General 7/13/04

GROUNDWATER CONTAMINATION IN THE REGIONAL AQUIFER

BENEATH

THE LOS ALAMOS NATIONAL LABORATORY

LANL General (Groundwater, wells)

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ABSTRACT

In the past several years, the Los Alamos National Laboratory (LANL) has installed an extensive network of monitoring wells for detection of chemical and radioactive contaminants in the regional aquifer. Unfortunately, misinterpretation of the sampling data and inadequate installation of the monitoring wells have concealed the fact that radionuclide and chemical contaminants are present in the regional aquifer beneath canyon and mesa settings. Although the current levels of these contaminants are probably below any harmful level, it is the apparent inability to acquire reliable data and to interpret it properly that generate concern. This report documents the installed features of the monitoring wells that distort the data and particular trends in the data that reveal a failure to recognize the situation. There is an immediate need for installation of additional monitoring wells at critical locations.

LANL'S investigation of the regional aquifer is intended to comply with the Resource Conservation and Recovery Act (RCRA). However, many of the LANL monitoring wells do not meet RCRA requirements. One requirement of RCRA is that monitoring wells shall provide groundwater samples that are representative of the groundwater in the aquifer strata. The majority of the LANL monitoring wells were drilled using polymer-based drilling fluids and/or bentonite clay muds that may prevent the detection of contamination and/or introduce false indications of contamination.

The drilling fluids caused the groundwater chemistry at the immediate location of many monitoring wells to change from oxidizing to strongly reducing. The new, unnatural chemistry that surrounds the monitoring wells will remove many contaminants including radionuclides from groundwater entering the wells by chemical processes that include adsorption, precipitation, coprecipitation, and reductive precipitation. Uranium is an important radionuclide contaminant at LANL that is removed from groundwater entering many monitoring wells by reductive precipitation.

The bentonite clay in drilling muds is a strong adsorbent to remove many radionuclide contaminants from the groundwater. Furthermore, the bentonite clay muds and drilling fluids also reduce the permeability of the aquifer strata near the wells, with the result that water samples are collected from the stagnant zone that surrounds the wells and do not represent the chemistry of the groundwater in the aquifer. LANL is aware of the altered zone of chemistry that surrounds the screened intervals in many monitoring wells, and predicts that the altered chemistry will be present for the next three to ten years. However, LANL reports to the public do not adequately represent this uncertainty.

This report presents findings from the trend analyses of LANL contaminant data for groundwater samples collected from the recently installed set of monitoring wells. The trend analyses confirm that the radionuclide contaminants strontium-90 and technetium-99 are present in groundwater in the regional aquifer and illustrate the action that would be expected by the injection of drilling fluids and bentonite clay muds into the aquifer strata. The trend analyses prove the presence of the radionuclide contaminants in the regional aquifer beneath the Laboratory facility but do not reveal the level of contamination actually present in the groundwater.

This report presents findings that technetium-99 and chemical contaminants are present in groundwater beneath the LANL low-level radioactive waste disposal landill, MDA G. It is possible that other radionuclide contaminants are present in the regional aquifer beneath MDA G.

This report presents a review of the design of LANL monitoring wells and an evaluation of selected data, showing that at many monitoring well locations, screens were not installed in the aquifer strata having the highest hydraulic conductivity (i.e., permeability). The strata with the highest hydraulic conductivity are expected to have the highest levels of contamination and are the fast pathways for travel of contaminated groundwater. One example of LANL's inability to install well screens in aquifer strata that have high hydraulic conductivity is the monitoring well that is installed for monitoring the impact of MDA G on the regional aquifer. At this well the screens were not installed in the high hydraulic conductivity strata present in the basalt and in gravels of the channel of the ancestral river that is present below MDA G.

The poor understanding of groundwater contamination beneath MDA G creates concerns for the continued operation of the RCRA disposal facility and for DOE's strategy to leave the large volume of legacy wastes "buried in place" at many locations on the Laboratory facility.

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1.0 Executive Summary

The regional aquifer beneath the Los Alamos National Laboratory (LANL) is a valuable groundwater resource. Beneath canyon and mesa settings, groundwater in the regional aquifer is contaminated with radionuclide and chemical contaminants. Presently, the nature and extent of the groundwater contamination is poorly understood. There is also insufficient knowledge of the physical setting of the regional aquifer with a special need for the study of aquifer strata that are fast pathways for contaminated groundwater.

LANL's investigation of the regional aquifer is intended to comply with RCRA. However, many of the LANL monitoring wells do not meet RCRA requirements. The monitoring wells were installed in boreholes drilled with drilling fluids and bentonite clay muds. The fluids and bentonite clay capture many radionuclide and chemical contaminants and remove them from groundwater entering the wells. In addition, many LANL monitoring wells have the well screens installed in inappropriate aquifer strata; water samples do not come from strata most likely to be contaminated.

LANL reports to the public claim the only radionuclide contaminant in the regional aquifer to be very low levels of tritium. Trend analyses in this report confirm that the radionuclide contaminants technetium-99 and strontium-90 are present in the regional aquifer. Other radionuclide contaminants may be present. The improper installation of monitoring wells prevent an accurate understanding of the type and levels of radioactive and chemical contaminats that are present.

The principal source for radionuclide and chemical contamination in the canyon settings are the large volumes of liquid wastes from Laboratory operations that were discharged to the canyons over the past 60 years. The data in LANL reports show that strontium-90 contamination is present in the regional aquifer beneath Los Alamos and Mortandad Canyons. Other radionuclide contamination may be present. The chemical contamination include perchlorate and solvents.

The principal source of contamination for mesa settings are the many landfill disposal sites (LANL MDA's) that contain large volumes of radioactive and chemical wastes. Landfill disposal of chemical and radioactive wastes has been a disposal practice since the early years of Laboratory operations.

MDA G is a 65-acre landfill that has been in operation since the 1950's. Large volumes of chemical and radioactive wastes are disposed of in trenches and shafts at MDA G. Presently, MDA G is the Laboratory's active facility for landfill disposal of low-level radioactive waste. Trend analyses confirm the presence of the radionuclide contaminant technetium-99 in the regional aquifer beneath MDA G. Other radionuclide contaminants that may be present include iodine-129 and uranium. The chemical contamination in the regional aquifer beneath MDA G is solvents.

The poor understanding of groundwater contamination beneath MDA G creates concerns for the continued operation of the RCRA disposal facility and for DOEs strategy to leave the large volume of legacy wastes "buried in place" at many locations on the Laboratory facility.

2.0 Introduction

LANL, the United States Department of Energy (DOE), and the New Mexico Environment Department (NMED) are performing an investigation across the 43-square mile Laboratory facility to characterize the physical setting of the regional aquifer and to determine the presence or absence of radionuclide and chemical contaminants in groundwater.

The Laboratory facility is underlain by a thick interval of unsaturated strata. The depth to the top of the regional aquifer is commonly greater than 500 feet (ranging up to greater than 900 feet) for canyon settings and greater than 800 ft (ranging up to greater than 1200 feet) for mesa landscapes. Perched zones of saturation may occur within the thick section of unsaturated strata.

The strategy and schedule for the investigation of the regional aquifer are described in the LANL Hydrogeologic Workplan document.[1] An important mission of the Hydrogeologic Workplan is to characterize the regional aquifer sufficiently to satisfy the Hazardous and Solid Waste Amendments (HSWA) portion of the Laboratory's United States Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) operating permit.[2] A requirement of RCRA is for the Laboratory facility to have a network of monitoing wells that are installed in aquifer strata where contaminants may be present. The Hydrogeologic Workplan includes a schedule for installation of 32 monitoring wells in the regional aquifer below the RCRA facility.

Through year 2003, LANL has installed more than 20 monitoring wells in the regional aquifer. Figures 1 and 2 are maps for the locations of 18 of the LANL monitoring wells. The wells are R-5, R-7, R-9, R-12, R-13, R-14, R-15, R-16, R-19, R-20, R-21, R-22, R-23, R-25, R-31, R-32, CDV-R-15, and CDV-R-37. The majority of the wells are multiple-screened with Westbay* sampling apparatus for collection of groundwater samples from discrete screened intervals installed at different depths in the regional aquifer.

Many of the LANL monitoring wells do not meet RCRA requirements. This report documents the non-compliance with RCRA for LANL monitoring wells R-7, R-9i, R-15, and R-22. The findings presented in this report are from information in the LANL well completion and well geochemistry reports for the four wells.

3.0 RCRA Requirements for Monitoring Wells

The United States Environment Protection Agency (EPA) has published a document that describes RCRA requirements for the installation of monitoring wells on RCRA facilities. The document is titled "RCRA Groundwater Monitoring: Draft Technical Guidance"[3] (referred to in this report as "the EPA RCRA document").

The following list presents RCRA requirements for the installation of monitoring wells at LANL.

1. A RCRA requirement under 40 CFR Part 264 Subpart F Sect. 264.97 is for LANL to install a groundwater monitoring system that yields representative groundwater samples from the uppermost aquifer beneath the Laboratory facility.

Many of the LANL monitoring wells do not produce representative groundwater samples because of 1. the use of drilling fluids and bentonite clay muds in the boreholes for the wells, and 2. the installation of long well screens that cause mixing and dilution of contamination present in discrete intervals of aquifer strata. This report describes the nonrepresentative groundwater samples that are collected from LANL monitoring wells R-7, R-9i, R-15, and R-22.

EPA has identified the "uppermost aquifer" as the geologic strata nearest the ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected within the facility's property boundary. "Aquifer" is defined as the geologic strata that are capable of yielding a significant amount of groundwater to wells or springs (40 CFR Sect. 260.10). Many groundwater supply wells in the region of LANL are installed at a depth of greater than 1800 feet below the water table into the regional aquifer. Therefore, at LANL a minimum requirement of RCRA is to characterize the upper several hundred feet of the regional aquifer to identify and install monitoring wells in the aquifer strata that are capable of yielding a significant amount of water; the aquifer strata that have a high hydraulic conductivity and are fast pathways for groundwater travel.

LANL monitoring well R-22 is located close to MDA G, the Laboratory's active landfill for disposal of low-level radioactive waste. Well R-22 is a example of LANL's failure to identify, characterize, and install well screens in the discrete aquifer strata that are capable of significant yields of groundwater. See the findings for well R-22 in section 7.0 of this report. LANL monitoring wells R- 7 and R-15 are also examples of LANL's failure to characterize and install well screens in the uppermost aquifer. The boreholes for these wells were drilled into the top of productive aquifer strata. However, LANL did not characterize the aquifer strata or install a monitoring well in the strata. The boreholes were sealed back and a screen was installed at a shallow depth in the regional aquifer. See the findings for wells R-7 and R-15 in sections 5.0 and 6.0 of this report.

2. Groundwater monitoring shall include measurement, sampling, and analytical methods that accurately assess groundwater quality, and that provide early detection of hazardous constituents released to groundwater – A requirement of RCRA 40 CFR Sections 264.97(d) and 264.97(e).

The performance of groundwater monitoring at LANL are a violation of this RCRA requirement for several factors: the use of drilling fluids and bentonite clay muds in the boreholes that cause changes to the chemistry of the groundwater samples; the installation of long well screens that cause dilution of contamination; the failure to install well screens in the aquifer strata that have high hydraulic conductivity; the failure to successfully develop the well screens to establish efficient hydraulic communication with the aquifer strata; and the collection of groundwater samples from the stagnant zone with altered chemistry that surrounds the screened intervals. All of these factors prevent accurate assessment of groundwater quality and early detection of contaminants in groundwater.

3. Install monitoring wells close to the down-gradient side of hazardous waste management units (LANL MDAs), and locate screened intervals in all transmissive zones that may act as contaminant transport pathways – a RCRA requirement under 40 CFR Sections 264.95(a) and 264.97(a)(3).

The transmissive zones are the aquifer strata that have high hydraulic conductivity and are the fast pathways for travel of contaminated groundwater. LANL has not installed screened intervals in the transmissive zones in the regional aquifer beneath MDA G, the Laboratory's active landfill for disposal of low-level radioactive waste. LANL has installed monitoring wells at locations that are in close proximity to only a few of the 26 MDAs that are present on the RCRA facility.

4. As a general rule, monitoring well screens shall not have a length greater than 10 ft because long well screens may cause dilution of contamination - the LANL HSWA Permit[2] limits well screens in monitoring wells to a length of not greater than 10 feet.

Many of the LANL monitoring wells have screened lengths greater than 10 feet; screen lengths of 40 feet are common and LANL well R-15 has a screen length of 60 feet. See the discussion of LANL well R-16 in section 6.0 of this report.

The EPA RCRA document[3] contains basic guidance to assist in the selection of drilling procedures, the design and installation of monitoring wells, and the characterization of the uppermost aquifer pursuant to 40CFR Part 264, Subpart F, as follows:

A. Drilling should be performed in a manner that preserves the natural properties of the subsurface materials.

LANL's use of polymer-based drilling fluids and bentonite clay drilling muds has resulted in a great change to the physical and chemical properties of the aquifer strata that surround the monitoring wells.

B. The drilling method should allow for the collection of representative samples of rock, unconsolidated materials, and soil.

The use of the mud rotary drilling method at LANL has resulted in long intervals in boreholes in the regional aquifer where no samples are recovered of the aquifer strata

C. The drilling method should allow for the collection of representative groundwater samples. Drilling fluids (including air) should be used only when minimal impact to the surrounding formation and groundwater can be ensured.

The use of polymer-based drilling fluids and bentonite clay drilling muds in the boreholes for many LANL monitoring wells are preventing the collection of representative groundwater samples.

D. All monitoring wells should be developed to create an effective filter pack around the well screen, to rectify damage to the formation caused by drilling, to remove fine particles from the formation near the borehole, to remove any foreign materials (drilling fluids, bentonite clay muds, etc.) that may have been introduced into the borehole during drilling and well installation, and to assist in restoring the formation around the screen as well as the filter pack, so that mobile fines, silts, and clays are pulled into the well and removed.

The successful development of a well is extremely important to ensuring the collection of representative groundwater samples – a requirement of 40 CFR Part 264, Subpart F Sect. 264.97 (see requirement 1 above). A failure at LANL is the incorrect belief that drilling fluids and bentonite clay drilling muds can effectively be removed from the invaded strata that surround the screened intervals. Ensuring the collection of representative groundwater samples precludes the use of drilling fluids and bentonite clay drilling muds for drilling the boreholes for monitoring wells. Well development may accomplish an adequate flow of groundwater into the monitoring well for collection of samples. However, the chemistry of the groundwater samples are still affected by a long residence time in the aquifer strata that are invaded by the fluids and bentonite clay muds.

E. The design and installation of monitoring wells should determine groundwater flow directions and hydraulic gradient - a RCRA requirement under 40 CFR Sect. 264.97(f).

The network of LANL monitoring wells have greatly improved the contour map of the water table on the regional aquifer. However, RCRA requires that the groundwater flow directions and hydraulic gradients are determined for the discrete aquifer strata that have high hydraulic conductivity and are fast pathways for groundwater travel. For the regional aquifer beneath MDA G, RCRA requires that the groundwater flow directions and hydraulic gradients are determined for the aquifer strata in the basalt and in the Puye sediments (the river gravel strata) that have high hydraulic conductivity. The hydrogeologic setting beneath MDA G is described in section 7.0 of this report. LANL has not installed monitoring wells in the important aquifer strata beneath MDA G.

F. The hydraulic conductivities of the discrete aquifer strata that comprise the uppermost aquifer and its confining units should be measured, preferably with appropriate field methods.

The regional aquifer beneath LANL is heterogeneous and anisotropic. For this hydrostratigraphic setting, knowledge of the variation in hydraulic conductivity as a function of vertical position in the discrete aquifer strata is essential to understanding the potential migration of contaminants. LANL well R-22 is a god example of LANL's failure to measure the hydraulic conductivities of the discrete strata below MDA G that have high hydraulic conductivity Section 8.0 of this report describes LANL's failure to gain knowledge of aquifer strata that have high hydraulic conductivity.

G. The vertical position of monitoring well screens are functions of:

a. hydrogeologic factors that determine the distribution of, and fluid/vapor phase transport within, potential pathways of contaminant migration to and within the uppermost aquifer, and

b. the chemical and physical characteristics of contaminants that control their distribution in the subsurface.

At LANL, factors a and b require that screened intervals in monitoring wells are installed in 1. appropriate strata at a shallow depth in the regional aquifer to ensure early detection of hazardous constituents that are released to the unsaturated zone and travel down to the top of the regional aquifer and 2. at depth intervals within the regional aquifer in aquifer strata with high hydraulic conductivity. Concerning factor a, LANL has installed long screens at the top of the regional aquifer. The long well screens are not focused on the water quality at a shallow depth in the regional aquifer.

Concerning factor b. LANL has failed to install screened intervals in the upper several hundred feet of the regional aquifer in the discrete strata that have high hydraulic conductivity. Examples of this failure are in sections of this report for wells R-7, R-15, and R-22.

4.0 Issues Concerning the use of Bentonite Clay Muds and Drilling Fluids in the Boreholes of LANL Monitoring Wells

Drilling fluids and/or bentonite clay drilling muds were used during drilling the boreholes for all but one of the LANL monitoring wells. The only well where drilling fluids and muds were not used is well R-9.

4.1 Concerns for Mud Rotary Drilling Methods

Presently, LANL is using the mud rotary drilling method for installation of monitoring wells. The LANL wells on Figures 1 and 2 that were installed in boreholes drilled with mud rotary methods that used bentonite clay drilling muds include R-14, R-16, R-20, R-21, R-23, and R-32.

The EPA RCRA document[3] for the construction of RCRA monitoring wells states the following concern for boreholes drilled with bentonite clay muds:

"Bentonite muds may adsorb metals, potentially reducing contaminant concentrations and affecting the reliability of sampling results."
"Drilling fluid invasion of permeable zones may compromise validity of subsequent monitoring well samples."

LANL established a team of experts as the External Advisory Group (EAG) to review activities conducted by the Hydrogeologic Workplan. The EAG Semi-Annual Report dated Dec. 23, 1999[4] lists 17 disadvantages for installing monitoring wells in boreholes that were drilled with the mud rotary method. The EAG report contains the following summary statements concerning use of the mud rotary drilling method:

" The use of mud rotary drilling techniques is largely inappropriate for the goal of the LANL Hydrogeologic Workplan. Drilling with mud carries the risk of adsorbing contaminants onto the bentonite that permeates into the pore space around the well screen and is not removed by well development. Should this occur, it could result in reduced concentrations or non-detects on contaminants that are actually present in the vicinity of the well."

"The artificial entrainment of bentonite clay drilling muds in the pore space around a monitoring well is clearly not desirable. This is because these materials can remove from solution the very constituents that need to be monitored by the well. This is a significant concern for LANL since radionuclides are known to be adsorbed by these clays. That the drilling mud, i.e., bentonite, penetrates into the aquifer strata is not disputed. It is reasonable to assume that fairly extensive intrusion of the bentonite into the aquifer strata can be expected. It is argued that well development, via high-flow pumping, using surge blocks, etc. is sufficient to remove blockage and create adequate flow through the well screen when a well has been drilled with mud. This is generally true. However, sufficient water flow is not the only consideration here. It is extremely unlikely that such well development techniques can remove the extruded bentonite sufficiently to assure that residual clay materials are not present in the pore space around the wells and serving as an adsorptive barrier to contaminant detection and quantification. Unfortunately, if no contamination is detected then there is simply no way (without drilling another well by a different technique) to determine whether the contaminant is truly absent at this point or whether it is being adsorbed by residual drilling fluids."

"The EAG would therefore caution LANL about using mud drilling techniques for the installation of the deep regional monitoring wells. If bentonite clay drilling mud is to be used, it should be used sparingly (e.g., as a lubricant only) and it would be best to avoid it altogether when drilling zones where the well screens will be located."

Large amounts of bentonite muds were introduced into the permeable strata in the regional aquifer in the LANL boreholes that were drilled with the mud rotary method. The bentonite clay drilling mud can not be recovered from the aquifer by well development methods.

The LANL wells on Figures 1 and 2 that were installed in boreholes drilled with mud rotary methods that used bentonite clay drilling muds include R-14, R-16, R-20, R-21, R-23, and R-32. Figure 2 shows that all of the monitoring wells surrounding MDA's G and L were installed in boreholes drilled with the mud rotary method using bentonite clay muds. The exception is well R-22 that is installed in a borehole drilled with polymer-based drilling fluids. The unreliable contaminant data from well R-22 is discussed in section 7.0 of this report. All of the monitoring wells that surround MDAs G and L are unreliable for detection of many contaminants of concern for the wastes disposed of in the two MDAs.

Figures 1 and 2 show that the three LANL monitoring wells that are located between MDA G and the Santa Fe Buckman well field are wells R-22, R-23, and R-16. The improper construction of the three wells makes them unreliable for the detection of many radionuclide and chemical contaminants in groundwater.

The next section of this report describes the mud rotary drilling of LANL monitoring well R-16. The discussion of LANL well R-16 is based on the LANL Well R-16 Completion Report.[5]

LANL Well R-16

Figures 1 and 2 show that LANL well R-16 is located between the Laboratory's low-level radioactive waste disposal facility (MDA G) and the Santa Fe Buckman well field. The monitoring well is a multiple-screen completion with three screened intervals located at different depths in the regional aquifer. A Westbay* groundwater sampling system is installed in the well. The Westbay* system produces a small volume of groundwater at a slow rate which prevents collection of groundwater from aquifer strata outside of the zone of the invaded drilling muds and fluids. The use of bentonite clay drilling muds and polymer drilling fluids in the borehole for LANL well R-16, the use of chemical additives for development of the well screens, and the collection of groundwater samples with the Westbay* system have a combined effect of making the well unreliable for the detection of radionuclide contaminants in groundwater at low levels.

During the mud rotary drilling of the borehole for LANL well R-16 the mud rotary drilling lost circulation of drilling fluids for the depth interval of 867 ft to 1047 ft within the regional aquifer. The lost circulation indicates a depth interval of aquifer strata with high permeability. The lost circulation shows that there was a great invasion of bentonite clay drilling muds into the highly permeable strata. The total amount of drilling fluid used for drilling the borehole in the regional aquifer at well R-16 was greater that 38,350 gallons of water to which greater than 31,100 lb of bentonite clay drilling mud was added. In addition, organic polymer drilling fluids were used during drilling the borehole in the regional aquifer. The RCRA concerns for the use of polymer-based drilling fluids are discussed in section 4.2 of this report.

LANL used chemical additives during the development of the monitoring wells that were installed in the mud rotary boreholes. The additives increased the dispersion of the bentonite clays in the aquifer strata, increasing the total surface area of bentonite clays for adsorption (removal from groundwater) of dissolved metal and radioactive contaminants.

The EPA RCRA document[3] contains the following statement concerning boreholes drilled with bentonite muds, and use of chemical additives for well development:

"Bentonite muds form a filter cake on the sides of the borehole, thus reducing the effective porosity of formations in the borehole, and compromising the design of the well. Bentonite may also affect local ground-water pH. Additives to modulate viscosity and density may also introduce contaminants to the system or force large, unrecoverable quantities of mud into the formation."

The issues that are presented in this report show the poor reliability of contaminant analyses for groundwater samples collected from LANL monitoring wells that are installed in boreholes drilled with the mud rotary method.

4.2 Concerns for Boreholes Drilled With Drilling Fluids and Foams

The majority of the LANL monitoring wells displayed on Figure 1 were installed in boreholes drilled with polymer-based drilling fluids and drilling foams. Changes in the chemistry of the groundwater and in the chemistry of the aquifer strata were initiated at the time of introduction of the drilling fluids and foams into the strata as the borehole was drilled. In general, well development activities were several months after the drilling fluids were injected into the aquifer strata. A large change in the chemistry of groundwater and chemistry of the aquifer strata occurred before the first groundwater samples were collected from the monitoring wells for contaminant analyses. The altered chemistry in the zone surrounding the screened interval in many LANL monitoring wells is depicted in Figure 3. The altered chemistry results in removal of contaminants from groundwater that enters the well by the set of chemical processes that are shown on Figure 3.

The EPA RCRA document[3] for monitoring well construction contains the following guidance against the use of drilling fluids in boreholes for RCRA monitoring wells:

"Drilling fluids, drilling fluid additives, or lubricants that impact the analysis of hazardous constituents in groundwater samples should not be used. Some organic polymers and compounds provide an environment for bacterial growth, which reduces the reliability of sampling results."

The drilling fluids and foams used in the boreholes of the LANL monitoring wells provided an environment for bacterial growth. The bacterial growth caused the development of a zone of strong reducing chemistry in groundwater and in aquifer strata for an unknown radius around the borehole.

The development methods that were used in many of the LANL monitoring wells were insufficient to establish efficient mixing of groundwater in the zone of altered chemistry with groundwater in the regional aquifer. The poor mixing is shown on Figure 4. The result for LANL multiple-screened monitoring wells equipped with Westbay* sampling apparatus is that groundwater samples are collected from the zone of stagnant groundwater in the aquifer strata that surrounds the screened intervals. The Westbay* sampling system does not purge large volumes of groundwater before collection of groundwater samples for contaminant analyses. LANL is aware of the altered zone of chemistry that surrounds the screened intervals in many LANL monitoring wells and predicts that the altered chemistry will be present for a period of the next 3 to 10 years.[6]

The nonrepresentative groundwater samples collected from many LANL monitoring wells are a violation of RCRA.

The October 2002 Semi-Annual Report of the EAG[7] contains the following discussion of the use of drilling fluids in the boreholes of monitoring wells:

"Give careful consideration to the geochemical DQOs for each monitor well to be drilled; consider using drilling methods that would have fewer detrimental impacts on aqueous/contaminant geochemistry when appropriate, even though this approach might be much more expensive during the drilling process."

"The EAG realizes that drilling conditions on the Pajarito Plateau are extremely difficult, time-consuming and expensive. It must be argued, however, that drilling wells inexpensively and quickly that

1. *require increasingly energetic/time-consuming/expensive development procedures to remove entrained drilling materials,*

2. *alter aqueous chemistry for two to 10 years (based on estimates of drilling fluid degradation rate*

3. *might alter aquifer material surface chemistry for an unknown radius around the well bore for an unknown time (e.g., potentially resulting in the reductive precipitation of uranium and other radionuclides, much like an in situ remediation around the monitoring well), and*

4. *continue to require expensive periodic analytical suites during the re-equilibration period that might result in data of questionable quality and errors in interpretation,*

should perhaps not be considered so inexpensive after all."

"For certain canyons, it might be less expensive overall to drill in a more expensive manner and have increased confidence in the chemistry data sooner, rather than having to wait several additional years to attain the needed level of confidence."

The impact of the zone of altered chemistry to cause the collection of nonrepresentative samples of groundwater from LANL monitoring wells R-7, R-9i, R-15, and R-22 are discussed in the following sections of this report.

5.0 Groundwater Contamination in the Regional Aquifer Beneath Los Alamos Canyon at LANL Well R-7

The information presented in this section is from the LANL Well R-7 Completion Report[8] and the LANL Well R-7 Geochemistry Report.[9] LANL monitoring well R-7 is a multiple-screen well with three screened intervals that is located in upper Los Alamos Canyon. Screen no. 3 has a length of 42 feet and is installed at the top of the regional aquifer. Information in the LANL reports[8,9] show that the filter pack sediments and aquifer strata that surround screen no. 3 are not well developed. The Westbay* sampling system in well R-7 collects groundwater samples from the stagnant zone of groundwater that surrounds screen no. 3.

Figure 5 shows the gradual decline in levels of strontium-90 and strontium that has occurred for screen no. 3 in well R-7 for groundwater samples collected over a one-year period because of the zone of altered chemistry that is caused by the use of drilling fluids. The unnatural chemical processes that lower the levels of strontium and strontium-90 in groundwater were introduced in the drilling fluids several months before the first groundwater samples were collected for contaminant analyses. The actual activity of strontium-90 in the regional aquifer is not known and may be much greater than the low values that are reported in the LANL geochemistry report.[9]

Strontium is a chemical that is commonly present in groundwater. The source of strontium in groundwater is the natural occurrence of strontium in the aquifer strata. Groundwater samples from properly installed monitoring wells will show little change in strontium levels between quarterly sampling events. For example, drilling fluids were not used in the borehole for LANL monitoring well R-9. For this well, strontium levels in four succeeding quarterly groundwater samples show little change and are 160, 160, 150, and 160 ppb, respectively.[10]

Strontium and strontium-90 have identical chemical properties. The pronounced decline in strontium and strontium-90 levels shown in Figure 5 is because of the removal of these constituents from groundwater in the zone of altered chemistry that surrounds well R-7. The trend analyses presented in Figure 5 of the analytical results for well R-7 confirm that the radionuclide contaminant strontium-90 is present in the regional aquifer below Los Alamos Canyon.

Other radionuclide contaminants that were measured at low levels in groundwater samples collected from well R-7 include americium-241; cesium-137; plutonium-238; plutonium-239,240; technetium-99; and uranium-235.[9] Some of the measured low levels of contamination may be because of analytical error; the contaminants may not be present in groundwater. However, the use of drilling fluids in the R-7 borehole, the poor development of the well screen and the possible dilution effects of the 42-foot long well screen prevent an accurate understanding of the presence or absence of the radionuclide contaminants in the regional aquifer below Los Alamos Canyon.

LANL Well R-7 is located in upper Los Alamos Canyon where Laboratory effluent has been released, including radionuclides and inorganic chemicals. Known groundwater contaminants in the shallow alluvial sediments in upper Los Alamos Canyon include americium-241; cesium-137; plutonium-238; plutonium-239,240; strontium-90; tritium; uranium-235; and uranium-238.[11] Note the close comparison of this list of known contaminants in Los Alamos Canyon to the list of radionuclide contaminants recorded at low levels in the regional aquifer at LANL monitoring well R-7.

The strong reducing chemistry at LANL well R-7 causes the uranium analyses in groundwater samples from well R-7 to be anomalously low. The uranium analyses on groundwater samples from Monitoring well R-7 are not valid for knowledge of uranium levels in groundwater in the regional aquifer beneath Los Alamos Canyon. The effect of the reducing chemistry on uranium in groundwater is discussed in section 9.0 of this report.

6.0 Groundwater Contamination in the Regional Aquifer Beneath Mortandad Canyon at LANL Well R-15

The information presented in this section is from the LANL Well R-15 Completion Report[11] and the LANL Well R-15[12] Geochemistry Report. Groundwater samples collected from LANL monitoring well R-15 show that radionuclide and chemical contamination is present in the regional aquifer beneath Mortandad Canyon. A validated (>3 sigma) strontium-90 activity of 1.51 pCi/L was measured in the third quarter round of groundwater samples.[12] The radionuclide contamination recorded at low levels include americium-241; cesium-137; plutonium-238; and plutonium-239,240.[12] Some of the measured low levels may be due to analytical error; some of the recorded contaminants may not be in groundwater.

LANL records show that known groundwater contaminants in shallow, saturated alluvial sediments in Mortandad Canyon include americium-241; cesium-137; plutonium-238; plutonium-239,240; strontium-90; tritium; uranium-235; uranium-238; nitrate; chloride; sulfate; and other inorganic solutes.[11] Note the close comparison of this list of known radionuclide contaminants in the shallow groundwater to the list of radionuclide contaminants that are recorded in groundwater samples from LANL well R-15.

Perchlorate levels in groundwater samples collected from monitoring well R-15 range from <2.80 to 4.19 ppb.[12] A proposed drinking water standard for perchlorate is 1 ppb. Perchlorate levels as high as 200 parts per billion have been measured in the groundwater in the alluvial sediments in Mortandad Canyon and a perchlorate level of 20 parts per billion was measured in perched groundwater present in the borehole for well R-15.[11]

Radionuclides that were detected in the perched groundwater present in the R-15 borehole include americium-241 and tritium; the measured tritium level in the perched groundwater was 3,770 pCi/L.[11]

Issues for the construction of LANL well R-15 that impact the reliability of analytical results are the use of drilling fluids in the borehole and the installation of a 60-ft long screen that straddles the top of the water table and spans intervals of aquifer strata with differing values of hydraulic conductivity. Figure 6 shows that the 60-ft screen crosses a layer of clayey fine-grained sediments that is present at a depth of 1007 to 1009 feet below land surface. Figure 6 shows the large change in static water level that has occurred since construction of the monitoring well. The installation of the long well screen across the fine-grained sediments is allowing groundwater from above the fine-grained layer to drain down inside the well and mix with groundwater present below the fine-grained layer. The mixing will dilute contaminant levels that are present at a shallow depth in the regional aquifer. LANL monitoring well R-15 does not meet RCRA requirements for representative groundwater samples.

For the location of LANL well R-15 it is very important to have early detection of contaminants that travel beneath Mortandad Canyon and enter the coarse sediments with high hydraulic conductivity that are present at the top of the regional aquifer. Accurate information on the presence of contamination at the top of the regional aquifer below Mortandad Canyon requires that monitoring wells are installed at the top of the aquifer with a screen length that does not cross confining layers and that allows for collection of groundwater samples from a shallow depth in the regional aquifer. It is also important that drilling fluids and bentonite clay muds are not used in the borehole interval that is drilled into the regional aquifer.

An immediate activity that should be performed at LANL monitoring well R- 15 are remedial measures to stop the downward flow of groundwater in the well The successful performance of remedial measures should restore the original water table on the regional aquifer at a depth of 964 feet. After restoration of the original water table a low-flow sampling system should be installed in well R-15 to collect groundwater samples from the top of the regional aquifer. Replacement of well R-15 with a RCRA-compliant monitoring well will be necessary if remedial measures are unsuccessful.

The RCRA requirement to install monitoring wells in Mortandad Canyon to a depth of several hundred feet in the regional aquifer is described in section 3.0 of this report. The borehole log in the LANL Well R-15 Completion Report[11] shows that Totavi Lentil sediments are present in the depth interval of 1100 to 1107 feet, the total depth of the borehole. These sediments are known to have very high hydraulic conductivity. For well R-15, the top of the regional aquifer is at a depth of 964 feet and the top of the Totavi Lentil sediments is at a depth of 136 feet in the regional aquifer.

The LANL Well R-15 Completion Report[11] predicts that the Totavi Lentil sediments at the location of well R-15 have a total thickness of 65 feet. It is unfortunate that the R-15 borehole did not drill through the total thickness of the Totavi Lentil sediments and install a monitoring well in this interval of important aquifer strata. Presently, groundwater contamination and groundwater hydrology are poorly understood for the regional aquifer beneath Mortandad Canyon.

7.0 Groundwater Contamination in the Regional Aquifer Beneath MDA G at LANL Well R-22

The information presented in this section is from the LANL Well R-22 Completion Report[13] and the LANL Well R-22 Geochemistry Report.[14] LANL monitoring well R-22 is located atop Mesita del Buey immediately east of Material Disposal Area G (MDA G), the Laboratory's active landfill for disposal of low-level radioactive waste. The location of MDA G is shown on Figure 2. Well R-22 is a multiple-screen completion with five screened intervals installed at depths ranging from the top of the regional aquifer to a depth of 500 feet in the aquifer. The drilling fluids that were used in the borehole for this monitoring well have caused the development of a strong reducing chemistry in the groundwater that enters the well at screen no. 1, 2, and 4. Information in the LANL well R-22 Completion Report[13] shows that screens no. 1 and 2 are poorly developed. The Westbay* sampling system collects water samples from the stagnant zone of groundwater that surrounds the screened intervals.

Trend analyses show that the radionuclide contaminant technetium-99 is present in groundwater in the regional aquifer beneath MDA G. Technetium-99 activities in groundwater samples from screen no.3 and no.4 were validated levels (>3sigma) of 4.9 and 4.3 pCi/L, respectively.[14] The trend analyses in figure 6 show the declining levels of technetium-99 that occur over four quarterly sampling events for three of the screened intervals in well R-22. The declining levels of technetium-99 were shown in all five screened intervals in the well.

Other radionuclide contaminants that were recorded at low levels in the groundwater samples collected from monitoring well R-22 include americium-241; cesium-137; iodine-129; plutonium-238; plutonium-239,240; and strontium-90.[14] Some of the measured low levels of contamination may be because of analytical error; some of the contaminants that were recorded at low levels may not be present in the regional aquifer. However, the unnatural chemistry that surrounds well R-22 prevents an accurate understanding of the presence of contamination in the regional aquifer beneath MDA G.

The strong reducing chemistry in the zone that surrounds well R-22 is responsible for the anomalously low values of uranium in groundwater samples. The uranium analyses on groundwater samples from well R-22 are not valid for understanding the presence of uranium contamination in the regional aquifer beneath MDA G. Uranium chemistry is discussed in section 9.0 of this report.

A large quantity of the radionuclide contaminant iodine-129 is disposed of at MDA G.[15] Iodine-129 is mobile for transport through the unsaturated zone beneath MDA G,[15] and it is possible that this radionuclide is present in the regional aquifer. Iodine-129 was measured at a value of 18 pCi/L in the first quarter of groundwater samples collected from screen no. 3.[14]

Volatile and semivolatile chemical contaminants are present in groundwater samples collected from well R-22.[14] These contaminants are commonly known as solvents. In the past, a large volume of solvents were disposed of in trenches at MDA G. The LANL geochemistry report for well R-22 assigns the degradation of the drilling fluids as being the source of the chemical contaminants detected in groundwater from well R-22.[14] The use of drilling fluids in the borehole for well R-22 prevent an accurate understanding of the chemical and radionuclide contamination in the regional aquifer beneath MDA G.

An important issue for LANL well R-22 (and many other LANL monitoring wells) is the failure to install screened intervals in aquifer strata that are fast pathways for groundwater travel. The fast pathway strata also have the greatest potential for the presence of contamination, and the highest levels of contamination. Figure 8 displays the depth intervals for screened intervals in LANL well R-22. The figure shows that the screened intervals are installed in aquifer strata with low hydraulic conductivity and that screens were not installed in aquifer strata within the Cerros del Rio basalt and coarse gravels in the Puye sediments that have very high hydraulic conductivity. Because of MDA G, there is a special need to characterize chemical and radionuclide contamination in the fast groundwater pathways. The measured values of hydraulic conductivity that are posted on Figure 8 are from the LANL Hydrologic Tests Report.[16]

There is a need to understand the direction and rate of groundwater travel in the fast groundwater pathways that are present below MDA G. The thick interval of river gravels in the R-22 borehole shows that an ancestral channel of the Rio Grande River is located below MDA G. The hydrostratigraphic setting of the ancestral channel is shown on Figure 9. The direction of groundwater flow in the coarse gravels that are in the ancestral channel may be southward; a markedly different flow direction from the easterly direction shown by the contour map of the water table on the regional aquifer in Figure 1. Similarly, the directions of groundwater flow in the fast pathways in the basalt strata beneath MDA G are not known. Presently, groundwater contamination and groundwater hydrology are poorly understood for the regional aquifer beneath MDA G.

8.0 Failure of LANL to Acquire Accurate Knowledge of Aquifer Properties

Activities that have been performed for the LANL Hydrogeologic Workplan[1] are not developing an accurate understanding of the physical properties of the regional aquifer. The physical property that has received greatest study in LANL monitoring wells is hydraulic conductivity. Unfortunately, many measured values of hydraulic conductivity are anomalously low because of 1. the incomplete development of the screened intervals in the monitoring wells, 2. the failure to install screened intervals in aquifer strata that have high hydraulic conductivity (see Figure 8), 3. the failure of pumping tests to discharge groundwater at a high enough rate to stress the aquifer, 4. the use of the wrong analytical methods to calculate aquifer properties from injection test data, and 5. most pumping tests are in monitoring wells (and supply wells) with long screen intervals that span aquifer strata with differing values for hydraulic conductivity; the pumping tests determine an average value for hydraulic conductivity that greatly underestimates the hydraulic conductivity of the highly permeable strata that are fast pathways for travel of groundwater.

The information presented in this report for monitoring wells R-7. R-15 and R-22 shows the failure of LANL to gain knowledge of aquifer strata that have high hydraulic conductivity. Additional information on the poor knowledge that LANL has of fast pathways in the regional aquifer is shown by Table 4.3.2. – "Hydraulic Conductivity Estimates" in the LANL Report, "Groundwater Annual Status Report for Fiscal Year 2002".[17] The table shows the hydraulic conductivity of basalt to range from 0.04 ft/day to 14.87 ft/day. The table does not capture the high hydraulic conductivity that is present in the basalt strata in the regional aquifer beneath MDA G where estimated values of 200 and 400 ft/day are based on the borehole log in the LANL Well R-22 Completion Report and a conversation with the driller.[18]

In Table 4.3.2 the hydraulic conductivity values for the Totavi Lentil sediments range from 0.54 ft/day to 32.29 ft/day. The table does not capture the high hydraulic conductivities of the Totavi Lentil sediments that are present in the regional aquifer beneath Los Alamos and Mortandad Canyons, and beneath MDA G. An estimated value of 500 ft/day for the Totavi Lentil sediments in the regional aquifer beneath MDA G is based on the borehole log in the LANL well R-22 completion report and a conversation with the driller.[18]

Two of the hydraulic conductivity values listed in Table 4.3.2 are for injection tests in Totavi Lentil sediments present in LANL monitoring well R-31.[19] The listed values of 1.23 and 0.75 ft/day are incorrect because of the use of wrong analytical methods to interpret the test data and because the two screened intervals are surrounded by a thick interval of sloughed sediments that flowed around the well screens as the drill casing was retracted.[19] The injection test measured the hydraulic conductivity of the sloughed sediments. A review of information in the LANL Well R-31 Completion Report[19] of the description of drilling activities in the Totavi Lentil sediments in the borehole of well R-

31 and a review of the borehole log establish an estimated hydraulic conductivity for the thick section of Totavi Lentil Sediments in the regional aquifer at LANL monitoring well R-31 to range from 250 to 500 ft/day.

During 1995 to 1996, a field study measured the hydraulic properties of the unsaturated strata beneath MDA G and MDA L. The locations of the two MDA's are shown on Figure 2. The findings from the study are published in a journal article by Neeper.[20] The field study determined the unsaturated Cerros Del Rio Basalt beneath MDA G and MDA L to have a hydraulic conductivity greater than 1,000 Darcies (greater than 2,400 feet/day). The stratigraphy beneath MDA G is shown in Figure 8. Hydraulic conductivity is a physical property of aquifer strata that is independent of the fluid in the strata being either water or air. The measured value of hydraulic conductivity in the unsaturated basalt strata show that the estimated values posted on Figure 8 for hydraulic conductivity values of the basalt strata in the regional aquifer are conservative.

9.0 Reductive Precipitation of Uranium From Groundwater

Over the past 60 years, research at LANL has used large quantities of uranium. There is a need for accurate knowledge of the levels of uranium in the regional aquifer.

A review of uranium analyses for groundwater samples collected from LANL monitoring wells where drilling fluids were used shows that the drilling fluids are causing removal of uranium from groundwater by the chemical process known as reductive precipitation. The drilling fluids were used in a large number of the monitoring wells. Uranium is a natural constituent in the regional aquifer and is generally present at levels of approximately 1 part per billion.[21] Groundwater samples collected from many of the LANL monitoring wells show anomalously low values for dissolved uranium. The validity of uranium analyses in all of the wells where drilling fluids were used is questionable.

The review of chemical analyses for the LANL monitoring wells included in this report shows that reductive precipitation is removing uranium from groundwater at wells R-7, R-9i, and R-22. The values of dissolved uranium in groundwater samples from these wells are not representative of levels in the aquifer.

9.1 Anomalous Uranium Levels in LANL Well R-7

At LANL well R-7, the polymer-based drilling fluids caused the development of a strong reducing chemistry in the zone surrounding screen no. 3 at the top of the regional aquifer. The strong reducing chemistry is shown by the very low values for dissolved sulfate and the presence of a hydrogen sulfide odor at the well site during the collection of groundwater samples.[9] Because of the strong reducing chemistry groundwater in the regional aquifer has very high levels for dissolved iron (17mg/L) and manganese (3.4 mg/L).[9] Because of reductive precipitation, dissolved uranium is at an anomalously low value of 0.051 ppb in groundwater samples collected from screen no. 3.[9] For comparison, a groundwater sample collected at the top of the regional aquifer in the borehole for well R-7 had a uranium level of 2.1 ppb.[8]

9.2 Anomalous Uranium Levels in LANL Well R-9i

LANL monitoring wells R-9 and R-9i are located in Los Alamos Canyon near the eastern boundary of the Laboratory facility. Drilling fluids were not used in the borehole for well R-9. Groundwater was present in two perched zones during the drilling of the borehole. Chemical analyses on groundwater samples collected from the two perched zones measured uranium values of 1.22 parts per billion (ppb) for the upper zone and 48.4 ppb for the lower zone, respectively.[22] The proposed EPA maximum contaminant level for uranium in drinking water is 7 ppb. In addition, plutonium-238 was detected at a validated level of 0.76 pCi/L in a groundwater sample collected from the lower perched zone in the borehole for well R-9.[22] At well R-9 the two perched zones were sealed off and the well has a single screen at the top of the regional aquifer.

Because of the presence of plutonium-238 and the high level of uranium in the lower perched zone, monitoring well R-9i was installed at a location close to well R-9 with screened intervals installed in the two perched zones.[23] Drilling fluids were used in the borehole for well R-9i. Groundwater samples for contaminant analyses were collected on a quarterly schedule from well R-9i for a one-year period. For the lower perched zone, the measured levels of uranium for successive quarters were 0.068, 0.04, 0.02, and <0.003 ppb, respectively.[10] The declining trend of the very low values is because of the removal of uranium from groundwater samples entering the well by reductive precipitation. For comparison, note that a uranium value of 48.4 ppb was measured in the groundwater sample collected from the lower perched zone in the well R-9 borehole.[22]

For the lower perched zone in well R-9i, analyses of the quarterly groundwater samples recorded very low values of plutonium-238 ranging from <0.006 pCi/L to -0.001 pCi/L.[10] Note that a much higher plutonium-238 value of 0.76 pCi/L was measured in a groundwater sample collected from the lower perched zone in the well R-9 borehole.[22]

For the upper perched zone in well R-9i, a trend analysis shows declining levels of dissolved uranium from a value of 0.588 ppb for the first quarterly groundwater sample to a value of 0.194 ppb for the groundwater sample collected in the fourth quarter.[10] Note that the groundwater sample collected from the upper perched zone in the R-9 borehole had a measured value for dissolved uranium of 1.22 ppb.[22]

Comparison of the analytical data from the R-9 borehole to the R-9i monitoring well is instructive in showing the large decline in contaminant analyses for plutonium and uranium that occurred because of the use of drilling fluids. It is important to note that a very large decline in contaminant levels for plutonium and uranium occurred at monitoring well R-9i before the first groundwater samples were collected for contaminant analyses. A similar large decline in contaminants may have occurred at many of the LANL monitoring wells that were installed in boreholes where drilling fluids were used.

9.3 Anomalous Uranium Levels in LANL Well R-22

At LANL well R-22, the polymer-based drilling fluids caused the development of a strong reducing chemistry in the zone surrounding well screens no. 1, 2, and 4. For screen no. 1, located at the top of the regional aquifer, the strong reducing chemistry is shown by the very low values for dissolved sulfate and the presence of hydrogen sulfide odors at the well site when groundwater samples are collected from screen no.1[14]. Because of the reducing chemistry very high values for dissolved iron (14.9 mg/L) and manganese (4.4 mg/L) are present in groundwater samples from screen no.1.[14] Dissolved uranium values are very low and show a declining trend to 0.02 ppb. The anomalously low values of dissolved uranium in groundwater samples from well R-22 are because of reductive precipitation that is caused by the use of drilling fluids in the R-22 borehole. The levels of total dissolved uranium and isotopic uranium in groundwater below MDA G are not accurately known.

The analytical data presented in this report are from the LANL geochemistry reports for the R-series monitoring wells. The analytical data show that nonrepresentative groundwater samples are collected from the large number of LANL monitoring wells where the drilling methods used drilling fluids and foams. For many of the monitoring wells, the LANL geochemistry reports describe the strong reducing chemistry in groundwater that is caused by the drilling fluids. However, the LANL reports do not acknowledge that the analyses on groundwater samples collected from these monitoring wells are unreliable to provide accurate knowledge of the levels of dissolved uranium and other radionuclide contaminants that are present in the regional aquifer.

10.0 Affect of High Levels of Dissolved Iron and Manganese on Contaminant Chemistry in LANL Monitoring Wells and on Well Development

The very high levels of dissolved iron and manganese in LANL monitoring wells are because the strong reducing chemistry dissolves these constituents from the aquifer strata. The natural dissolved iron and manganese levels in groundwater are very low (0.05 mg/L or less) in the oxidizing chemistry that is naturally present in the regional aquifer. Presently, the high levels of dissolved iron and manganese are causing precipitation of iron and manganese oxide/hydroxide coatings on the surfaces of the aquifer strata , on the filter pack sediments that surround the well screen, and also on the well screen. The coatings are a "slimy" gelatinous substance that obstruct the flow of groundwater through the aquifer strata ,the filter pack sediments, and the well screen. The coatings increase the difficulty to develop the screened intervals and the coatings continue to be deposited after the well development activities were terminated.

The precipitation of the iron and manganese from groundwater also has potential to remove dissolved contaminants from groundwater by the chemical process coprecipitation. In addition, the pervasive presence of the iron and manganese oxide/hydroxide coatings in the zone surrounding the monitoring wells are a serious issue for removing radionuclide contaminants from groundwater because the coatings have strong adsorption properties for many of these dissolved contaminants. The coatings are stable in the normal oxidizing groundwater environment which means that the coatings may be present for decades and will lower the validity of contaminant analyses of groundwater samples collected from the monitoring wells.

11.0 Misinformation in LANL Reports and Meetings with the Public

The LANL Geochemistry Reports for monitoring wells R-7, R-9i, and R-22 document the unnatural chemistry that has resulted from the use of drilling fluids in the boreholes for the wells. However, the reports do not state the obvious fact that much of the contaminant analyses presented in the reports are unreliable. For example, the LANL Well R-22 Geochemistry Report contains the following statement:

"Activities of technetium-99 were less than detection in groundwater samples collected from screens #1 and #2. Based on these findings, it is not likely that the isotope migrated from TA-54 (MDA G) because it was not observed at the regional water table at well R-22."

The trend analyses in Figure 7 of this report are evidence that technetium-99 is present in groundwater samples collected from screen #1 in well R-22. The low values of technetium-99 in groundwater collected from the screen are because of the unnatural chemistry that is caused by the use of drilling fluids in the borehole for well R-22.

Another example of the misinformation that is present in the LANL reports is the following statement from the LANL well R-7 Geochemistry Report:

"Americium-241; cesium-137; plutonium-238; plutonium-239,240; strontium-90; technetium-99; and uranium-235 were not detected in the groundwater samples collected from well R-7."

The term "not detected" is commonly used in the LANL geochemistry reports and will lead many readers to believe that the contaminant is not present in groundwater. In reality, the term "not detected" means that the contaminant was detected by the analytical method at a low level; a low level that is possibly an error of the analytical method. However, the low levels may be a result of the unnatural chemistry that surrounds screen #3 in LANL well R-7. The trend analyses in Figure 5 of this report are evidence that strontium-90 is present in the regional aquifer at well R-7. All of the radionuclide contaminants that are listed as "not detected" in the well R-7 Geochemistry Report will be removed from groundwater by the unnatural, strongly reducing chemistry that surrounds screen #3.

At a public meeting held on January 7, 2004, LANL and DOE presented a proposed strategy for an accelerated schedule for completion of the investigation of environmental contamination at the Laboratory facility. A claim by LANL and DOE is that radionuclide contamination in the regional aquifer is limited to low levels of tritium. The presence of strontium-90 and technetium-99 in the regional aquifer beneath the Laboratory facility was not mentioned at the public meeting.

Concerning MDA G, DOE and LANL assured the people at the public meeting that an "intensive study" had not found releases of contamination. A LANL study of MDA G identified technetium-99 as one of the most mobile contaminants disposed of in trenches at MDA G.[15] However, the LANL study concluded that releases of technetium-99 from MDA G would not reach the top of the regional aquifer for a period of 600 years.[15] The measurement in groundwater samples from well R-22 of technetium-99 and chemical contamination in the regional aquifer beneath MDA G was not mentioned at the public meeting. Figure 7 shows the presence of technetium-99 in the regional aquifer beneath MDA G.

A document delivered to the public that attended the DOE and LANL meeting displayed the LANL monitoring wells as monitoring wells for contamination in the regional aquifer.[24] The document did not explain that improper well construction practices make many of the wells unreliable for detection of contamination in the regional aquifer. The LANL estimate that many of the wells will not provide groundwater samples with an unaltered chemistry for a period as great as 10 years[6] was not mentioned at the public meeting.

The DOE and LANL accelerated cleanup strategy proposes to leave the large volume of legacy wastes disposed of in trenches and shafts at many locations across the Laboratory facility "buried in place" with little additional monitoring. DOE and LANL claim that this is a correct strategy because a careful study shows that contamination has not been released from MDA G to the regional aquifer and therefore, by analogy contamination is being contained at the other MDA's where radioactive and chemical wastes are disposed of in trenches and shafts. The validity of the accelerated cleanup strategy is now in question because of the presence of radionuclide and chemical contamination in the regional aquifer beneath MDA G. There is a need to install monitoring wells in the regional aquifer in the immediate vicinity of the other LANL MDAs that contain large volumes of legacy radioactive and chemical wastes. Presently, monitoring wells in the regional aquifer are not installed at locations that are close to many of the LANL MDAs that contain legacy wastes.

The presence of radionuclide and chemical contamination in the regional aquifer below MDA G raises a serious concern for the continued use of MDA G as a licensed disposal facility for low-level radioactive waste. An immediate activity is required to determine the nature and extent of contamination in the regional aquifer below MDA G. This investigation will require the installation of several RCRA-compliant monitoring wells to characterize the radionuclide and chemical contamination present at the top of the regional aquifer and in the fast groundwater pathways in the aquifer strata beneath the landfill disposal facility. The fast pathways are shown on Figure 8. It is also important to determine the direction and rate of travel for groundwater in the fast pathways.

LANL operations are regulated by RCRA. The RCRA facility does not have a network of monitoring wells that meet RCRA requirements. There is a poor understanding of the nature and extent of radionuclide and chemical contamination in the regional aquifer beneath the Laboratory facility. There is also a poor understanding of the fast pathways for groundwater travel in the regional aquifer.

A technical review of activities conducted for the Hydrogeologic Workplan is necessary. A study of each of the LANL monitoring wells is required to determine their future value. This review should be conducted by a panel of experts in the following disciplines:

- Hydrogeology (with emphasis in measurement of aquifer properties and contaminant hydrology),
- Geochemistry (with emphasis in monitoring well installation requirements to acquire reliable information on contaminant chemistry),
- Geophysics (with emphasis in groundwater borehole geophysics), and
- Groundwater modeling of regional groundwater flow in aquifer strata that are anisotropic and heterogeneous.

12.0 Sentry Monitoring Wells for the Protection of Groundwater Supply Wells

The poor understanding at LANL of groundwater contamination and groundwater hydrology requires the installation of early warning monitoring wells (sentry wells) to protect the groundwater resources of San Ildefonso Pueblo and Pueblo de Cochiti. Sentry wells are also needed for the Santa Fe Buckman well field, and the supply wells that provide water to the Laboratory facility, to the communities of Los Alamos, White Rock, and to Bandelier National Monument. It is very important that drilling fluids, foams, and muds are not used during drilling of the boreholes into the regional aquifer. The sentry wells shall collect groundwater samples that are representative of the fast pathways within the regional aquifer. The groundwater samples shall be suitable for the detection of low levels of chemical and radionuclide contamination.

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11. LANL Well R-15 Completion Report, LANL Report LA-13749-MS.

12. LANL Well R-15 Geochemistry Report, LANL Report LA-13896-MS.

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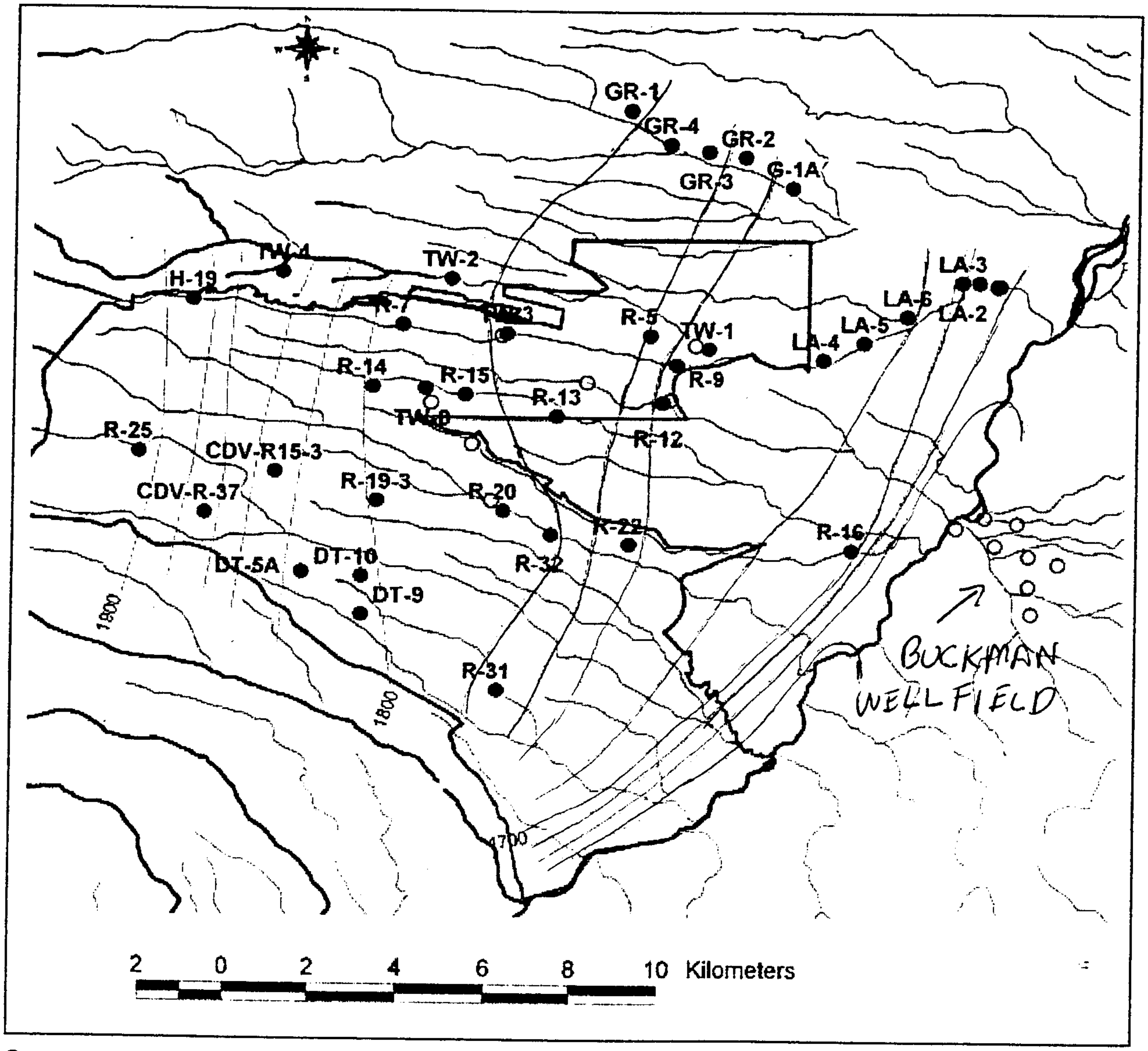


Contour interval = 20 m

Figure 1

Water table map, using primarily data from wells with relatively short screens at or near water table (from Nylander et al. 2003).

TA-54 Well Locations

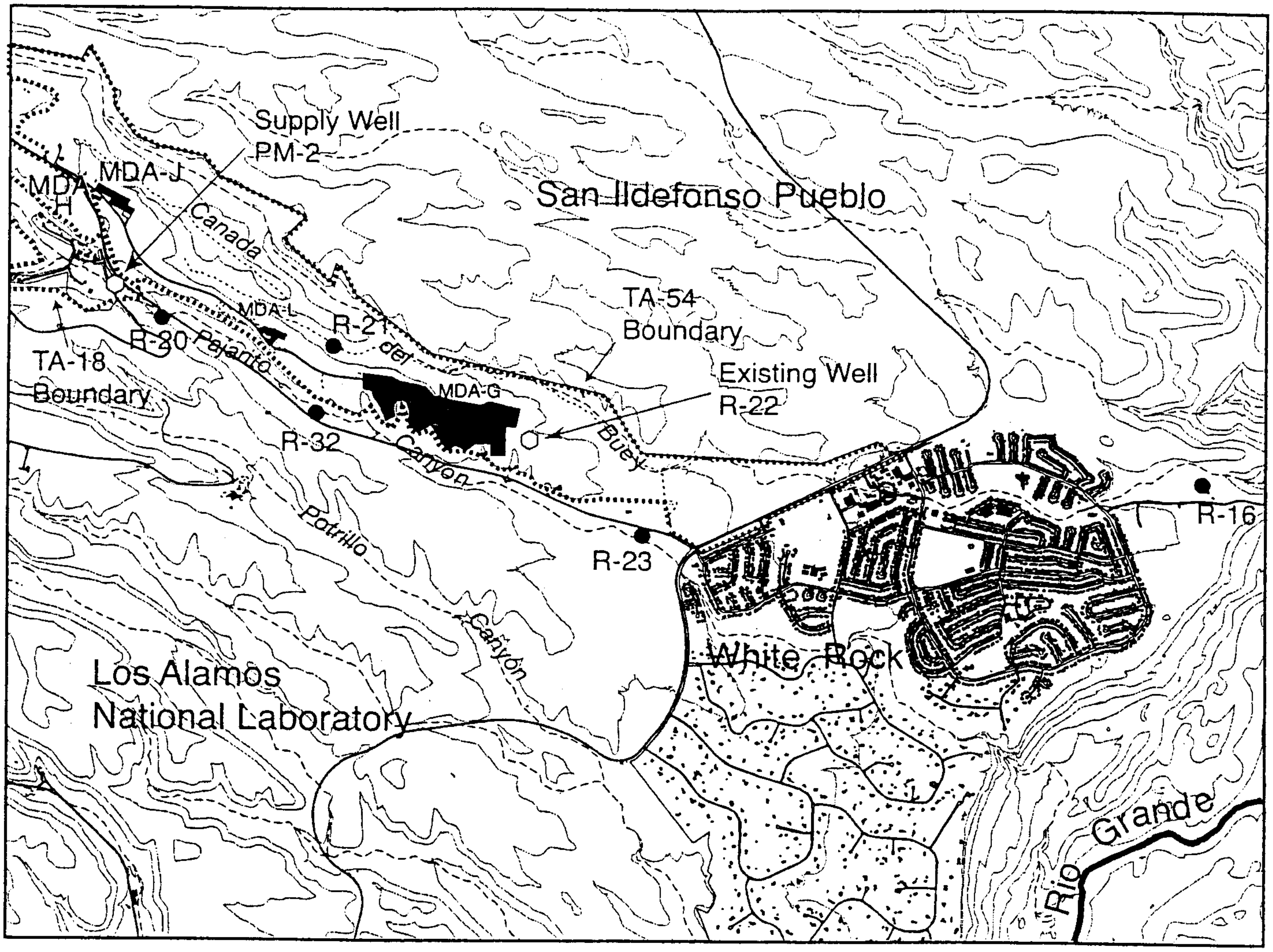


Figure 2
LANL characterization wells (R-wells) in the region of MDA G and MDA L (from LANL, March 2003).

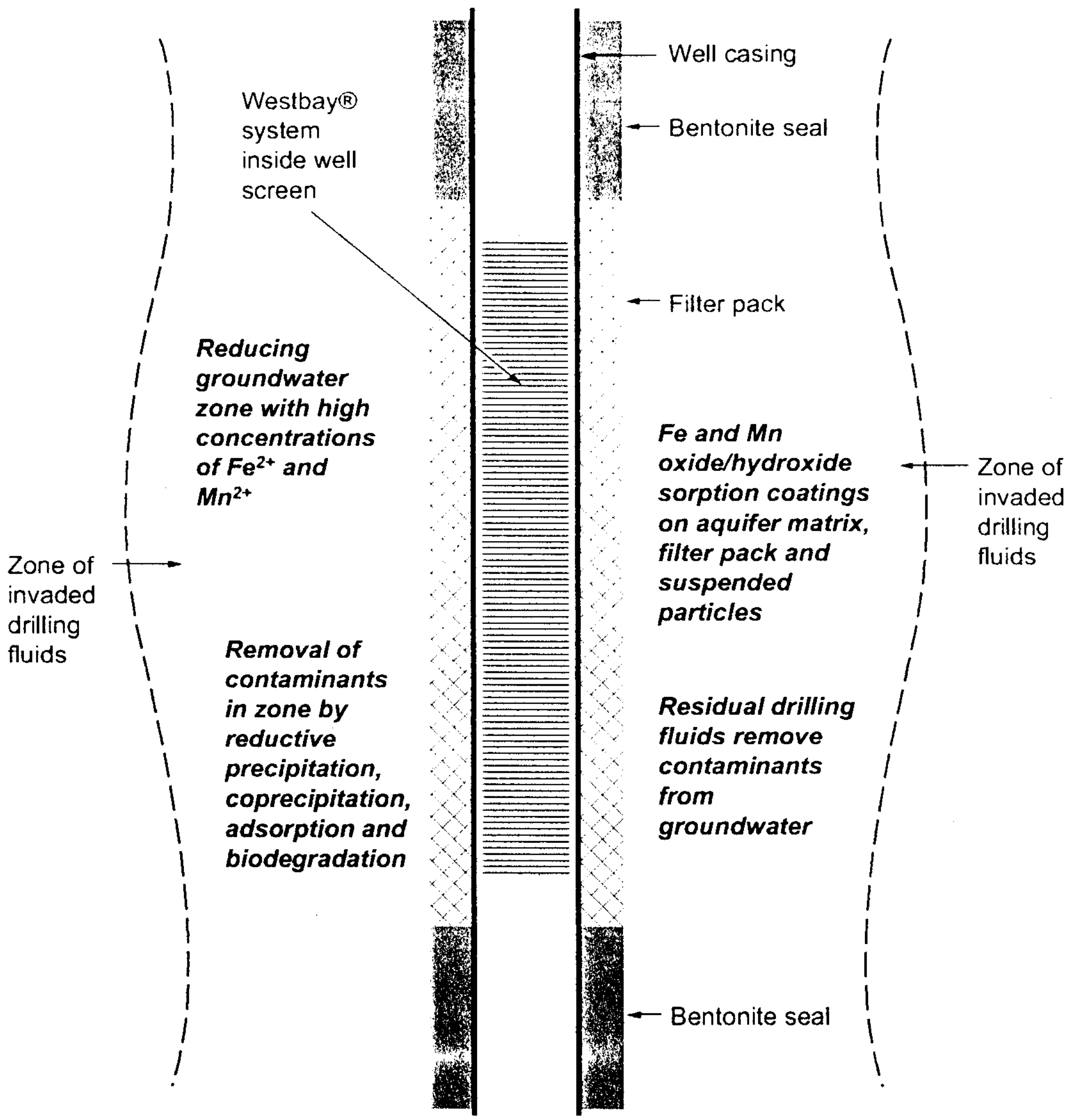


Figure 3

Altered chemical environment in poorly developed zone surrounding a screened interval in a LANL multiple-screened characterization well

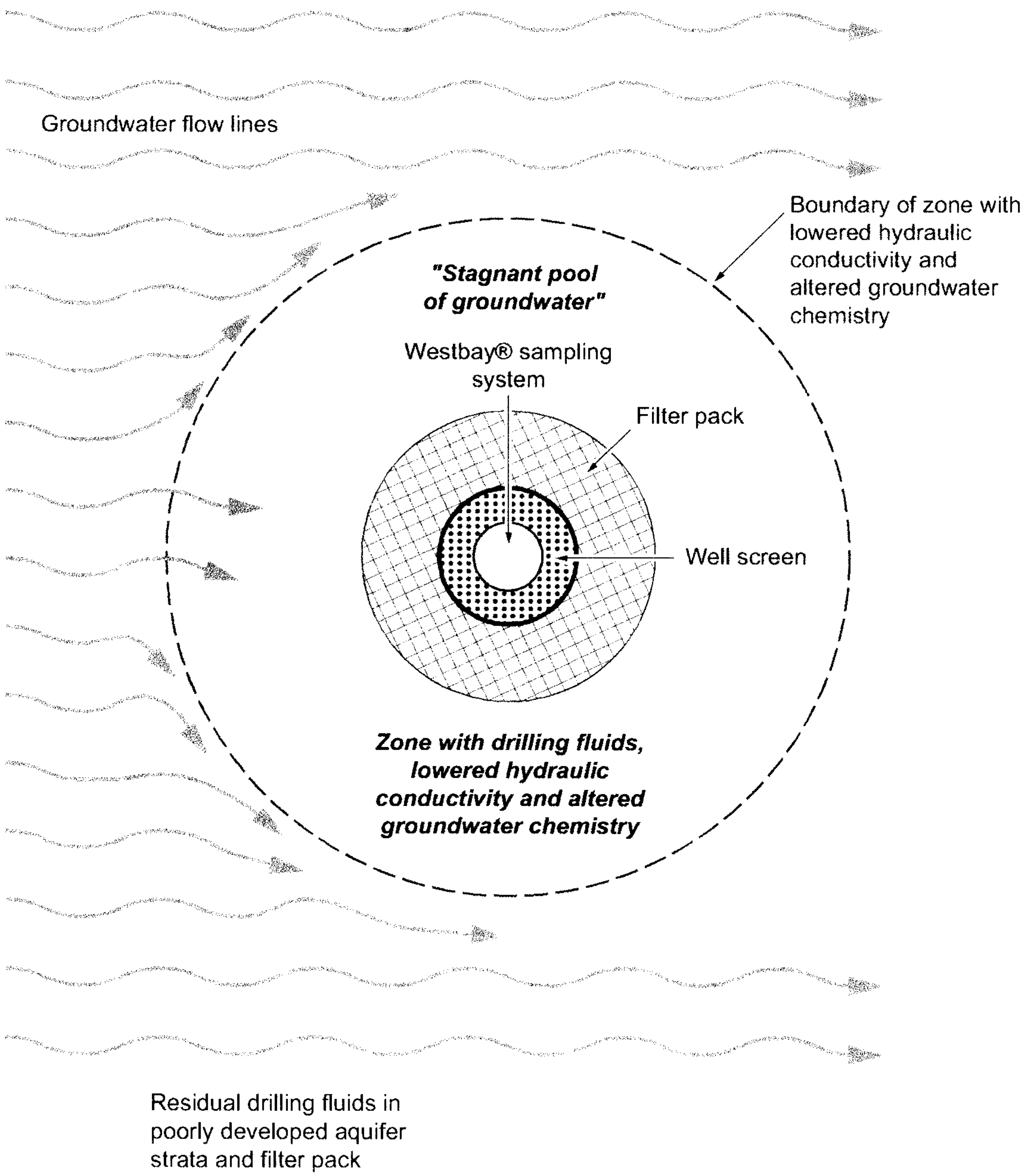
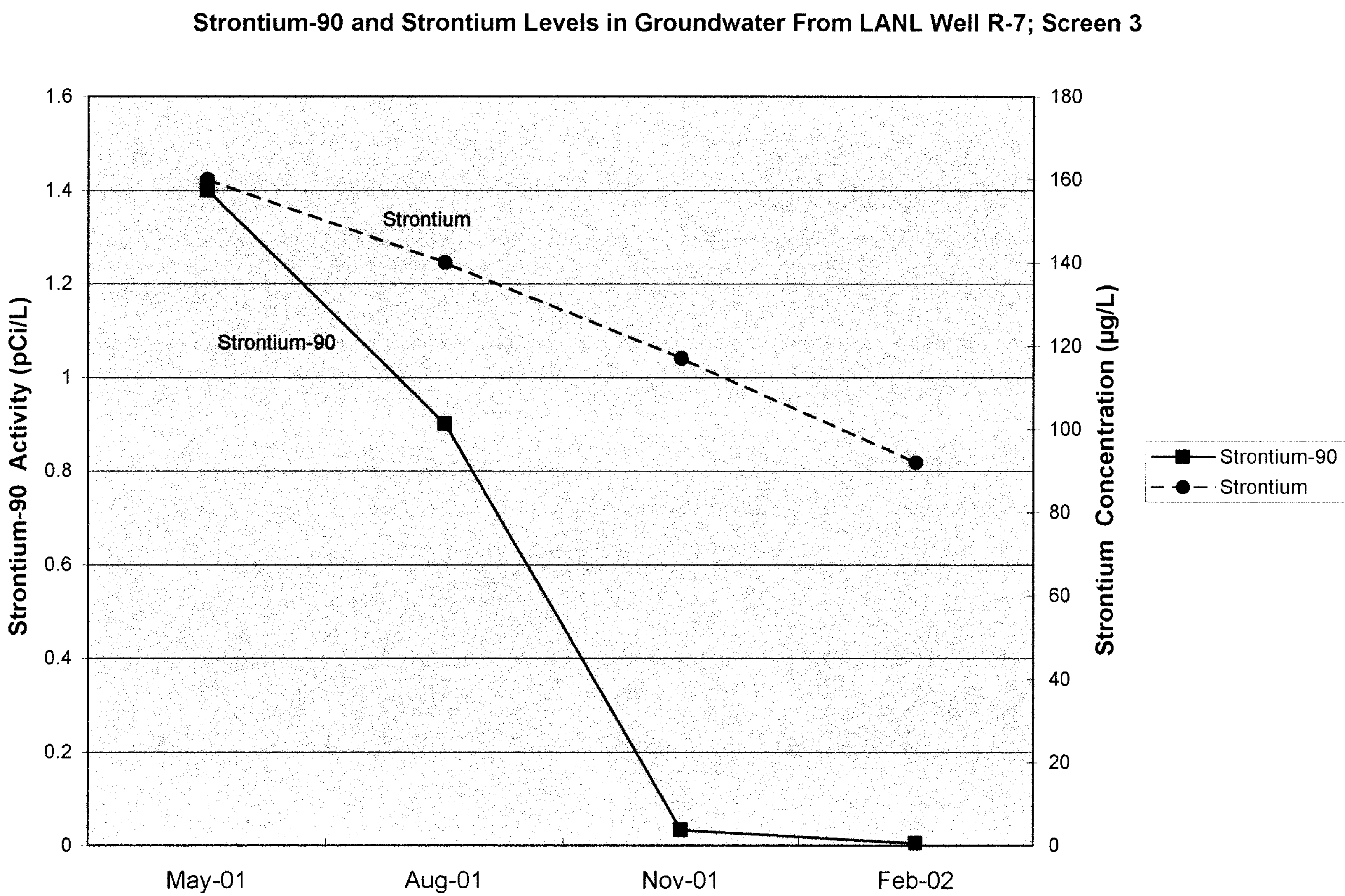


Figure 4

Overhead view of a screened interval in a LANL multiple-screened characterization well showing the poor mixing of regional groundwater with the zone of altered chemistry that surrounds the screen

Figure 5


Strontium-90 and Strontium Levels in Groundwater From LANL Well R-7; Screen 3
Strontium-90 Activity (pCi/L)
Strontium Concentration (µg/L)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
180
160
140
120
100
80
60
40
20
0
Strontium
Strontium-90
May-01
Aug-01
Nov-01
Feb-02
Strontium-90
Strontium

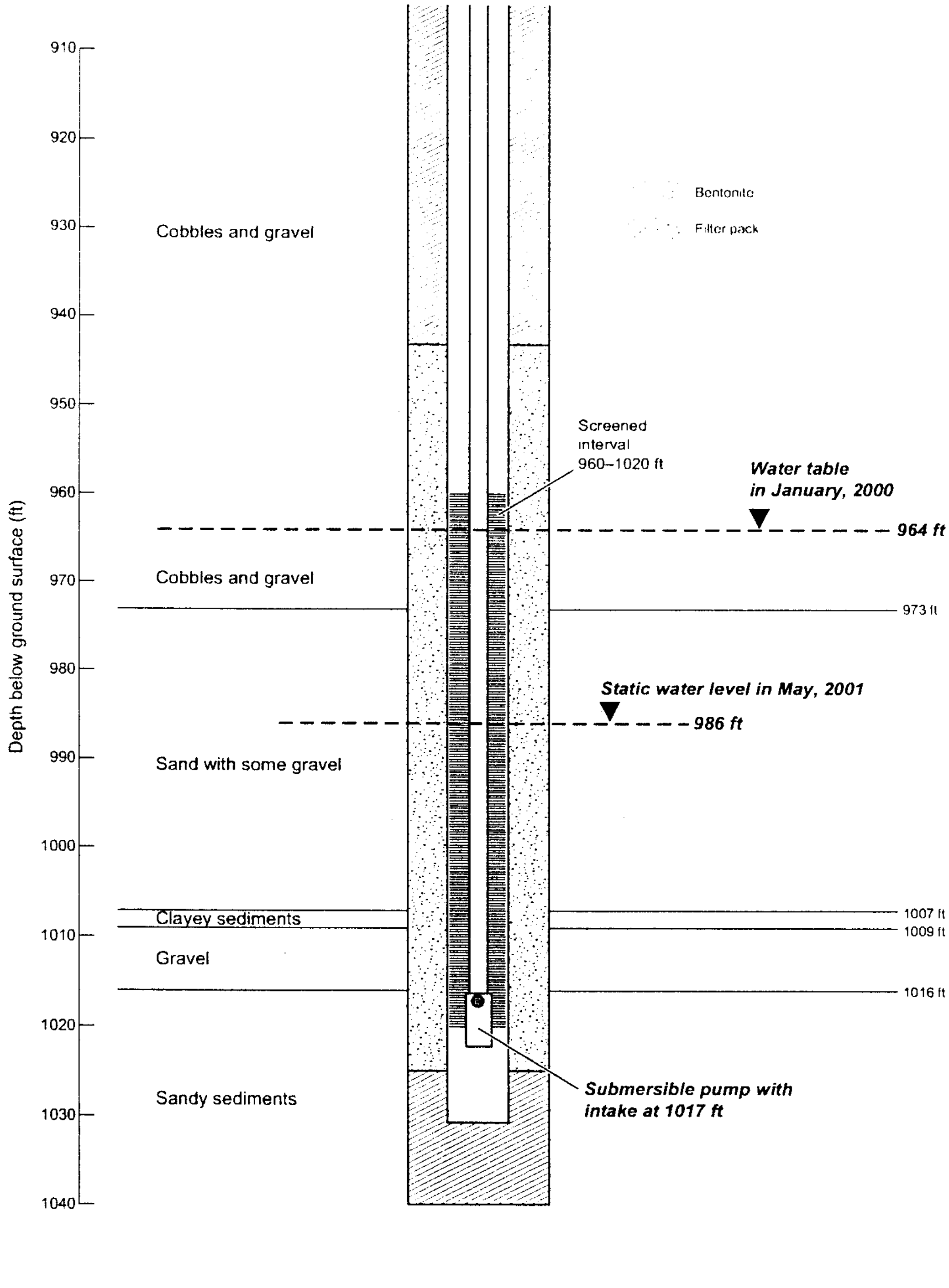
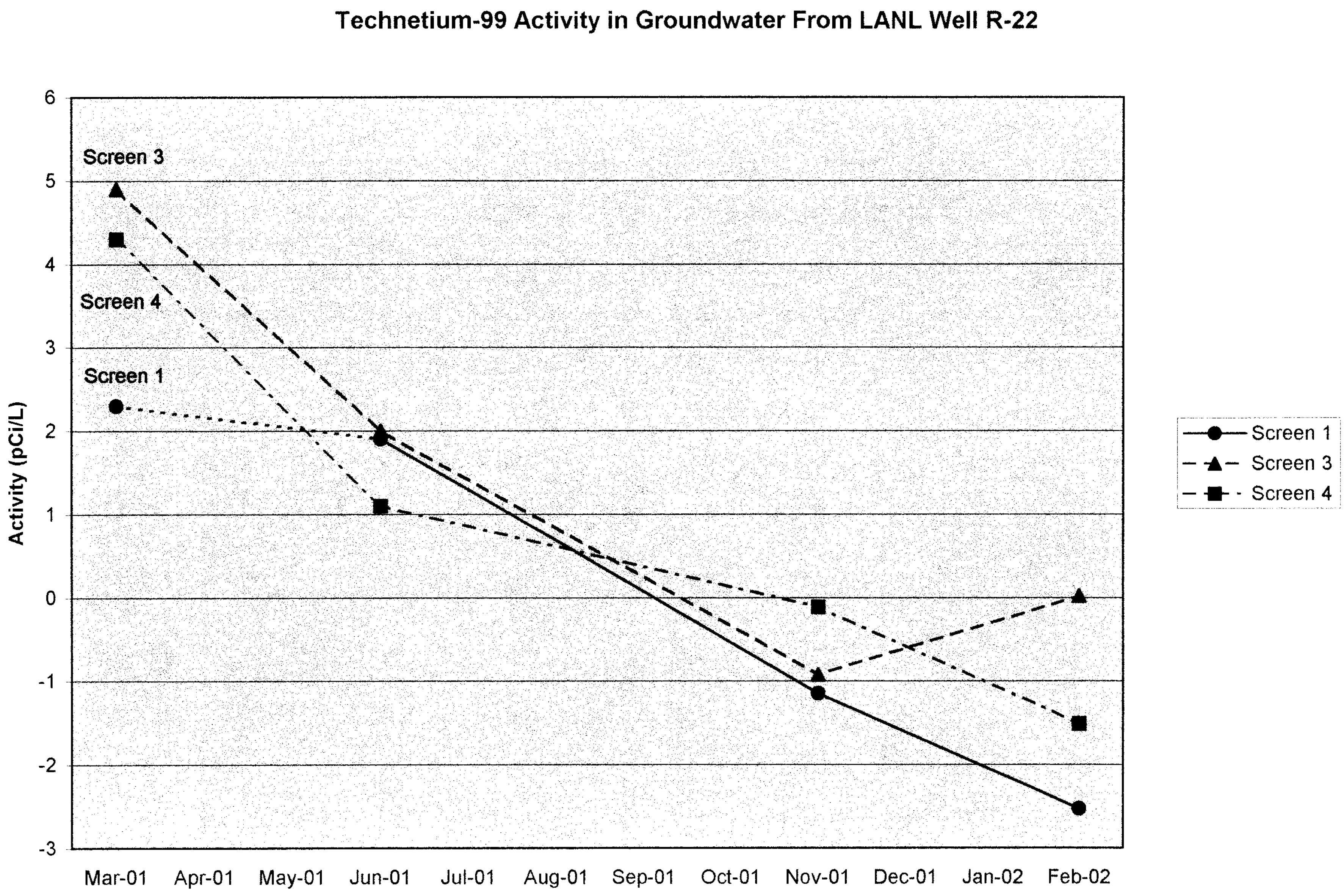


Figure 6

Hydrostratigraphy and changes in water level at LANL monitoring well R-15

Figure 7


Technetium-99 Activity in Groundwater From LANL Well R-22
Activity (pCi/L)
6
5
4
3
2
1
0
-1
-2
-3
Screen 3
Screen 4
Screen 1
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Feb-02
Screen 1
Screen 3
Screen 4

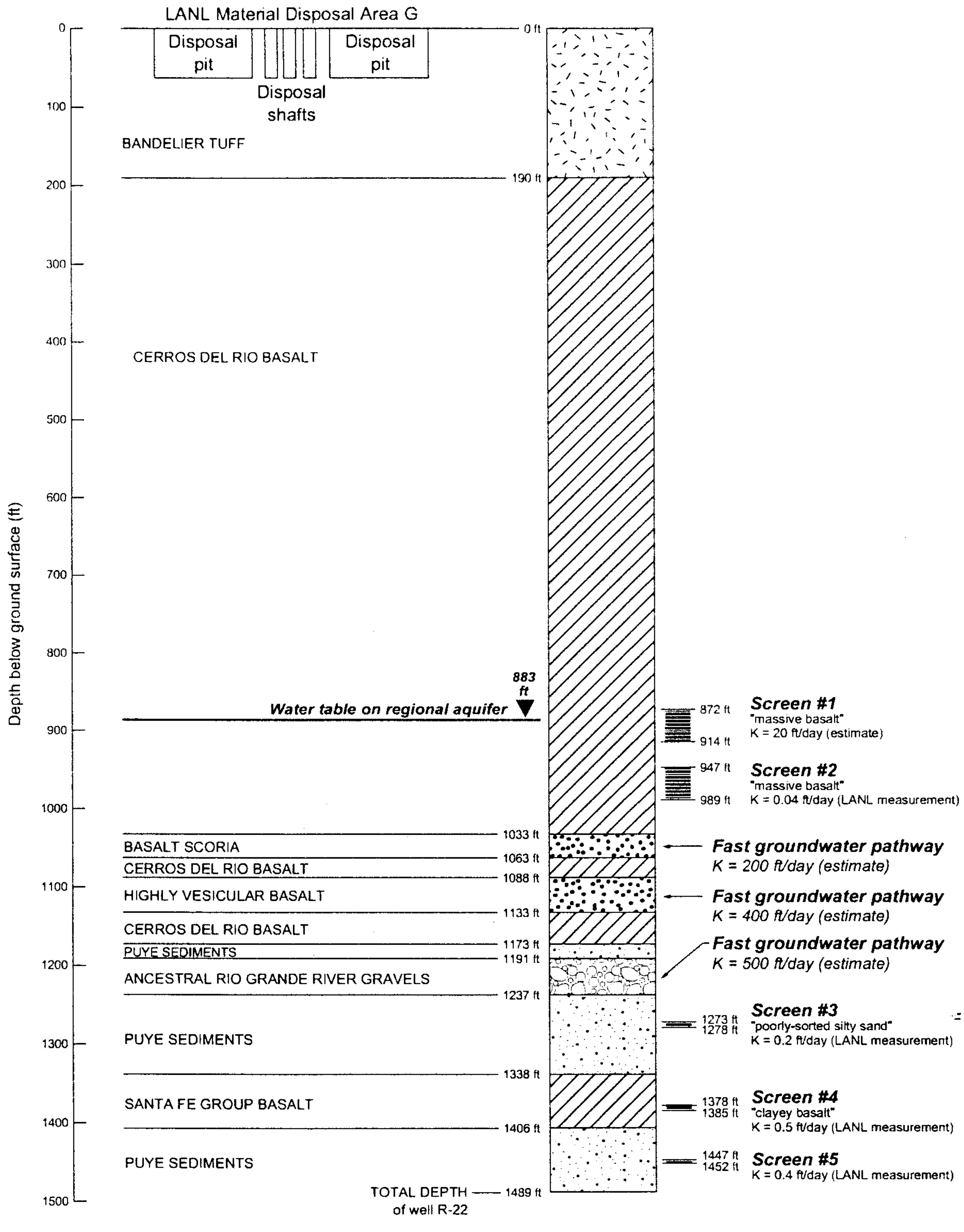


Figure 8

Location of screens in LANL well R-22 compared to aquifer strata that are fast groundwater pathways

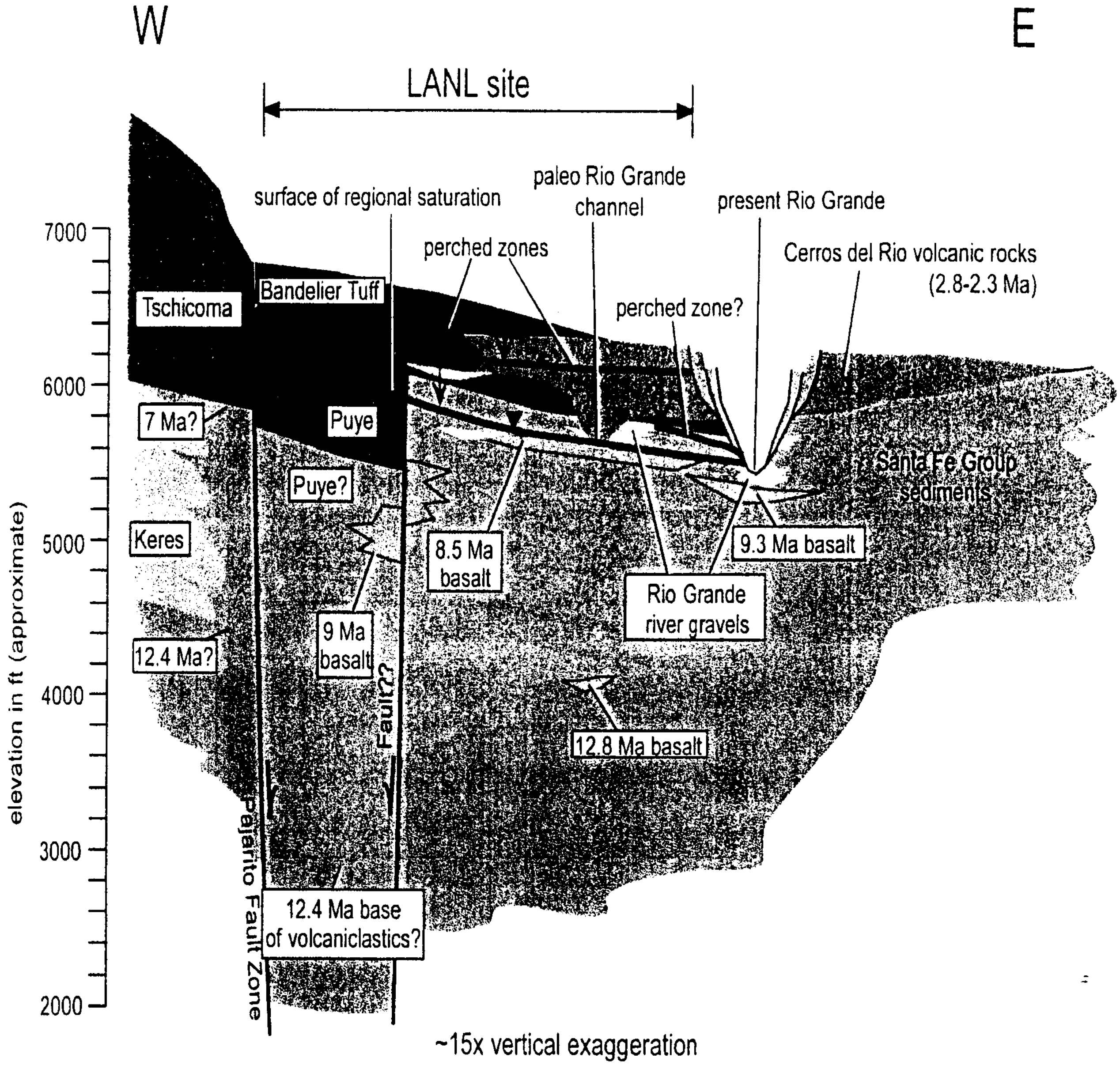


Figure 9

Schematic cross-section through the Laboratory illustrating current conceptual relationships between major stratigraphic components (from Nylander et al. 2002)