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Los Alamos National Laboratory

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FIELD IMPLEMENTATION PLAN

FOR THE DRILLING AND TESTING OF LANL REGIONAL AQUIFER CHARACTERIZATION WELL R-19

Environmental Restoration Project

Canyons Focus Area

Allyn Pratt, Leader

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2352

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CONTENTS

ACRONYMS AND ABBREVIATIONS iv

OVERVIEW 1

INTRODUCTION 1

- Location 1
- Roles and Responsibilities 1
- Health and Safety 1
- Waste Management 4

DRILLING PLAN 4

- Pre-Drilling Activities 4
- Drilling Equipment/Procedures 4
- Drilling Contingencies 5
- Decontamination and Demobilization 5
- Site Restoration 5

WELL DESIGN 6

- Design Life and Assumptions 6
- Borehole Annular Space 6
- Well Casings 6
- Well Screen 6
- Backfill and Annular Materials 6
- Well Development 8
- Surface and Well-Head Completion 8
- Pump, Transducer and Data Logger 8

GEOLOGIC CHARACTERIZATION 8

- Geologic Materials 8
- Geophysical and Video Logging 11

HYDROLOGIC CHARACTERIZATION 12

- Unsaturated Zone(s) 12
- Saturated Zone(s) 12

GEOCHEMICAL CHARACTERIZATION 13

- Unsaturated Zone(s) 13
- Saturated Zone(s) 14

DOCUMENTATION AND REPORTING 17

- Field Documentation 17
- Well Record for State Engineer 17
- Well-Completion Report 18

REFERENCES 18

APPENDIX A PHASE 1 DRILLING PLAN REGIONAL CHARACTERIZATION WELL R-19 19

APPENDIX B PHASE 2 DRILLING PLAN REGIONAL CHARACTERIZATION WELL R-19 21

Figures

1. Map showing the location of well R-19....2
2. Functional organization of R-19 personnel....3
3. Conceptual well design of R-19....7
4. Predicted geology at R-19 from the site-wide 3-D geologic model....9
5. Hydrogeologic cross section through R-19....10

Tables

1. Roles and Responsibilities....4
2. Sampling and analysis of cuttings and core samples....11
3. Predicted Saturated Zones and Groundwater Sampling at R-19....12
4. Sampling and Analysis of Ground Water....14
5. Volumes of Water Required for Analyses....16
6. Parameters to be Measured in the Field When Sampling Groundwater....16
7. Required Field Documentation....17

ACRONYMS AND ABBREVIATIONS

AR	Air rotary
ASTM	American Society for Testing and Materials
BMP	Best management practice
DOC	Dissolved organic carbon
DOE	Department of Energy
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
HSA	Hollow-stem auger
HSWA	Hazardous and Solid Waste Amendments
LANL	Los Alamos National Laboratory
MCL	Maximum contaminant level
NMED	New Mexico Environment Department
NTU	Nephelometric turbidity units
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

OVERVIEW

- *Well R-19 is intended to characterize geologic, hydrologic and geochemical conditions associated with possible perched and regional groundwater as well as intervening unsaturated zones in the poorly known central part of the Laboratory.*
- *More specifically, it shall provide information for the area between plume-chasing well CDV-15-3 and supply well PM-2.*
- *R-19 is located within TA-36, approximately 1500 ft west of the switchback on, and 100 ft north of ridge road on the mesa top between Potrillo Canyon and an unnamed tributary to Threemile Canyon (Figure 1).*
- *R-19 is located within FMU-67 (DX), a limited security area, requiring that all personnel either hold a DOE "Q" security clearance, or be continuously escorted by a Q-cleared person.*
- *R-19 shall be drilled in two phases. Phase-1 drilling shall include continuous coring using a hollow stem auger to an undetermined depth between 0 and 400 ft and setting of surface casing to a selected depth between 0 and 140 feet.*
- *In Phase 2, drilling shall continue to a total depth of approximately 1950 ft using casing-advance, air-rotary (AR) equipment and selected coring methods.*
- *Perched zones of saturation may be encountered in the Guaje Pumice Bed, in the Puye Formation, and the Cerros del Rio basalts.*
- *The regional water table is projected to occur at a depth of approximately 1120 ft.*
- *The well is planned for multiple-screen completion: three within perched zones of saturation and two within the regional zone of saturation.*

INTRODUCTION

This Field Implementation Plan (FIP) provides guidance for the execution of planned drilling and testing activities for characterization well R-19. The objective of the FIP is to ensure consistency and quality of characterization data.

Location

Characterization well R-19 is located within TA-36 approximately 1500 feet west of the switchback on, and 100 feet north of ridge road on the mesa top between Potrillo Canyon and an unnamed tributary to Threemile Canyon (Figure 1).

Roles and Responsibilities

The roles and responsibilities for the technical team are shown in Table 1. The functional organization of the R-19 implementation is illustrated in Figure 2.

Health and Safety

All fieldwork shall be conducted in accordance with LANL ER Project Health and Safety Plan (HASP) and the Site Specific Health and Safety Plan (SSHASP), and LANL ESH ID No. 99-0299. In the event of an accident or emergency, DX-DO, EHS-5 and ESH-1 field representatives, and EM&R will be notified immediately.

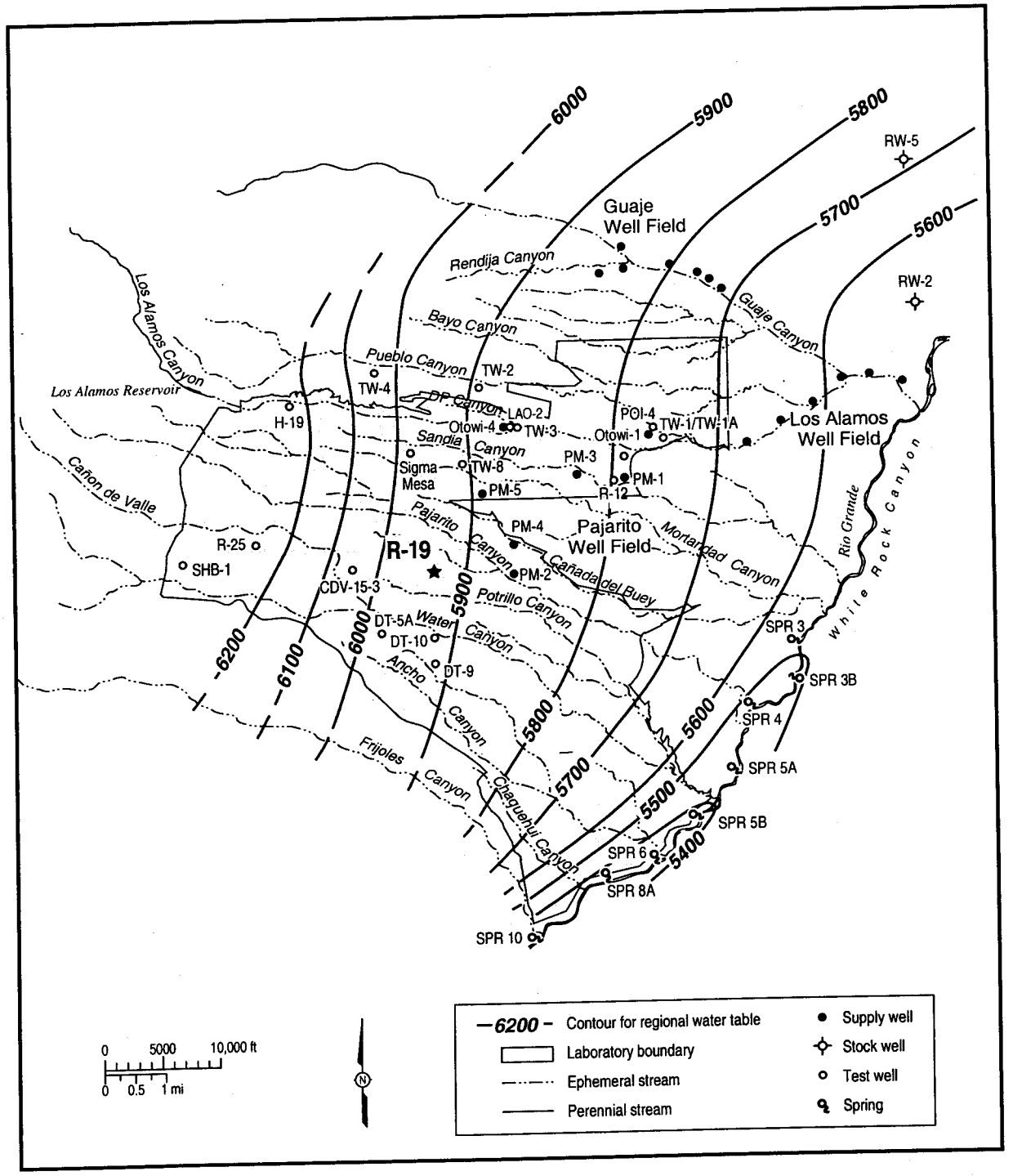

Figure 1. Map showing the location of well R-19.

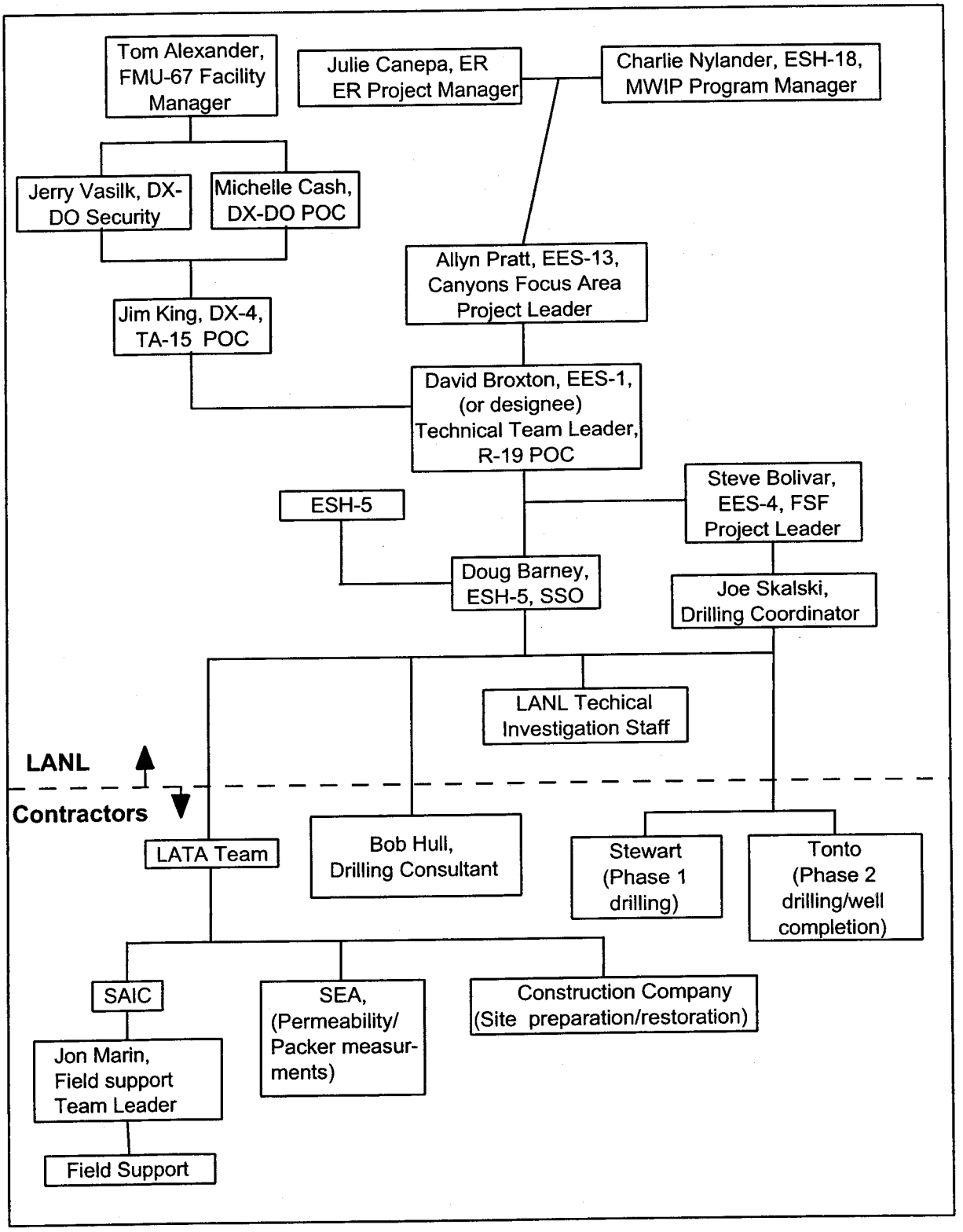

Figure 2. Functional organization of R-19 personnel.

Table 1. Roles and Responsibilities.

Personnel	Org.	Position	Project Responsibilities
Charlie Nylander	ESH-18	MWIP Program Manager	Responsible for MWIP management.
Allyn Pratt	LANL/ EES-13	Focus Area Project Leader (FPL)	The FPL is the line manager for R-19.
David Broxton	LANL/ EES-1	Technical Team Leader	Responsible for the success of the drilling and testing program.
Gene Turner	DOE	Point of Contact (POC)	Liaison between DOE and LANL.
Patrick Longmire	LANL/ CST-7	Geochemistry Principal Investigator (PI)	Provides technical leadership on geochemistry.
David Rogers	LANL/ ESH-18	Unsaturated-Zone Hydrology PI	Provides technical leadership on unsaturated-zone hydrology.
William Stone	LANL/ EES-5	Saturated-Zone Hydrology PI	Provides technical leadership on saturated-zone hydrology.
David Vaniman	LANL/ EES-1	Geology PI	Provides technical leadership for geology.
Bob Hull	LATA	Drilling Consultant	Provides technical leadership for design and implementation of drilling and testing.
Joe Skalski	LANL/ EES-4	Drilling Coordinator	Manages ER drilling contractors for project.
Jon Marin	SAIC	FTM/FTL/ Geologist/Sampler	Responsible for field support activities, including field operations documentation.
Robert Baran, Doug Barney	LANL/ ESH-5	SSO	Responsible for site safety for all contractors.
Clint Daymon	SAIC	SSO	Responsible for site safety for LATA team.
Ron Trueblood	SAIC	Asst. FTL/Asst. SSO/Sampler	Assist field support activities.
Stephanie Hagelberg	LANL/ Weirich	SMO Sample Coordinator	Coordinates sample documentation
Joe Sena	SAIC	Sampler/Asst. FTL	Assist field support activities.

Waste Management

A site-specific Waste Characterization Strategy Form (WCSF) describes the on-site management of groundwater and cuttings as well as the temporary storage of wastes that are pending the determination of disposal requirements. A notice of intent (NOI) to discharge benign wastewater on-site has been prepared by ESH-18 for NMED approval.

DRILLING PLAN

Pre-Drilling Activities

Pre-drilling activities shall include obtaining all required permits and access agreements, preparing site-specific plans (SSHASP, WCSF, FIP, etc.), securing line-management approval to commence field activities, site preparation and installation of a cellar for hydraulic casing jacks. Site preparation shall involve minor earth work to improve roads as necessary, to level a pad area of approximately 200 ft by 200 ft, to create a berm around the site and to install erosion control BMPs as necessary. Installation of a cellar involves excavating a pit, pouring a concrete floor, installing a steel box, and backfilling around the steel box.

Drilling Equipment/Procedures

R-19 is being installed in two phases. Phase 1 involves drilling as deep as possible using hollow-stem-auger (HSA) equipment. Phase 2 involves drilling to TD by multiple casing-advance using air-rotary (AR) equipment and selected coring methods.

Phase 1 drilling -- The Phase-1 strategy at R-19 is to drill as deep as possible using hollow-stem auger drilling methods to assess the presence of possible perched groundwater zones.

During Phase 1, R-19 shall be continuously cored from the surface to the depth limit of the equipment using 4-in. inside diameter (ID) Truspin™ hollow-stem augers with a Moss™ wireline core-retrieval system.

Using the in-place 4 1/4-in. HSA string as a guide, the borehole shall be reamed to a diameter of 22-in. from the surface to approximately 140 ft.

The 22-in. HSAs shall be removed and 18-in. diameter, 20-ft-long steel casing joints shall be welded together to extend from the Phase 1 total depth to 3 ft above the ground surface. Cement slurry shall be tremied to approximately 10 ft inside and outside the bottom of the casing.

Phase 2 drilling -- During Phase 2, drilling shall be conducted by air rotary methods to permit hydrogeologic characterization and installation of a monitoring well in the major saturated zones at R-19. As planned, drilling operations shall be conducted 24 hrs per day on a 7-day-per-week schedule. This shall be accomplished by two 12-hr shifts per day (6:00 AM - 6:00 PM and 6:00 PM - 6:00 AM).

During Phase 2, coring may be implemented as deemed necessary to:

- obtain the lithologic information required to satisfactorily land casing,
- provide material for hydraulic property testing, geochemical core sampling, and
- facilitate detection of contamination.

Drilling Contingencies

During Phase 2, the following drilling contingencies may be implemented depending on the results of characterization activities:

- Whenever possible, groundwater samples shall be collected by airlifting the water through the drilling circulation system.

- Mud circulated into the borehole as casing lubricant shall be contained within the lined waste- management area onsite.

- Formation water generated during drilling operations shall be containerized in 3,000-gal polyethylene tanks staged in the waste-management area.

- Cement plugs shall be installed to provide landings for casing.

Decontamination and Demobilization

When possible, decontamination shall be accomplished by dry methods to minimize liquid waste. Wet methods may be employed on small volumes of sampling and drilling equipment, using potable water and Alconox. Large pieces of drilling equipment requiring decontamination shall be taken to the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50 for cleaning.

Site Restoration

Upon completion of drilling activities at R-19, all equipment shall be demobilized and all wastes generated shall be removed. Site restoration shall involve returning the site to the approximate original contour and reseeding with native vegetation. If approved by the ER project, DX-DO and NMED, benign drill cuttings may be used in site-restoration.

WELL DESIGN

The installation of the well shall follow the requirements of the LANL ER Project Standard Operating Procedure for *Monitor Well Construction* (LANL-ER-SOP-05.01 REV. 06).

Design Life and Assumptions

The conceptual design of R-19 is illustrated in Figure 3. Details may be modified based on information obtained during drilling and review by NMED. R-19 is designed for a life expectancy of 50 yrs. Based on analysis of historical decline of the static water level in the area, the length of the screen straddling the regional water table at R-19 shall be 25 ft.

Borehole Annular Space

R-19 shall be constructed inside a telescoped borehole during retraction of the steel drill casing. A record of borehole diameters and depth intervals shall be kept during drilling. The final diameter shall be sized so as to provide a minimum annular space of 2 in. between the outside diameter of the well screen/casing and the borehole wall.

Well Casings

R-19 shall be constructed of 5.56-in. OD, schedule 40, 304 stainless-steel casing with flush-threaded joints for the 10-ft interval above and below the stainless-steel screen (Figure 3). A capped 30-ft section of stainless-steel casing shall be attached below the screen to serve as a sump. A transition from stainless steel to mild steel shall be provided above the highest zone of saturation. This shall be accomplished by welding a type 304 stainless-steel pin to the cut-off bottom of a section of mild steel pipe. This shall provide full thickness of mild steel at the stainless-to-steel connection. The low-carbon steel casing shall be installed in 20-ft lengths and shall extend 3.5 ft above ground surface. Centralizers shall be spaced along the stainless-steel casing every 40 to 60 ft and placed immediately above and below the well screen. Surface casing of 16-in. OD, Schedule 40, low-carbon steel shall be installed from 37 ft below ground level to 3.5 ft above the ground surface.

Well Screen

R-19 shall be constructed with multiple sections of 5.56-in. OD, stainless-steel, wire-wrapped screen with a 0.01 in. slot size, positioned in selected perched intervals and in the regional saturated zone (Figure 3). Two 10-ft screens are planned for installation in perched zones of saturation while one 25-ft screen and two 10-ft screens are planned for installation in the regional zone of saturation. The 25-ft screen shall be set with 5 ft above the regional water table.

Backfill and Annular Materials

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

Borehole below final well depth -- The interval from TD up to 5 ft below the well screen shall be sealed with a bentonite grout (30% bentonite, 70% water).

Primary filter packs --The filter packs shall consist of round, clean, washed, and resieved silica sand with a uniformity coefficient of 2.0 or less. The primary filter pack shall extend a distance of 10 ft above and below the well screen.

Secondary filter packs -- Finer (30-70), clean, washed, silica sand shall be emplaced 3 ft below and 5 ft above the primary filter pack to impede the movement of any bentonite grout toward the screen.

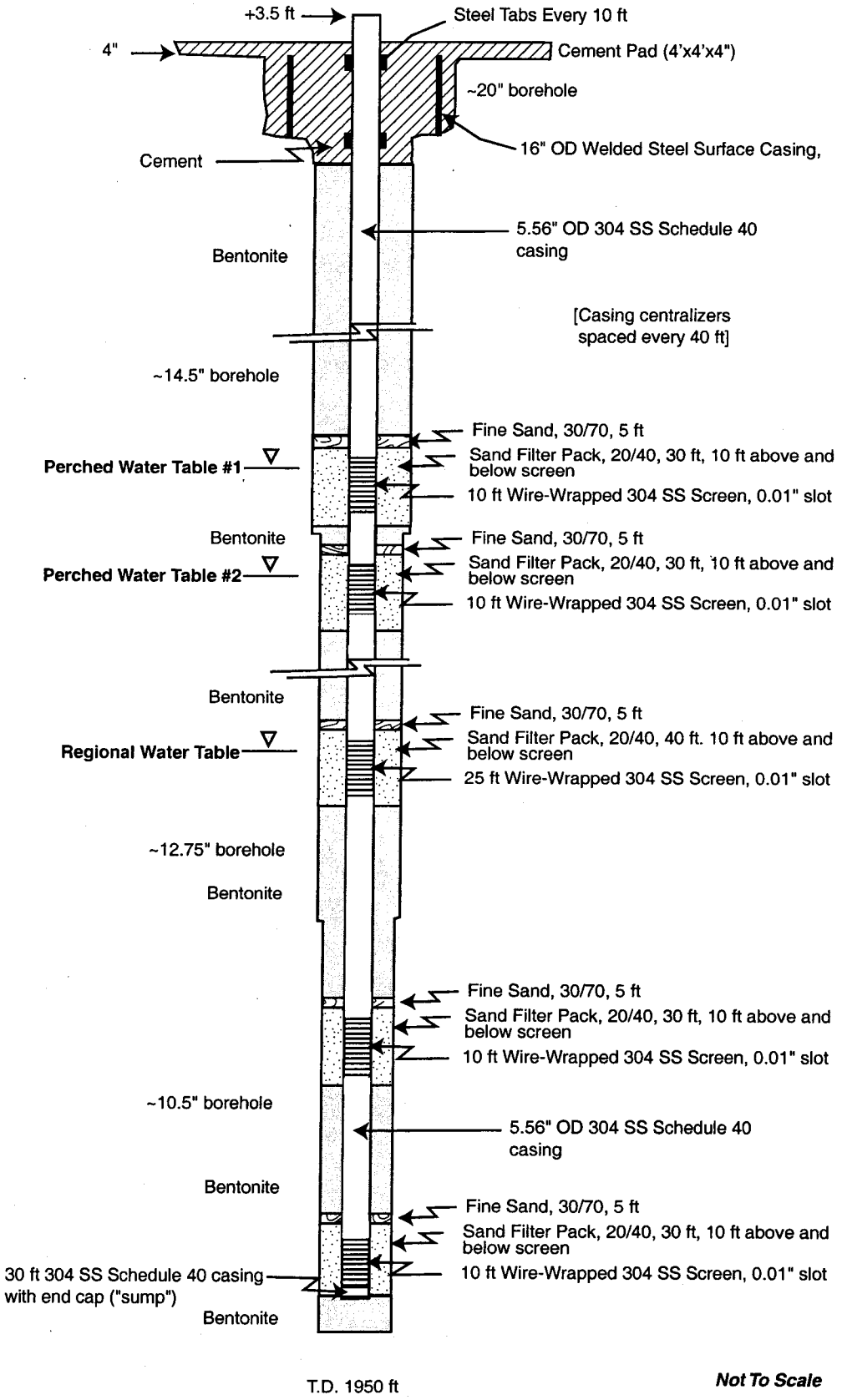

Figure 3. Conceptual well design of R-19.

Borehole between secondary filter packs -- The annular space between filter packs and up to a depth of 50 ft below land surface shall be sealed with bentonite grout (30% bentonite, 70% water). The annular space from a depth of 50-ft to land surface shall be sealed with cement grout. The cement grout shall meet the requirements of ASTM C150, Standard Specifications for Portland Cement. The 16-in. surface casing shall be installed with cement grout in the annular spaces between the surface casing and the borehole wall and the surface casing and well casing.

Well Development

Development of a well with multiple screens differs from that of a well with a single screened interval and involves several steps:

1. Airlift along the entire well length from the top down using a 4-hole jetting tool with bleed holes located a few hundred ft above the tool to reduce pressure at the jets.

2. Switch to water and jet from the bottom up.

3. Alternatively, to avoid the need to trip the N rod out of the hole at each change from airlifting to jetting and vice-versa, run a jetting tool with a check valve on N rod, jet with water and alternately airlift up a B rod placed inside an N rod. Use of dual-wall drill pipe for airlifting and jetting would make this process more efficient.

4. Pack off each screened interval and air develop it with a B rod inside an N rod, starting at the top of the production casing and working down. Impart a "washing" action by turning air on and off.

5. Strive for a turbidity value of 5 NTU, but cease development when water quality no longer improves.

Surface and Well-Head Completion

The ground around the top of the well shall be completed with a 4 ft x 4 ft x 4 in. concrete pad keyed into the annulus (Figure 3). The well head shall consist of 3 ft of 18-inch steel casing sticking up through the cement pad. A locking equipment box will be positioned atop the steel casing to prevent unauthorized access to the well. Steel guard posts will be installed around the cement pad and well head to prevent damage by vehicles.

Pump, Transducer and Data Logger

Sampling and water-level measurement at R-19 shall be primarily accomplished by Westbay equipment to be installed after well construction and development.

GEOLOGIC CHARACTERIZATION

Characterization well R-19 will provide additional information on the geologic setting beneath Ancho Canyon. Predicted depths to geologic contacts are shown in Figures 4 and 5.

Geologic Materials

Cuttings and core samples shall be collected from R-19 for geologic characterization, as determined by the Geology PI. Table 2 lists the planned sampling for cuttings and core samples. Selection of geologic materials for specific analysis shall be based upon examination during drilling or after the well is completed. Additional testing of samples may include mineralogy by X-ray diffraction, petrography by modal analysis of thin sections and geochemistry by X-ray fluorescence. Samples shall be identified, labeled and handled through normal chain-of-custody control, transported to the FSF, and transferred to the Geology PI or designee.

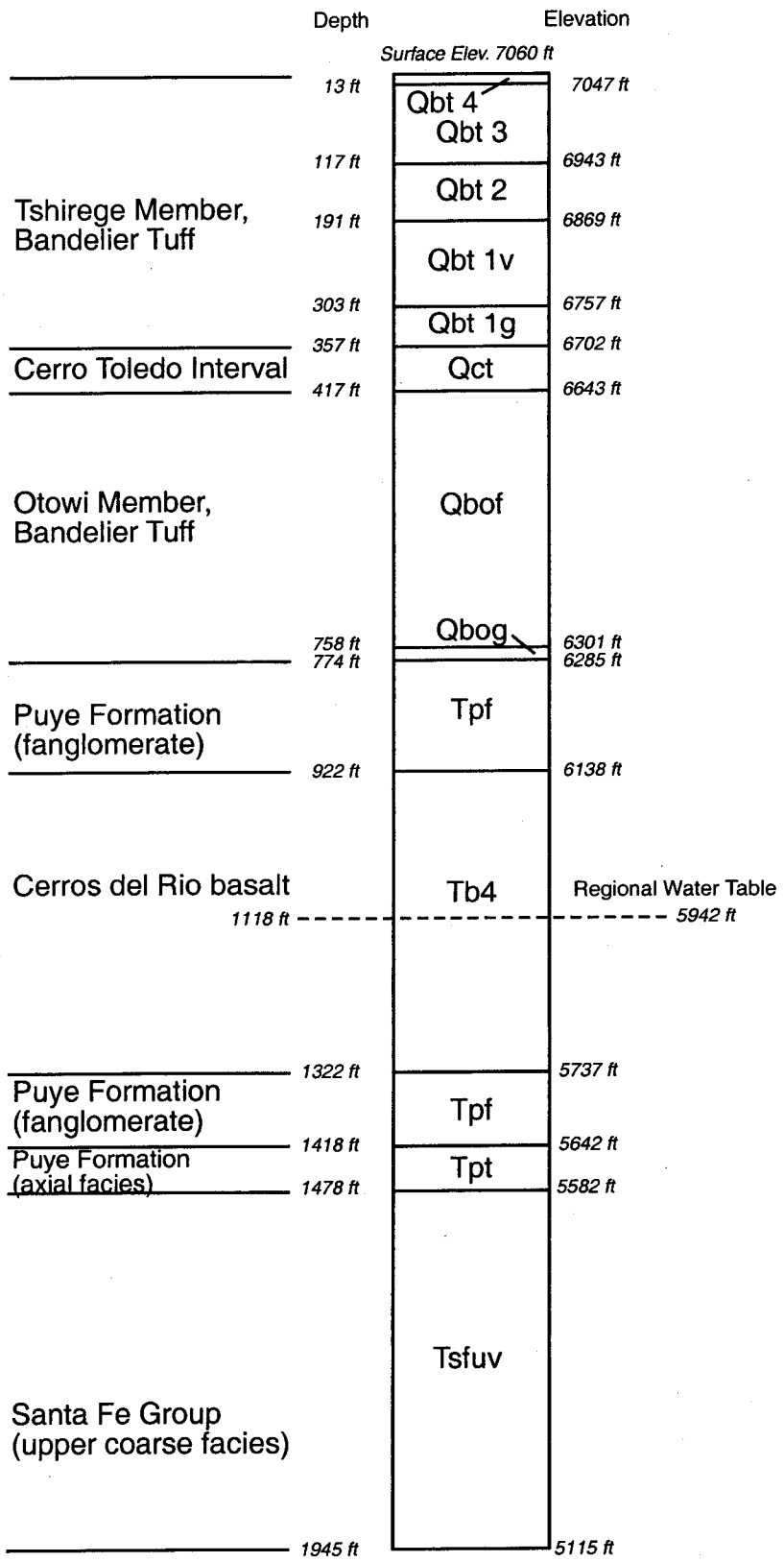

Figure 4. Predicted geology at R-19 from the site-wide 3-D geologic model.

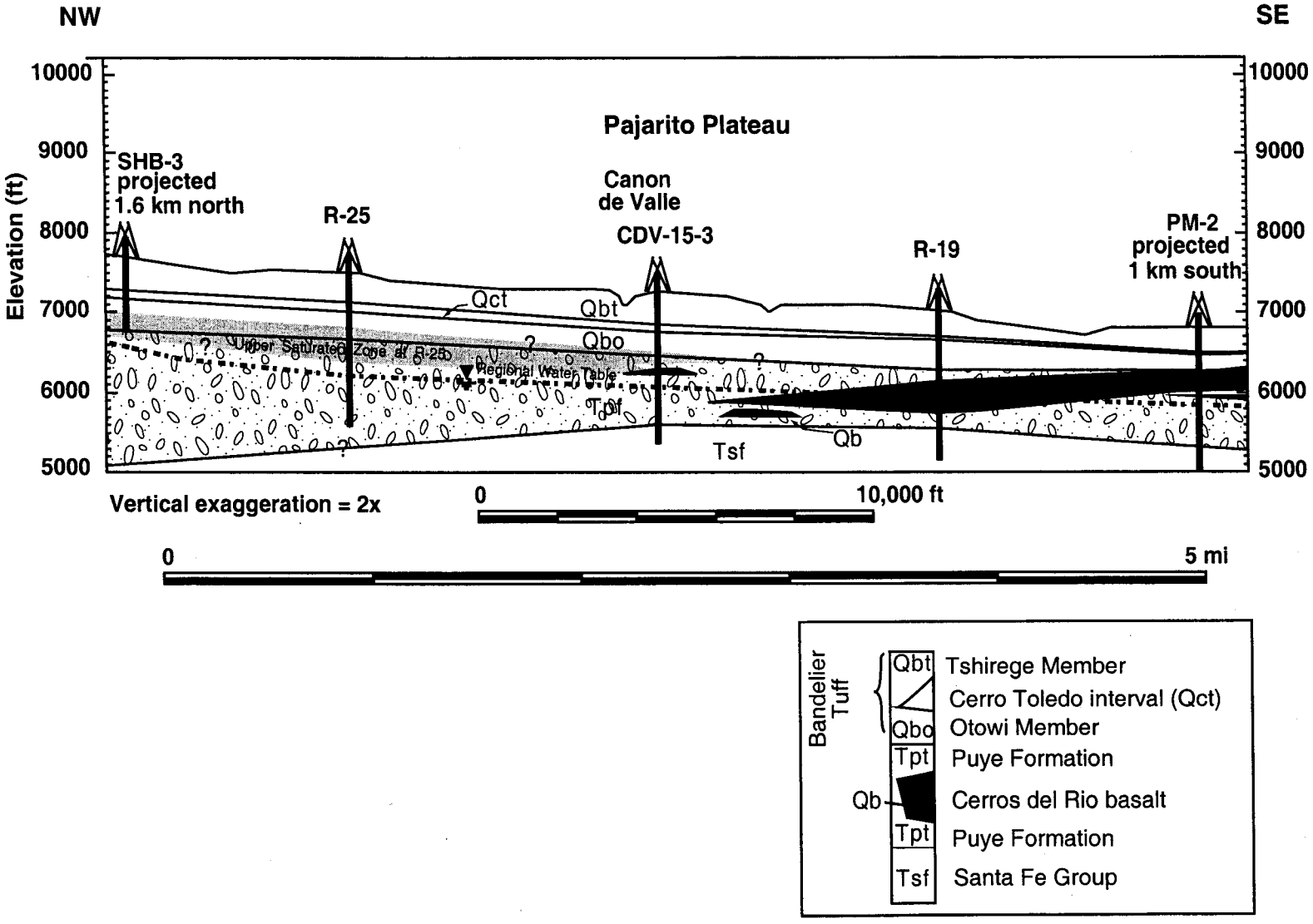

Figure 5. Hydrogeologic cross section through R-19.

R-19 Field Implementation Plan

Table 2. Sampling and analysis of cuttings and core samples
(See Tables 4 and 5 for sampling and analysis of groundwater).

Sampling Criterion & Frequency	Test	Sample Size	Container	Preservation	No. of Samples Phase 1/Phase 2
Geologic Characterization					
As selected by Geology PI	XRD, XRF, petrography	3" Core	Plastic bag	N/A	To be determined
Hydrologic Characterization					
If there are no field-screening hits, sample every 5' plus any intervals of potential hydrologic significance.[1]	Moisture (EES-1)[2]	2" core/ 250 ml cuttings	125 or 250 ml glass jar	Must not freeze or overheat	86/181
	Matric potential (EES-1)	2" core/ 100 ml cuttings	Plastic bag no head space	Must not freeze or overheat	86/181
if rad or VOC hits, switch to coring & go to **Geochemical Characterization**	Hydraulic properties package	6" core	Stainless steel sleeve in Core-Protec	Must not freeze or overheat	86/53
Geochemical Characterization					
If VOC hits	VOA, SW 846	6" core	Core-Protec	4° C	0/4
	SVOA, SW 846	6" core	Core-Protec	4° C	0/4
Otherwise, Perched Water Zones (5 samples) one, 5 ft above saturation one, in saturation one, 10 ft below p. horizon one, in perching horizon one, 5 ft below p. horizon	Rads Tritium Inorganics % organic carbon	12" core 6" core 9"core	Double bag Double bag Double bag	4° C 4° C 4° C	22/37 22/37 22/37
Regional Water Zone (5 samples) one, 20 ft above saturation one, 10 ft above saturation one, 1 ft within saturation two, below static water level	Rads Tritium Inorganics % organic carbon	12" core 6" core 9" core	Double bag Double bag Double bag	4° C 4° C 4° C	22/37 22/37 22/37
Others as selected by Geochemistry PI[3]	Tritium	(Archived Core-Protec samples)			14/TBD
	Pore water by unsaturated flow apparatus	(Archived Core-Protec samples)			0/TBD
	Isotopes	(Archived Core-Protec samples)			12/TBD

[1] high clay content, strong iron oxidation, fractures, elevated moisture, saturation front
[2] after moisture measurement, samples may be used for anion and dry bulk density analysis by EES-1 as well as chloride analysis by EES-5
[3] if heavy staining or stained/lined fractures, suggestive of possible contaminant transport

Geophysical and Video Logging

Logging with selected geophysical tools provides additional characterization of geologic materials penetrated by R-19, as discussed in the Section 4.1.6 of the Hydrogeologic Work Plan (LANL 1998, 59599). This includes logging of both open and cased intervals and depends on borehole conditions. Geophysical logging with the natural-gamma-radiation tool shall be performed in R-19 whenever there is a change in casing size, but before telescoping to the next smaller diameter casing, to minimize the number of casings that must be penetrated in logging. Selected intervals of open borehole may also be logged by video camera for further geologic characterization.

HYDROLOGIC CHARACTERIZATION

According to the current conceptual hydrogeologic model for mesas, precipitation drains into subsurface units such as the Guaje Pumice Bed, and ultimately perhaps into deeper units. Characterization well R-19 should provide the data necessary to test this conceptualization. Table 3 gives the number and projected positions of saturated zones expected at R-19.

Table 3. Predicted Saturated Zones and Groundwater Sampling at R-19.

Groundwater Zone	Sample Number	Top (ft)	Bottom (ft)	Thick (ft)	Comments
Perched Zone in Guaje Pumice Bed	1	758	774	16	Possible perched groundwater in Guaje Pumice Bed of the lower Otowi Member
Perched Zone in Puye Formation and/or in Cerros del Rio Basalt	2	774	922	148	Possible perched groundwater in fanglomerate facies and/or in thin olivine basalt atop massive basalt
Regional Aquifer	3	1118	1322	204	Estimated depth to regional water table in massive basalt flow
Regional Aquifer	4	1418	1478	60	Sample regional groundwater in Puye Formation axial facies.

Unsaturated Zone(s)

Water (and thus contaminants) can move downward from the surface to saturated zones, especially in recharge areas. Thus, the characterization of hydrologic properties of the geologic materials lying above perched and regional zones of saturation is important. This may involve both field and laboratory testing of such unsaturated materials.

Field tests – Although hydraulic properties of unsaturated materials may be investigated by means of various air-permeability tests, none are planned for R-19. Geophysical logging shall provide some hydrologic information.

Laboratory tests -- Hydraulic properties of selected unsaturated materials may also be tested in the laboratory. Sampling shall proceed as shown in Table 2. The hydrologic samples must be packaged immediately onsite to prevent moisture loss and steps must be taken to prevent the samples from freezing or overheating (usually by taking them to the FSF under chain-of–custody control for tracking purposes). Duplicate core samples shall be collected approximately every 10th sample. Samples preserved in Core-Protec™ sleeves are suitable for analysis of the full suite of hydraulic properties (saturated hydraulic conductivity, moisture content, density, porosity, moisture characteristic curve and estimation of van Genuchten parameters).

During Phase 1, hydrologic samples, each consisting of approximately 6-inches of HSA core, shall be collected at approximately 5-ft intervals. The number of core samples collected during Phase-2 drilling will depend upon the actual amount of coring implemented.

Saturated Zone(s)

Field tests -- Hydraulic properties of materials in both perched and the regional zones of saturation shall be investigated by in-situ methods, as applicable.

Slug or pumping tests of the regional aquifer may be conducted once the well is completed. It is desirable, for comparison purposes, to collect hydraulic-property information both before and after installation of the Westbay system. For efficiency, pre-Westbay testing shall be coupled closely with well development as outlined below.

1. With packers still in place after development, perform hydrologic (constant-rate) testing before leaving the interval. Run a transducer down the B rod.
2. Allow the water level to recover, but verify this by checking water level before the test.
3. Inject hydrant water for the test at a rate of approximately 3 gpm. (Allow 1 hr for this injection.)
4. Collect recovery water-level data by transducer.
5. Construct a real-time plot of results to facilitate the decision as to when to end the test.

Appropriate LANL ER Project Standard Operating Procedures for *Well Slug Tests* (LANL-ER-SOP-07.03 REV. 0) and *Aquifer Pumping Tests* (LANL-ER-SOP-7.04 REV. 1) as well as ASTM SOPs (ASTM 1994) shall be followed.

When saturated conditions are encountered and standing water accumulates in the borehole, depths to water shall be measured by the FTL/FTM, using a dedicated water-level meter and/or a pressure transducer system according to LANL ER Project Standard Operating Procedures for *Fluid Level Measurements* (LANL-ER-SOP-07.02 REV.0). All water levels shall be measured to the nearest 1/100th of a foot and recorded as depth below ground surface. If the water-level probe used is not graduated, fractions of a foot shall be determined using a measuring tape. Measurements shall be repeated until results are reproduced (all readings shall be recorded). It is important to obtain readings for as many borehole depths as possible. *An electronic water-level database shall be kept that tabulates eight observations in order:* ***borehole TD, casing TD, amount of open hole, depth to water, date, pre-water-level-measurement drilling activity, time between activity and water-level measurement, comments.*** This information will be used to determine vertical head distribution. Preparation of this database shall be coordinated with the Saturated-Zone Hydrology PI.

Laboratory tests -- Samples for analysis of hydraulic properties shall be collected as shown in Table 2. Saturated materials may be analyzed for fewer parameters than those from unsaturated zones: hydraulic conductivity and porosity. The number or core samples analyzed depends on the actual amount of coring implemented.

GEOCHEMICAL CHARACTERIZATION

Drilling characterization well R-19 provides the opportunity to evaluate the natural and contaminant chemistry of both the unsaturated and saturated geologic materials as well as the waters beneath the well location.

Unsaturated Zone(s)

Some selected cores collected during Phase 1 may be submitted for geochemical analysis. The Geochemistry PI may also select samples from unsaturated zones encountered in Phase 2 for analysis.

Geological material -- The geochemical samples shall be selected to represent differing lithologic characteristics. The samples shall be submitted to an appropriate off-site laboratory for various analyses: percent or fraction of solid organic carbon, tritium, radioactive isotopes (gamma spectroscopy, gross alpha, gross beta, gross gamma, 241Am, 137Cs, 238Pu, 239Pu, 240Pu, 90Sr, 234U, 235U, 236U, 238U), and inorganics (including metals and trace elements).

Water – Based on field screening results, water may be extracted from unsaturated materials.

Saturated Zone(s)

Of particular interest in the geochemical characterization are the presence and concentrations or activities of natural solutes and any contaminants in geologic material and water associated with saturated zones. This includes both perched zones and the regional zone of saturation.

Geological material -- Depending on the number of perched-water zones encountered during Phase 2, up to 31 core samples (including three duplicates) may be collected for analysis of various constituents. Samples shall be collected according to the plan shown in Table 2.

Analyses of interest for geologic material from the saturated zones at R-19 include percent or fraction of solid organic carbon, low-detection tritium, radioactive isotopes (gamma spectroscopy, gross alpha, gross beta, gross gamma, 241Am, 137Cs, 238Pu, 239Pu, 240Pu, 90Sr, 234U, 235U, 238U), and inorganics (including anions, metals and trace elements). If VOCs are detected during field screening, Phase 2 core samples shall be submitted for VOC and SVOC analysis.

Water -- Saturated conditions are anticipated in Phase 2 (Table 3). Table 4 gives details for required sampling and analysis of groundwater. If perched water is encountered within the unsaturated zone, one sample shall be collected within the perching layer and one sample shall be collected 5ft below the perching layer. To minimize drill-rig down time, water samples shall be collected from the cyclone. Samples shall be collected as directed by the Geochemistry PI, according to three guidelines:

- Each saturated interval containing sufficient groundwater to accumulate 5 ft of standing water in the borehole shall be sampled, if possible,
- The depth of sample collection shall be the depth to water measured immediately prior to groundwater sampling; and
- The depth that groundwater flowed into the borehole shall be recorded on the sample collection log for each sample.

Table 4. Sampling and Analysis of Groundwater.

Estimated Number of Water Samples	Analysis	Container	Preservation	Filtered through acetate 0.45 micrometer	Volume each sample (L)	Special Instruction	Collect Archival Sample	Archival Sample Volume (L)
6 plus 1 duplicate	Metals (dissolved)	250 ml plastic	HNO3 to pH2, 4°C	Yes	0.25	EES-1		
6 plus 1 duplicate	Metals (total)	250 ml plastic	HNO3 to pH2, 4°C	No	0.25	EES-1		
6 plus 1 duplicate	Anions (dissolved)	250 ml plastic		Yes	0.25	EES-1		
6 plus 1 duplicate	Anions (total)	250 ml plastic		No	0.25	EES-1		
6 plus 1 duplicate	VOCs	2-40 ml amber glass w/ septum cap	HCL to pH2, 4°C	No	0.08	Paragon		
6 plus 1 duplicate	PAH	1 L amber glass	4°C	No	1	Paragon		
6 plus 1 duplicate	Pesticides/ PCBs	1 L amber glass	4°C	No	1	Paragon		
6 plus 1 duplicate	High Explosives (14,15)	1 L amber glass	4°C	No	1	Paragon		
6 plus 1 duplicate	Major cations, trace elements and metals (dissolved)	500 ml poly	HNO3 to pH2, 4°C	Yes	0.5	Paragon	X	0.5
6 plus 1 duplicate	Major cations, trace elements and metals (total)	500 ml poly	HNO3 to pH2, 4°C	No	0.5	Paragon	X	0.5

Estimated Number of Water Samples	Analysis	Container	Preservation	Filtered through acetate 0.45 micrometer	Volume each sample (L)	Special Instruction	Collect Archival Sample	Archival Sample Volume (L)
6 plus 1 duplicate	γ spec, Am^{241}, Cs^{137} $Pu^{238,239,240}$, $U^{234,235,238}$, Sr^{90} (dissolved)	1 gallon plastic	HNO3 to pH2, 4°C	Yes	4.55	Paragon	X	4.55
6 plus 1 duplicate	γ spec, Am^{241}, Cs^{137} $Pu^{238,239,240}$, $U^{234,235,236,238}$, Sr^{90} (total)	1 gallon plastic	HNO3 to pH2, 4°C	No	4.55	Paragon	X	4.55
6 plus 1 duplicate	Stable isotopes ($^{18}O/^{16}O$, D/H)	30 ml glass w/ poly seal cap	Ambient temperature	No	0.03	Paragon/ Geochron	X	0.03
6 plus 1 duplicate	Stable isotopes ($^{15}N/^{14}N$)	1 gallon plastic	H2SO4 to pH2, 4°C	No	4.55	Paragon/ Coastal	X	4.55
6 plus 1 duplicate	Tritium (low-level screening)	500 ml poly	Ambient temperature	No	0.5	Teledyne	X	0.5
6 plus 1 duplicate	Tritium (low-level or Liquid scintillation)	500 ml poly	Ambient temperature	No	0.5	University of Miami	X	0.5
6 plus 1 duplicate	RVGrossα,β plus RVGrossγ	500 ml poly	Ambient temperature	No	0.5	TA-21 Count Laboratory	X	0.5
6 plus 1 duplicate	Total cyanide	500 ml poly	NaOH to pH12, 4°C	No	0.5	Paragon	X	0.5
6 plus 1 duplicate	Humid acid	0.5 L amber glass		Yes Silver filter	0.5-1	Huffman	X	1
6 plus 1 duplicate	Total organic carbon	1L amber glass w/ poly seal cap	4°C	No	1	Paragon	X	1
6 plus 1 duplicate	TUICPMS(16)	500 ml poly	HNO3 to pH2, 4°C	No	0.5	GEL	X	0.5
6 plus 1 duplicate	TUICPMS(16)	500 ml poly	HNO3 to pH2, 4°C	Yes	0.5	GEL	X	0.5
6 plus 1 duplicate	TUKPA(17)	500 ml poly	HNO3 to pH2, 4°C	No	0.5	Paragon	X	0.5
6 plus 1 duplicate	TUKPA(17)	500 ml poly	HNO3 to pH2, 4°C	Yes	0.5	Paragon	X	0.5
6 plus 1 duplicate	Gross α,β, And γ	1L poly	HNO3 to pH2, 4°C	No	1	Paragon	X	1
6 plus 1 duplicate	Gross α,β, And γ	1L poly	HNO3 to pH2, 4°C	Yes	1	Paragon	X	1
6 plus 1 duplicate	NH4, NO3, N02	1L poly	H2SO4 to pH2, 4°C	No	1	Paragon, If turbid sample, add more preservative	X	1
6 plus 1 duplicate	NH4, NO3, N02	1L poly	H2SO4 to pH2, 4°C	Yes	1	Paragon, If turbid sample, add more preservative	X	1
6 plus 1 duplicate	Br^{-1}, Cl^{-1}, Fl^{-1}, PO4, SO4	250 ml poly	Ambient temperature	No	0.25	Paragon	X	0.25
6 plus 1 duplicate	Br^{-1}, Cl^{-1}, Fl^{-1}, PO4, SO4	250 ml poly	Ambient temperature	Yes	0.25	Paragon	X	0.25
			Each Sample	Total Volume (L)	29.26	Each Archived Total Volume	Sample (L)	25.18
			Each Sample	Filtered Volume (L)	9.55	Each Archived Filtered	Sample Volume (L)	9.3

(1) High explosive compounds and degradation products are HMX, RDX, 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, tetryl, nitrobenzene, 2,4,6-trinitrotoluene, 4-amino-2,6-DNT, 2-amino-4,6-DNT, 2,6-dinitrotoluene, 2,4-dinitrotoluene, 2-nitrotoluene, 3-nitrotoluene, 4-nitrotoluene, and 1,4- dinitrobenzene.
(2) Analyzed by high-pressure liquid chromatography (HPLC).
(3) TUICPMS = total uranium coupled plasma mass spectrometry.
(4) TUKPA = total uranium kinetic phosphorometric analysis.

As described in Table 4, up to seven groundwater samples may be collected during Phase 2 in R-19. This includes a duplicate for QA/QC purposes collected from the first saturated zone sampled. No other QA/QC samples shall be collected (Chapter 5, QAPP). The Geochemistry PI

shall be notified and shall coordinate analytical methods and preferred laboratories with the SMO prior to sampling.

For each groundwater-sampling event, field personnel shall perform specific activities:

- Record the date, time, borehole ID, depth to water prior to sampling, and the depth that water entered the borehole, on the sample collection log;
- Prevent groundwater samples from freezing or over-heating;
- Collect approximately 15 gal of groundwater from the cyclone for each saturated zone (Table 5) having sufficient volume to support sampling;
- Immediately record field-measured parameters for groundwater samples (Table 6);
- Using a nitrogen gas filtering apparatus provided by CST-12, filter approximately 5 gal of each groundwater sample;
- Add preservatives to appropriate sample containers (Table 4);
- Save, label, and store the filters for each groundwater sample;
- Fill appropriate sample containers with filtered and nonfiltered groundwater (Table 4);
- Place custody seals on each sample container;
- Store sample portions in appropriate transport containers (Table 4);
- Transport the samples to the SMO at the FSF; this will require coordination with the Geochemistry PI and sample coordinator (ICF Kaiser) to provide the electronic and paper chains-of-custody for transfer of samples to the SMO; and
- Transport the indicated sample portion to the count lab at TA-21 (Radvan) for radiological screening required prior to sample shipment from the SMO.

Table 5. Volumes of Water Required for Analyses.

Groundwater Sample	Volume (L)	Archived Sample	Volume (L)	Total Volume (L)	Plus NMED split (25%)	Contingency Volume (gallons)
Nonfiltered	19.71	Nonfiltered	15.88	35.34	35.34 L = 7.8 gallons	10
Filtered	9.55	Filtered	9.3	19.1	19.1 L = 4.2 gallons	5
Total	29.26	Total	25.18	54.44	54.44 L = 12 gallons	15

Table 6. Parameters to be Measured in the Field When Sampling Groundwater.

Measurement	Precision[1]	Method
pH	±0.02	LANL-ER-SOP-06.02
Specific conductance	±1 µmho/cm (25°C)	LANL-ER-SOP-06.02
Temperature	±1 °C	LANL-ER-SOP-06.02
Turbidity (nephelometric)	±1 NTU[2]	EPA Method 180.1

1. Precision with which measurement shall be recorded
2. NTU = nephelometric turbidity unit

Samples of groundwater encountered in Phase 2 at R-19 shall be submitted to Paragon and other laboratories for the analyses shown in Table 4. Table 5 lists volumes of water required while Table 6 specifies chemical parameters to be measured in the field and the appropriate LANL SOP to be followed.

DOCUMENTATION AND REPORTING

Information generated in conjunction with the installation of R-19 shall be presented or preserved in various reports and records.

Field Documentation

Table 7 lists all documentation to be completed during the course of fieldwork. The contents and format of most of these documents are well established. However, to ensure consistency in the Sample Collection Logs, team members are reminded to include ***well number, sample ID, location ID (if necessary), sample type (D = drill cuttings; C = core), upper and lower depth of interval sampled (ft) and purpose (Geo = geology, Hydro Prop = hydraulic properties and Geochem = geochemical analysis).***

Table 7. Required 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	As Needed
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

The identified individual or their approved designee shall complete all documentation at the frequency given. Documentation shall be relinquished to the FTM and the Data Manager daily or as needed.

Ideally, *Daily Well Reports*, giving current status and recent activities, should be e-mailed the following day. As far as possible, they shall be distributed *no more than three days after the date they cover*. For example, the daily report for Monday, Tuesday and Wednesday may be delivered no later than Thursday and the Friday report may be delivered no later than the following Monday. Thus, no one should ever receive more than three such reports at a time; one or, at the most, two at a time is preferable.

Well Record for State Engineer

A well record form shall be completed and submitted to the State Engineer Office within 10 days following completion of well R-19. The form requires information on the well owner, location (legal

description), drilling contractor, descriptions of well construction and water-bearing strata, a detailed lithologic log of the borehole, and other general information (drilling method, depth to water, etc.). The form must be signed by the driller.

Well-Completion Report

The Well-Completion Report shall be prepared following demobilization and restoration of the drill site. The report, written to document not only well construction, but also geologic, hydrologic and geochemical characterization findings, shall be submitted to.DOE and NMED (for information only).

References

ASTM (American Society for Testing and Materials), 1994. "ASTM Standards on Ground Water and Vadose Zone Investigations," Sponsored by ASTM Committee on Rock and Soil (D-18), Philadelphia, Pennsylvania **(ASTM 1994)**

LANL (Los Alamos National Laboratory), June 1993. "RFI Work Plan for Operable Unit 1132," Los Alamos National Laboratory Report LA-UR-93-768, Los Alamos, New Mexico. **(LANL 1993, ER ID 15316)**

LANL (Los Alamos National Laboratory), May 22, 1998. "Hydrogeologic Workplan," Los Alamos, New Mexico. **(LANL 1998, ER ID 59599)**

APPENDIX A
Phase 1 Drilling Plan
Regional Characterization Well R-19

Total Days	Activity Days	Contractor	Activity Description	Date
			Phase 1	
			DX RCT performs pre-job radiological survey of R-19 pad area.	12/7/99
			Readiness Review completed	12/13/99
			Conduct kickoff meeting, DX security training, DU training, borrow radios	DBT
S-1	1	SBDC	Mobilize and set up hollow stem auger (HSA) drill and support equipment.	DBT
S-2	1	SBDC	Drill with 4 _" inside diameter (ID) Truspin™ HSAs, and collect continue core, as deep as possible, probably 100 ft to 230 ft. If perched water encountered with the 4 _" HSAs, stop drilling at base of perched zone and attempt to seal off perched water using the 18" welded steel surface conductor casing.	DBT
			DX RCT visits site to perform 2nd radiological survey of R-19 pad area after few feet of drilling penetration.	DBT
S-3	1	SBDC	Modify the drill head to over-ream the 4 _" ID Truspin™ ID HSAs with 12 _" ID HSAs as deep as possible, probably 40 ft to 100 ft. Welded character of Tshirege unit 2 may prevent any deeper penetration of the 12 _" HSAs.	DBT
		SBDC	Trip out the 4 _" HSAs while backfilling with cuttings or sand from TD to depth of 12 _" HSAs.	DBT
		SBDC	Trip out the 4 _" HSAs from the depth of the 12 _" HSAs to the surface.	DBT
S-4	1	SBDC	Mix and tremie bentonite slurry to the bottom of the 12 _" ID HSAs.	DBT
		SBDC	Trip in center bit for 12 _" HSAs.	DBT
		SBDC	Drill 12 _" HSAs as deep as possible, probably an additional 5 ft to 10 ft. Drilling action will pull the bentonite slurry up the borehole annulus to stabilize the borehole wall.	DBT
S-5	1	SBDC	Trip out the 12 _" HSAs from TD to the surface.	DBT
		SBDC	Install 18" diameter carbon steel conductor casing with welded joints from the TD of the 12 _" HSAs to a stickup of approximately 3 ft. This casing must be perfectly vertical.	DBT
		SBDC	Mix and tremie 10 ft of portland cement to the bottom inside the 18" steel casing.	DBT
		SBDC	Lift, spin, and lower 18" steel casing repeatedly into the cement plug to achieve a uniform seal.	DBT
		SBDC	Allow cement plug to cure overnight, or weekend, if possible.	DBT
S-6	1	SBDC	Mix and tremie portland cement to the outside of the 18" casing from the from the cement plug to approximately 10 ft below the ground surface.	DBT
		SBDC	Weld plate on top of 18" surface casing to secure access.	DBT
		SBDC	Demobilize Phase 1 drill rig.	DBT

Total Days	Activity Days	Contractor	Activity Description	Date
			Site Preparation	
P-1		Parker	Level pad area approximately 200 ft by 200 ft in size.	DBT
			DX RCT visits site to perform repeat radiological survey of R-19 pad area after site preparation.	DBT
P-1	1	Parker	Install erosion control BMPs	DBT
		Parker	Build access ramp from ridge road to site by installing a steel pipe culvert under the access ramp, to maintain ditch drainage, and allow heavy equipment access to the drill pad.	
P-2		Parker	Excavate a pit (carefully) surrounding the 18" surface casing approximately 7 ft by 10 ft by 5 ft deep. If the 18" surface casing is touched or moved by a piece of equipment, stop operations immediately and survey the casing. If it's off plumb, it will have to be re-installed.	DBT
S-7	1	SBDC	Install forms for 1 ft thick, reinforced concrete floor, on level pit floor surrounding the 18" casing.	DBT
		SBDC	Backfill dirt on outside of concrete forms to hold forms in place during cement pour.	
		SBDC	Install 2" access pipe and tremie elbow into the 18" surface casing within the concrete form so that 2" pipe is within the cement.	
		SBDC	Mix and pour cement into form with 1" thick rebar.	
		SBDC	Allow cement to cure overnight, or over weekend, if possible.	
S-8	1	SBDC	Position steel box around the surface casing atop cement floor (carefully).	DBT
		SBDC	Backfill around the steel box to grade with base coarse gravel tamped in place with a mechanical tamping apparatus.	
P-3		Parker	Complete site leveling so that lip of steel box is a nominal 1" above level grade.	
S-8		SBDC	Place plywood sheets atop open steel box and secure with weights (augers or straw bails).	
		Parker	Demobilize Phase 1 site prep equipment, support trailers and vehicles if Phase 2 not to commence immediately.	

This schedule is based on a 10-hour workday.

APPENDIX B
Phase 2 Drilling Plan
Regional Characterization Well R-19

Total Shifts	Activity Shifts	Contractor	Activity Description	Date
			Phase 2	
			Conduct Phase 2 kickoff meeting, DX security training, DU training, and borrow radios.	TBD
30	30	Dynatec	Mobilize and set up air rotary drill rig and support equipment.	TBD
		Dynatec	Trip in 13 5/8" casing and under-reamer to depth of cement plug in surface casing.	TBD
		Dynatec	Drill with 13 5/8" casing and under-reamer with mud assist to depth of 1st perched water (projected at Tsankawi Pumice Bed at 400 ft).	TBD
		Dynatec	Airlift perched water geochemical sample.	TBD
		Dynatec	Drill with 13 5/8" casing and under-reamer dry to 10 ft below base of 1st perched water.	TBD
		Dynatec	Remove 13" under-reamer and pull back 13 5/8" casing to perching horizon.	TBD
		Dynatec	Mix and tremie cement plug below 13 5/8" casing.	TBD
		Dynatec	Haul 11 3/4" casing to site while cement plug cures.	TBD
		Dynatec	Lower 13 5/8" casing to cement plug foundation.	TBD
		Dynatec	Install pressure grout seal to land 13 5/8" casing at base of 1st perched water horizon.	TBD
60	30	Dynatec	Trip in 11 3/4" casing and under-reamer to depth of grout seal inside 13" casing.	TBD
		Dynatec	Airlift excess grout before plugging 11 3/4" system.	TBD
		Dynatec	Drill with the 11 3/4" under-reamer and casing with mud assist to depth of second perched water zone (projected at Guaje Pumice Bed at 745 ft).	TBD
		Dynatec	Airlift perched water geochemical sample.	TBD
		Dynatec	Drill with 11 3/4" casing and under-reamer dry to 10 ft below base of 2nd perched water.	TBD
		Dynatec	Remove 11 3/4" under-reamer and pull back 11 3/4" casing to perching horizon.	TBD
		Dynatec	Mix and tremie cement plug below 11 3/4" casing.	TBD
		Dynatec	Haul 9 5/8" casing to site while cement plug cures.	TBD
		Dynatec	Lower 11 3/4" casing to cement plug foundation.	TBD
		Dynatec	Install pressure grout seal to land 11 3/4" casing at base of 2nd perched water horizon.	TBD
90	30	Dynatec	Trip in 9 5/8" casing and under-reamer to depth of grout seal inside 11" casing.	TBD
		Dynatec	Airlift excess grout before plugging 9 5/8" system.	TBD
		Dynatec	Drill with the 9 5/8" under-reamer and casing with mud assist to depth of regional groundwater table (projected at 1145 ft in basalt).	TBD
		Dynatec	Airlift regional groundwater geochemical sample.	TBD
		Dynatec	Drill with 9 5/8" casing and under-reamer to TD of borehole (projected to be 1950 ft).	TBD
91	1	Dynatec	Pull back 9 5/8" casing while backfilling borehole to depth of well completion.	TBD

Total Shifts	Activity Shifts	Contractor	Activity Description	Date
95	3	Dynatec	Install 2 tremie lines to depth of well completion.	TBD
		Dynatec	Measure and document length of all components of well.	TBD
		Dynatec	Install well.	TBD
125	30	Dynatec	Tremie well completion annular materials to annular space below casing.	TBD
		Dynatec	Pull back casing and tremie lines in 20-ft increments to backfill annular materials around stainless steel portions of well.	TBD
		Dynatec	Pull back casing and tremie lines in 60-ft increments to backfill annular materials around carbon steel portions of well, if borehole wall stability allows.	TBD
		Dynatec	Tremie annular materials to depth of surface casing.	TBD
145	20	Dynatec	Mix and tremie cement as annular material within interval of surface casing.	TBD
		Dynatec	Weld surface casing stickup in place.	TBD
		Dynatec	Remove steel box.	TBD
		Dynatec	Pour cement into steel box cavity.	TBD
		Dynatec	Complete well head and cement pad (with posts).	TBD
150	5	Dynatec	Develop Well	TBD

Depending on Dynatec support, Phase 2 operations will be conducted on two 12-hour work shifts per day.