Written Testimony by Dr. Barcelona to the 2010 Public Hearing on the LANL Resource Conservation and Recovery Act (RCRA) Permit

Technical Memorandum on the Los Alamos National Laboratory (LANL) Ground Water Monitoring Program with an emphasis primarily on the Well Screen Analysis Report - Revision 2 (WSAR-2) (LA-UR-07-2852, May 2007) AR 14684. and the Ground Water Background Investigation Report - Revision 3, (GBIR-3) (LA-UR-07-2853, May 2007) AR14685.

By: Dr. Michael J. Barcelona, Professor and Past Chair, Department of Chemistry, Western Michigan University, Kalamazoo, MI 49008

My comments are based on review of the reports noted above and the correspondence that offered an analysis of the WSAR-2and GBIR-3 by scientists at the U.S.E.P.A. R.S. Kerr Ground Water and Ecosystems Restoration Division particularly the E.P.A. review dated March 30, 2009 [document missing in the NMED Administrative Records (AR)]. I offer them in the hope that the New Mexico Environment Department (NMED) will exhaustively re-evaluate the Resource Conservation and Recovery Act (RCRA) program apparently in place at LANL. In effect it’s a call to return to basics and start over in the monitoring effort.

I have been working in hydrogeochemistry since the early 1980’s. Part of this work has included review and suggested revisions of RCRA guidance which embodies the state of hydrologic and geochemical science and regulations applied to hazardous waste sites. It also included technical assistance in the preparation of the RCRA Technical Enforcement Guidance Document in its original published form.

The review of the documents noted above was rather disturbing. Given the multiplicity of historic waste disposal sites and waste streams (Both RCRA listed and radionuclides) it is astounding that the LANL monitoring approach does not comply with the legal requirements of RCRA and is not in accord with associated established precedent. The main problem areas in the monitoring plan and its execution are briefly summarized below. Many of these points have been made by the U.S. EPA and the National Research Council in their 2007 Report (Plans and Practices for Ground Water Protection at LANL, 2007) [missing in the NMED AR]:

1. RCRA monitoring programs should be driven by waste type and the waste discharges over time in the context of hydrostratigraphic units and potential contaminant transport pathways. These elements do not seem to be the focus of the LANL program.

2. The LANL waste units (especially the RCRA "regulated unit" waste disposal facilities) should be identified clearly as well as specific up-gradient and down-gradient monitoring wells and corresponding points of compliance as required in 40 CFR Section 264.95. Exhibit 1 shows the location of LANL RCRA regulated units MDA G. MDA L and MDA H and the network of monitoring wells in the regional aquifer.

3. Water samples LANL collected from springs and fully-screened production wells are inadequate to define background conditions. Single screen completions in well characterized hydrostratigraphic zones are needed at the waste unit and facility-wide level. The well locations and screen placements should be chosen based on the hydrogeology, not on Monte Carlo simulations and a fate and transport model based largely on assumptions and often incorrect values for aquifer properties.

4. LANL's use of bentonite and other drilling muds was unnecessary. Air-rotary casing advance drilling methods can be used in this type of hydrogeologic setting. Bentonite clay and organic drilling muds should never be used in the vicinity of well screens because development efforts rarely are successful particularly when there is excessive mud loss during drilling (R-32 screen one, > 2 tons of mud lost) see Table 4-5 from LANL WSAR-2 in Exhibit 2. AR 14685, p. 116.

5. The NMED Hazardous Waste Bureau sent a letter to DOE/LANL on April 5, 2007 that imposed the rehabilitation of mud-rotary monitoring wells R-20 (screen #1 and #2) and R-32 (screen #1). However, the LANL Workplan for R-Well Rehabilitation and Replacement (LA-UR-06-3687, June 2006) AR 14154 accurately described the requirement to recover all of the bentonite drilling mud from the screened interval. The pertinent excerpt from the report is pasted below:

> "If not completely removed by subsequent development, bentonite can serve as both a source of ions to groundwater as well as a sink for sorbing cations and organic species (p.3.)"

6. But it was not feasible to remove the large amount of clay drilling mud from the three screened intervals. The factors that prevent removing more than ~5 % of the clay from the screened intervals are the following:

A). The very high hydraulic force of the mud-rotary drilling method to force the clay-rich drilling mud into the geologic strata in the open borehole compared to the low power of the pumping and jetting methods to remove the clay.

B). The clay suspended in the drilling fluid would tend to form a paste in the openings in the geologic strata.

C). The restrictive pipe-based design of the well screens prevented the extraction methods from removing much of the clay. The restrictive design of the pipe-based screens is displayed in Exhibit 3.

D). There is a limit to the amount of power that can be used to recover the bentonite clay through the well screens. The powerful Hydropuls jetting tool did serious damage to the two screens in Well R-20. The pertinent excerpt from the LANL Pilot Well Rehabilitation Study Summary Report (LA-UR-07-1640, March, 2007) AR 14663. p. vii. is shown below:

> At R-20 it was concluded that the severe hydraulic shock induced by the Hydropuls tool had degraded the permeability of

the sediments around the screens. Also, when the Hydropuls tool was removed from the well, bentonite seal material was observed on the top of the tool, and at various later times there was evidence of bentonite seal material being removed from screen 1. Apparently the powerful action of the Hydropuls was too aggressive and either liberated seal that previously had been improperly placed adjacent to screen 1, or brought seal material down to the screened interval from above the well screen. These findings make the Hydropuls tool an unlikely candidate for redevelopment at other wells.

The damage caused by the powerful Hydropuls tool in the two screens in Well R 20 is proof that great energy can not be used in the attempt to remove the drilling clay from the screened intervals in the LANL monitoring wells. The Hydropuls experience in Well R-20 demonstrates that the clay can not be removed from the screened intervals.

7. The assessment in the LANL 2009 Interim Facility Wide Monitoring Plan (2009 Interim Plan) AR 31663. p. f-63. that the two screens in well R-20 are rehabilitated and produce water samples that are reliable and representative for all contaminants of concern is uncertain because it is highly unlikely that more than 10% of the drilling clay was removed from the screens and the screens were damaged by the powerful action of the Hydropuls. The determination that the two screens produce reliable sample was based merely on a review of the chemistry of water samples using the assessment methods in the WSAR-2.

However, the March 30, 2009 report by the EPA and the 2007 report by the National Research Council (NRC) described the reasons that the study of only water quality data could not determine that the LANL monitoring wells produced reliable data. The EPA and the NRC recommended that LANL conduct laboratory and field studies to determine that the monitoring wells produced reliable water samples. The recommended studies apparently have not been conducted.

In fact, the NMED May 25, 2007 approval letter for the WSAR-2 AR 14713 also recommended that DOE and LANL perform laboratory and field tests. An excerpt from the letter follows:

> "NMED notes that the conclusions obtained in the report [i.e., the WSAR-2] were derived mainly from analysis of extent data in the literature, possibly under conditions different from the Los Alamos National Laboratory's site (the site). The absence of critical site-specific data, such as adsorption properties, reaction kinetics and microbial activities, implies that there would be uncertainties and limitations in using the methodology developed in the report to assess the quality of groundwater samples collected from monitoring wells installed at this site. NMED is especially concerned about the uncertainty with respect to monitoring certain potential contaminants of concern, such as the highly adsorptive radionuclides. NMED therefore suggests that the Permittees consider conducting proper laboratory and field studies to address the uncertainty regarding whether or not the monitoring wells installed as the monitoring network are capable of providing reliable data to monitor potential releases of the highly adsorptive radionuclides from operation of the Laboratory to groundwater."

8. The large quantity of bentonite clay that is present in the screened intervals of many of the LANL monitoring wells biased (low) the values of hydraulic conductivity that were measured for the aquifer strata. The two obvious sources for the large amount of bentonite clay in the zone surrounding the well screens are 1). the bentonite clay drilling muds and 2). the bentonite clay grout that was used to backfill the annular space between the borehole wall and the well casing.

The hydraulic conductivity values (Ksat) measured in many of the LANL monitoring wells are in Table 2-3 in the LANL *Hydrogeologic Synthesis Report* (LA-14263-MS, December 2005) AR missing. The low Ksat of 4.20 ft/day for screen 1 in well R-32 is because of the approximately 4,234 pounds of bentonite clay that was forced into the aquifer strata by the hydraulic force exerted in mud-rotary drilling. The lithology log in Appendix C in the LANL Well R-32 Completion Report (LA-UR-03-3984, June 2003) AR 2375 describes the geologic strata in the depth interval of screen 1 as "River gravels interpreted to occur from 863 to 870 ft bgs."

The two tons of bentonite clay that flowed into the river gravels is direct evidence that the aquifer strata at screen 1 in well R-32 had a very high Ksat possibly greater than 100 ft/day compared to the low value of 4.30 ft/day that was published in the LANL *Hydrogeologic Synthesis Report.* Table 2-3 in the *Hydrogeologic Synthesis Report* lists Ksat values for 9 screens that were drilled with bentonite clay muds. It is most likely that the bentonite clay has lowered the Ksat values measured in the geologic formations where the screens are installed as well.

A special situation is the very low Ksat value of 0.002 ft/day that was measured in screen 2 in monitoring well R-26. Screen 2 does not produce water samples because the screened interval is so tightly plugged by the bentonite clay introduced by the mud-rotary drilling and also by a problem in well construction that allowed the well screen to be invaded by bentonite clay grout. The presence of the bentonite clay in screen 2 was described in the LANL *Evaluation of the Suitability of Wells Near Technical Area 16 for Monitoring Contaminant Releases from Consolidated Unit 16-021(c)-99, Revision 1* (LA-UR-07-6433, September 2007) (TA-16 Well Evaluation Report) AR 30191. The pertinent excerpts from the report are shown below:

> "R-26. Bentonite is present at Screen 2. The source of this bentonite is not known, but it was probably introduced during well completion. The presence of bentonite may result from a seal integrity problem or from the presence of residual drilling mud" (p. 22).
>
> <u>4.2.3.8 R-26</u> "R-26 has one screen (Screen 2) in the regional aquifer. During sampling at Screen 2 in 2005, it was discovered that the lower port was plugged with bentonite. In November 2005, the transducer was relocated to another port in the same screened interval. Still, collected pressure data are suspect because bentonite was present in the screen (p. 30)."

The LANL TA-16 Well Evaluation Report acknowledges that the bentonite clay in screen 2 in well R-26 was because of the mud-rotary well drilling and a problem in well construction. However this report and other LANL reports including the *Hydrogeologic Synthesis Report* use the very low Ksat value measured in the plugged screen as a representative value for the Ksat of the regional aquifer.

Another example is screen 5 in multiple-screen monitoring well CdV-R-15-3. Figure 7.2-1 in the Well CdV-R-15-3 Completion Report (LA-13906-MS, April 2002) AR 4259 shows that greater than 90% of the screen is surrounded by bentonite clay grout because of a problem in construction of the well. The bentonite clay plug is responsible for the very low Ksat of

0.25 ft/day that is listed in Table 2-3 in the LANL *Hydrogeologic Synthesis Report*.

The incorrect information on aquifer properties that is presented in the LANL reports is a serious problem. Estimates of contaminant mobility, transport rates and likely arrival times at points of compliance can be thrown off by orders of magnitude by the use of faulty K's. A detailed evaluation is necessary to identify the incorrect information that is present in the LANL reports on aquifer properties below the LANL waste disposal facilities and site wide.

9. LANL's use of multiple screened wells has permitted bore-hole flow and cross contamination between aquifer formations during drilling and well construction. They do not meet RCRA requirements for discrete well screens. Multiple screens make actual contaminant release, detection, and transport pathways very difficult, if not impossible, to document.

LANL monitoring well R-22 located ~ 500 feet down-gradient of the RCRA "regulated unit" MDA G is an example of the problems presented by installing a multiple-screen monitoring well. A large suite of RCRA hazardous constituents and also tritium were detected in samples from the deepest screen (five) in this well. Screen 5 is located 560 feet below the water table of the regional aquifer. The excerpt shown below is from LANL report *Response to Concerns About Selected Regional Aquifer Wells at Los Alamos National Laboratory* – (LA-UR-04-6777, September 2004) (AR missing from index) which recognized the on-going contamination detected in the water samples collected without purging from well R-22:

> "Thirty-one volatile and semi-volatile organic compounds have also been detected in water from well R-22. Only two of these, pentachlorophenol (1 detection, 6.2 ppb, MCL = 1 ppb) and

> benzo(a)pyrene (2 detections, 0.24 ppb, MCL = 0.2 ppb) were present at concentrations above the MCL. Monitoring for organic compounds at well R-22 will continue" [MCL means Maximum Contaminant Level allowed in the EPA Drinking Water Standards] (p. 35)."

There is a very high level of uncertainty associated with monitoring results from fully or multiple screened wells potentially impacted by drilling muds, bore-hole flow, and without purging. In light of this and the proximity of LANL waste units to the regional aquifer and a number of public water supply wells, the monitoring program should be completely re-designed and started anew exercising sound professional judgment.

The groundwater contamination measured in the no-purge samples collected from screen five in well R-22 is likely the result of cross-flow of contaminated groundwater within the borehole during drilling from an unknown aquifer zone. In effect, the borehole acts as a conduit for the vertical transport of contaminants. At well R-22, well screens were not installed in apparently high Ksat hydrostratigraphic zones (e.g., the RCRA "uppermost aquifer) that were identified by the drilling operations, the lithologic log or the Schlumberger (Trademark) geophysics conducted in the open borehole.

The apparent current use for well R-22 is measurement of water levels. I would suggest strongly that NMED require installation of a minimum of two new single-screen monitoring wells near the location of well R-22 to investigate potential groundwater contamination down-gradient of MDA G. One well should be installed a short distance below the water table. The other well should be installed in the high permeability strata that are present approximately 150 feet below the water table. See Exhibit 4, the suite of Shlumberger geophysics logs for well R-22.

10. There is no empirical evidence provided by LANL that the use of drilling muds in screened intervals can be rehabilitated. The changes in geochemistry which occur in drilling mud impacted aquifer formations have not been measured and they would be expected to seriously influence contaminant mobility and detection in water samples.

11. LANL efforts to estimate the oxidation-reduction (redox) status of aquifer formations potentially impacted by drilling muds using water samples is ill-conceived since water samples do not capture mineral contaminant interactions. Also, the chemical parameters LANL selected to estimate redox status must be determined analytically in the field, not in the laboratory. Total organic carbon (indicative of some organic drilling muds) or alkalinity (indicative of microbial degradation of organic constituents) may be more useful indicators in this regard. Total organic carbon must be done in the lab on preserved samples. Alkalinity must be done in the field.

12. The presence of elevated levels of total organic carbon is evidence of residual organic drilling products. However, the absence of total organic carbon in water samples produced from an impacted monitoring well does not demonstrate that organic drilling products have been removed from the geologic formations. This fact was documented in the LANL WSAR-2. The pertinent excerpt from the report follows:

> "Figure 4-2a shows that slightly less than one-half of the 80 screens included in this report had achieved TOC <2 mg/L by the end of development. (Note that the majority of these screens were developed prior to establishment of the TOC monitoring guideline.)

> However, from this plot there appears to be little correlation between the level of TOC achieved and the present-day reliability of the water-quality samples from that screen (p. 13). The lack of correlation between ending TOC and present conditions in a screen implies that a significant inventory of residual organic drilling fluid component may remain in a screen interval even after development, and yet not be directly detectable from groundwater samples. This conceptual model, which is described later in section 4.5, assumes that some proportion of the organic constituents used in a borehole adsorbs or partitions strongly onto geologic material or onto cellulosic lost-circulation material, and that these organic constituents may not be detected in water-quality samples simply because they have been immobilized or trapped and are only negligibly soluble. However, their presence can be inferred from the subsequent development of reducing conditions and lingering elevated concentrations of biodegradation products, as discussed in section 4.5 (p. 13)."

There is a very high level of uncertainty associated with monitoring results from fully or multiple screened wells potentially impacted by drilling muds, bore-hole flow, and without purging. The WSAR-2 was an assessment of water samples produced from 80 screened intervals. However, no-purge samples were collected from 52 (65%) of the screened intervals. The NMED Hazardous Waste Bureau had approved the collection of no-purge water samples despite the requirement in the NMED LANL Compliance Order on Consent (COOC) that a sufficient amount of water should be purged from each screened interval to ensure that samples of *in situ* formation water are collected. Preferably a flow cell, thermometer, and electrodes for pH, dissolved oxygen, oxidation-reduction potential, and specific conductance should be used connected to a good submersible bladder pump. These pumps can be used at depth by the use of one-way check valves between the pump in the screened interval and the surface. This is just good professional practice. With the electrode readings one can document when water from the formation is being pumped stabilizes in ionic composition and is not stagnant water from the borehole. The measurements can be very useful in subsequent sampling events.

In light of this and the proximity of LANL waste units to the regional aquifer and a number of public water supply wells, the monitoring program should be completely re-designed and started anew exercising sound professional judgment.

It would be surprising if chemical and radiological contamination had not migrated away from waste units and compromised ground water quality within the area. Unfortunately, the current monitoring system cannot unequivocally answer that question. The public deserves to be better protected.

I appreciate the opportunity to present my testimony.

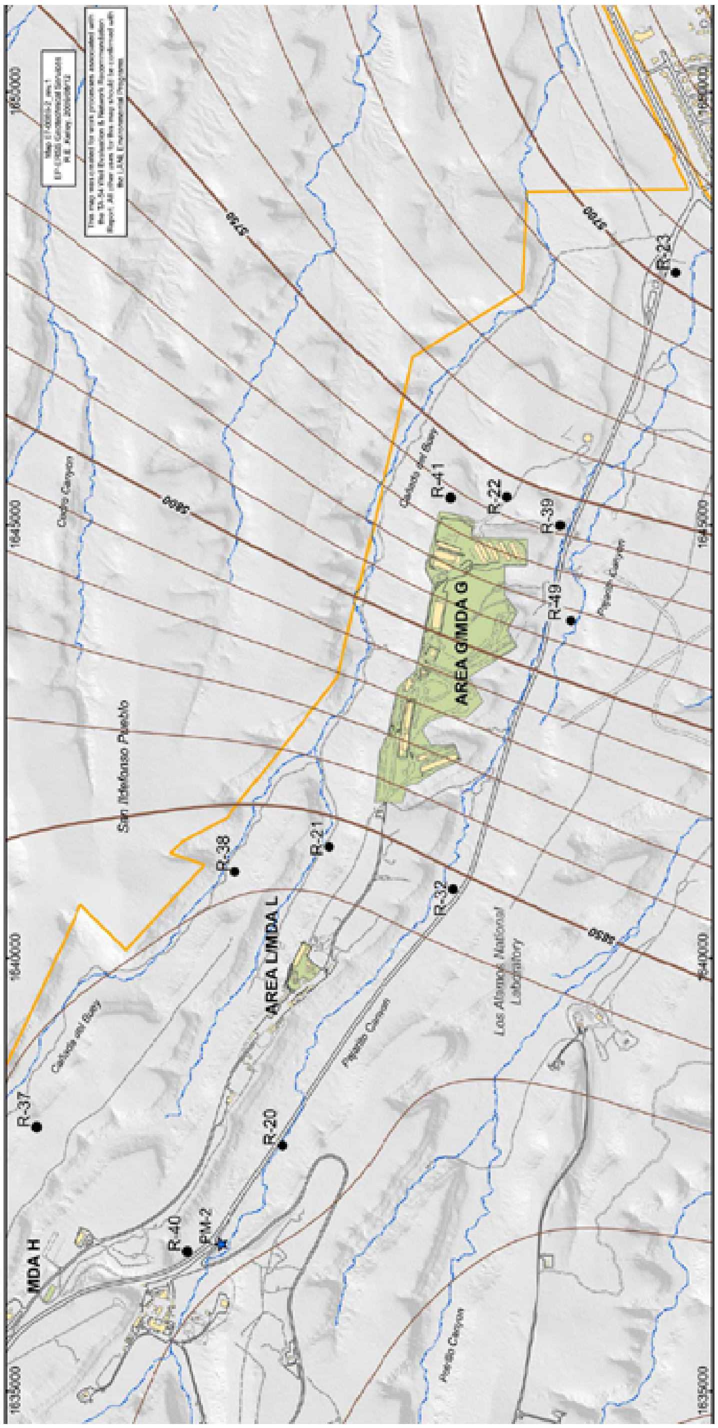
Exhibit 1. AR 32022

RCRA regulated units MDA G, MDA L and MDA H at LANL TA-54

- The distance from the northern boundary of MDA L to well R-38 is ~ 1/4 mile

- The contour lines are the elevation of the water table of the regional aquifer

- The R-wells are the monitoring wells installed in the regional aquifer.



Source: Figure 2.3-13 *"Regional monitoring wells, water supply wells, and groundwater gradient" in* LANL Report *MDA G CME Report – Rev 1* (LA-UR-09- 5509 September 2009).

EXHIBIT 2 AR 14685, p. 116.

Table 4-5

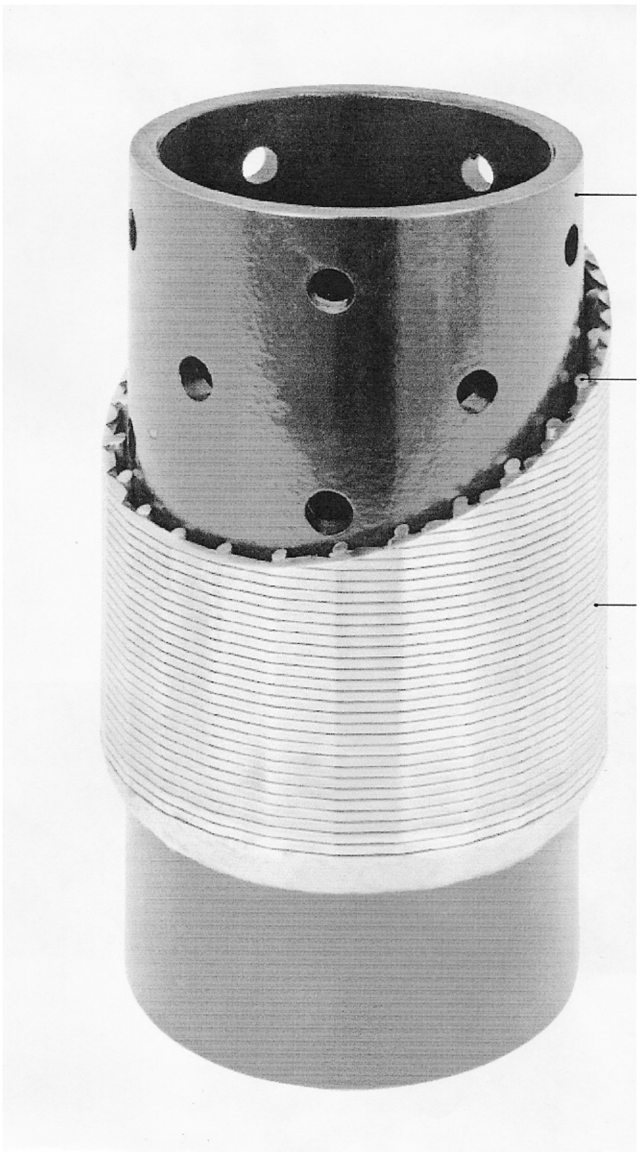
Examples of Organic and Inorganic Drilling Fluids Used in Borehole Screen Intervals Drilled Primarily with Bentonite Mud

Well Screen	Screen Depth (ft)	Water (gal.)	Bentonite (lb)	PAC-L (lb)	N-SEAL (lb)	Soda Ash (lb)	MAGMA FIBER (lb)	QUIK-FOAM (gal.)	EZ-MUD (gal.)	LIQUI-TROL (gal.)
R-14 Screen 1	1205	14157	3836	95	247	0	292	23	0	3.2
R-14 Screen 2	1289	8485	2300	57	148	0	175	14	0	1.9
R-16 Screen 2	866	3120	2530	4	65	8	65	0	21	0.4
R-16 Screen 3	1018	2873	2330	4	60	8	60	0	19	0.4
R-16 Screen 4	1238	6550	5312	9	136	17	136	0	44	0.9
R-20 Screen 1	907	3253	614	17	9	0	54	0	0	7.7
R-20 Screen 2	1150	3361	634	18	9	0	56	0	0	8.0
R-20 Screen 3	1330	2784	525	15	8	0	46	0	0	6.5
R-32 Screen 1	871	7592	4234	8	135	0	135	0	4	0.7
R-32 Screen 3	976	7592	4234	8	135	0	135	0	4	0.7

Notes: This list is limited to screens in multiple-screen wells. It does not include the three single-screen wells drilled with bentonite mud (R-2, R-4, and R-6). This list does not include additional chemical treatments conducted after well installation. Information compiled by J. Pavletich from Well Completion Reports (LANL 2003, 076062; LANL 2003, 076061; LANL 2003, 079600; LANL 2003, 079602) and drillers' field logbooks. Quantities used in the interval are estimated from the total use by apportioning it according to the length of screen interval, including 10 ft above and below it. For example, if the total use over a 100-ft section is recorded as 90 gal. of Product X, and the screen interval is 10 ft, then the quantity used in that interval is estimated as 30-ft/100-ft = 0.33 x 90 gal. = 30 gal.

Exhibit 3

Schematic of the pipe-based wire-wrap stainless steel well screens that are installed in the LANL mud-rotary multiple-screen monitoring wells R- 14, R-16, R-20 and R-32.

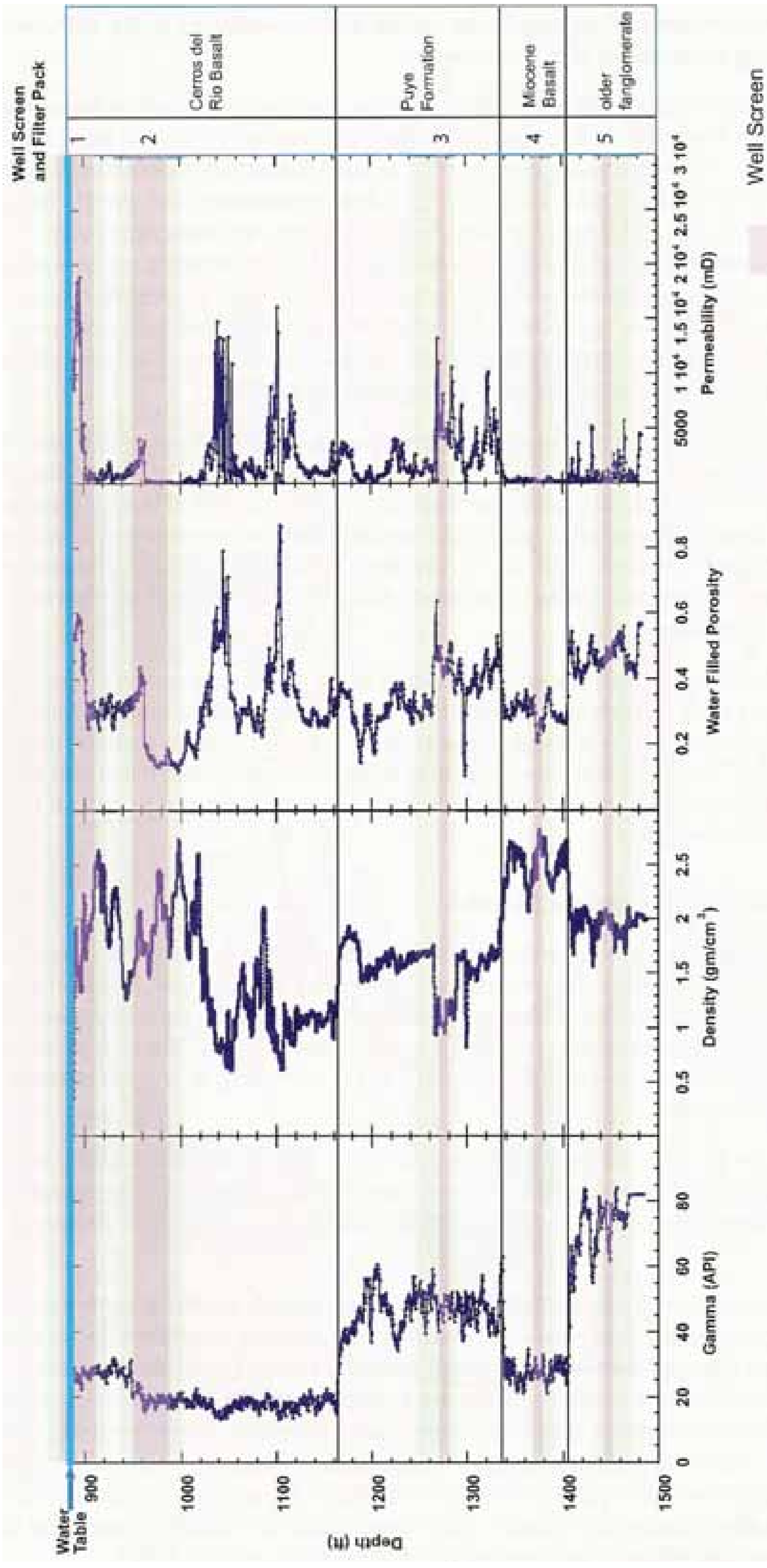


The set of drill holes through the 4.5 inch inside diameter base pipe are only ~15% of the surface area of the stainless steel screen.

Type 304 stainless steel rods are welded to the base pipe and to each wrap of the wire-wrap screen.

The coils of Type 304 stainless steel wire are wrapped around the base pipe with an opening between each coil of one-hundredth of an inch (0.010 inch). One-hundredth of an inch is the thickness of three human hairs.

Exhibit 4
SCHLUMBERGER[R] GEOPHYSICS IN LANL MONITORING WELL R-22



- Geophysical logs and well screen locations in the regional aquifer for well R-22
Source: Figure 5 in LANL Report LA-UR-04-6777, September 2004 AR 13899.