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Date: June 28, 2006
Refer to: EP2006-0618

Mr. James Bearzi
NMED – Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

RECEIVED
JUN 2006
Hazardous Waste Bureau

SUBJECT: SUBMITTAL OF THE DRILLING WORK PLAN FOR REGIONAL MONITORING WELL R-35

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the "Drilling Work Plan for Regional Monitoring Well R-35." Submittal of this work plan fulfills requirement (#14) in the New Mexico Environment Department's (NMED's) approval with modifications for the "Interim Measures Work Plan for Chromium Contamination in Groundwater," dated May 5, 2006. The requirement calls for a work plan to be submitted to NMED within 30 days of receipt of the letter for installing a regional monitoring well "with the sole objective of delineating the vertical extent of contamination in the regional aquifer near the location of well R-28."

A letter from Los Alamos National Laboratory (LANL) dated June 9, 2006, and the associated approval from NMED dated June 15, 2006, changed the due date for the work plan to June 30, 2006. The R-35 work plan proposes an alternate location that was agreed to following a meeting with NMED on May 12, 2006. The proposed well will meet NMED's requirement and will provide additional information to address further the nature and extent of chromium contamination and any potential impacts on supply well PM-3.

If you have questions, please contact Danny Katzman (505) 667-6333 (katzman@lanl.gov) or Mat Johansen at (505) 665-5046 (mjohansen@doeal.gov).

Sincerely,

for Andrew Phelps, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

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

AP/DG/DK/ew

Enclosure: Two hardcopies and two electronic files of the Drilling Work Plan for Regional Monitoring Well R-35

Cy: (w/enc)
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LA-UR-06-3964
June 2006
ER2006-0533

Drilling Work Plan for Regional Aquifer Wells R-35a and R-35b

Los Alamos
NATIONAL LABORATORY
EST. 1943

CD included with this document

Prepared by Environmental Programs–Water Stewardship Program

Los Alamos National Laboratory, operated by Los Alamos National Security, LLC, for the U.S. Department of Energy under Contract No. DE-AC52-06NA25396, has prepared this document pursuant to the Compliance Order on Consent, signed March 1, 2005. The Compliance Order on Consent contains requirements for the investigation and cleanup, including corrective action, of contamination at Los Alamos National Laboratory. The U.S. government has rights to use, reproduce, and distribute this document. The public may copy and use this document without charge, provided that this notice and any statement of authorship are reproduced on all copies.

LA-UR-06-3964
ER2006-0533

Drilling Work Plan for Regional Aquifer Wells R-35a and R-35b

June 2006

Responsible project leader:

Danny Katzman	for	Project Leader	EP-WSP	6/30/06
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Andrew Phelps		Associate Director	EP	6/30/06
Printed Name	Signature	Title	Organization	Date

Responsible DOE representative:

David Gregory		Federal Project Director	DOE-LASO	
Printed Name	Signature	Title	Organization	Date

Primary Purpose	Two single-screen wells, R-35a and R-35b, are being installed in the vicinity of municipal supply well PM-3 to satisfy a requirement stated in the New Mexico Environment Department (NMED) letter dated May 5, 2006, "Approval with Modifications for the Interim Measures Work Plan for Chromium Contamination in Groundwater," to evaluate vertical migration of chromium contamination in the regional aquifer. The original site for this investigation was in the vicinity of R-28, but the location was moved near PM-3 after consulting with NMED (Figure 1). The two single-screen wells at the R-35 location will result in two well screens set at different depths in the regional groundwater system for measuring water quality and pumping responses associated with pumping at production wells, especially at PM-3 (Figure 2). • R-35a, the deeper of the two wells, will contain a well screen that is placed within the depth interval of the upper part of the well screen (louvers) at PM-3. R-35b will contain a well screen placed near the top of the regional zone of saturation. The paired-well configuration is designed to answer the following questions about water quality: (1) is chromium contamination present in regional groundwater near PM-3, and (2) if present, does chromium in groundwater vary as a function of depth, and is it likely to be drawn into the well screen at PM-3? If chromium contamination is not present, then the R-35 wells will be used as sentry wells for PM-3. • Water levels in the paired wells will be monitored using dedicated transducers to identify hydraulic responses to pumping at production wells, especially PM-3. These data will be used to evaluate hydraulic connectivity in the regional zone of saturation between the upper portions of the regional groundwater and deeper zones corresponding to the upper screen interval at PM-3. Figure 2 shows the stratigraphy, lithology, and selected borehole geophysical logs for PM-3. Figure 3 is a geologic cross section showing the distribution of hydrostratigraphic units in the vicinity of wells R-28 and PM-3 and the predicted geology at the two R-35 wells.
Conceptual Model	Hexavalent chromium contamination is present in the upper part of the regional groundwater system at R-11 and R-28. Natural hydraulic gradients in the area are expected to cause the contamination to move eastward with possible local northeast gradients resulting from the pumping of municipal water at PM-3 (Figure 3). Thick Miocene basalt probably provides a lower confining bed for the vertical movement of chromium contamination, restricting the movement of chromium to the portion of the aquifer adjacent to the upper part of the well screen at PM-3. Two conceptual models of groundwater flow were presented in the "Interim Measures Work Plan for Chromium Contamination in Groundwater." According to the first conceptual model, the top of the regional zone of saturation has a poor hydrologic connection with deeper zones pumped at PM-3 because of the strong vertical anisotropy of aquifer materials. In this case, groundwater flows laterally downgradient and may not be drawn into the submerged screen at PM-3. According to the second conceptual model, natural and pumping-induced vertical gradients cause groundwater to be drawn towards the PM-3 well screen, resulting in the distribution of chromium over a greater vertical depth. The two R-35 wells are designed to test elements of these conceptual models by determining the eastern extent of chromium contamination in the vicinity of PM-3 and the vertical distribution of chromium in the interval near the top of the PM-3 well screen.
Drilling Approach	The conceptual drilling approach for installing R-35a and R-35b is given in Attachment 1. R-35a is the deeper of the two boreholes, and it will be installed first so information about the hydrologic properties of the rocks in the interval between the water table and the top of the Miocene basalt may be collected before the target depths of two well screens are selected. Fluid-assisted air-rotary drilling is the primary method for advancing both boreholes through the vadose zone. Use of drilling fluids will be minimized to the extent possible, but where needed, a graded approach to the introduction of drilling fluids will be used to avoid problems with drilling, as described in the following section. Once the boreholes reach the lower part of the vadose zone (approximately 700-ft depth), drill casing will be lower into a bentonite plug placed at the bottom of the borehole. This sealed drill casing will isolate possible perched zones and stabilize the upper parts of the borehole before drilling into the regional zone of saturation. An attempt will be made to drill into the regional zone of saturation using fluid-assisted air-rotary methods in an open borehole. An open borehole is particularly desirable at R-35a because a more complete suite of geophysical logs can be collected in uncased boreholes, leading to more complete characterization of the regional zone of saturation. As the open borehole is advanced, caving of poorly consolidated geologic units such as the

	Totavi Lentil and Santa Fe Group deposits may result in unstable borehole conditions that could lead to the loss of drilling equipment and possibly the borehole itself. If unstable conditions are detected, smooth-walled casing will be used to advance the borehole past the unstable zones. The use of a casing-advance system in conjunction with open-hole air-rotary drilling may be sufficient to reach the target depth of the boreholes. However, mud-rotary drilling may be used to complete the R-35a borehole in the event that insurmountable borehole stability problems are encountered while drilling with air-rotary and casing-advance systems. Aggressive and timely well-development techniques will be used to minimize the impacts of drilling fluids on water quality in the completed well. The planned well development activities are described below.
Potential Drilling Fluids, Composition, and Use	Fluids and additives may be used in different combinations to overcome drilling problems. A graded approach will be used when introducing or increasing fluids so that as little fluid as possible is used to complete the borehole. The graded approach also defers the use of additives such EZ-MUD and bentonite until such time other methods for producing stable borehole conditions are exhausted. The following fluids and additives are consistent with those previously used in the drilling program at Los Alamos National Laboratory (LANL) and have been characterized geochemically. • Compressed air, a fluid to circulate cuttings from the borehole, will be used during all air-rotary drilling operations; • Potable water from the municipal water supply will be used during all fluid-assisted air-rotary drilling to aid circulation of cuttings and aid delivery of other drilling additives; • QUIK-FOAM, a blend of alcohol ethoxy sulfates, is a foaming agent, and it will be used during all fluid-assisted air-rotary drilling to aid circulation of cuttings; • EZ-MUD is a liquid polymer emulsion containing partially hydrolyzed polyacrylamide/polyacrylate (PHPA) copolymer. Because of the potential impact on groundwater quality, its use is limited to drilling situations where it can improve borehole stability or it is needed to control lubricity and fluid viscosity when drilling with bentonite or foam; • Bentonite, a sodium-montmorillonite clay, increases viscosity and reduces filtration loss into the formation. It is the primary circulation fluid during mud-rotary drilling, the drilling technique of last resort if air-rotary and casing-advance systems encounter insurmountable borehole stability problems; • N-SEAL, spun glass wool, is lost-circulation material, and it will be used when lost-circulation zones are encountered during air-rotary and mud-rotary drilling; and • PAC-L, natural cellulosic polymer, is added to bentonite during mud-rotary drilling to reduce filtration loss into the formation.
Hydrogeologic and Geochemical Objectives	• The objective of the shallow screen at R-35b is to further define the lateral extent of chromium contamination in the regional groundwater. The proposed location is especially important for determining if LANL-derived contamination is present in regional groundwater in the vicinity of PM-3. • The deep screen at R-35a will help define the vertical extent of chromium (and other) contamination and is especially important in the context of monitoring for potential impacts to PM-3 because it will be placed within a zone that may be a potential pathway for contamination to enter PM-3. • If chromium is not present in one or both wells, the R-35 well pair may be used as sentry wells upgradient of PM-3. • Water levels at R-35a and R-35b will be continuously monitored during pumping of PM-3 to evaluate the hydraulic connectivity in the regional zone of saturation between the water table and the upper production zone at PM-3. • A secondary objective is to determine if perched-intermediate water zones occur in the vicinity of PM-3. This purpose will be addressed to the extent possible allowed by borehole conditions, but drilling methods will be optimized to install the two regional aquifer wells.

Potential Groundwater Occurrence and Detection	• *Perched:* 500–600 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 is clay- and silt-rich lake beds. • *Regional:* 795 ft, regional groundwater is expected to occur in the Totavi Lentil and in underlying Santa Fe Group sands. Methods for groundwater detection may include driller's observations about water production, water-level measurements, borehole video, and borehole geophysics.
Core Sampling	• Core will be collected from the surface to the top of Cerros del Rio basalt in adjacent core hole SCC-6 that is scheduled to be drilled as part of the approved "Interim Measures Work Plan for Chromium Contamination in Groundwater." If borehole conditions are favorable, 10 to 20 ft of core will be collected in two intervals: (1) at total depth in R-35a and (2) at total depth in R-35b. The core will be used to assess the ability of aquifer materials to react with dissolved chromium along regional groundwater flow paths. These data support evaluation of monitored natural attenuation as a possible remedy.
Groundwater Screening Sampling	• Screening water samples will be collected during drilling at any perched horizon producing sufficient water for sampling. • A screening water sample will be collected from each well screen at the end of development. Screening samples of groundwater will be analyzed for cations/metals (dissolved and total) and anions (dissolved) by the Earth and Environmental Sciences (EES-6) chemistry laboratory.
Groundwater Characterization Sampling	• Groundwater samples will be collected from the completed wells between 10 and 60 days after well development, in accordance with the requirements of the March 1, 2005, Compliance Order on Consent. These samples will be analyzed for the full suite of constituents, including radiochemistry, metals/cations (including hexavalent chromium), general inorganic chemicals, volatile organic compounds, and stable isotopes. • Subsequent groundwater samples will be collected under the "Interim Measures Work Plan for Chromium Contamination in Groundwater" and the "Interim Facility-Wide Groundwater Monitoring Plan."
Geophysical Testing	• In R-35a, a full suite of geophysical logs will be run in the open borehole, if possible. The logs will be collected by Schlumberger, Inc., and include triple lithodensity, array induction, combined magnetic resonance, natural and spectral gamma, elemental capture sonde, thermal and epithermal neutron, and formation microimager logs. In cased portions of the borehole, the geophysical logs will include triple lithodensity, natural and spectral gamma, elemental capture sonde, and thermal and epithermal neutrons. These logs will be used 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, gamma, and induction tools will be used if open-hole conditions allow logging from the surface to approximately 700-ft depth in R-35a.
Well Completion Design	Two single-screen wells will be installed in the regional zone of saturation. The shallow well (R-35b) will target a high-permeability unit near the regional water table. The deep well (R-35a) will target a high-permeability zone adjacent to the upper part of the well screen in PM-3.

Well Development	The well may be developed by both mechanical and chemical means. The mechanical means is the primary method of development and includes swabbing, bailing, air lifting, jetting, and pumping. The chemical means will be used only in cases where mechanical means are ineffective in removing residual drilling fluids. The chemical means include using sodium acid pyrophosphate (SAPP) or AQUA-CLEAR PFD to remove natural and added clays and/or chlorination to kill bacteria introduced during well completion. The general approach to well development is as follows: • After the well is bailed and the screen is swabbed, a pump will be raised and lowered across the well screens during pumping development. Jetting and air lifting will be used as necessary to assist in development. These development steps will be repeated as necessary until water-quality parameters indicate that development is successful. • Water-quality parameters to be monitored include pH, specific conductance, temperature, turbidity, total organic carbon (TOC), and acetone, as applicable. The target water-quality parameters are turbidity of less than 5 nephelometric turbidity units and TOC of less than 2 parts per million, and the other parameters stable.
Hydraulic Testing	A single-step pumping test, injection test, or slug test will be conducted in each well.
Number of Well Screens	Two single-screen wells will be installed. At R-35b, the screen will be about 20 ft in length, and the target depth is estimated to be about 50 ft below the regional water table. At R-35a, the screen will be about 10 ft in length, and the target depth is estimated to be about 300 ft below the water table. Figure 3 shows the approximate positions of the well screens, but their actual positions will be based on characterization data from drill cuttings and borehole geophysical logs collected at R-35a.
Sequence and Duration of Drilling Activities: Proposed Start Date September 25, 2006	• Drilling: 45 days • Well development: 10 days • Pump testing: 14 days • Characterization sampling: 10 to 60 days following well development • Site restoration: 7 days

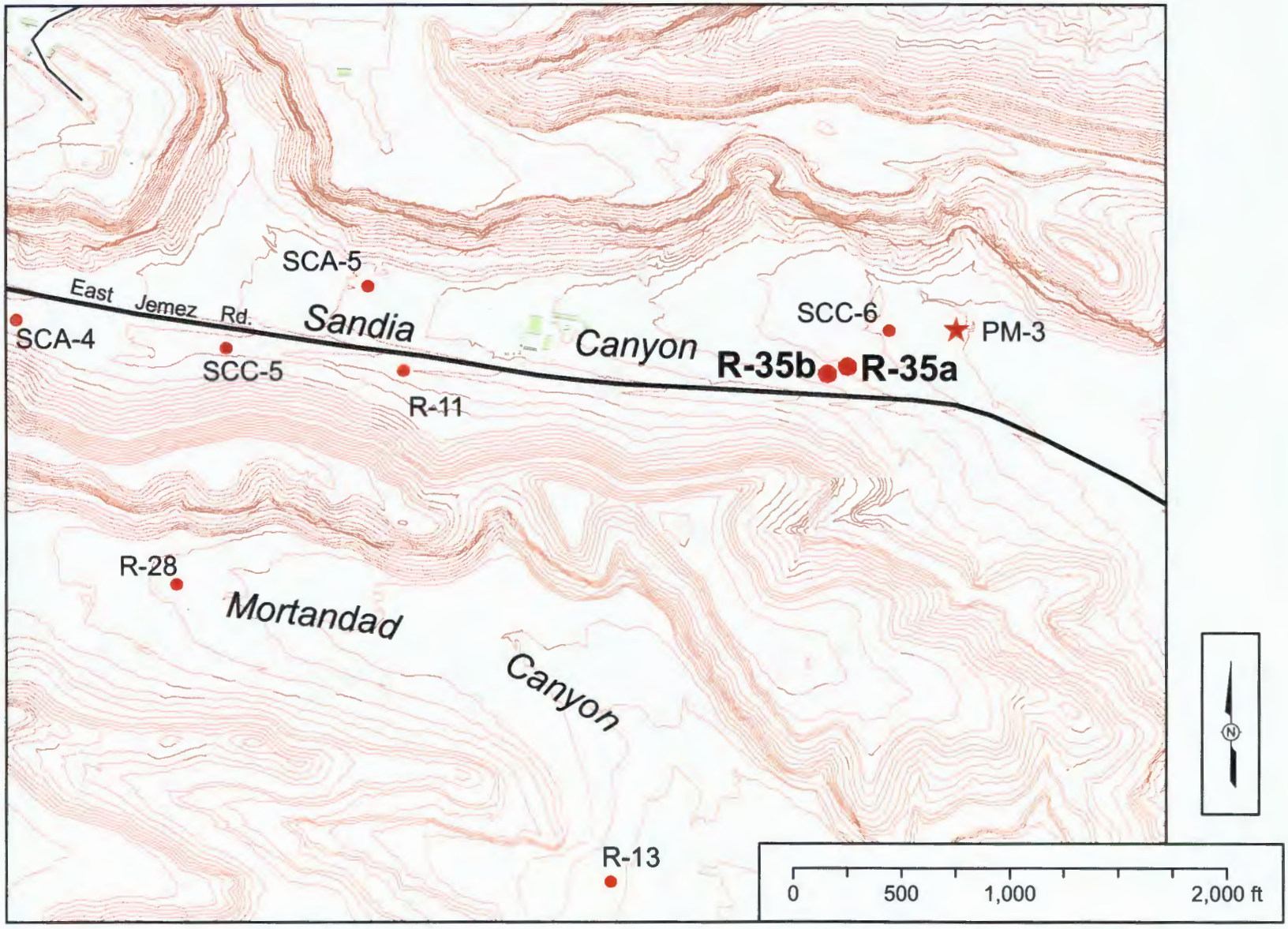


Figure 1. **Map showing locations of proposed monitoring well R-35, municipal supply well PM-3, and characterization wells R-11 and R-28 that contain chromium contamination**

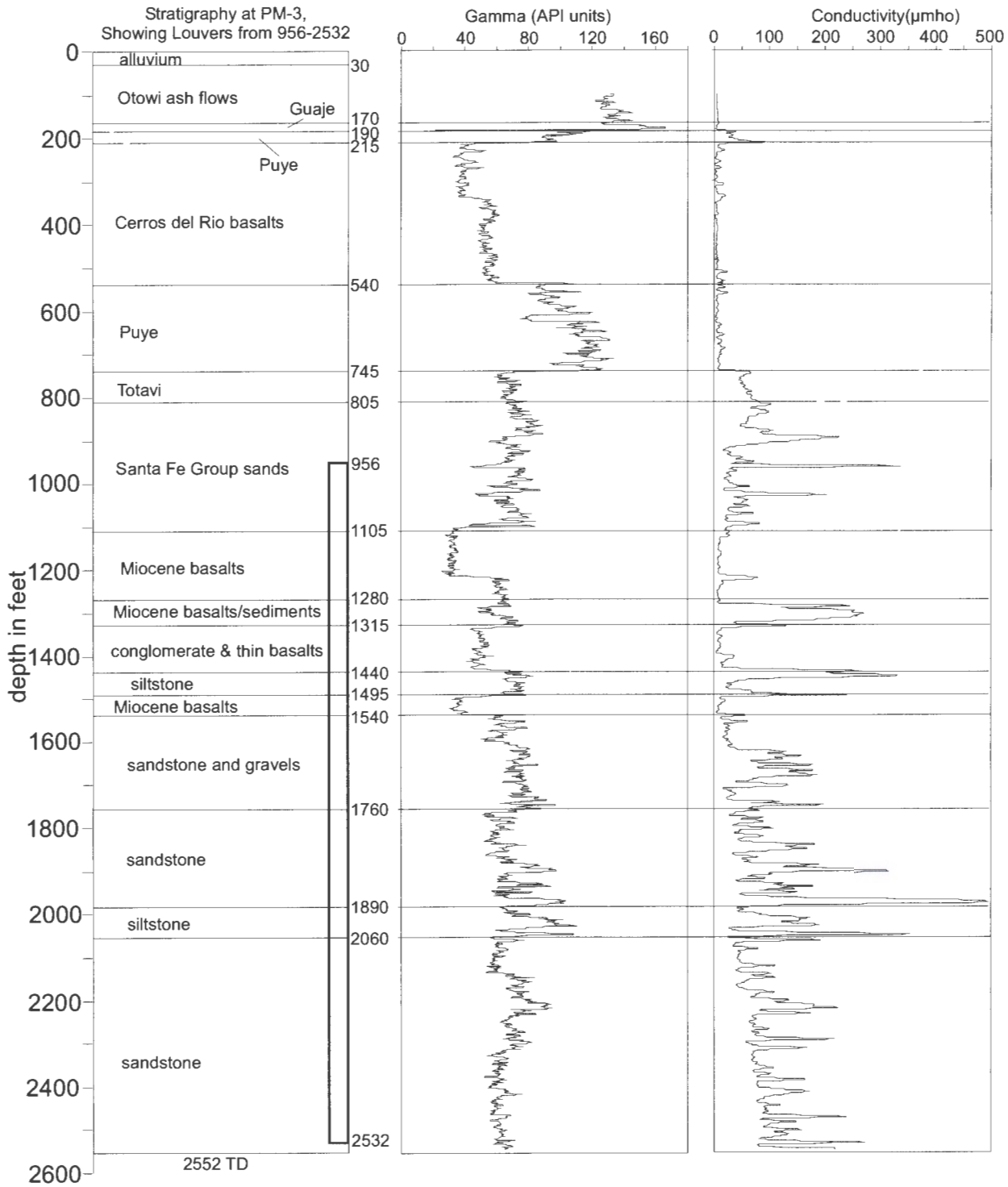
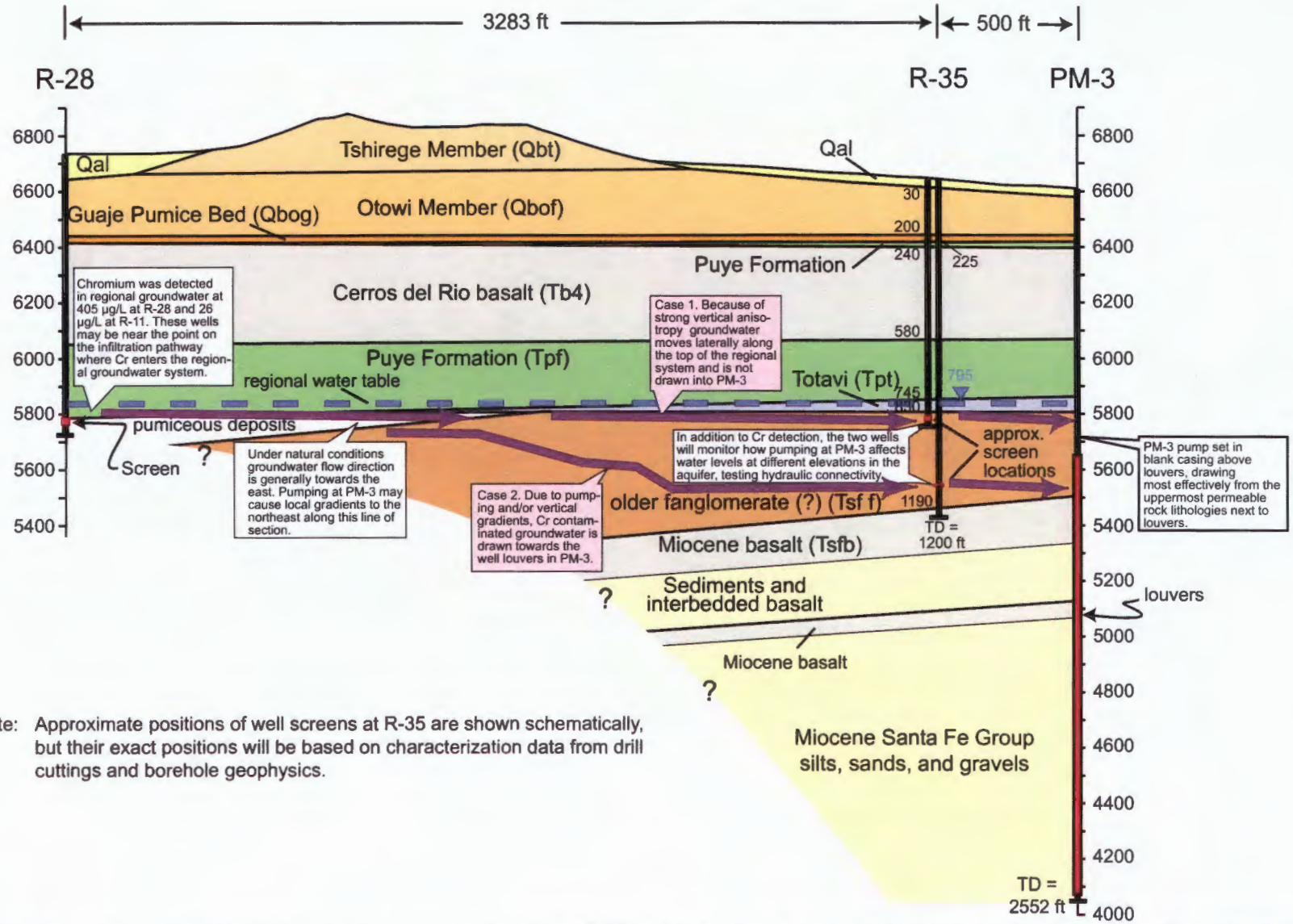


Figure 2. **Lithologic log for municipal supply well PM-2 showing position of well louvers and borehole gamma and conductivity logs**

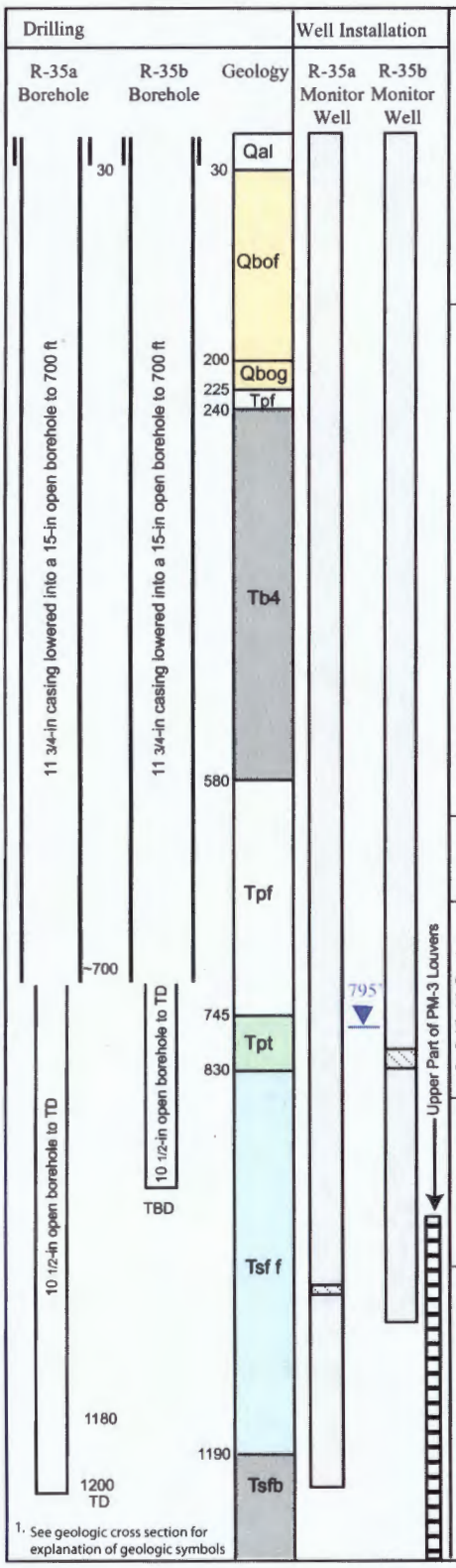


Note: Approximate positions of well screens at R-35 are shown schematically, but their exact positions will be based on characterization data from drill cuttings and borehole geophysics.

Figure 3. Conceptual hydrogeologic cross-section from R-28 to PM-3 showing the distribution of geologic units, the water table (blue dashed line), predicted geology at monitoring wells R-35a and R-35b, and potential chromium groundwater pathways (purple arrows)

Attachment 1

Conceptual Drilling Approach
for Installing Wells R-35a and R-35b



GENERAL APPROACH

Two single-screen wells will be installed in separate boreholes. The deeper of the two wells will be installed first so that borehole geophysics can be used to guide selection of screen locations in both wells. Drill cuttings and geophysical data collected from the first borehole will be used to characterize geologic contacts, depth of the regional water table, and high-permeability zones within the regional aquifer. The target depth for the first borehole is approximately 1220 ft, and it includes the upper 425 ft of the regional ground water system, which has a predicted water level of 795 ft below ground surface. In the first well, the well screen will be placed in the highest permeability zone that is within the upper portion of the screen at PM-3. The second well will target the most permeable zone near the top of the regional groundwater.

CONCEPTUAL DRILLING METHODS

R-35a well:

1. Set conductor thru the alluvium to estimated 30'+ depth.
2. Drill a 15" hole using air rotary with foam and fluid assistance down to 700'+-.
3. At 700+-, log open borehole using LANL geophysical tools and camera.
4. Lower in a string of 11¾" casing to 700'+-.
5. Attempt to drill to total depth using fluid-assited air-rotary drilling; switch over to casing advance system if neccesary to overcome borehole stability problems.
6. Rig up a casing advance system and advance the 11 ¾" casing to base of Totavi at ~830'.
7. With reverse circulation, drill out of 11 ¾" casing with a 10 ½" bit using air rotary with foam and fluid assistance down to 1180 ft. If problems are encountered, use a 9 5/8" casing advance system to get to TD.
8. If casing advance systems cannot achieve target depth, switch to mud-rotary drilling.
9. Collect 10 to 20 ft core at total depth of the borehole (core from 1180 to 1200 ft).
10. Collect open- and/or cased-hole geophysics for regional groundwater system, as appropriate.
11. Install single-screen well.

R-35b well:

The R-35b monitoring well will be drilled upgradient of the R-35a well to avoid the effects of drilling fluids used to install the deeper borehole. The drilling techniques used at R-35b are the same as those used at R-35a, except conventional circulation air-rotary methods will be used. Collect 10 to 20 ft of core at total depth.

SAMPLE SYSTEM

A submersible pump will be installed in both wells.

WELL DEVELOPMENT

Well development will include bailing, airlifting, jetting, and surging. Well screens will be further developed by pumping. The pump will be moved across the well screen to clean up the entire screen length. The development steps described above will be repeated as necessary until water quality parameters indicate that development was successful. Water samples will be collected and analyzed during the various stages of development using field and rapid turn-around laboratory methods to evaluate the presence of residual drilling fluids.

ADVANTAGES OF THIS APPROACH

- If the deep borehole can be drilled without casing advance, a full suite of open-hole geophysical logs can be collected to guide selection of well-screen intervals.
- Single-screen wells with submersible pumps are relatively easy to install and can be developed more thoroughly.

DISADVANTAGES OF THIS APPROACH

- This approach requires that two separate boreholes be drilled successfully.
- In the deep borehole, reaching the target depth in the regional groundwater system involves significant risk.
- If casing advance becomes necesary, especially in the deep borehole, then building a well inside of casing could lead to construction problems such as sloughing during casing retraction or the inability to retract the casing over one or both screen intervals.
- Collection of poorly consolidated core in a water-filled borehole may have limited success if air-circulation during coring is necessary because the resulting turbulence may cause core disaggregation.