosing the Field Implementation Plan for R-9 for your information. This plan is primarily designed as a guide for Field Unit 4 personnel during drilling and testing, but you may find it useful as a summary of planned activities. We welcome information exchanges with NMED during drilling and testing activities associated with this well.

If you have any questions or concerns please call Bonnie Koch at (505) 665-7202 or Dave Broxton at (505) 667-2492.

Sincerely,

Jorg Jansen, Program Manager
LANL/ER Project

Sincerely,

for Theodore J. Taylor, Program Manager
DOE/LAAO

JJ/TT/ss

Enclosure: Field Implementation Plan for the Drilling and Testing of LANL Regional Characterization Well R-9

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Los Alamos National Laboratory

FIELD IMPLEMENTATION PLAN

FOR THE DRILLING AND TESTING OF LANL REGIONAL CHARACTERIZATION WELL, R-9

Prepared By Field Unit 4
Environmental Restoration Project
Allyn Pratt - Field Project Leader

September 1997

Revision 2

CONTENTS

1.0 INTRODUCTION 1-1
- 1.1 Scope and Purpose 1-1
- 1.2 Environmental Setting 1-1
- 1.3 Roles and Responsibilities 1-2

2.0 DRILLING PLAN 2-1
- 2.1 Pre-Drilling Activities 2-1
- 2.2 Drilling Methods and Sequence 2-1
- 2.3 Decontamination and Demobilization 2-3

3.0 WELL DESIGN AND CONSTRUCTION 3-5
- 3.1 Design Life and Assumptions 3-1
- 3.2 Borehole Annular Space 3-1
- 3.3 Well Casings 3-1
- 3.4 Well Screen 3-1
- 3.5 Backfill Materials 3-2
- 3.6 Well Development 3-2
- 3.7 Surface Completion 3-2
- 3.8 Installation of Submersible Pump and Water-Level Transducer 3-2

4.0 SAMPLING AND ANALYSIS PLAN 4-1
- 4.1 Contaminant Characterization 4-1
  - 4.1.1 Collection of core samples 4-1
  - 4.1.2 Collection of groundwater samples 4-2
- 4.2 Hydrogeologic Characterization 4-5
  - 4.2.1 Collection of core and cuttings samples 4-5
  - 4.2.1.1 Geotechnical, geochemical, and hydrologic characterization 4-5
  - 4.2.2 Collection of Samples for geologic characterization 4-6
  - 4.2.3 Collection of samples for characterizing moisture extracted from core 4-7
- 4.3 Borehole Measurements 4-8
  - 4.3.1 Open borehole measurements with the color camera 4-8
  - 4.3.2 Open borehole measurements with the borehole geophysical tools 4-8
  - 4.3.3 Measurements with radioactive source tools 4-9
  - 4.3.4 Measurements inside the completed well with borehole geophysical tools 4-9
  - 4.3.5 Air permeability measurements in open borehole intervals 4-9
  - 4.3.6 Borehole water levels 4-9
  - 4.3.7 Slug tests 4-10

5.0 WASTE MANAGEMENT 5-1

ACRONYMS AND ABBREVIATIONS

AR	air rotary
DOC	dissolved organic carbon
ER	Environmental Restoration
ESH	Environmental Safety and Health
FIP	Field Implementation Plan
FPL	Field Project Leader
FSF	Field Support Facility
FTL	Field Team Leader
FTM	Field Team Manager
HASP	Health and Safety Plan
LANL	Los Alamos National Laboratory
MCL	maximum contaminant level
PAH	polynuclear aromatic hydrocarbon
PPE	personal protective equipment
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RCT	Radiological Control Technician
RSP	Radiological Screening Personnel
SVOCs	semivolatile organic compounds
SSO	Site Safety Officer
SSHASP	Site Specific Health and Safety Plan
SPCC	Spill Prevention Control and Countermeasures
SOP	standard operating procedure
TD	total depth
TOC	total organic carbon
UFA	unsaturated flow apparatus
VOCs	volatile organic compounds
WCSF	Waste Characterization Strategy Form

1.0 INTRODUCTION

This field implementation plan (FIP) describes the drilling, construction, completion, and testing activities for characterization borehole R-9 in Los Alamos Canyon. R-9 is located at the eastern boundary of the Laboratory, west of State Road 4. This borehole was begun in May, 1996, but drilling was suspended at a depth of 32.5 ft and surface casing was set to a depth of 10 ft after caving problems were encountered in the hole. The planned depth for this borehole is nominally 750 ft.

This hole is called LAOI-7 in the Los Alamos/Pueblo Canyon Workplan, but is renamed R-9 here to be consistent with the nomenclature used to identify boreholes to the regional aquifer in the Hydrogeologic Workplan. This borehole is also referred to as R-9 in the Canyons Core Document.

1.1 Scope and Purpose

R-9 is primarily designed to provide water-quality and water-level data for potential intermediate-depth perched zones and for the regional aquifer downgradient of numerous mesa top and canyon floor contaminant source areas in upper Los Alamos and Pueblo Canyons. Collectively, these source areas are referred to as Aggregate 1 in the Hydrogeologic Workplan. Collection of these water quality and water level data is critical for the success of this borehole.

R-9 is also designed to collect hydrologic and geologic data that contribute to the understanding of the vadose zone and regional aquifer in this part of the Laboratory. These data will include key parameters for numerical flow and transport models and for geochemical models. The hydrologic and geologic data also will be used in conjunction with data from other planned characterization boreholes as well as from other data sources to evaluate and update the site-wide conceptual model.

Although R-9 is primarily a characterization well, its design is such that it meets the requirements of a monitor well as defined in the HSWA permit. Incorporation of this well into a Laboratory-wide groundwater monitoring program will be evaluated at a later date when the results of this characterization activity are integrated with other groundwater investigations of the Hydrogeologic Workplan.

1.2 Environmental Setting

Saturated conditions are common in alluvium in Los Alamos Canyon from its headwaters to a point about a one-half mile east of the confluence with DP Canyon. Laboratory surveillance data indicate that the alluvial groundwater body was contaminated by treated and untreated effluents from Laboratory operations since 1944. These Laboratory releases included mobile contaminants such as ^{3}H and ^{90}Sr (probably originating from TA-2 and TA-21) as well as less mobile species such as ^{238}Pu, $^{239/240}Pu$, ^{241}Am, and ^{137}Cs. Loss of saturation east of the confluence with DP

Canyon suggests that water in the alluvium may be infiltrating and recharging intermediate-depth perched zones or the regional aquifer.

Intermediate-depth perched groundwater occurs in the canyons north and south of the R-9 location in Los Alamos Canyon. It is not known if these perched groundwaters are laterally connected or if they represent isolated groundwater systems that are spatially controlled by recharge from canyon floors. In lower Sandia Canyon, an intermediate-depth perched zone was identified during drilling of water supply well PM-1 at a depth of approximately 450 ft within a thick section of the Cerros del Rio Basalts. No water quality data were collected for this perched groundwater zone. In lower Pueblo Canyon, a similar zone of intermediate-depth perched groundwater was encountered within Cerros del Rio Basalts in wells Otowi 1, TW-1, TW-1A and POI-4. Laboratory surveillance data show the presence of ^{3}H, NO_3, Cl, PO_4, (TW-1, TW-1A) and ^{137}Cs (TW-1A) at various activities and concentrations below MCLs, except for NO_3 (23 mg/l NO_3-N; MCL NO_3-N = 10 mg/l). Well POI-4 confirmed the presence of NO_3, PO_4, Cl, and other solutes in intermediate-depth perched zone groundwater at a depth of 160 ft to 181 ft in basalt.

Based on our current understanding of groundwater flow directions, the general direction of groundwater flow in the regional aquifer is eastward in the vicinity of R-9 (see Fig. 2-9 of the Hydrogeologic Workplan). Thus, based on our current understanding of groundwater flow directions, R-9 is sited to characterize water quality within the regional aquifer downgradient of source areas in Aggregate 1.

Predicted depths to geologic contacts and estimates of depth to perched and regional groundwater are shown in Table 1-1. These estimates are based on the projection of R-9 to a cross section between supply wells Otowi 1 and PM-1. Major uncertainties in predicted depths to groundwater and to geologic units include the projection of the perched groundwater in Cerros del Rio Basalts, the location of the lower contact for the Cerros del Rio Basalts, and the identity and thickness of formations in the Santa Fe Group.

One goal of R-9 is to determine the depth of major stratigraphic contacts including the base of the Puye Formation and the Totavi Lentil, both of which lie below the top of the regional aquifer. Additionally, the hole is designed to penetrate and identify the formation in the upper 30 ft or so of the Santa Fe Group. These data will be used in conjunction with data from other planned regional aquifer drill holes to constrain the site-wide 3-D stratigraphic model for the Pajarito Plateau. Based on current projections, the required geologic data can be obtained from R-9 by drilling approximately 100 ft into the regional aquifer (top expected at approximately 647 ft). Thus, R-9 has an initial planned depth of 750 ft, but it may be deepened as necessary to collect the geologic information identified above.

1.3 Roles and Responsibilities

The roles and responsibilities for implementation of this drilling plan are shown in Fig. 1-1 and in Table 1-2.

Figure 1-1. Organization Chart For Well R-9 Investigation Team

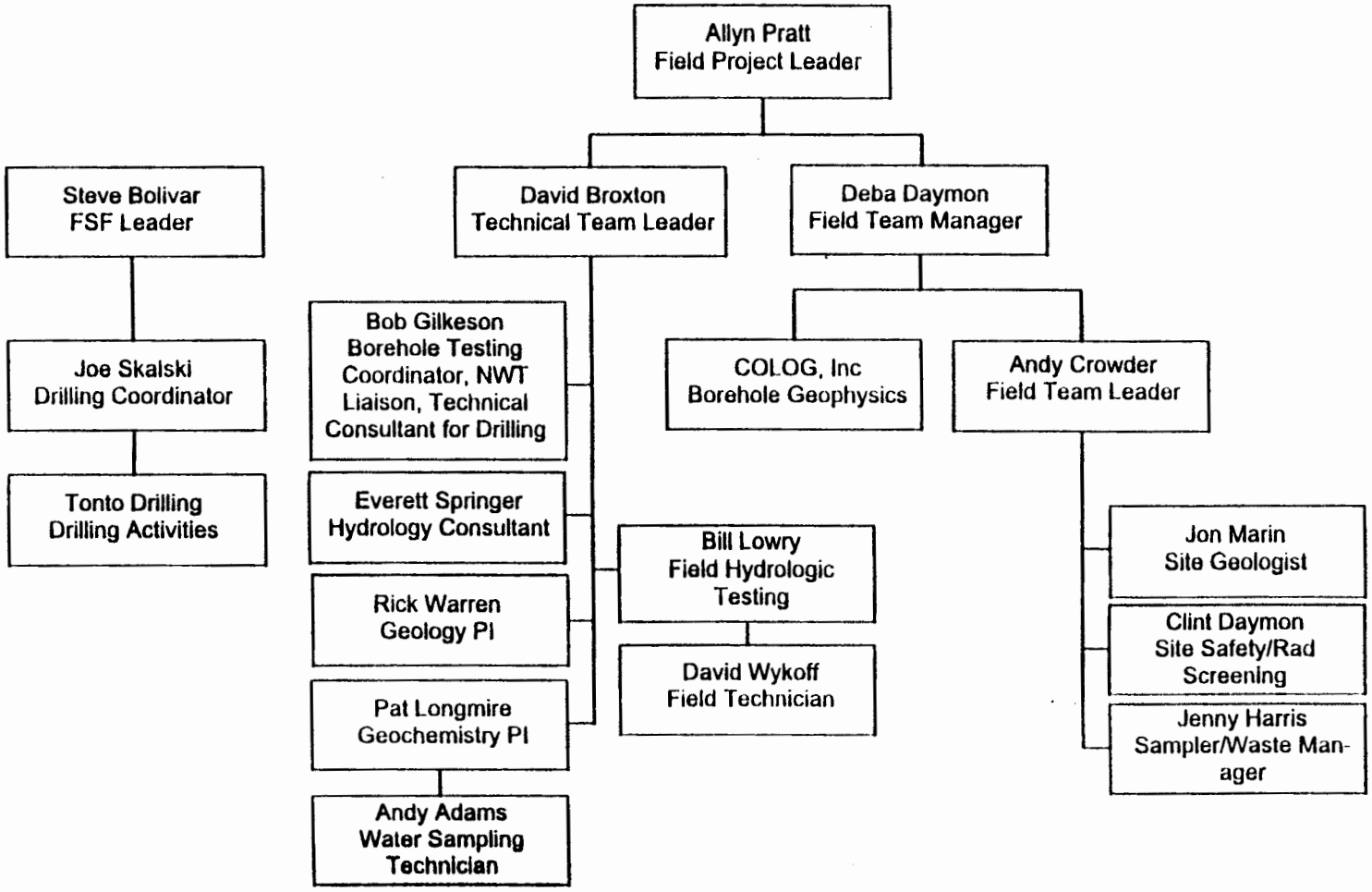


Table 1-2. (cont)

Andy Crowder	Field Team Leader (FTL)	Responsible for oversight of site activities and field team on a daily basis. Coordinates with FTM and technical team leader to ensure that provisions of all site specific plans are implemented during field operations. Responsible for daily documentation of field activities.
Jon Marin	Site Geologist	Responsible for the logging and curation of drill core and cuttings and associated documentation. Record geohydrologic borehole data and provide real-time stratigraphic interpretation for permeability tests.
Clint Daymon	Site Safety Officer/Radiological Screening Personnel(SSO/RSP)	Responsible to identify and implement all health and safety requirements in the field. Institutes daily tailgate meetings and documents daily H&S activities and audits. Responsible for radiological screening of personnel, samples, and equipment.
Jenny Harris	Sampler/Waste Manager	Responsible for sample collection and management of waste generated during field activities. This includes preparation of all associated documentation for these areas.
Andy Adams	Field Assistant	Collect pore water and groundwater samples, measure field water chemistry parameters, filter and preserve water samples, and prepare QA documents for sample collection and analysis.
David Wykoff	Borehole Measurement Technician	Perform and interpret borehole video, geophysical, and air permeability measurements.

Depth (ft)	Lithology
318 - 672	Unsaturated Puye Fm.: potential perched saturated zones are projected at depths of 345 ft and 500 ft., and the top of the regional aquifer is projected at a depth 647 ft. The perched zones at depths of 345 ft and 500 ft are included for planning purposes only; they are included as placeholders for scheduling the characterization of up to two additional perched zones encountered in the Puye Formation. There are no geologic or hydrologic data indicating the presence of perched groundwater at these particular depths.
672 - 717	Saturated Totavi Lentil
717 - 750 T.D.	Saturated Santa Fe Group - "Chaquehui Fm." ?

T.D. indicates total depth of the borehole

The borehole for well R-9 shall be drilled with Air Rotary (AR) methods including:

1) AR downhole percussion hammers on 4.5 in. O.D. and 7.0 in. O.D. dual wall drill casings to drill an open borehole. The downhole hammers shall be America West Drilling Supplies Model numbers RC 55 (5.5 in. borehole) and RC 44 (4.875 in. borehole), and Ingersoll Rand Model No. 380 (8 in. borehole).

2) AR Geobarrel™ 101 mm continuous coring system to collect continuous core while drilling open borehole.

3) AR HOLTE™ and STRATEX™ casing advance systems that operate on 4.5 in. O.D. dual wall casing and downhole percussion hammers to simultaneously drill and advance steel casing in the borehole. Steel casing sizes include 14 in. O.D., 12.75 in. O.D., 10.75 in. O.D., and 5 in. O.D.. Drilling shall start with the 14 in. O.D. casing and shall telescope down to smaller sizes as required by drilling efficiency, borehole stability and to seal off the borehole at the base of perched zones of saturation. The 5 in. O.D. casing is to be used inside the 14 in. O.D. casing to prevent "whipping" of the AR continuous core system inside the 14 in. O.D. casing. Open borehole shall be drilled below the depth to which the casing is installed by drilling with the continuous core system or with the downhole center return percussion hammer.

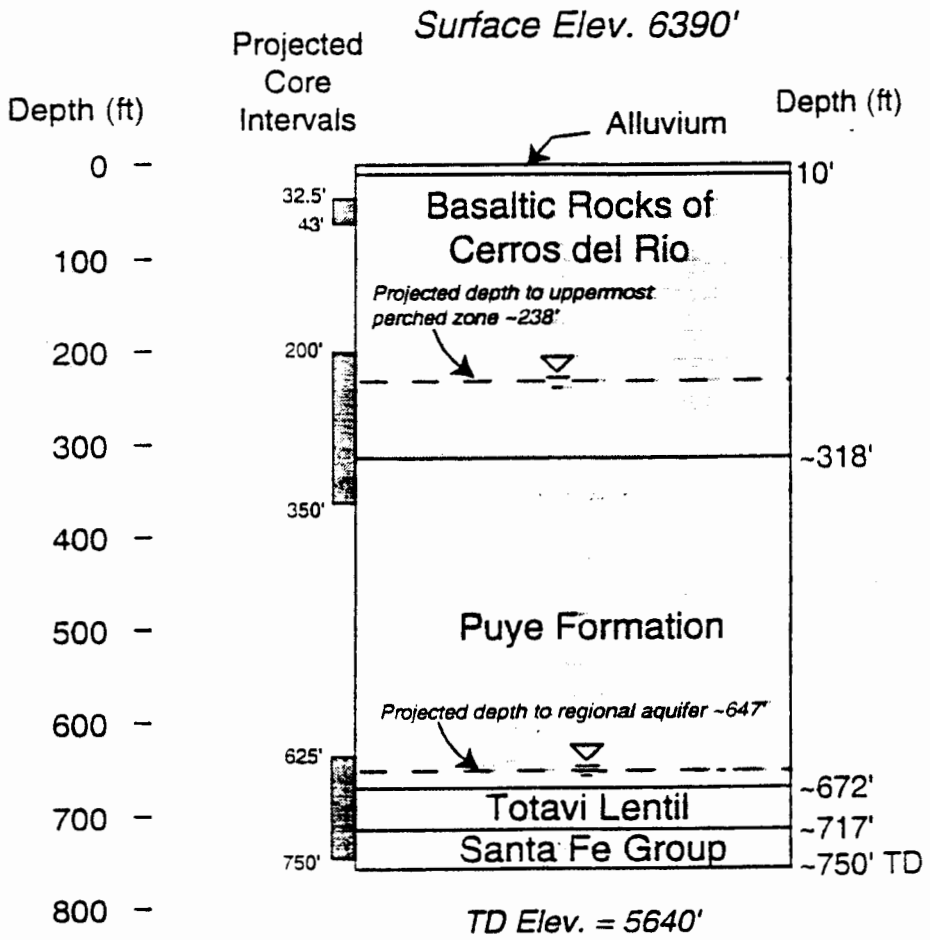
The 10.75 in. steel casing shall be advanced in the borehole to the depth where the screened interval will be installed in the regional aquifer. Advancing the 10.75 in. casing to this depth will drill a 12.25 in. borehole which is required for construction of a 5.68 in. O.D. well with a 3 in. minimum annular space between the well and the borehole wall.

The scheduled intervals to collect continuous core (approximately 38% of the total borehole) are shown in Fig. 2-2 and are as follows:

- 33 ft to 43 ft,

cases equipment will be taken to TA-50 for decontamination. All equipment will be smeared by a Radiological Control Technician (RCT) before it can be demobilized from the drill site.

Figure 2-2. Proposed Coring Intervals in R-9



3.5 Backfill Materials

A tremie line shall be used to place all backfill materials in the borehole.

Borehole below well. The borehole below the well shall be sealed with a bentonite grout (30% bentonite, 70% water) that is injected with a tremie line. The borehole shall be sealed with the bentonite grout to a depth of 5 ft below the well screen.

Filter pack. The filter pack shall be round, clean, washed and resieved silica sand with a uniformity coefficient of 2.0 or less, and at least 98% of the filter pack material shall be within the size designation for the 0.010. in slot size of the well screen. The filter pack shall extend a distance of 2 ft above and below the well screen.

Transition zone. A fine sand transition zone shall extend a distance of 10 ft above and 3 ft below the filter pack. The fine sand shall be clean, washed silica sand.

Borehole above transition zone. The borehole annular space above the transition zone to land surface shall be sealed with a bentonite grout (30% bentonite, 70% water) that is injected with a tremie line during retraction of the telescoped drill casings. The bentonite grout shall be placed in the borehole to the depth of the steel surface casing. The surface casing shall be installed with cement grout in the annular space between the surface casing and the borehole wall and in the annular space between the surface casing and well casing. The cement grout shall meet the requirements of American Society for Testing and Materials C150, Standard Specifications for Portland Cement, including the latest revisions thereof. Bentonite may be added to the cement, up to 6 percent by weight of the cement.

3.6 Well Development

Well development will proceed in accordance with LANL-ER-SOP-05.02, R0, "Well Development." Development shall include surging with a surge block, and either bailing or pumping until the nephelometric turbidity units (N.T.U.) can be consistently measured at five (5) or less, if possible.

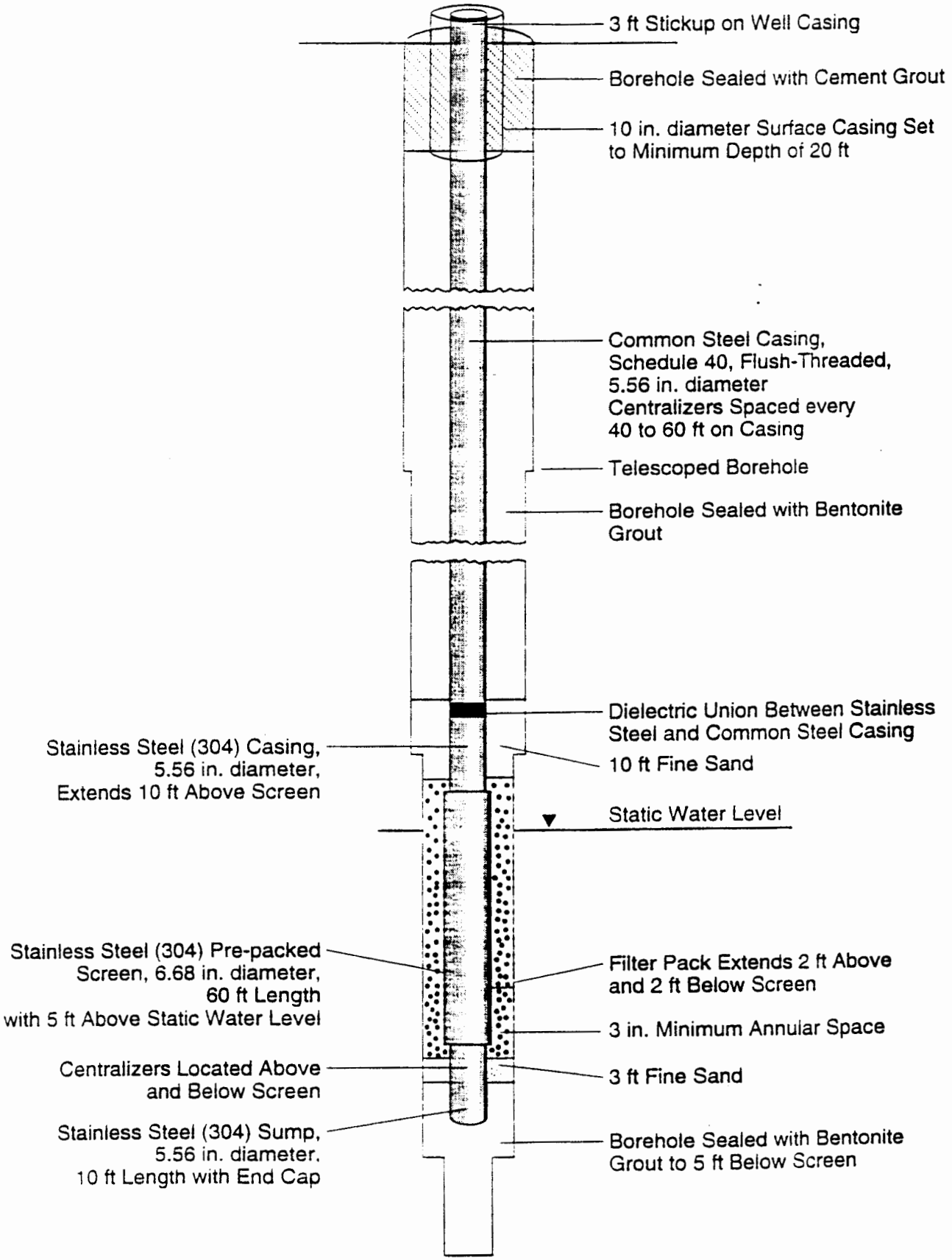
3.7 Surface Completion

The top of the well will be finished with a concrete pad with dimensions of 4 ft x 4 ft x 4 in. The concrete pad shall be keyed into the well annulus. A weather-protected, lockable equipment enclosure shall be mounted above the top of the well casing.

3.8 Installation of Submersible Pump and Water-Level Transducer

A dedicated submersible pump with an electric motor and water-level transducer shall be installed in Well R-9 following well completion and development. The submersible pump, the electric motor, and the motor leads (in the saturated zone) shall be constructed of a GRUNDFOS REDI-FL04™ Pump, a GRUNDFOS™ Environmental

Figure 3-1. **Well Design**



ft and 43 ft. However, additional core for VOA and SVOA analyses shall be collected if a PID field screening detect occurs. If a PID screening detect occurs, three 6 in. core samples will be submitted. One 6 in. core for SVOA's, one for the SW 846 VOA method, and one for the methanol contaminant VOA method.

Five samples for radionuclide and inorganic contaminant characterization will be collected in the vicinity of the uppermost anticipated perched zone and any other perched zone encountered during continuous core collection. Depths are projected in Table 4-1 and guidelines are as follows: one sample collected 5 ft above the water level, one sample in the zone of saturation, one sample in the confining layer, one sample 5 ft below the saturated zone, and one sample 10 ft below the saturated zone for a total of 5 samples. If other perched zones are encountered during continuous coring, then samples will be collected in the same manner as for the first perched zone. When perched zones are encountered during open hole drilling, one core sample will be collected in the zone of saturation. one sample in the confining layer, one sample 5 ft below the saturated zone, and one sample 10 ft below the saturated zone for a total of 4 samples.

Five core samples for radionuclide and inorganic contaminant characterization will be collected in the vicinity of the top of the regional aquifer. The depths for these samples will be determined after the depth to the regional aquifer and locations of key geologic contacts are established by drilling; however, guidelines for sample selection is as follows. One sample will be collected 20 ft above the top of the regional aquifer and one sample will be collected 10 ft above the top of the regional aquifer. One sample will be collected within the top 1 ft of the regional aquifer. Two samples will be collected below the static water level; one of these will be in the Totavi Lentil and the other in the upper Santa Fe Group.

4.1.2 Collection of groundwater samples

The field team will perform the following activities:

1. collect groundwater samples from borehole R-9;
2. record field-measured parameters for groundwater samples;
3. preserve the samples in the field; and
4. transport the samples to the FSF for shipping samples to appropriate analytical laboratories. EES-1 will analyze borehole water samples for major cations and anions and trace elements (24 hour turn around).

The number and location of groundwater samples will be determined by the Geochemistry PI in consultation with other members of the technical team in the field. Duplicate groundwater samples will be collected for all perched systems encountered. One set of the samples will be submitted for chemical and isotopic analysis as described below. The second set of samples will be retained as an archival sample set for reanalysis or further testing as necessary.

Unfiltered groundwater samples collected for analyses of stable isotopes of hydrogen and oxygen shall be transferred to completely full, clean 30 ml glass bottles with poly seal caps. The samples shall be stored at ambient temperature and shall be delivered daily to the FSF. The FSF shall ship the samples to an ER Project approved laboratory (Geochron-Weston) for analyses.

Unfiltered groundwater samples shall be collected for ^{14}C and $^{13/12}C$ stable isotope analyses when the characterization well is installed and developed. Approximately 8-12 gallons of regional aquifer groundwater may be required for ^{14}C analysis based on HCO_3^- concentrations (100-200 ppm) and SO_4^{2}- concentrations (<20 ppm) measured at supply well Otowi-1.

Unfiltered groundwater samples collected for analyses of ^{3}H shall be transferred to clean 500 ml plastic containers. A duplicate set of samples shall be collected. The samples shall be stored at ambient temperature and shall be delivered daily to the FSF. The FSF shall ship one set of these samples to Teledyne for analyses. Analytical detection limits for ^{3}H are 3±25 pCi/L, using liquid scintillation methods at Teledyne. Activities of ^{3}H may be below 25 pCi/L in the regional aquifer at borehole R-9. All samples will be initially analyzed for ^{3}H at Teledyne. Duplicate samples shall be sent to the University of Miami for low-level analyses where analyses from Teledyne are less than 50 pCi/L and verification of these results are required in the judgment of the Geochemistry PI.

Groundwater samples collected for analyses of dissolved radionuclides (excluding ^{3}H) shall be filtered through an acetate 0.45 micrometer membrane, transferred to clean 1.0-gallon plastic bottles, and acidified with concentrated HNO_3 to pH2 or less. Unfiltered groundwater samples collected for analyses of total radionuclides (excluding tritium) shall be transferred to clean 1.0-gallon plastic bottles, and acidified with concentrated HNO_3 to pH2 or less. The samples shall be stored on ice at 4°C and shall be delivered daily to the FSF. The FSF shall ship these samples to an ER Project approved contract laboratory for analyses. ^{90}Sr shall be analyzed by gas proportional counting, ^{137}Cs shall be analyzed by gamma spectroscopy, and ^{241}Am, ^{238}Pu, ^{239,240}, ^{234}U, ^{235}U, and ^{238}U shall be analyzed by alpha spectrometry.

Groundwater samples collected for analyses of dissolved organic carbon (DOC) fractionation shall be filtered through a silver 0.45 micrometer membrane, and transferred to clean 1,000 ml amber glass bottles. No acidification of the DOC samples is required. The samples shall be stored on ice at 4°C and shall be delivered daily to the FSF. The FSF shall ship these samples to an ER Project approved laboratory specializing in DOC fractionation analyses; Huffman Laboratories, Golden CO is preferred.

Unfiltered groundwater samples collected for analyses of total organic carbon (TOC) shall be transferred to clean 1,000 ml amber glass bottles. The samples shall be stored on ice at 4°C and shall be delivered daily to the FSF. The FSF shall ship these samples to an ER Project approved laboratory for analyses; Weston, Lionville, PA is preferred.

Cerros del Rio Basalt

Samples from the Cerros del Rio basalt will have the following initial test performed:

- In-situ water content,
- Porosity,
- Particle density, and
- Bulk density.

The Hydrology Consultant and Borehole Testing Coordinator will evaluate the results of the initial tests and decide if the samples are acceptable for further testing.

For those samples that are acceptable, the following tests or a selected subset will be performed:

- Saturated hydraulic conductivity both air and water, and
- Water retention curve at 0 cm, 100 cm, 340 cm, 1020 cm, 5100 cm, 10200 cm, and 15300 cm.

Hydraulic conductivity of the fracture/matrix system will be determined by the borehole measurements. Porosity of the fracture/matrix system will be determined by using the borehole digital camera to estimate fracture properties, primarily aperture, in conjunction with the matrix porosity determined in the laboratory. The air permeability tests will allow direct comparison of the conductivity values determined in the field and the lab.

Puye Formation

The particle size distribution within the Puye Formation makes a determination of the hydrologic properties of this interval difficult. It may be possible that a sample is cored that consists of particles less than 2 mm in diameter. In this case, the tests described below will be performed. For samples with particles greater than 2 mm in size (gravel and cobbles), sample preparation will include sieving which will destroy the inherent structure of the less than 2 mm material making measurements such as saturated hydraulic conductivity and in-situ water content suspect and of limited value.

Samples from the Puye Formation will have the following tests performed:

- Particle size analysis and texture of less than 2 mm fraction,
- In-situ water content (if sieved analysis not performed),
- Porosity (on less than 2 mm fraction),
- Particle density (on less than 2 mm fraction),
- Bulk density (on less than 2 mm fraction),
- Saturated hydraulic conductivity by both water and air (if sieved analysis not performed), and
- Water retention curve at 0 cm, 100 cm, 340 cm, 1020 cm, 5100 cm, 10200 cm, and 15300 cm (on less than 2 mm fraction in the unsaturated portion of the Puye Formation only).

The FSF shall ship the core samples to an ER Project-approved laboratory to analyze the porewater (vadose zone) samples for stable isotopes and anions. The FSF shall submit the other set of collocated samples to CST-7 for extraction of the porewater from the core using an unsaturated flow apparatus (UFA) and analysis of the porewater for major cations and anions, trace metals, and trace elements by EES-1.

4.3 Borehole Measurements

Borehole measurements will be performed during drilling and in the installed well. During drilling, borehole measurements will be performed in open borehole intervals. These measurements include color camera, a suite of borehole geophysics including radioactive source tools, air permeability (borehole anemometry and straddle packer), water level and slug test. Borehole measurements with tools that use radioactive sources shall not be performed in unstable open borehole intervals that may collapse. In unstable borehole intervals, these measurements shall be performed through core rod or dual wall drill casing. The borehole measurements shall be performed following instructions in LANL ER-SOP 04.04 - GENERAL BOREHOLE LOGGING.

The borehole measurements are listed in Table 4-13. The time required for measurements with each tool are listed in Table 4-14.

The borehole measurements will be performed as part of drilling activities in the borehole interval below the depth to which the telescoped drill casing has been advanced.

4.3.1 Open borehole measurements with the color camera

Color camera records shall be collected in an open borehole interval after the caliper log is run. The color camera record shall be collected with an axial view camera while lowering the camera in the open borehole. The axial view camera record shall be viewed in "real time" to determine the stability of the borehole and to identify borehole intervals where higher resolution is needed with the sidescan view camera.

4.3.2 Open borehole measurements with the borehole geophysical tools

Geophysical tools which shall be used for open borehole measurements and the sequence in which they shall be used are as follows:

1. caliper
2. natural gamma radiation (single point resistivity and self-potential)*
3. electromagnetic induction
4. magnetic susceptibility
5. gamma gamma (density)**
6. neutron (thermal/epithermal)**

**measurements only in saturated intervals
**measurements only in stable open borehole or inside casing

and over weekends. Water level measurements shall be documented in the daily record of field activities. Paper and digital records of pressure transducer measurements shall be collected.

4.3.7 Slug tests

When drilling activities first reach a zone of saturation, drilling shall stop at a depth of 5 ft within the zone of saturation and the drilling equipment shall be retracted from the borehole. A pressure transducer and data logger shall be installed to monitor water levels in the saturated zone. The pressure transducer and data logger are described in the section concerning water levels measurements (Section 4.3.6). The monitoring shall determine when the water level has recovered from the disturbance caused by the drilling activities. After the water level has recovered and water samples have been collected, a slug test shall be performed with a bailer or with a solid cylinder. The bailer or solid cylinder shall be inserted into the saturated zone. The data logger shall be monitored to determine that the water level has restablized after insertion of the device. Then, the data logger shall be programmed to acquire data on a logarithmic schedule to record the rapid change in water level that will occur when the bailer or cylinder is removed from the saturated zone. The slug test shall be performed following the instructions in ER Project SOP-07.03 Rev 0. The drawdown that results from the extraction of the device and the rate of recovery to the static water levels shall be recorded. Paper and digital records of slug test measurements shall be collected. The data set shall be analyzed with the method of Bouwer and Rice (Water Resources Research, 1976, v. 12 (#3) pp. 423-428) to determine the hydraulic conductivity of the saturated zone.

Table 4-2. Geotechnical Characterization on Core Samples in R-9

						Contract Lab			Field Tests		
Sample ID	Location ID	Contract Lab Sample Number	Projected Sample Interval (ft)	Sample Location Description	Core Length Require-ment (in.)	Basalt Suite	Puye Suite	Santa Fe Suite	Matric Potential	Water Content	Tritium
		1	200-318	dense aphanitic basalt	6	x			?	?	?
		2	200-318	slightly vesicular basalt	6	x			?	?	?
		3	200-318	highly vesicular basalt	6	x			?	?	?
		4	200-318	fractured basalt	6	x			?	?	?
		5	238-293	perched zone of saturation in basalt	6	x			?	?	?
		6	238-293	perched zone of saturation in basalt (duplicate)	6	x			?	?	?
		7	293-298	confining unit at base of perched zone in basalt	6	x			?	?	?
		8	325-350	saturated zone in Puye	6		x		?	?	?
		9	345-350	confining unit at base of perched zone in Puye	6		x		?	?	?
		10	625-672	represen-tative samples in Puye: ash fall tuff	6		x		?	?	?
		11	625-672	clay beds	6		x		?	?	?
		12	625-672	silt beds	6		x		?	?	?
		13	625-672	sand and gravel beds	6		x		?	?	?
		14	672-717	Totavi Lentil Fm	6			x	?	?	?
		15	717-750	Santa Fe Fm	6			x	?	?	?
		16		field selected	6				?	?	?

Table 4-3. Hydrologic Characterization on Core Samples in R-9

Sample ID	Location ID	Contract Lab Sample Number	Projected Sample Interval (ft)	Sample Location Description	Core Length Require-ment (in.)	Stable Isotopes	Unsaturated Flow Apparatus
		1	40	in shallow basalt	6	x	x
		2	210	unsaturated basalt section with high moisture	6	x	x
		3	~225	5' above first perched zone	6	x	x
		4	~310	perched zone confining layers	6	x	x
		5	~310	perched zone confining layers (duplicate)	6	x	x
		6	~315	base of basalt if unsaturated	6	x	x
		7	~325	top of Puye if unsaturated	6	x	x
		8	~340	unsaturated Puye with high moisture content	6	x	x
		9	~350	unsaturated Puye with high moisture content	6	x	x
		10	~405	perched zone confining layers	6	x	x
		11	~565	perched zone confining layers	6	x	x
		12	~625	collect on 10' intervals until regional aquifer	6	x	x
		13	~635	collect on 10' intervals until regional aquifer	6	x	x

Table 4-5. Analyte List, Estimated Quantitation Limits, and Analytical Methods for Radionuclide Constituents in Borehole Core Samples

Analyte	Half-Life (yr)	Detected Emission	MDA[a] (pCi/g)	Analytical Method
^{241}Am	432.2	α	0.01	α-Spectrometry
^{3}H	12.3	β	300	LSC[b]
^{238}Pu	87.7	α	0.1	α-Spectrometry
$^{239,240}Pu$[c]	2.410×10^4	α	0.1	α-Spectrometry
^{90}Sr	29.1	β	2	GPC[d]
^{234}U	2.46×10^5	α	0.1	α-Spectrometry[e]
^{235}U	7.04×10^8	α	0.1	α-Spectrometry[e]
^{238}U	4.47×10^9	α	0.1	α-Spectrometry[e]
Gamma spectroscopy[f]	-	γ	1.0[g]	γ-Spectroscopy
Gross-alpha	-	α	10	GPC or LSC
Gross-beta	-	β	10	GPC or LSC
Gross-gamma	-	γ	2.0	NaI(Tl)[j] HPGe[h] detection

a. MDA = minimum detectable activitiy
b. LSC = liquid scintillation counting
c. The ^{239}Pu and ^{240}Pu isotopes cannot be distinguished by alpha spectrometry. The half-life of ^{239}Pu is given.
d. GPC = gas proportional counter
e. Radionuclide may also be analyzed by ICPMS.
f. The gamma spectroscopy analyte list is given in Table 4-8.
g. NaI(Tl) = thallium-doped sodium iodide
h. HPGe = high-purity germanium

Table 4-7. Analyte List, Estimated Detection Limits, and Analytical Methods for Inorganic Constituents in Groundwater Samples[a]

Analyte	EDL[b] (µg/L)	Analytical Method	Analytical Protocol
Metals (dissolved)			
Aluminum	10	ICPES[c]	SW-6010B
Antimony	0.1	ICPMS[d]	SW-6020
Arsenic	1	ETVAA[e]	SW-7060A
Barium	2	ICPES	SW-6010B
Beryllium	5	ICPES	SW-6010B
Boron	10	ICPES	SW-6010B
Cadmium	1	ICPMS	SW-6020
Calcium	10	ICPES	SW-6010B
Chromium	2	ICPES	SW-6010B
Cobalt	2	ICPES	SW-6010B
Copper	2	ICPES	SW-6010B
Iron	10	ICPES	SW-6010B
Lead	3	ICPMS	SW-6020
Magnesium	10	ICPES	SW-6010B
Manganese	2	ICPES	SW-6010B
Mercury	0.2	CVAA[f]	SW-7470A
Nickel	2	ICPES	SW-6010B
Potassium	10	ICPES	SW-6010B
Selenium	0.2	ETVAA	SW-7740
Silver	0.2	ICPMS	SW-6020
Sodium	50	ICPES	SW-6010B
Thallium	2	ICPMS	SW-6020
Uranium	1	ICPMS	SW-6020
Vanadium	2	ICPES	SW-6010B
Zinc	10	ICPES	SW-6010B
Anions (dissolved)			
Bromide	20	IC[g]	SW-9056
Chlorate	20	IC	SW-9056
Chloride	20	IC	SW-9056
Fluoride	20	IC	SW-9056
Nitrate	40	IC	SW-9056
Nitrite	40	IC	SW-9056
Phosphate	20	IC	SW-9056
Sulfate	100	IC	SW-9056
Other Inorganics (dissolved)			
Silica	200	Colorimetry	EPA Method 370.1
Total cyanide	20	Colorimetry	SW-9012A

Table 4-8. Analyte List, Estimated Quantitation Limits, and Analytical Methods for Radionuclide Constituents in Groundwater Samples[a]

Analyte	Half-Life (yr)	Detected Emission	EQL[b] (pCi/L)	Analytical Method
^{241}Am	432.2	α	0.03	α-Spectrometry
^{3}H	12.3	β	25	LSC[c]
^{3}H (low level)	12.3	β	1	Electrolytic enrichment
^{238}Pu	87.7	α	0.03	α-Spectrometry
$^{239,240}Pu$[d]	2.410×10^{4}	α	0.02	α-Spectrometry
^{90}Sr	29.1	β	0.5	GPC[e]
^{234}U	2.46×10^{5}	α	0.1	α-Spectrometry[g]
^{235}U	7.04×10^{8}	α	0.1	α-Spectrometry[g]
^{238}U	4.47×10^{9}	α	0.1	α-Spectrometry[g]
Gamma spectroscopy[h]	-	γ	20[i]	γ-Spectroscopy
Gross-alpha	-	α	3.0	GPC or LSC
Gross-beta	-	β	3.0	GPC or LSC
Gross-gamma	-	γ	100	NaI(Tl)[j] HPGe[k] detection

a. All water samples will be filtered to remove particles larger than 0.45 µm at the time of collection.
b. EQL = estimated quantitation limit
c. LSC = liquid scintillation counting
d. The ^{239}Pu and ^{240}Pu isotopes cannot be distinguished by alpha spectrometry. The half-life of ^{239}Pu is given.
e. GPC = gas proportional counter
f. ICPMS = inductively coupled plasma mass spectrometry
g. Radionuclide may also be analyzed by ICPMS.
h. The gamma spectroscopy analyte list is given in Table 4-8.
i. The EQL for ^{241}Am and ^{137}Cs is 20 pCi/L; the EQL for other analytes will vary.
j NaI(Tl) = thallium-doped sodium iodide
k. HPGe = high-purity germanium

Table 4-10. Analyte List and Analytical Methods for Additional Parameters in Groundwater Samples[a]

Analyte	Analytical Method
Stable Isotopes[b]	
Carbon-14. Carbon-13	Accelerator MS[c]
Deuterium/Hydrogen	Accelerator MS
Oxygen-18/Oxygen-16	MS
Other Analytes	
DOC[d] (humic acids)	Modified EPA Method 415
Hardness (as $CaCO_3$)	EPA Method 130

a. All water samples will be filtered to remove particles larger than 0.45 µm at the time of collection.
b. Stable isotopes will be measured in intermediate-depth ground water samples.
c. MS = mass spectrometry
d. DOC = dissolved organic carbon fractionation

Table 4-12. Container and Preservation Requirements

Number of Samples	Collect Archival Samples	Sample Type	Analysis	Core Length	Container
21		Core (soil)	Rad	12 in.	Double Bag
		(includes one duplicate)	^{90}Sr, ^{137}Cs, ^{241}Am, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, and $^{239/240}Pu$	4 in.	Double Bag
			Inorganics	9 in.	Double Bag
			VOA, methanol containment	6 in.	methanol filled vial
			VOA, SW 846	6 in.	Core Protect
			SVOA	6 in.	Core Protect
13-21		Intact Core	Geotech	6 in.	Core Protect
		(includes one duplicate)			
13		Core	Stable Isotopes	3 in.	Core Protect
		(includes one duplicate)	UFA	3 in.	Core Protect
		Water Samples			
# of Samples		Analysis	Container	Preservation	Special Instruction
up to 7	x	major cations and anions (dissolved)	125 ml plastic	4°C	filtered through acet micrometer
up to 7	x	trace elements and metals (total)	125 ml plastic	HNO3 to pH2. 4°C	
up to 7	x	trace elements and metals (dissolved)	125 ml plastic	HNO3 to pH2, 4°C	filtered through acet micrometer
up to 7	x	nutrients-nitrogen species (dissolved)	125 ml plastic	4°C	filtered through acet micrometer
up to 7	x	radionuclides (dissolved)	1 gallon plastic	HNO3 to pH2, 4°C	filtered through acet micrometer
up to 7	x	radionuclides (total)	1 gallon plastic	HNO3 to pH2, 4°C	
up to 7	x	stable isotopes	30 ml glass w/ poly seal cap	ambient temperature	non filtered
up to 7	x	tritium	500 ml plastic	ambient temperature	screening to Teledyne
up to 7	x	tritium (low level)	500 ml plastic	ambient temperature	low level to U. of Miami
		dissolved organic carbon	1 L amber glass	4°C	filtered through silver 0.4
up to 7					membrane, to Huff
up to 7		total organic carbon	1 L amber glass	4°C	non filtered
up to 7		VOA's	40 ml glass w/ septum cap	4°C	
up to 7		SVOA's	two x 1 L amber glass	4°C	collect 2 liters, 1 for P PAH's

Table-4-14. Borehole Measurement Rates

Borehole Tool	*Borehole Travel Rate* (ft/min)	
	Measure	Transport
Borehole color camera		
Axial view	5-10	45
Sidescan view	1-5	45
Natural gamma, single-point resistance, and self-potential	15	45
Electromagnetic induction	15	45
Magnetic susceptibility	15	45
Three-arm caliper	15	45
Gamma-gamma density	12	45
Neutron-thermal/epithermal	12	45
Fluid resistivity and temperature	6	45
Borehole anemometer	3	45
Straddle packer air permeability	(5-15 min)*	10
Water level meter	(1 min)	45
Transducer (slug test)	(1-12 hr)*	45

* Time for measurements at discrete depths in an open borehole

6.0 HEALTH AND SAFETY

All field work will be performed and monitored in accordance with the approved ER Project Health and Safety Plan (HASP) and the Site Specific Health and Safety Plan (SSHASP), LANL # 183.

In the event of an accident immediately notify ESH-5 and ESH-1 field representatives.

Table 7-1. Field Documentation

Documentation	Responsible Person	Frequency
Daily Activity Log	FTL	Daily
FTL Logbook	FTL	Daily
Daily Drill Report Form	Geologist/FTL	Daily
Geological Field Log	Geologist	As Needed
Sample Collection Log	Sampler	As Needed
COC, Request For Analysis	Sampler/Geochemist	As Needed
Exclusion Zone Sign In Log	SSO	Daily
Miscellaneous Monitoring Forms	SSO/RSP	Daily
Tailgate Meeting Attendance Form	SSO	Daily
SSO Logbook	SSO	Daily
Visitor's Sign In Log	SSO/FTL	Ongoing
Waste Mgt. Logbook	Waste Mgr.	As Needed
Miscellaneous Waste Mgt. Forms	Waste Mgr.	As Needed
Weekly Summary Report	FTM	Weekly
Field Photographs	All	As Needed
Air Permeability Measurements	Technician	As Needed
Water Level Measurements	Technician	As Needed
Borehole Geophysics	Technician	As Needed
Slug Tests	Technician	As Needed

Appendix A

Equipment List

ITEM	RENT	BUY	COMMENTS	PER ITEM COST	NO. OF ITEMS	COST
SAMPLING Flow Cell for Insitu Groundwater Parameters						
YSI Water Quality Monitor		N/A	FU 4 already owns	$0	1	**$0**
YSI replacement probes		X	Supplier	$560	1	**$560**
pH buffer solutions: 7.01, 4.01, 10.01		X	Ben Meadows	$7	2	**$14**
SC calibration solutions		X	Ben Meadows	$15	2	**$30**
QED 45 micron filters		X	Supplier	$15	10	**$150**
QED coarse in-line filters		X	Supplier	$15	10	**$150**
Osmonics silver in-line filters		X	Supplier	$20	10	**$200**
1,000 ft Water Level Meter		X	In-Situ	$1,700	1	**$1,700**
Hermit 3000 Data Logger		X	In-Situ	$1,800	1	**$1,800**
PXD-261 Pressure Transducer		X	1300 ft Teflon cable, reel-mounted	$6,145	1	**$6,145**
Lrg. Bailer		X	EnviroTech	$495	1	**$495**
Super Slug Software		X		$200	1	**$200**

ITEM	RENT	BUY	COMMENTS	PER ITEM COST	NO. OF ITEMS	COST
HEALTH AND SAFETY Disposable Coveralls (24 pr/box)		X	Lab Safety Supply	$107	20	**$2,140**
Nitrile Gloves		X	Hazco (100 pr)	$15	4	**$60**
Work Gloves		X	Hazco	$5	20	**$100**
Safety Glasses		X	Lab Safety	$10	10	**$100**
Ear Plugs		X	Hazco (200 pr)	$32	2	**$64**
Barrier Tape		X	Metzger s	$30	5	**$150**
Deionized Water		X	Crystal Spring (5 gals)	$7	50	**$350**
Noise Meter	X		Hazco (weekly)	$85	7	**$595**
First Aid Kit		X	Safety Master	$47	2	**$94**
Air Horn		X	Ben Meadows	$13	2	**$26**
Portable Eye Wash		X	Hazco	$335	1	**$335**
Hard Hats		X	Lab Safety	$7	10	**$70**
Fire Extinguisher		X	Hazco (ABC, 20 lbs)	$87	2	**$174**
Photoionization Detector		X	Hazco (includes case and calibration kit)	$5,200	1	**$5,200**
Mini-Ram		N/A	FU 4 already owns			0
Decon SS Sprayer		X	Hazco	$103	2	**$206**
Alconox		X	For decon (case)	$109	1	**$109**

ITEM	RENT	BUY	COMMENTS	PER ITEM COST	NO. OF ITEMS	COST
WASTE MANAGEMENT 3,000-gal skid-mounted Frac Tanks		X	Containers to store drill cuttings and water	$5,200	2	$10,400
Tank Truck	X		For disposal of well development water		1	
Seamless flexible membrane liner		X	To be installed under tanks to provide secondary containment with containment capacity of 10% of tank capacity		2	
Roll-off Bins	X			$300/mo	2	$1,800

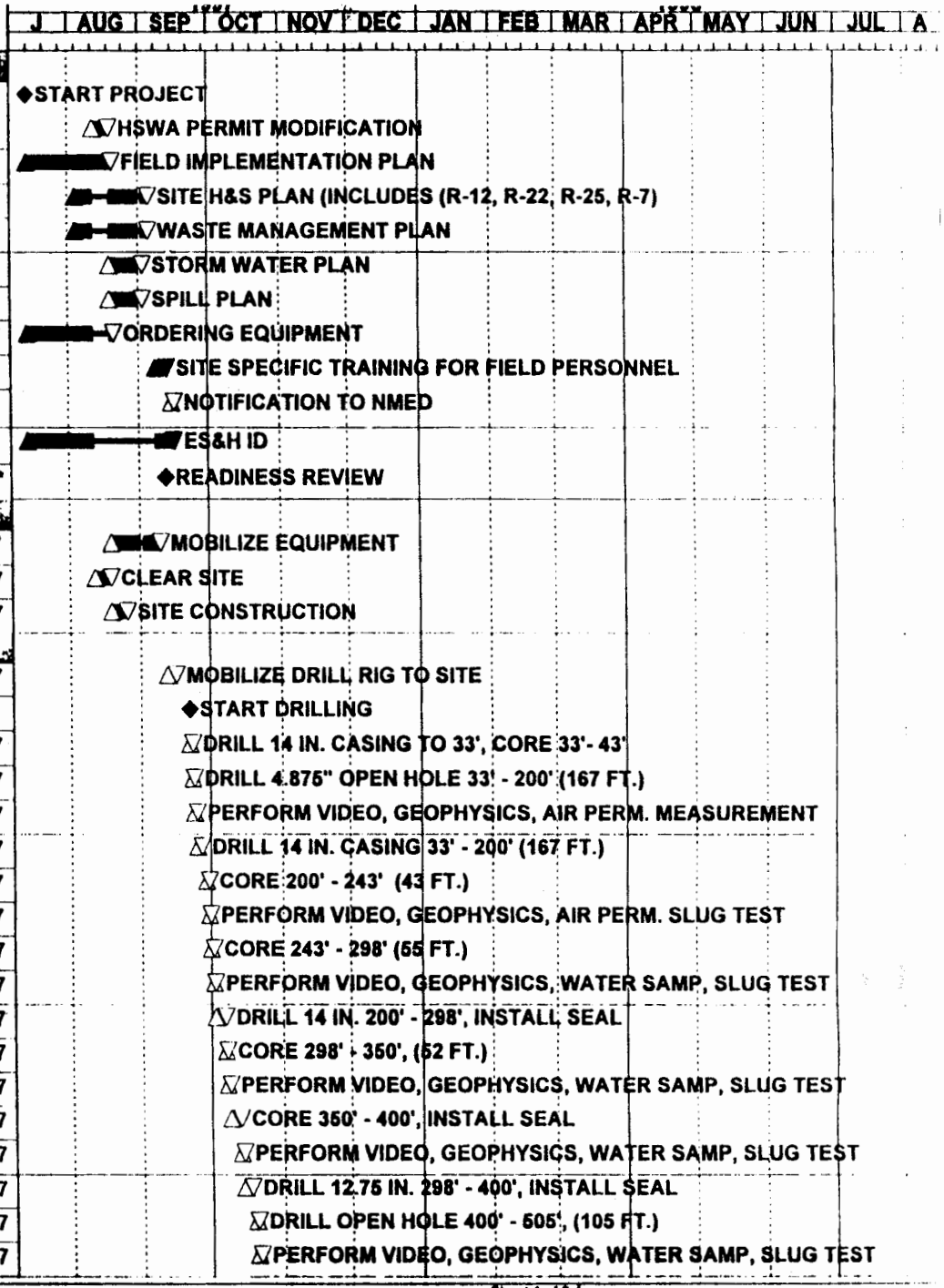
ITEM	RENT	BUY	COMMENTS	PER ITEM COST	NO. OF ITEMS	COST
MISCELLANEOUS Well Housing		X	Supplier			
Cement Pad and 4 Posts		X	Drilling Sub	$32	1	$32
Film		X	Furr's (36 exp., 200 ASA)	$8	3	$24
Film Development		X	Local (2 prints ea.)	$24	3	$72
Video Cassettes		X				
Video Development		X				
Cellular Phone	X		US West (1phone/month)	$225	3 mos	$675
Portable Toilet	X		L&L Portable (1 unit/month)	$88	3 mos	$264
Portable Lighting		N/A	Provided by Tonto			0
Office Trailer (monthly)	X		GE Capitol	$300	3 mos	$900
Field Lab Trailer						
Canopy		X	Sam's Club	$200	2	$400
Tables		X	Sam's Club	$25	4	$100
Portable Generator			FSF to Supply			0
Garbage Dumpster						
Field Logbooks		X	Forestry Supplier	$15	6	$90
Gatorade		X	Sam's Club (case)	$13	35	$455
Potable Water		X	Furr's (2.5 gals)	$2	100	$200
Coolers		X	WalMart	$25	2	$50
Lap Top Computer w/software		X	Arrowhead	$4,000	1	$4,000
Corrosive Storage Cabinet		X	Supplier	$370	1	$370
Flammable Storage Cabinet		X	Supplier	$320	1	$320

TOTAL DAYS	ACTIVITY DAYS	ACTIVITY DESCRIPTION
11	1	Perform borehole video, geophysics, measure water level, collect groundwater samples, perform slug test.
13	2	Trip in HOLTE™ system to 200 ft and drill 14 in. casing to 298 ft (98 ft of drilling), install seal. Changeout HOLTE™ system for continuous core system.
14	1	Continuous core to 350 ft (52 ft of continuous core) or to within the top 30 ft of the Puye Fm. Trip out continuous core system from 350 ft (It is assumed that the second perched zone of saturation is at 345 ft).
15	1	Perform borehole video, geophysics, air permeability measurements, measure water level, collect groundwater sample, perform slug test.
16	1	Trip in continuous core system and core to base of second saturated zone to 400 ft (50 ft of continuous core). Install bentonite pellet seal at base of second saturated zone. Trip out continuous core system.
17	1	Perform borehole video, geophysics, measure water levels, collect groundwater samples. Perform slug test.
20	3	Mill shoe on 14 in. casing at 298 ft. Trip in STRATEX™ system to 298 ft and drill 12.75 in. casing to 400 ft (102 ft of drilling), install seal.
21	1	Changeout STRATEX™ system for downhole hammer system. Drill 4.875 in. open hole to top 5 ft of the third saturated zone to 505 ft (105 ft of drilling). (It is assumed that the third saturated zone occurs in the central region of the Puye Fm). Trip out downhole hammer system from 505 ft.
22	1	Perform borehole video, geophysics, air permeability measurements, measure water level, collect groundwater sample, perform slug test.
24	2	Trip in continuous core system and continuous core to base of third saturated zone to 560 ft (55 ft of continuous core). Install bentonite pellet seal at base of third saturated zone. Trip out continuous core system from 560 ft.

TOTAL DAYS	ACTIVITY DAYS	ACTIVITY DESCRIPTION
41	1	Demobilize air drill rig from R-9. Mobilize Smeal rig to R-9.
43	2	Insert pre-packed well screen. well casing, and centralizers into 10.75 in. drill casing to 712 ft. Install sand pack and fine sand transition zones with tremie lines during retraction of 10.75 in. drill casing. This assumes static water level for regional aquifer is at a depth of 647 ft, the well has a 60 ft screen interval with the screen extending 5 ft above the top of the regional aquifer and a 10 ft sump.
47	4	Install bentonite grout with tremie lines during retraction of telescoped drill casings to land surface.
49	2	Install surface casing, backfill cellar with cement, install cement pad, develop well, demobilize Smeal rig from site.
51	2	Install submersible pump and transducer, sample well.

Drill days are 10 hours.
The 51 day schedule includes 10 days of rig standby for borehole measurements. This standby period will be greatly reduced if borehole measurements are done in the evenings and weekends. An additional reduction in time will occur if there are less than three perched zones. Each perched zone adds approximately 3 days to the project.

Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish
FIELD PREPARATION				
START PROJECT	0	0	14JUL97A	
HSWA PERMIT MODIFICATION	5	5	12AUG97	18AUG97
FIELD IMPLEMENTATION PLAN	30	6	14JUL97A	19AUG97
SITE H&S PLAN (INCLUDES (R-12, R-22, R-25, R-7)	15	12	04AUG97A	04SEP97
WASTE MANAGEMENT PLAN	15	12	04AUG97A	04SEP97
STORM WATER PLAN	10	10	19AUG97	02SEP97
SPILL PLAN	10	10	19AUG97	02SEP97
ORDERING EQUIPMENT	12	2	14JUL97A	20AUG97
SITE SPECIFIC TRAINING FOR FIELD PERSONNEL	5	5	08SEP97*	12SEP97
NOTIFICATION TO NMED	1	1	15SEP97	15SEP97
ES&H ID	30	6	14JUL97A	15SEP97
READINESS REVIEW	0	0		11SEP97*
SITE PREPARATION				
MOBILIZE EQUIPMENT	15	15	19AUG97	09SEP97
CLEAR SITE	5	5	12AUG97	18AUG97
SITE CONSTRUCTION	5	5	19AUG97	25AUG97
WELL CONSTRUCTION				
MOBILIZE DRILL RIG TO SITE	2	2	12SEP97	15SEP97
START DRILLING	0	0	22SEP97*	
DRILL 14 IN. CASING TO 33', CORE 33'- 43'	1	1	22SEP97	22SEP97
DRILL 4.875" OPEN HOLE 33' - 200' (167 FT.)	1	1	23SEP97	23SEP97
PERFORM VIDEO, GEOPHYSICS, AIR PERM.	1	1	24SEP97	24SEP97
DRILL 14 IN. CASING 33' - 200' (167 FT.)	2	2	25SEP97	26SEP97
CORE 200' - 243' (43 FT.)	1	1	29SEP97	29SEP97
PERFORM VIDEO, GEOPHYSICS, AIR PERM. SLUG TEST	1	1	30SEP97	30SEP97
CORE 243' - 298' (55 FT.)	1	1	01OCT97	01OCT97
PERFORM VIDEO, GEOPHYSICS, WATER SAMP, SLUG	1	1	02OCT97	02OCT97
DRILL 14 IN. 200' - 298', INSTALL SEAL	2	2	03OCT97	06OCT97
CORE 298' - 350', (52 FT.)	1	1	07OCT97	07OCT97
PERFORM VIDEO, GEOPHYSICS, WATER SAMP, SLUG	1	1	08OCT97	08OCT97
CORE 350' - 400', INSTALL SEAL	2	2	09OCT97	13OCT97
PERFORM VIDEO, GEOPHYSICS, WATER SAMP, SLUG	1	1	14OCT97	14OCT97
DRILL 12.75 IN. 298' - 400', INSTALL SEAL	3	3	15OCT97	17OCT97
DRILL OPEN HOLE 400' - 505', (105 FT.)	1	1	20OCT97	20OCT97
PERFORM VIDEO, GEOPHYSICS, WATER SAMP, SLUG	1	1	21OCT97	21OCT97



Project Start	30JUL97
Project Finish	19MAR98
Data Date	12AUG97
Run Date	27AUG97

Early Bar
Progress Bar
Critical Activity

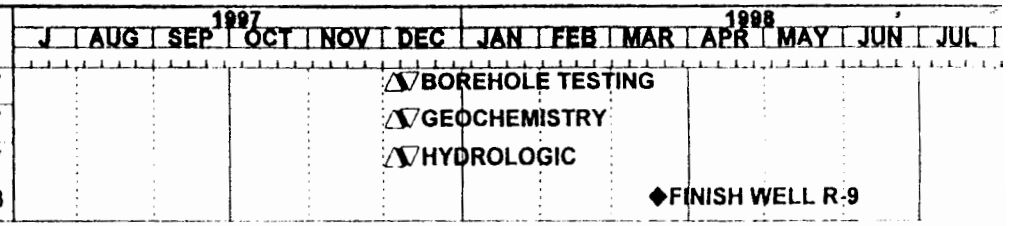
© Primavera Sys[illegible]ic.

WELL

LANL

DRILLING SCHEDULE FOR WELL R-9

Draft

Los Alamos
NATIONAL LABORATORY

Activity Description	Orig Dur	Rem Dur	Early Start	Early Finish
BOREHOLE TESTING	5	5	05DEC97	11DEC97
GEOCHEMISTRY	5	5	05DEC97	11DEC97
HYDROLOGIC	5	5	05DEC97	11DEC97
FINISH WELL R-9	0	0		19MAR98