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TA-16

Date: October 25, 2005
Refer to: ER2005-0762

Mr. John Young
Permits Management Program
NMED – Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

SUBJECT: DRILLING WORK PLANS: R-17, R-24, R-27, LADP-5, LAOI-3.2a, LAOI-7, R-23i, R-16a, CDV-16-2(i)r, R-10, R-10a

Dear Mr. Young:

Please find attached eleven drilling work plans (work plans) prepared in response to the letter from the NMED ("re: Response to Drilling Scope for Calendar Year 2005") dated June 24, 2005. Several of these work plans were previously submitted in draft form to NMED for review. The attached revisions address comments received via email from NMED (J. Young) on August 22, 2005 (see attached). Work plans are included herein for wells R-17, R-24, R-27, LADP-5, LAOI-3.2a, LAOI-7, R-23i, R-16a, CDV-16-2(i)r, R-10, and R-10a. Several of these wells, including R-10, R-10a, R-24, CDV-16-2(i)r, and LAOI-7 have already been drilled, and final well design at those wells reflects interactions and agreements made between the Laboratory and NMED. An additional drilling work plan for well R-3 is forthcoming.

Some of the comments (e.g., Comment # 5) provided by NMED on the draft work plans will be addressed in the subsequent Well Completion reports. A few additional comments (e.g., Comment #s 9 and 17) that discuss sieving of formation materials to support selection of filter pack) are not addressed in the work plans because the Laboratory believes that further discussion with NMED is needed to resolve the various concerns. Therefore, the Laboratory requests a series of meetings with NMED to resolve these issues.

6578

If you have any questions, please contact Danny Katzman at (505) 667-6333 or Tom Whitacre at (505) 665-5042.

Sincerely,

David McInroy, Deputy Program Director
Environmental Remediation & Surveillance
Los Alamos National Laboratory

Sincerely,

David Gregory, Federal Project Director
Department of Energy
Los Alamos Site Office

DK/jk

Enclosures: 1) Email and attached comments from J. Young, NMED
2) Drilling Work Plans: R-17, R-24, R-27, LADP-5, LAOI-3.2a, LAOI-7, R-23, R-16a, CDV-16(I)r, R-10, R-10a

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(-Sieve: CMU Sieve 2.2
Subject: Drilling Plan comments
Date: Mon, 22 Aug 2005 14:58:23 -0600
(-MS-Has-Attach:
(-MS-TNEF-Correlator:
Thread-Topic: Drilling Plan comments
Thread-Index: AcWnXDw3QdGE8IUeSHyur2Qa+D6REQ==
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(-OriginalArrivalTime: 22 Aug 2005 21:01:42.0911 (UTC) FILETIME=[B2D5C0F0:01C5A75C]
(-Proofpoint-Spam: 0
(-PMX-Version: 4.7.1.128075

Danny and Jean,

Here are the comments we have developed regarding the drilling plans. Mostly a little more discussion in a some areas is all that needs to be added. Let us know if you have any questions.

John

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Comments Regarding the Well Drilling Plans

Drilling methods:

1. Reverse circulation drilling should be considered and utilized. This technique limits the intrusion of drill fluids into the surrounding formation.
2. When discussing drilling methods for the regional aquifer boreholes, clarify what "minor" borehole stability, minor loss of circulation or other conditions that may warrant the use of fluids or the advancement of drill casing. Provide more detail as to when EZ-Mud may/will be utilized during drilling. Clarify if drill casing warranted will (and what) fluids also be employed (and at what rates)
3. Provide brief descriptions of the "triggers" for utilizing different drilling techniques.

Potential Drilling Fluids, Composition and Use

4. Provide a brief discussion of the rates, manufacturers recommended treatment rates/volumes for each of the potential drilling fluids (and development chemicals). A brief description of the possible subsequent problems (e.g., geochemical and hydraulic property impacts) associated with each should also be included.
5. Indicate in this section that a detailed accounting of all fluids used (including development chemicals) including type, volumes/rates of chemicals/additives used/injected in the borehole, rates at which the chemicals/additives were used, etc.
6. Provide a discussion of the progression of the use of each of the drilling fluids and a more detailed justification for the use each.
7. Provide information regarding N-SEAL. It couldn't be found on Baroid's website.

Hydrogeologic Objectives

8. UC/DOE must revise the objectives of each well to include accurate geochemical measurements (for all wells) whether the chemistry is a secondary or tertiary objective. It also applies for collecting accurate hydraulic property data as well (i.e., proper well construction and well development).
9. Accurate aquifer testing is fully dependent on well development and construction. Drilling fluids must be removed and screens and filter pack material must be selected based on aquifer characteristics (to mimic the formation) as close as possible.

Potential Groundwater Occurrence and Detection

10. Provide language stating that specific conductance and measurement of tracers added to the drilling fluids will also be monitored to see if intermediate groundwater zones have been encountered.

11. UC/DOE must also include language that video logging and geophysics will be completed on each borehole in order to more accurately identify intermediate perched groundwater bearing zones.

Core Sampling

12. Text regarding core sampling, handling, etc. must include a reference to section IX and other applicable sections of the Order.
13. The text must be revised to for core sampling analytical suites to include all potential contaminants found or suspected at adjacent SWMUs and AOCs and upgradient of the borehole.

Groundwater Screening Sampling

14. Historically, screening samples from boreholes have been a useful "indication of contaminants that may be present. Conservative tracers (e.g., tritium, nitrate, perchlorate, HE compounds) must be included in the screening analytical suite. UC/DOE must revise text regarding the analytical suite to include relevant conservative tracers.

Geophysical Testing

15. Language stating that full suite open hole geophysics will be conducted in each borehole unless otherwise justified (e.g., a nearby borehole or well that a full suite of geophysics were acquired) must be included in this section.
16. UC/DOE must include language that video logging for every intermediate and regional depth bore hole/well will be completed.

Well Completion and Design

17. UC/DOE must state that all well screens and filter pack materials will mimic as close as possible, the hydraulic properties of the adjacent hydrostratigraphic unit. This will help ensure a compliant monitoring well (be it for chemistry or water level measurements) is constructed.
18. This section must also include a statement about the wells being fitted with a transducer.
19. This section must also include a statement regarding the surface completion of the well and must be included in the attached schedule(s).
20. UC/DOE must also include language stating the methods to be used to construct each of the wells (e.g. methods used to place annulus material, select screen type, select filter pack material) will be documented and reported in the well completion report(s).

Well Development

21. Provide a statement that UC/DOE will develop wells more stringently if drilling fluids and completion fluids (fluids) are used or if multi-completion wells have been installed to ensure that residual fluids have been removed and do not impact water chemistry or hydraulic properties. A brief description of the procedure(s) must be provided.
22. Provide more detailed descriptions of the progression well development.
23. Provide a brief description of the rates of application and how the development fluids will be introduced. Identify the possible physical and chemical alterations and interferences that may arise from using these fluids. A detailed accounting of all fluids used (by type and volume) and removed must also be listed in this section.
24. Include a statement that UC/DOE will document how the well development procedures implemented now are more stringent than in years past. *Not sure the appropriate place/document or if there is a document currently available; however, it needs to be in the administrative record.*
25. NMED believes that the use of a flow cell and the measurements of redox/orp, specific conductance, and dissolved oxygen may be useful in determining if a well has been developed thoroughly. In addition, analyses of acetone/isopropyl alcohol must also be considered in wells where QUICK FOAM or EZ-MUD was used.
26. UC/DOE must contact Westbay, Barcad, others as to how they recommend developing multi-completion wells where drilling fluids are utilized in construction and development.
27. UC/DOE must include language that discusses how wells are purged and field parameters are acquired. NMED is concerned wells may be considered stabilized before the well has actually stabilized due to faulty field parameter collection (e.g., field parameters not collected and measured at the well head) and subsequently result in questionable water chemistry as in-situ conditions are not accurately reflected.

Hydraulic Testing

28. UC/DOE were informed in a letter dated XXXXXX that injection tests or slug tests introducing water is not to be accomplished. Therefore, tests where water is introduced to the formation must not be accomplished and thus listed in this section.

R-10:

29. UC/DOE must add water quality/geochemistry to the Hydrogeologic Objectives section.
30. Drilling methods must be sensitive enough to identify/detect possible perched zones (perhaps related to R-12). The plan must also address any monitoring of perched zones identified during drilling R-10 and must be included in the drilling work plan.
31. This work plan must also include in the objectives identification of the possible groundwater mound predicted by the hydrogeologic model.

R-24:

32. UC/DOE must consider drilling deeper into the regional aquifer considering the proximity to the Guaje Well field. By completing a borehole and well at greater depths within the regional aquifer more study of the effects of pumping on the hydrology can be observed.

R-27:

33. High explosive compounds and the degradation products must be added to the analytical suite identified in "Core Sampling". MNX, DNX, and TNX breakdown products of RDX must also be included in the suite.

Drilling Work Plan for Regional Aquifer Well LAOI-7

Primary Purpose	LAOI-7 is included in the "Los Alamos Canyon and Pueblo Canyon Intermediate and Regional Aquifer Groundwater Work Plan" to fulfill the Consent Order requirement to install an intermediate well in Los Alamos Canyon between alluvial wells LAO-4.5 and LAO-6. The primary purpose of LAOI-7 is to explore perched groundwater found in basalt at R-9/R-9i. LAOI-7 will also help characterize contaminant migration through the vadose zone in Los Alamos Canyon. LAOI-7 will be cored to collect samples for contaminant and moisture profiles. A single-screen well will be installed in the corehole if perched water is encountered; otherwise, LAOI-7 will be backfilled.
Projected Depth	The borehole should extend through the Cerros del Rio basalt and 20 ft into the Puye Formation, a target depth of approximately 350 ft, or to refusal.
Drilling Methods	Dry drilling using HQ coring techniques.
Potential Drilling Fluids, Composition, and Use	The corehole will be drilled dry to the extent possible. Foam will be used only if there are zones of persistent circulation loss or insufficient core recovery.
Hydrogeologic Objectives	• Define the western extent of perched groundwater found in basalt at R-9/R-9i, but absent in R-8. • Define the eastern extent of contaminant migration through the vadose zone in Los Alamos Canyon. • LAOI-7 will confirm the continuity of stratigraphic units identified in the R-8 and R-9 wells.
Potential Groundwater Occurrence & Detection	• Perched: 90 ft, perched water is possible in the Puye Formation on top of the Cerros del Rio basalt. • Perched: 300 ft, perched water is possible in central and lower part of the Cerros del Rio basalt, similar to the occurrence at R-9/9i. Methods for groundwater detection may include: drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	• Core analytical samples will be collected from lined core barrels, sealed in ProtecCore™ moisture protection, and submitted to the SMO under Chain-of-Custody • Collect vadose zone core and analyze for anions, cations/metals, radionuclides, and stable isotopes at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, and 350 ft or until core refusal, whichever comes first.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the full suite of constituents including radiochemistry, metals/cations, general inorganics, VOCs compounds, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	Borehole video, natural-gamma, and induction logs will be collected. The geophysical logs will be used in conjunction with other data collected in the corehole to characterize the hydrogeologic setting of perched water zones and to select the well-screen interval.
Well Completion Design	A single-screen well will be installed if perched water is found. Otherwise, the borehole will be plugged and abandoned in accordance with the Consent Order. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • surging and swabbing • bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	A constant-rate pumping test will be used if well development indicates that a high-transmissivity water-bearing interval is present. Slug tests will be used if well development indicates that a low-transmissivity water-bearing interval is present. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

LAOI-7 Coring Schedule	
Start Date August 23, 2005	
Activity	**Duration (days)**
Coring	14
Development	7
Pumping Testing	14
Investigation-Derived Waste Analyses	45
Site Restoration	7

Drilling Work Plan for Regional Aquifer Well R-23i

Primary Purpose	Well R-23i is being installed to sample possible intermediate perched groundwater encountered while drilling the R-23 regional aquifer well. The possible perched groundwater was detected outside the R-23 drill casing at a depth of ~470 ft in the Cerros del Rio basalts. However, the depth and thickness of the perched zone are uncertain.
Projected Depth	R-23i will be drilled to the uppermost perched groundwater zone encountered. The maximum depth for R-23i will be 700 ft, the base of the lowermost of the interflow deposits within the basalt that could host perched groundwater.
Drilling Methods	The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust suppression at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	Determine if perched intermediate water zones exist and characterize the water quality.
Potential Groundwater Occurrence & Detection	• Perched: 240 - 550 ft, perched water is possible in the Cerros del Rio basalts and intercalated sediments based on observations during the drilling of R-23 Methods for groundwater detection may include; drillers observations, water level measurements, borehole video, and borehole geophysics
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.
Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the identified suite of constituents including: radionuclides, metals/cations, general inorganics, VOCs, high-explosives compounds, and stable isotopes. • Subsequent groundwater monitoring will be conducted under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• borehole video camera will be used when open-hole conditions allow logging. • natural gamma and induction tools may be run, if needed for correlation to R-23 A full suite of contracted geophysical logs will not be conducted at R-23i, since it is adjacent to R-23 where a full suite was collected.

Well Completion Design	One screen will be placed within an optimal perched groundwater within the Cerros del Rio basalt or intercalated sediments. A dedicated submersible pump will be used for groundwater sampling. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

R-23i Drilling Schedule	
Start Date October 11, 2005	
Activity	**Duration (days)**
Drilling	30
Development	7
Pumping Testing	14
Surface Completion	1
Investigation-Derived Waste Analyses	45
Site Restoration	7

Drilling Work Plan for Regional Aquifer Well R-16a

Primary Purpose	R-16a will replace screen 1 in R-16, which is blocked by drill casing that could not be extracted during well construction. The purpose of R-16 is to identify the water table and determine vertical gradients for the regional aquifer near the Rio Grande and to serve as a monitoring point between TA-54 and the Rio Grande. It is also an important data point for evaluating the relationship between the regional water table and springs in White Rock Canyon.
Projected Depth	Approximately 700 ft.
Drilling Methods	The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust suppression at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic objectives	• Define the top of the regional water table near White Rock Canyon. • Determine source of springs in White Rock Canyon. • Determine relationship of regional water table to Rio Grande. • Define vertical gradients near the Rio Grande. • Determine water quality at the water table. No contaminants have been detected in screens 2, 3, or 4 of R-16. • Compare water quality at top of regional aquifer to water quality at nearby springs
Potential Groundwater Occurrence & Detection	• Regional aquifer is expected to occur at 621 ft. Methods for groundwater detection may include; drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	Core will not be collected because: • The vadose zone was characterized during the drilling of R-16.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.
Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development. This sample will be analyzed for the full suite of constituents including radiochemistry, metals/cations, general inorganics, VOCs, high explosives, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• borehole video camera will be used when open-hole conditions allow logging. • natural gamma and induction tools may be run, if needed for selection of appropriate screen placement.

Well Completion Design	Single screen near the top of the regional aquifer fitted with a dedicated submersible pump
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

R-16a Drilling Schedule	
Start Date September 13, 2005	
Activity	**Duration (days)**
Drilling/Well Construction	30
Development	7
Pump Testing	14
Surface Completion	1
Characterization Sampling	10–60 following development
Site Restoration	7

Drilling Work Plan for Intermediate Aquifer Well LAOI-3.2a

Primary Purpose	The LAOI-3.2 well was installed as part of the "Los Alamos Canyon and Pueblo Canyon Intermediate and Regional Aquifer Groundwater Work Plan" (LANL 2003, 82612) in Feb. 2005 to provide information about potential impacts to the vadose zone downgradient of the solid waste management units at TA-21, TA-2, and TA-53. In particular, LAOI-3.2 was designed to investigate impacts to the vadose zone from releases of radioactive liquid effluent from the 21-011(k) outfall. LAOI-3.2 originally was planned to be 300 ft deep to investigate the occurrence of possible perched water identified in the Puye Formation by a borehole video taken during the drilling of nearby production well Otowi-4. However, during coring operations at LAOI-3.2 an upper perched zone was encountered from 140 to 163.5 ft below ground surface in the Guaje Pumice Bed A well was installed in this upper perched zone prior to reaching the original target depth of 300 feet. LAOI-3.2a is planned for the original target horizon in the Puye Formation. This well will help define the lateral extent of the deeper perched groundwater found in the Puye Formation at wells O-4 and R-6i.
Projected Depth	LAOI-3.2a will be sited within 50 ft of LAOI-3.2, near the confluence of DP and Los Alamos Canyons. Based on the depths of the perched zones at R-6i and O-4, the target depth is 300 ft or the top of Cerros del Rio basalt, whichever is encountered first. LAOI-3.2a will be drilled without core to 160 ft. Core will be collected from 160 to TD, or refusal, to satisfy the original investigation objectives of determining the extent of vertical migration of contaminants through the vadose zone.
Drilling Methods	This corehole will be advanced with HQ-size equipment. Air will be used to clear cutting from the hole. At greater depths, if needed, water be added to enhance cuttings removal. If groundwater is encountered at the projected depth and a well is to be installed, the borehole will be reamed either with hollow stem auger or a rotary bit. Only air or air and water will be used. Volumes and/or rates of drill additive usage will be accurately tracked and documented in the field log notebook.
Potential Drilling Fluids, Composition, and Use	The primary proposed drilling fluid is air. If necessary to clear cuttings from the borehole, water may be added to the air stream. No other fluids are proposed. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Little new geologic information will be gained because of the proximity of LAOI-3.2a to other deep wells; however, LAOI-3.2a will confirm stratigraphic contacts identified in the TW-3 and O-4 lithologic logs. • LAOI-3.2a will identify the occurrences of perched intermediate groundwater in the Puye Formation, if present. • Core from LAOI-3.2 and LAOI-3.2a will constrain the location and rate of percolation from the vadose zone to the regional aquifer by determining the vertical distribution of moisture and contaminants.
Potential Groundwater Occurrence & Detection	• Perched: 134 ft, perched water was encountered in the base of the Otowi Member and through the Guaje Pumice Bed at adjacent well LAOI-3.2. • Perched: 250 ft, perched water was encountered in the Puye Formation at nearby wells O-4 and R-6/R-6i Methods for groundwater detection may include; drillers observations, water level measurements, borehole video, and borehole geophysics

Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.
Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the identified suite of constituents including radionuclides, metals/cations, general inorganics, VOCs, and stable isotopes. • Subsequent groundwater monitoring will be conducted under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• borehole video camera will be used when open-hole conditions allow logging. • natural gamma and induction tools may be run, if needed for correlation to nearby wells A full suite of contracted geophysical logs will not be conducted at LAOI-3.2a.
Well Completion Design	A single well screen will be installed if perched intermediate groundwater is encountered in the Puye Formation at LAOI-3.2a. A well has already been installed at LAOI-3.2 for perched water found in the Guaje Pumice Bed. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include: pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

LAOI-3.2a Tentative Drilling Schedule	
Proposed Start Date November 13, 2005	
Activity	**Duration (days)**
Drilling	30
Development	7
Pumping Testing	14
Surface Completion	1
Investigation-Derived Waste Analyses	45
Site Restoration	7

Drilling Work Plan for Regional Aquifer Well LADP-5

Primary Purpose	LADP-5 is located on a mesa bench immediately south of DP Canyon and is designed to investigate the western extent of tritium-, nitrate-, and perchlorate-bearing perched groundwater that was recently discovered in R-6i.
Projected Depth	• **Corehole:** 350 ft or core refusal • **Intermediate Aquifer Borehole:** LADP-5 will be drilled to approximately 650 ft which is the R-6i zone of saturation.
Drilling Methods	**Corehole:** Dry drilling with a combination of hollow-stem-auger continuous sampling and HQ coring.
	Intermediate Aquifer Borehole: The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust suppression at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole stability Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	**Corehole:** Potable water, municipal water supply, aid in lubricity **Intermediate Aquifer Borehole:** The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Determine if the perched intermediate water zone detected at R-6i extends to this location • Determine the water quality in the perched intermediate zones (if present). • Core from LADP-5 will constrain the location and rate of percolation in the vadose zone from the former 0-11(k) outfall by determining the vertical distribution of moisture and contaminants.
Potential Groundwater Occurrence & Detection	• Perched: 520 ft, perched water is possible in the Guaje Pumice Bed • Perched: 600 ft, perched water is possible in the Puye Formation as evidenced in R-6i and O-4 Methods for groundwater detection may include; drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	• Core analytical samples will be collected from lined core barrels, sealed in ProtecCore™ moisture protection, and submitted to the SMO under Chain-of-Custody • Collect vadose zone core and analyze for anions, cations/metals, radionuclides, and stable isotopes at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, and 350 ft or until core refusal, whichever comes first.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the identified suite of constituents including radionuclides, metals/cations, general inorganics, VOCs, high-explosives compounds, and stable isotopes. • Subsequent groundwater monitoring will be conducted under the Interim Facility-Wide Groundwater Monitoring Plan.
Geophysical Testing	• borehole video camera will be used when open-hole conditions allow logging. • natural gamma and induction tools may be run, if needed for correlation to R-6/R-6i A full suite of contracted geophysical logs will not be conducted at LADP-5.
Well Completion Design	**Corehole:** Plugged and abandoned in accordance with the Consent Order
	Regional Aquifer Borehole: One screen will be placed within an optimal perched groundwater within the Puye Formation. A dedicated submersible pump will be used for groundwater sampling. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval • or the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include: pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

LADP-5 Tentative Drilling Schedule	
Proposed Start Date October 8, 2005	
Activity	**Duration (days)**
Drilling	30
Development	7
Pumping Testing	14
Surface Completion	1
Investigation-Derived Waste Analyses	45
Site Restoration	7

Drilling Work Plan for Intermediate Aquifer Well CdV-16-2(i)r

Primary Purpose	The purpose of this well is to replace the original CdV-16-2(i) which does not produce groundwater from the completed well screen. The replacement well will target the top of the groundwater zone encountered in original CdV-16-2(i) and will be located adjacent to the original well.
Projected Depth	Approximately 900 ft.
Drilling Methods	The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust controlled at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be included in the Well Completion Report.
Hydrogeologic objectives	Install a well in the uppermost intermediate perched water zone.
Potential Groundwater Occurrence & Detection	• Perched water was observed flowing into CdV-16-2(i) starting at approximately 825 ft. Methods for groundwater detection may include drillers' observations, water level measurements, borehole video, and borehole geophysics.
Core Sampling	Core will not be collected because • this is a mesa-top site away from any known surface contamination sources, and • nearby well R-25 did not encounter any contamination in the upper vadose zone.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.
Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development. This sample will be analyzed for the full suite of constituents including: radiochemistry, metals/cations, general inorganics, VOCs, high explosives, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• borehole video camera will be used when open-hole conditions allow logging. • natural gamma and induction tools may be run, if needed for selection of appropriate screen placement.
Well Completion Design	Single screen in the first encountered perched water (800-900 ft interval) fitted with a dedicated submersible pump

Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality is unacceptable, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick.

CdV-16-2(i)r Drilling Schedule	
Start Date July 1, 2005	
Activity	**Duration (days)**
Drilling/Well Construction	30
Development	7
Pump Testing	14
Surface Completion	1
Characterization Sampling	10–60 following development
Site Restoration	7

Drilling Work Plan for Regional Aquifer Well R-10

Primary Purpose	Installation of R-10 is required by the Consent Order and the Work Plan for Sandia Canyon and Cañada del Buey (LANL 1999, 64617). The location in lower Sandia Canyon was selected in coordination with NMED and the Pueblo of San Ildefonso. The R-10 location will have two regional aquifer boreholes. • R-10 is moved to lower Sandia Canyon to fulfill a request by the Pueblo of San Ildefonso for a monitoring well on their land. • Further refine the understanding of the effects of pumping in the Buckman well field. • The R-10 well pair will also test the conceptual model of contaminant transport from lower Pueblo Canyon to springs in the vicinity of White Rock. • R-10 is primarily a hydrology well and penetrates to depths sufficient to identify hydraulic responses to pumping at Buckman well field. • Secondarily, R-10 will be useful for monitoring groundwater for mobile constituents (e.g., tritium, nitrate, and perchlorate).
Projected Depth	Approximately 1165 ft, approximately 500 ft into the regional aquifer to target the high-permeability units that may be preferential flow pathways.
Drilling Methods	The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust controlled at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be included in the Well Completion Report.
Hydrogeologic Objectives	• Determine if perched intermediate water zones exist in basalts of the vadose zone, and check the water quality. • Determine the depth to regional groundwater in a poorly characterized area. • Determine the relationship of the water table to springs in White Rock Canyon. • Test the hypothesized flow path from Pueblo Canyon to the springs near White Rock. • Evaluate the influence of the Buckman well field on flow directions, velocity, and contaminant transport. • Secondary purpose is to monitor groundwater for mobile constituents (e.g. tritium, nitrate, and perchlorate)
Potential Groundwater Occurrence & Detection	• Perched: 280–380 ft, perched water was encountered in the lower part of Cerros del Rio basalt and in underlying sediments at nearby wells R-12 and PM-1. The perching horizon was clay- and silt-rich lake beds in both boreholes. • Regional: 665 ft, Regional groundwater is expected to occur in Santa Fe Group silts and sands. Methods for groundwater detection may include; drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	Core will not be collected because: • There is no known contamination in the area • Surface water infiltration occurs up-canyon and therefore no vadose zone contamination is expected
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the full suite of constituents including radiochemistry, metals/cations, general inorganics, VOCs, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• In the regional aquifer borehole, run a geophysical suite of logs to characterize moisture distribution and identify perched groundwater in the vadose zone and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used to select well screen depths. The suite and timing of geophysical logging will depend on borehole conditions. • LANL's borehole video camera will be used when open-hole conditions allow logging.
Well Completion Design	Two regional aquifer well screens will target high-permeability units. This well will be fitted with a multi-level sampling system such as Westbay or Barcad. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality is unacceptable, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include: pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick.

R-10 Drill Schedule	
Start Date August 23, 2005	
Activity	**Duration (days)**
Drilling of R-10a/Well Construction	30
Development of R-10a	7
Pump Testing at R-10a	14
Characterization Sampling of R-10a	10–60 following development
Drilling of R-10	45
Development of R-10	7
Pump Testing at R-10	14
Characterization Sampling of R-10	10–60 following development
Site Restoration at R-10a/R-10	7

Drilling Work Plan for Regional Aquifer Well R-10a

Primary Purpose	Installation of R-10 is a requirement of the Consent Order and the Work Plan for Sandia Canyon and Cañada del Buey (LANL 1999, 64617). The location in lower Sandia Canyon was selected in coordination with NMED and the Pueblo of San Ildefonso. The R-10 location will have two regional aquifer boreholes. • R-10a is the shallower of a pair of wells in lower Sandia Canyon on San Ildefonso Pueblo land • Intended to bound the eastern extent of contaminants detected in R-12 • Further refine the understanding of the effects of pumping in the Buckman well field. • R-10a is primarily a monitoring well designed to collect water-quality data near the top of the regional aquifer.
Projected Depth	765 ft, approximately 100 ft below the top of the regional aquifer.
Drilling Methods	The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust controlled at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Determine the stratigraphy in an area where no other data exist. • Corroborate stratigraphy with what was observed in R-16 and R-12. • Determine if perched intermediate water zones exist in basalts of the vadose zone, and check the water quality. • Determine the depth to regional groundwater in a poorly characterized area. • Determine the relationship of the water table to springs in White Rock Canyon. • Measure the water quality at the top of the regional aquifer. • Test the hypothesized flow path from Pueblo Canyon to the springs near White Rock. • Evaluate the influence of the Buckman well field on flow directions, velocity, and contaminant transport.
Potential Groundwater Occurrence & Detection	• Perched: 280–380 ft, perched water was encountered in the lower part of Cerros del Rio basalt and in underlying sediments at nearby wells R-12 and PM-1. The perching horizon was clay- and silt-rich lake beds in both boreholes. • Regional: 665 ft, Regional groundwater is expected to occur in Santa Fe Group silts and sands. Methods for groundwater detection include; drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	Core will not be collected because • there is no known contamination in the area, and • surface water infiltration occurs up-canyon and therefore no vadose zone contamination is expected.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the full suite of constituents including radiochemistry, metals/cations, general inorganics, VOCs, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• Natural gamma, induction and neutron logs may be run in R-10a to characterize moisture distribution, identify perched groundwater in the vadose zone, and to aid in placement of the screen in the regional aquifer.
Well Completion Design	Single screen in the first productive interval in the regional aquifer below the regional aquifer water table fitted with a dedicated submersible pump Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality is unacceptable, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick.

R-10a Drill Schedule	
Start Date July 12, 2005	
Activity	**Duration (days)**
Drilling of R-10a/Well Construction	30
Development of R-10a	7
Pump Testing at R-10a	14
Characterization Sampling of R-10a	10–60 following development
Drilling of R-10	45
Development of R-10	7
Pump Testing at R-10	14
Characterization Sampling of R-10	10–60 following development
Site Restoration at R-10a/R-10	7

Drilling Work Plan for Regional Aquifer Well R-17

Primary Purpose	Installation of R-17 is required by the Consent Order and is also included in the Work Plan for Pajarito Canyon (LANL 1998, 58820). R-17 will provide information on perched and regional aquifer groundwater in the west-central part of LANL, and more specifically in the area beneath the confluence of Pajarito and Twomile Canyons. The location is approximately 100 meters below (east) of the flood retention structure, downstream of SWMUs in TA-3, -6, -59, and 69.
Projected Depth(s)	• **Corehole**: 300 ft or core refusal • **Regional Aquifer Borehole**: R-17 will be drilled to approximately 1220 ft; 250 ft below the estimated top of the regional aquifer
Drilling Methods	**Corehole:** Dry drilling with a combination of hollow-stem-auger continuous sampling and HQ coring equipment.
	Regional Aquifer Borehole: The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust suppression at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	**<u>Corehole:</u>** Potable water, municipal water supply, aid in lubricity **<u>Regional Aquifer Borehole:</u>** The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Determine the extent of thick Cerro Toledo deposits in the central part of LANL • Determine the presence and character of Cerros del Rio (?) dacitic lavas • Determine the thickness and character of the Puye Formation These data are needed to refine the 3-D geologic model, which is critical for identifying geologic controls on groundwater pathways. • Identify the presence of perched intermediate saturated zones in order to evaluate groundwater pathways and interconnections between the surface and deep groundwater in Pajarito Canyon. • Measure the water table elevation in the regional aquifer. • Provide aquifer characteristics and chemistry data for improving the regional flow and transport model. • R-17 will provide water-quality data downgradient of release sites in the upper parts of the watershed and upgradient of TA-18. Springs in upper Pajarito Canyon contain explosive compounds; the probable source of contaminants is TA-15. However, it is unlikely contaminants from TA-15 are present in R-17, unless the water table map is not accurate in this location..
Potential Groundwater Occurrence & Detection	• Perched: 125 ft, perched water is possible in the Cerro Toledo interval • Perched: 570 ft, perched water is possible in the Guaje Pumice Bed • Perched: 680 ft, perched water in the Puye Formation on top of the Cerros del Rio basalt or Tschicoma dacite • Perched: 840 ft, perched water within the lavas • Regional: 970 ft, Regional groundwater is expected to occur in Puye Methods for groundwater detection may include drillers observations, water level measurements, borehole video, and borehole geophysics.

Core Sampling	• Core analytical samples will be collected from lined core barrels, sealed in ProtecCore™ moisture protection, and submitted to the SMO under Chain-of-Custody • Collect vadose zone core and analyze for anions, cations/metals, radionuclides, high explosives, barium,and stable isotopes at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, and 300 ft or until core refusal, whichever comes first. • Collect water sample if perched groundwater is encountered
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.
Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the identified suite of constituents including radionuclides, metals/cations, general inorganics, VOCs, high-explosives compounds, and stable isotopes. • Subsequent groundwater monitoring will be conducted under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• In the regional aquifer borehole, run a geophysical suite of logs to characterize moisture distribution and identify perched groundwater in the vadose zone and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used to select well screen depths. The suite and timing of geophysical logging will depend on borehole conditions (i.e. cased vs open hole). • In core hole and regional aquifer borehole, LANL's borehole video camera will be used when open-hole conditions allow logging. • In the core hole, LANL owned natural gamma and induction tools may be run, if needed, for correlation to the regional aquifer borehole
Well Completion Design	**Corehole:** Plugged and abandoned in accordance with the Consent Order
	Regional Aquifer Borehole: Up to two screens. One screen will be fully submerged in the Puye or the lavas near the top of the regional aquifer. If the lavas near the top of the aquifer have very low permeability, a second screen may be installed in more permeable rocks of the underlying Puye Formation. If the well is a single completion, then a dedicated submersible pump will be installed. If two screens are installed, then the well will be fitted with a multi-zone sampling system such as Westbay, Barcad, or equivalent as proposed by the drilling contractor. Well screens will be isolated with a removable bridge plug until the final dedicated sampling system is installed. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.

Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

R-17 Tentative Drilling Schedule	
Proposed Start Date November 14, 2005	
Activity	**Duration (days)**
Drilling	30
Development	7
Pumping Testing	14
Surface Completion	1
Investigation-Derived Waste Analyses	45
Site Restoration	7

R-17 Tentative Coring Schedule	
Proposed Start Date October 17, 2005	
Activity	**Duration (days)**
Coring	6

Note: The coring rig is a different rig than the drilling rig. See drilling schedule for all other activities related to the site.

Drilling Work Plan for Regional Aquifer Well R-24

Primary Purpose	Installation of R-24 is required by the Consent Order and will consist of two separate boreholes: a corehole drilled to investigate the anion and contaminant profile, and a borehole targeting the regional aquifer with the following in mind: • The original R-24 site in the Consent Order, located west of the Pajarito fault north of Cañon de Valle, is no longer needed for hydrologic characterization. • R-24 is being moved to Bayo Canyon, east of the former TA-10 site, to fulfill a Consent Order requirement for a regional well at that location. • R-24 will determine if perched intermediate water occurs beneath Bayo Canyon and to determine the water quality at the top of the regional aquifer in association with the TA-10 site investigation.
Projected Depth	• Corehole: 300 ft or to core refusal • Regional Aquifer Borehole: 840 ft, about 100 ft into the regional aquifer.
Drilling Methods	**Corehole:** Dry drilling with a combination of hollow-stem-auger continuous sampling and HQ coring equipment.
	Regional Aquifer Borehole: The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust suppression at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings • EZ-MUD™ may be added to improve foam performance and hole conditions Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.
Potential Drilling	**Corehole:** Potable water, municipal water supply, aid in lubricity

Fluids, Composition, and Use	**<u>Regional Aquifer Borehole:</u>** The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Further refine the edge of the Cerros del Rio basalt field. • Further evaluate the distribution of the pumiceous unit of the Puye Formation. • Refine the dip, thickness, and distribution of the Miocene basalt. • Determine if perched intermediate water zones exist and check the water quality. • Determine the regional aquifer water level and measure water quality in the regional aquifer.
Potential Groundwater Occurrence & Detection	• Regional: 740 ft - Regional groundwater is expected to occur in the older fanglomerate. Methods for groundwater detection may include drillers observations, water level measurements, borehole video, and borehole geophysics.
Core Sampling	• Core analytical samples will be collected from lined core barrels, sealed in Proteccore™ moisture protection, and submitted to the SMO under Chain-of-Custody • Collect vadose zone core and analyze for anions, cations/metals, radionuclides, and stable isotopes at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, and 300 ft or until core refusal, whichever comes first.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling and at the top of the regional aquifer, if not drilling with mud. • Collect screening water sample from the screen at the end of development. Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the full suite of constituents including radiochemistry, metals/cations, general inorganics, VOCs, and stable isotopes. • Subsequent groundwater samples will be collected under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• In the regional aquifer borehole, run a geophysical suite of logs to characterize moisture distribution and identify perched groundwater in the vadose zone and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used to select well screen depths. The suite and timing of geophysical logging will depend on borehole conditions (i.e. cased vs open hole). • In core hole and regional aquifer borehole, LANL's borehole video camera will be used when open-hole conditions allow logging. • In the core hole, LANL owned natural gamma and induction tools may be run, if needed for correlation to the regional aquifer borehole
Well Completion Design	**Corehole:** Plugged and abandoned in accordance with the Consent Order
	Regional Aquifer Borehole: Single screen in the first productive interval in the regional aquifer below the regional water table fitted with a dedicated submersible pump
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick. Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

R-24 Drilling Schedule	
Start Date July 27, 2005	
Activity	**Duration (days)**
Drilling/Well Construction	30
Development	7
Pump Testing	14
Surface Completion	1
Characterization Sampling	10–60 following development
Site Restoration	7

R-24 Tentative Coring Schedule	
Proposed Start Date August 1, 2005	
Activity	**Duration (days)**
Coring	6

Note: The coring rig is a different rig than the drilling rig. See drilling schedule for all other activities related to the site.

Drilling Work Plan for Regional Aquifer Well R-27

Primary Purpose	Installation of R-27 is required by the Consent Order. The location for R-27 in the "Hydrogeologic Workplan" (LANL 1998, 59599) was at the confluence of Cañon de Valle and Water Canyon. However, that location is technically not feasible, and it abuts sensitive threatened- and endangered-species habitat. After several visits, including some attended by NMED representatives, the well was moved to its current location about 1 mi below the confluence of Cañon de Valle and Water Canyon. R-27 will provide information about the presence of intermediate perched zones, and water quality in the regional aquifer downgradient of TA-11, -16, and -49.
Projected Depth	• **Corehole**: 300 ft or core refusal • **Regional Aquifer Borehole**: R-27 will be drilled to approximately 1100 ft, penetrating at least 300 ft into the regional aquifer and targeting more permeable sedimentary rocks below the lavas that are expected to be present at the water table. If the drilling conditions are too difficult to reach the target depth, the borehole will be drilled far enough below the water table to install a single screen.
Drilling Methods	**Corehole:** Dry drilling with a combination of hollow-stem-auger continuous sampling and HQ coring.
	Regional Aquifer Borehole: The primary drilling method will be air-rotary with fluid-assist to total depth. Fluid use will be minimized throughout the drilling process. • Borehole will be started by drilling dry with dust controlled at the surface discharge point • Water mist will be added to the injected air stream when air alone is not keeping the borehole clean of cuttings • QUIK-FOAM™ will be mixed with the injected water when the water alone is not keeping the borehole stable and clean of cuttings Borehole conditions may require the use of additional drilling fluids or alternative drilling methods. Conditions that may warrant this addition include greater borehole depths, minor borehole instability, or minor loss of circulation. Minor borehole instability is defined as sloughing of the borehole wall leading to loss of borehole depth. Minor loss of circulation is defined as reduced fluid returns to the ground surface short of complete loss of fluid returns. The second alternative for addressing unfavorable borehole conditions would be the use of drill casing. Casing may be used through highly unstable or high fluid-loss zones. Casing off the borehole would be preferred over mud-rotary at this location because of the likelihood of porous and fractured lava being encountered in the borehole. It is possible that mud-rotary drilling will not sufficiently address loss of circulation in potential voids, lava tubes, and fractures. Conventional mud-rotary drilling may be used in deeper, highly unstable formations if drill casing options have been exhausted. Conditions that may warrant the switch to mud-rotary include stuck casing, or if all casing strings have been telescoped in the hole and mud is necessary to retain usable borehole diameters.

Potential Drilling Fluids, Composition, and Use	**Corehole:** Potable water, municipal water supply, aid in lubricity **Regional Aquifer Borehole:** The following potential fluids and additives may be used and are consistent with those previously used in the drilling program at LANL and have been geochemically characterized. • Potable water, municipal water supply, aid in delivery of other drilling additives • QUIK-FOAM™, a blend of alcohol ethoxy sulfates, used as a foaming agent. It is added at 0.5–2.0 gallons per 100 gallons potable water. • EZ-MUD™, a liquid polymer emulsion containing partially hydrololyzed polyacrylamide/polyacrylate (PHPA) copolymer, used as a borehole stabilizer, and to increase lubricity and fluid viscosity. It is added at 0.5–1.0 quarts per 100 gallons potable water during foam or mud rotary drilling • Bentonite, sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is added at 15–50 pounds per 100 gallons potable water. • N-SEAL™, spun glass wool, lost circulation material at 20–70 pounds per 100 gallons of drilling fluid. • Drispac™, natural cellulosic polymer, reduces filtration loss into the formation and inhibits clay hydration. It is added at 0.5–1.0 pounds per 100 gallons of potable water during mud-rotary drilling. A detailed accounting of all fluids introduced and removed from the borehole will be documented on site and included in the Well Completion Report.
Hydrogeologic Objectives	• Determine if the lavas present are Cerros del Rio basalts or Tschicoma dacites. • Determine the presence and character of the Puye Formation. • Measure the thickness of the Cerro Toledo deposits. • Provide aquifer characteristics and water chemistry downgradient of firing and test sites to improve the regional flow and transport model. • Measure the permeability of the regional aquifer at this location.
Potential Groundwater Occurrence & Detection	• Perched: 170 ft, perched water is possible in the Cerro Toledo interval • Perched: 540 ft, perched water is possible in the Guaje Pumice Bed • Perched: 615 ft, perched water the Puye Formation on top of the Cerros del Rio basalt or Tschicoma dacite • Regional: 770 ft, Regional groundwater is expected to occur in Cerros del Rio basalt or Tschicoma dacite Methods for groundwater detection may include drillers observations, water level measurements, borehole video, and borehole geophysics
Core Sampling	• Core analytical samples will be collected from lined core barrels, sealed in ProtecCore™ moisture protection, and submitted to the SMO under Chain-of-Custody • Collect vadose zone core and analyze for anions, cations/metals, radionuclides, and stable isotopes at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, and 300 ft or until core refusal, whichever comes first.
Groundwater Screening Sampling	• Collect screening water samples during drilling at any perched horizon producing sufficient water for sampling • Collect samples for Total Organic Carbon analysis during development • Collect screening water sample from the well at the end of development Screening samples of groundwater will be analyzed for cations/metals (dissolved & total) and anions (dissolved) by the LANL EES-6 chemistry laboratory.

Groundwater Characterization Sampling	• A groundwater sample will be collected from the completed well between 10 and 60 days after well development, in accordance with the Consent Order. This sample will be analyzed for the identified suite of constituents including radionuclides, metals/cations, general inorganics, VOCs, high-explosives compounds, and stable isotopes. • Subsequent groundwater monitoring will be conducted under the Interim Facility-Wide Groundwater Monitoring Plan
Geophysical Testing	• In the regional aquifer borehole, run a geophysical suite of logs to characterize moisture distribution and identify perched groundwater in the vadose zone and to characterize the hydraulic properties of saturated rocks in the regional aquifer. The geophysical logs will also be used to select well screen depths. The suite and timing of geophysical logging will depend on borehole conditions (i.e. cased vs open hole). • In core hole and regional aquifer borehole, LANL's borehole video camera will be used when open-hole conditions allow logging. • In the core hole, LANL owned natural gamma and induction tools may be run, if needed for correlation to the regional aquifer borehole
Well Completion Design	**Corehole:** Plugged and abandoned in accordance with the Consent Order
	Regional Aquifer Borehole: One screen will be fully submerged in Tschicoma (?) lava near the top of the regional aquifer. If the lavas near the top of the aquifer have very low permeability, a second screen may be installed in more permeable rocks of the underlying sedimentary rock units. The well will be fitted with a multi-zone sampling system such as Westbay, Barcad, or equivalent as proposed by the drilling contractor. Well screens will be isolated with a removable bridge plug until the final dedicated sampling system is installed. Detailed description of well construction methods, materials, and quantities will be included in the Well Completion Report.
Well Development	Well may be developed by both mechanical and chemical means. Mechanical means include the following: • air-lifting • swabbing • surging and bailing • pumping. In general, well development will proceed from removing the large solids by air-lifting and/or bailing, followed by swabbing, and ending with pumping. If the water quality has not met the required target parameters, then swabbing may be repeated followed by pumping. If repeated attempts to improve water quality are unsuccessful, then well development chemicals may be employed. Chemical well development methods may be used to remove added or natural clays and to kill bacteria around the well. Chemicals and recommended application concentrations include the • use of sodium acid pyrophosphate (SAPP) at 15 pounds per 1,000 gallons of water in the targeted interval or • the use of AQUA-CLEAR PFD™ at 1 gallon per 500 gallons of water in the targeted interval. Water quality parameters will be monitored at the wellhead and may include the use of a flow-through cell. The parameters to be monitored include pH, specific conductance, temperature, turbidity, and total organic carbon (TOC). Target water quality parameters: turbidity < 5 NTU, TOC < 2 ppm, other parameters stable
Hydraulic Testing	Conduct single-step pumping test or slug tests. Water will not be added to the formation regardless of test type.
Surface Completion	A surface pad will be constructed of 2,500 psi concrete. The pad will be 5-ft by 5-ft and 6-in. thick Steel protective casing will be set in the concrete pad and the well secured with a locking lid. Steel bollards will be set in concrete just outside the concrete pad to protect the well installation.

R-27 Drilling Schedule	
Start Date October 7, 2005	
Activity	**Duration (days)**
Drilling	30
Development	7
Pumping Testing	14
Surface Completion	1
Investigation-Derived Waste Analyses	45
Site Restoration	7

R-27 Tentative Coring Schedule	
Proposed Start Date September 15, 2005	
Activity	**Duration (days)**
Coring	6

Note: The coring rig is a different rig than the drilling rig. See drilling schedule for all other activities related to the site.