The Los Alamos National Laboratory *Fieldwork Plan for R-22 Well Rehabilitation and Conversion* is Unacceptable and Must be Denied by the New Mexico Environment Department
Report Version February 20, 2009

By Robert H. Gilkeson, Registered Geologist
P.O. Box 670
Los Alamos, New Mexico 87544
rhgilkeson@aol.com 505-412-1930
And
Joni Arends, Executive Director
Concerned Citizens for Nuclear Safety
107 Cienega Street
Santa Fe, New Mexico 87501
jarends@nuclearactive.org 505 986-1973

Executive Summary. The Los Alamos National Laboratory *Fieldwork Plan for R-22 Well Rehabilitation and Conversion* is unacceptable and should be denied by the New Mexico Environment Department. The R-22 Plan fails to recognize the many reasons that it is not possible to convert well R-22 into a monitoring well for the detection of groundwater contamination from the hazardous and mixed wastes buried in MDA G. RCRA §264.99 requires a comprehensive investigation of the nature and extent of groundwater contamination in the regional aquifer below MDA/Area G and at the location of well R-22. At this time, the only use of well R-22 is the measurement of water levels. Both the National Academy of Sciences and the LANL scientists understand the lack of knowledge that exists for the hydraulic properties of groundwater travel in the regional aquifer, but the necessary and very important aquifer pumping tests and tracer tests to reduce the uncertainty are not being performed. It is very important to leave the Westbay[R] sampling system installed in well R-22 because removal of the system will allow the contaminated groundwater at the water table to drain down the open well and this drainage and cross-flow of groundwater in the open well must be prevented.

1. Background. On January 30, 2009, the Los Alamos National Laboratory (LANL) submitted the *Fieldwork Plan for R-22 Well Rehabilitation and Conversion* (R-22 Plan) to the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB). The NMED needs to deny the R-22 Plan for reasons presented in this report. Mr. James Bearzi, Chief of the HWB, provided the R-22 Plan to the author for review and comment. Previously, on January 28, 2009, the authors presented a report to Chief Bearzi that explained the many reasons well R-22 was not usable as a monitoring well. The R-22 Plan does not change the conclusions in the authors original report and that report is included as an attachment with this review and comment.

The purpose of the R-22 Plan is to convert the LANL characterization well R-22 into a monitoring well for the detection of groundwater contamination from the large waste disposal site known as MDA G / Area G at TA-54.

However, the R-22 Plan fails to recognize the many reasons that it is not possible to convert well R-22 into a monitoring well for the detection of groundwater contamination from the hazardous and mixed wastes buried in MDA G. Figure 1 shows the location of well R-22 approximately 500 feet east of the eastern boundary of MDA G/ Area G. MDA G / Area G is the largest waste disposal site at LANL and occupies 63 acres. Burial of radioactive and mixed wastes in unlined trenches and shafts began in 1957 at MDA G and burial of low-level radioactive continues to the present time at Area G.

MDA G is regulated under the Resource Conservation and Recovery Act (RCRA) as a "Regulated Unit" because hazardous wastes were buried at MDA G after July 26, 1982. RCRA requires that MDA G must have a network of groundwater monitoring wells that are in compliance with RCRA 40 CFR §§264.90 through 264.100 (a set of regulations known as RCRA 264 Subpart F). Presently, the required network of monitoring wells does not exist. This report describes the many reasons that the R-22 Plan will not be successful in the rehabilitation and conversion of well R-22 into a monitoring well that meets the requirements of RCRA 264 Subpart F. In addition, well R-22 cannot be rehabilitated to provide the water quality data that are necessary for the NMED LANL Consent Order to identify the final remedy for MDA G that will protect human health and the environment.

Figure 2 shows the as-built design of well R-22 with five well screens. Screen #1 is installed across the water table and screen #5 is installed at a depth of 560 feet below the water table. When the R-22 borehole was drilled in September of 2000, the top of the regional aquifer was at a depth of 883 feet below ground surface. The R-22 Plan will plug and abandon screens #4 and #5 and seal off screen #1. Jetting procedures will be used to redevelop screens #2 and #3. Then a pumping system will be installed in the well to produce water samples from screens #2 and #3. However, there are many factors that will prevent the rehabilitation of screens #2 and #3 from being successful. Those factors are described in the author's January 28, 2009 report and are summarized below. Well R-22 must be replaced because it does not meet the requirements of RCRA as a monitoring well but it is an important well for measurement of water levels.

- **Screen #2 in well R-22.** The top of the 42-foot long screen is located 64 feet below the water table and in a basalt formation with a very low permeability of 0.04 feet per day (0.04 ft/day). The R-22 Plan makes the mistake to assume that screen #2 samples groundwater at the water table but the seven foot lower water level measured in screen #2 compared to screen #1 is evidence that there is little hydraulic communication between screen #2 and the water table. The available information shows that screen #2 is installed in a section of the basalt that only produces small quantities of groundwater. It is a requirement of RCRA 264 Subpart F and the NMED Consent Order to install monitoring wells in productive aquifers that are along the expected pathways for contaminated groundwater to travel from waste disposal sites. Screen #2 is installed in a confining bed that is not a pathway for groundwater contamination from MDA G.

Because of the very low permeability at screen #2, **Darcy's law** calculates a lateral speed of groundwater travel in the basalt of only 13 feet per year for a time of 40 years for groundwater to travel from the eastern boundary of MDA G to screen #2 in well R-22 and travel times of 150 and 270 years for groundwater below the central and western parts of MDA G, respectively. The conservative values used in the calculation with Darcy's law are a saturated hydraulic conductivity of 0.04 ft/day, an effective porosity of 2% and a hydraulic gradient of 0.1887. The hydraulic gradient was calculated from the LANL contour map for the water table below MDA G. The long travel times for groundwater below MDA G to reach screen #2 in well R-22 show that the R-22 Plan to rehabilitate screen #2 is unacceptable and should be denied by the NMED.

- **Screen #3.** There are many factors that prevent screen #3 in well R-22 from being usable as a monitoring well to detect groundwater contamination from MDA G.

- The top of the 7-foot long well screen in located 390 feet below the water table and below thick layers of highly permeable aquifer strata that are not monitored by either screen #2 or #3.

- The available information show that the thick layers of aquifer strata above screen #3 have a high permeability in the range of 50 ft/day to possibly greater than 100 ft/day.

- For comparison, the permeability measured at screen #3 was a low value of 0.21 ft/day. The well R-22 lithologic log describes the unconsolidated sediments surrounding screen #3 as "very fine silty sand to pebble gravel" - a description of poorly sorted sediments that have low permeability and are not productive aquifers.

- For the measured permeability of 0.21 ft/day, **Darcy's law** calculates a lateral speed of groundwater travel of only 6 feet per year for a time of 80 years for groundwater to travel from the eastern boundary of MDA G to screen #3 in well R-22 and travel times of 330 and 580 years for groundwater below the central and western parts of MDA G, respectively. The conservative values used in the calculation with Darcy's law are a saturated hydraulic conductivity of 0.21 ft/day, an effective porosity of 25% and a hydraulic gradient of 0.1887. The long travel times for groundwater below MDA G to reach screen #3 in well R-22 show that the R-22 Plan to rehabilitate screen #3 is unacceptable and should be denied by the NMED.

- The drilling method invaded the #3 screened interval with organic drilling additives that have created a new reactive mineralogy with well known strong properties to prevent accurate detection and measurement of many LANL contaminants of concern for MDA G. The R-22 Plan does not recognize the LANL reports that describe the new mineralogy screen #3 that was created by the organic drilling additives.

- The R-22 Plan does not describe the mistake during the construction of well R-22 that invaded the filter pack sediments surrounding screen #3 with the bentonite clay grout materials that were used to seal the well annulus. The bentonite clay has well known strong properties to prevent the detection and accurate measurement of many contaminants from MDA G.

- The R-22 Plan does not recognize the LANL reports that show the well development performed in November of 2000 was not successful in removing the organic drilling additives or the bentonite clay grout from screen #3. The pipe-based design of the well screen is one factor that prevented the well development from being successful. The restrictive design of the pipe-based screen is displayed and described in Figure 3.

- The R-22 Plan does not recognize that the restrictive design of the pipe-based well screen will also prevent the redevelopment activities in the R-22 Plan from being successful in cleaning the new reactive mineralogy and the grout contamination from screen #3.

2. Overview of the groundwater contamination detected at LANL characterization well R-22 and the requirement of RCRA and the NMED Consent Order for a minimum of two new monitoring wells close to well R-22. At the location of well R-22, the groundwater in the regional aquifer is contaminated with hazardous and radionuclide waste that was released from the unlined trenches and pits at MDA G. The nature and extent of the groundwater contamination in the regional aquifer is not known because of the many mistakes in 1). the drilling, 2). the well construction, 3). the misplaced locations of well

screens, and 4). the no-purge methods that were used for collecting water samples from the five screened intervals in well R-22.

A water sample collected when the borehole drilled into the water table of the regional aquifer was contaminated with tritium @109 pCi/L and chloride @ 21 mg/L. The measured concentrations are much higher than the background values for tritium and chloride. The type and amount of contamination at the water table is not known because the water sample was diluted by the water-based organic drilling fluids. Screen #1 was installed across the water table but this screen never produced reliable and representative water samples of the original *in situ* formation water because of

- 1). the careless drilling methods in the R-22 borehole that allowed the original *in situ* groundwater at the water table to drain down the open borehole,
- 2). the new reactive mineralogy from the organic drilling fluids, and
- 3). the Westbay[R] no-purge sampling system that collected stagnant water samples from the zone with the new mineralogy.

The drilling operations did not seal off the contaminated aquifer zones near the top of the regional aquifer. Instead, the contaminated groundwater was allowed to drain down the open borehole. A large number of hazardous waste contaminants and also tritium were detected for many years in the water samples produced from the screens in well R-22 including screen #5, the deepest screen in the well. The tritium contamination is still detected in water samples from screen #5. See Table 1 on the next page.

Table 1. Tritium contamination***** in groundwater samples collected from screen # 5 in LANL characterization well R-22.

Sample Date	Tritium pCi/L	Sample Date	Tritium pCi/L	Sample Date	Tritium pCi/L
1. 06-26-2000	**14**	**6. 07-05-2005**	**11.1**	**11. 09-07-2007**	**7**
2. 12-07-2001	**17**	**7. 08-21-2006**	**8.7**	**12. 12-18-2007**	**7**
3. 03-07-2002	**15**	**8. 12-06-2006**	**7.8**	**13. 03-05-2008**	**3**
4. 07-10-2002	**13**	**9. 03-22-2007**	**8.1**	**14. 06-23-2008**	**6**
5. 11-21-2003	**12.5**	**10. 07-10-2007**	**7**	**15. 09-16-2008**	**7**

*** The background concentration for tritium in groundwater in the regional aquifer is 0.32 pCi/L. Source: LANL report LA-UR-07-2853 (May 2007)**

Table 2. Contaminants in groundwater samples collected from well R-22.

- Contaminants listed in the February 2002 LANL Well R-22 Completion Report LA- 13893-MS (February 2002)
- tritium - 109 picocuries per liter (pCi/L) at the water table of the regional aquifer
- chloride - 21 mg/L at the water table of the regional aquifer
- Contaminants listed in the September 2002 LANL Well R-22 Geochemistry Report LA-13986-MS (September 2002)
- tritium - many detections
- technetium-99 (4.3 and 4.9 pCi/L)
- *****pentachlorophenol (6.2 parts per billion (ppb))

– ***chloroform (0.94 ppb)
– ***phenol (19 and 32 ppb)
– ***4-methylphenol (44 to 210 ppb)
– ***2-butanone (6.9 to 8.9 ppb)
– ***diethylphthalate (1.3 ppb)
– benzo(a)pyrene (0.24 ppb)
– benzoic acid (3 to 12.5 ppb)
– butyl benzyl phthalate (9.8 ppb)
– toluene (0.2 to 0.76 ppb)
– methylene chloride (0.62 and 2.2 ppb)
– bis(2-ethylhexyl)phthalate (1.0 and 3.9 ppb)
– Several substituted benzene compounds including
– isopropylbenzene (0.16 to 0.54 ppb), and
– 1,4-dichlorobenzene (0.16 to 0.23 ppb).

A LANL report – (LA-UR-04-6777, September 2004) recognized the on-going contamination detected in the water samples produced from well R-22 as follows:

> - "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].

- Tritium and technetium-99 are radionuclide contaminants that are highly mobile. Large amounts of both contaminants are buried in unlined pits and shafts at MDA G and Area G. The detection of the two contaminants in water samples collected from well R-22 are evidence of groundwater contamination from MDA G and Area G.
- ***The six hazardous waste contaminants with asterisks in the above list are highly mobile in groundwater and all are commonly found in groundwater beneath hazardous waste dumps. There are large amounts of these contaminants in the mixed wastes buried in MDA G. The measurement of these contaminants in the water samples produced from well R-22 is evidence of groundwater contamination below MDA G. The nature and extent of the contamination is not known but must be investigated.

The tritium and hazardous waste contamination detected in screen #5 is probably because the contaminated groundwater at the water table and/or in another permeable layer of aquifer strata within the upper 200 feet of the regional aquifer was allowed to drain down the open borehole. Table 2 lists the hazardous and radionuclide contamination measured in the water samples collected from well R-22.

Table 3 at the end of this report lists the hazardous contaminants detected in screen #5 for water samples collected on January 10, 2001.

It is a serious mistake that the LANL R-22 Plan makes no mention of the many RCRA hazardous waste contaminants that were repeatedly detected in water samples collected for many years from well R-22. The LANL R-22 Plan only mentions the tritium contamination detected in screen #5.

However, the repeated detection of tritium contamination in the water samples produced from well R-22 is recognized by RCRA §264.98(f) as **"statistically significant evidence of contamination."** RCRA §264.98(f) required that LANL or DOE must determine whether there is statistically significant evidence of contamination for any chemical parameter and tritium is a chemical parameter.

Table 1 shows that the tritium contamination consistently measured in water samples collected from screen #5 were always more than one order of magnitude greater than the LANL background value for tritium in the regional aquifer. RCRA §264 Subpart F required LANL and DOE to formally notify the New Mexico Environment Department (NMED) of the tritium contamination within seven days of the determination that the tritium contamination represented statistically significant evidence of contamination. In addition, LANL and DOE were required to implement the RCRA Compliance Monitoring Program for MDA G that is described in 40 CFR §264.99.

RCRA §264.99 requires a comprehensive investigation of the nature and extent of groundwater contamination in the regional aquifer at the location of well R-22. At this time, the only use of well R-22 for this comprehensive investigation is the measurement of water levels. It is very important to leave the Westbay[R] sampling system installed in well R-22 because removal of the system will allow the groundwater at the water table to drain down the open well and this drainage and cross-flow of groundwater in the open well must be prevented.

The combination of the water-based drilling fluids and the cross-contamination that was allowed during drilling the R-22 borehole prevented the collection of water samples during drilling to identify the permeable layers of aquifer strata that are the pathways for the travel of groundwater contamination from MDA G to well R-22. Accordingly, there is an immediate need to install a minimum of two new single-screen monitoring wells close to well R-22 at appropriate locations between the well and MDA G. One well is necessary in the permeable aquifer strata that are present to a depth of approximately 25 feet below the water table. The second well is necessary in the thick layers of permeable aquifer strata that are present in the depth interval of approximately 150 to 250 feet below the water table.

Screen #1 in well R-22 is installed in the approximately 15-foot thick interval of permeable aquifer strata that are present immediately below the water table. This permeable zone is the **RCRA uppermost aquifer** and must be monitored by a reliable single-screen monitoring well. The R-22 Plan correctly recognized that screen #1 cannot be rehabilitated because of the new mineralogy formed in this screened interval by the organic drilling fluids. The R-22 Plan made a mistake to assume that screen #2 could replace screen #1.

Well R-22 does not have a screen installed in the thick zone of highly permeable aquifer strata in the depth interval of 150 to 250 feet below the water table. The R-22 Plan made a mistake to not identify the requirement of RCRA §264.99 for the installation of a monitoring well in this zone which is also recognized by RCRA as the uppermost aquifer.

3. The NMED ordered a detailed evaluation of the LANL characterization wells but short-circuited this evaluation for well R-22. The NMED Hazardous Waste Bureau (HWB) issued a letter on April 5, 2007 that ordered LANL to do a detailed evaluation of each screened interval in the LANL characterization wells to assess their potential value as a monitoring well. The pertinent excerpt from pages 2-3 of the NMED letter is pasted below and annotated with an evaluation of well R-22 with particular attention to the technically indefensible R-22 Plan in brackets.

- "The evaluations must assess each well's construction and location, paying particular attention to a well's, or group of wells', ability to yield samples capable of detecting contaminants of concern released from waste management units." *[It is not possible to rehabilitate screens #2 and #3 in well R-22 to produce water samples capable of detecting contaminants of concern from MDA G.]*

- "To the extent possible, wells should double as compliance monitoring points; the evaluation should consider this." *[The R-22 Plan will not make well R-22 usable as a compliance monitoring well.]*

- "Factors to consider in the evaluations, and for groundwater monitoring network design, include, but are not limited to:

- 1. well construction (e.g., excessive screen lengths, excessive filter pack length, damaged casing or screen); *[Screen #2 has an excessive length of 42 feet and an excessive length of filter pack sediments of 70 feet. Screen #3 has a short length of 7 feet surrounded by an excessively long length of filter pack sediments of 40 feet.]*

- 2. seal integrity between water bearing intervals, including influences from annular seal material; *[The filter pack sediments at screen #3 are contaminated with the bentonite clay grout annular seal material because of a mistake in constructing well R-22. The R-22 Plan does not mention the bentonite clay contamination.]*

- 3. spatial distribution of wells relative to groundwater flow, including any pumping influences; *[The groundwater flow in the fast pathway aquifer strata below and away from MDA G are poorly understood. Screens #2 and #3 in well R-22 are not installed in the fast pathway aquifer strata where contaminated groundwater from MDA G is expected to be present.]*

- 4. well locations and distribution relative to potential contaminant sources, including influences on groundwater flow direction and groundwater velocity from municipal supply wells; *[Well R-22 is too distant from MDA G and does not meet the point of compliance requirement of RCRA 24 Subpart F.]*

- 5. location of screened interval relative to hydrostratigraphic units monitored and the hydrologic properties of those units; *[Screen #2 is installed in a basalt formation with very low permeability. Aquifer strata with high permeability that are important to monitor are located above screen #2 but are not monitored by screen #2. Screen #3 is located 390 feet below the water table in poorly sorted unconsolidated sediments that have a low permeability. Screen #3 is located below three thick intervals of aquifer strata with high permeability that are important to monitor but are not monitored by well R-22.]*

- 6. influences on groundwater flow by geologic structures such as faults, folds, and fracture zones; *[An important factor missing from this list is the* ***important control of confining beds (e.g., layers of geologic formations with low permeability)*** *on the lateral and vertical travel of contaminated groundwater. The large difference between confining beds and the fast pathway aquifer strata have not been considered in the design of the monitoring well network for MDA G].*

- 7. influences from chemical, mineralogical, and physical impacts resulting from the use of drilling fluids and inadequate well development. The Permittees should incorporate the results from the Well Screen Analysis Report, as appropriate; *[The NMED HWB **still fails to understand** that the statistical scheme in the LANL Well Screen Analysis Report is not credible to determine that the impacted wells produce reliable and representative water samples.]*

- 8. remedies under consideration for the area (e.g., pump and treat, natural attenuation). *[An important remedy that is missing from this section is **wastes left in place in unlined trenches and shafts below a dirt cover.** This remedy requires comprehensive characterization of the hydrogeologic setting in the regional aquifer below MDA G and a large network of monitoring wells to assure long-term performance of the dirt cover. The comprehensive characterization and the required monitoring wells do not exist.]*

- "The Department expects the evaluation for each area (e.g., TA-54) to include recommendations regarding the design of the groundwater monitoring networks for the area, and where appropriate, the relevant watershed(s). The recommendations must: 1) identify any gaps in well coverage of groundwater zones (both laterally and vertically), 2) propose locations for additional monitoring wells, 3) identify the target hydrostratigraphic units, 4) identify wells and well screens that may pose a pathway for contaminant migration, 5) identify wells that are unsuitable or irreparable, 6) include plans to isolate or plug and abandon wells, well screens, or both, 7) recommend reduced functions (e.g., use for water level measurements only) for some well screens in some wells, and 9) identify any available wells suitable for monitoring releases from permitted or interim status waste management units." ***[Note by the authors. LANL and DOE have not provided the evaluation of TA-54 that is required by NMED on April 5, 2007 in the above paragraph!]***

4. The NMED ordered the rehabilitation of characterization well R-22 without a detailed evaluation. The NMED letter of April 5, 2007 did not require the detailed evaluation of well R-22. Instead, the NMED letter short-circuited the evaluation by placing an imposition for the rehabilitation of characterization well R-22 without a careful evaluation of the feasibility for the rehabilitation.

The NMED letter of April 5, 2007 ordered LANL and DOE to "rehabilitate" well R-22 by abandoning screens #4 and #5, sealing off screen #1 and equipping the well with pumping systems to produce groundwater only from screens #2 and #3.

However, for well R-22, the conclusion from the comprehensive evaluation ordered by the NMED for the LANL characterization wells is that

- **1). __none__** of the screened intervals in well R-22 can be rehabilitated to yield samples capable of detecting contaminants of concern from MDA G, and

- **2). the only use for well R-22 is measurement of water levels.** In fact, Section 5 of this report describes the essential need to maintain the five screened intervals in well R-22 for measurement of water levels.

5. The only use for well R-22 is measurement of water levels. The only value for well R-22 is the measurement of water levels during pumping tests to gain knowledge of the hydraulic properties of the regional aquifer and the R-22 Plan to permanently plug and abandon screens #4 and #5 and isolate screen #1 will greatly lower the value of well R-22 for that important purpose.

The National Academy of Sciences (NAS) 2007 report - *Plans and Practices for Groundwater Protection at the Los Alamos National Laboratory: Final Report* - described the need for more pumping tests to determine the hydraulic properties of the regional aquifer. The pertinent excerpts from the NAS report are pasted below:

- "The data from the [two LANL] aquifer tests suggested two competing conceptual models. First, the regional aquifer may be a leaky confined aquifer with leaky units located above a highly conductive layer that is about 260 meters (850 feet) thick. A second possible conceptualization is that the regional aquifer *appears* to behave like a leaky confined system because it contains interbedded layers of alternating high and low hydraulic conductivities that are sandwiched together into a high-yielding zone. (page 41)

- "LANL's present conceptualizations of the regional aquifer lead to very different pictures of how contaminants in the aquifer might behave. If there is low connectivity between layers within the aquifer, the contaminants might remain near the top of the regional aquifer and most likely discharge in the springs near the Rio Grande. On the other hand, higher connectivity could result in the contaminants spreading vertically and more likely entering the deep screened intervals of regional water supply wells." (page 47)

- **"Recommendation:** LANL should continue efforts begun under the Hydrogeologic Workplan to characterize the regional aquifer. <u>More large-scale pumping tests and improved analyses of the drawdown data</u> [from the pumping tests] are needed to establish a scientifically defensible conceptual model of the aquifer, i.e., leaky-confined, unconfined, or layered." (page 47).

- "Even though planned three-dimensional model simulations to further examine aquifer heterogeneity should provide a better interpretation of the aquifer test data, additional hydrogeologic characterization of the regional aquifer is warranted [i.e., additional long-term aquifer pumping tests at important locations including the area below and away from TA-54]. Geochemical information could also be used to corroborate the aquifer test data. Effective design of a groundwater monitoring system will require an accurate and complete conceptual model of the regional aquifer." (page 41)

A 2005 paper in *Vadose Zone Journal* by LANL scientists specifically identified the need for aquifer pumping tests to reduce the large uncertainty for the hydraulic properties of the regional aquifer at well R-22. The pertinent excerpts from the paper by Keating et al. *in Vadose Zone Journal* (Volume 4, August, 2005) are pasted below:

- "Travel times through the regional aquifer are poorly understood because of the lack of tracer tests and *in situ* measurements of effective porosity." (page 658)

- "(a) significant proportion of uncertainty in fluxes downgradient of LANL results from uncertainty in the permeability of the basalts. **[Note by the authors.** The San Ildefonso

Pueblo, the Rio Grande and the Buckman well field - an important drinking water supply for Santa Fe are downgradient of LANL.**]** Basalt units are very important for potential contaminant transport because of their expected low effective porosity. Therefore, we can expect at least a factor of 3 uncertainty in the associated travel times resulting in uncertainty in the flow equation." (page 666) **[Note by the authors.** The two basalt units in the regional aquifer at well R-22 have a thickness of 290 feet at the top of the regional aquifer and 70 feet at depth beginning at 450 feet below the water table. Knowledge of the hydraulic properties of both basalt units are very important to protect groundwater resources from contamination by the LANL wastes buried at MDA G.**]**

- "The current understanding of hydrostratigraphy, as implemented in the numerical models, is sufficient to explain general trends in heads (spatial and temporal) but is lacking in a few key areas such as in the vicinity of R-9, R-12, **R-22** [emphasis added], and R-16. Detailed transport calculations in the vicinity of these wells would benefit from a refinement of the hydrostratigraphic framework model" [page 667 to 668, Keating et al., 2005]

- "The implication of this work for contaminant transport issues is that because of parameter uncertainty, predicted fluxes and velocities are quite uncertain. Uncertainties in permeability and porosity values lead to additional model uncertainty. **These uncertainties can be reduced meaningfully with more data collection, including multiwell pumping and tracer tests."** [emphasis added] [page 668, Keating et al., 2005]

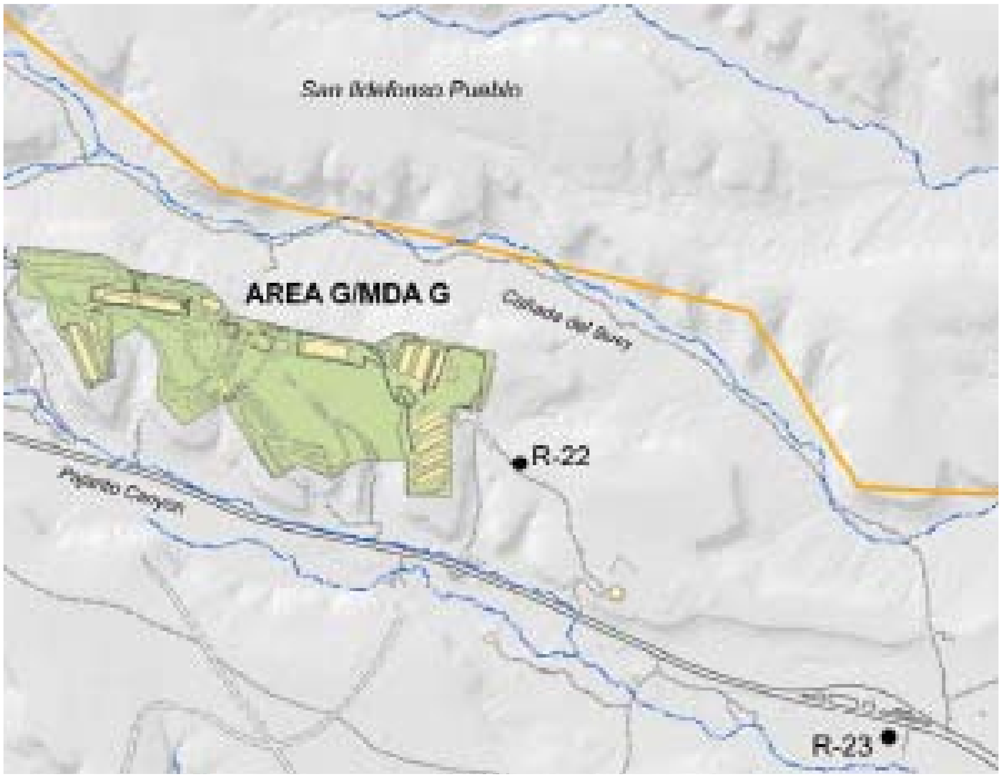
- Both the NAS and the LANL scientists understand the lack of knowledge that exists for the hydraulic properties of groundwater travel in the regional aquifer but the necessary and very important aquifer pumping tests and tracer tests to reduce the uncertainty are not being performed.

Table 3. Data summary for detected organic chemicals in the groundwater sample collected on January 10, 2001 from screen #5 in LANL characterization well R-22.
Source: Table A-40 *in* LANL Well R-22 Geochemistry Report

Analyte	Screen	Depth (ft)[a]	Collection Date	Field Preparation	Number of Analyses	Number of Detects	Detected Value (µg/L)	Non-detected Value (µg/L)	Drinking Water MCL[b] (µg/L)	Frequency of Detects > Drinking Water MCL	NMED[c] Groundwater Standard[d] (µg/L)	Frequency of Detects > NMED Groundwater Standard
Acenaphthene	5	1448	12/10/01	NF[e]	1	1	0.42	—[f]	—	—	—	—
Acenaphthylene	5	1448	12/10/01	NF	1	1	0.4	—	—	—	—	—
Anthracene	5	1448	12/10/01	NF	1	1	0.36	—	—	—	—	—
Benzo(a)pyrene	5	1448	12/10/01	NF	1	1	0.24	—	0.2	1/1	0.7	0/1
Benzo(b)fluoranthene	5	1448	12/10/01	NF	1	1	0.41	—	—	—	—	—
Benzo(k)fluoranthene	5	1448	12/10/01	NF	1	1	0.38	—	—	—	—	—
Bis(2-ethylhexyl)phthalate	5	1448	12/10/01	NF	1	1	1	—	6	0/1	—	—
Chloronaphthalene[2-]	5	1448	12/10/01	NF	1	1	0.46	—	—	—	—	—
DDT[4,4'-]	5	1448	12/10/01	NF	1	1	0.024	—	—	—	—	—
Diethylphthalate	5	1448	12/10/01	NF	1	1	1.3	—	—	—	—	—
Fluoranthene	5	1448	12/10/01	NF	1	1	0.38	—	—	—	—	—
Fluorene	5	1448	12/10/01	NF	1	1	0.42	—	—	—	—	—
Methylnaphthalene[2-]	5	1448	12/10/01	NF	1	1	0.42	—	—	—	—	—
Pentachlorophenol	5	1448	12/10/01	NF	1	1	6.2	—	1	1/1	—	—
Phenanthrene	5	1448	12/10/01	NF	1	1	0.4	—	—	—	—	—
Pyrene	5	1448	12/10/01	NF	1	1	0.49	—	—	—	—	—
Toluene	5	1448	12/10/01	NF	1	1	0.76	—	1000	0/1	750	0/1
Total Organic Carbon	5	1448	12/10/01	NF	1	1	4880	—	—	—	—	—

[a] The static water level for the regional aquifer at R-22 was 883 ft when the well was drilled.
[b] MCL = Maximum contaminant level. US Environmental Protection Agency (EPA) MCLs are from *National Primary Drinking Water Regulations*, 40 CFR Part 141. US EPA secondary MCLs are from *National Secondary Drinking Water Regulations*, 40 CFR Part 143. State of New Mexico MCLs are from *Drinking Water Regulations*, 20 NMAC 7.1.
[c] NMED = New Mexico Environment Department.
[d] State of New Mexico groundwater standards are from *New Mexico Water Quality Control Commission Regulations, Ground and Surface Water Protection*, 20 NMAC 6.2.
[e] NF = Nonfiltered.
[f] — = Not available or not applicable.

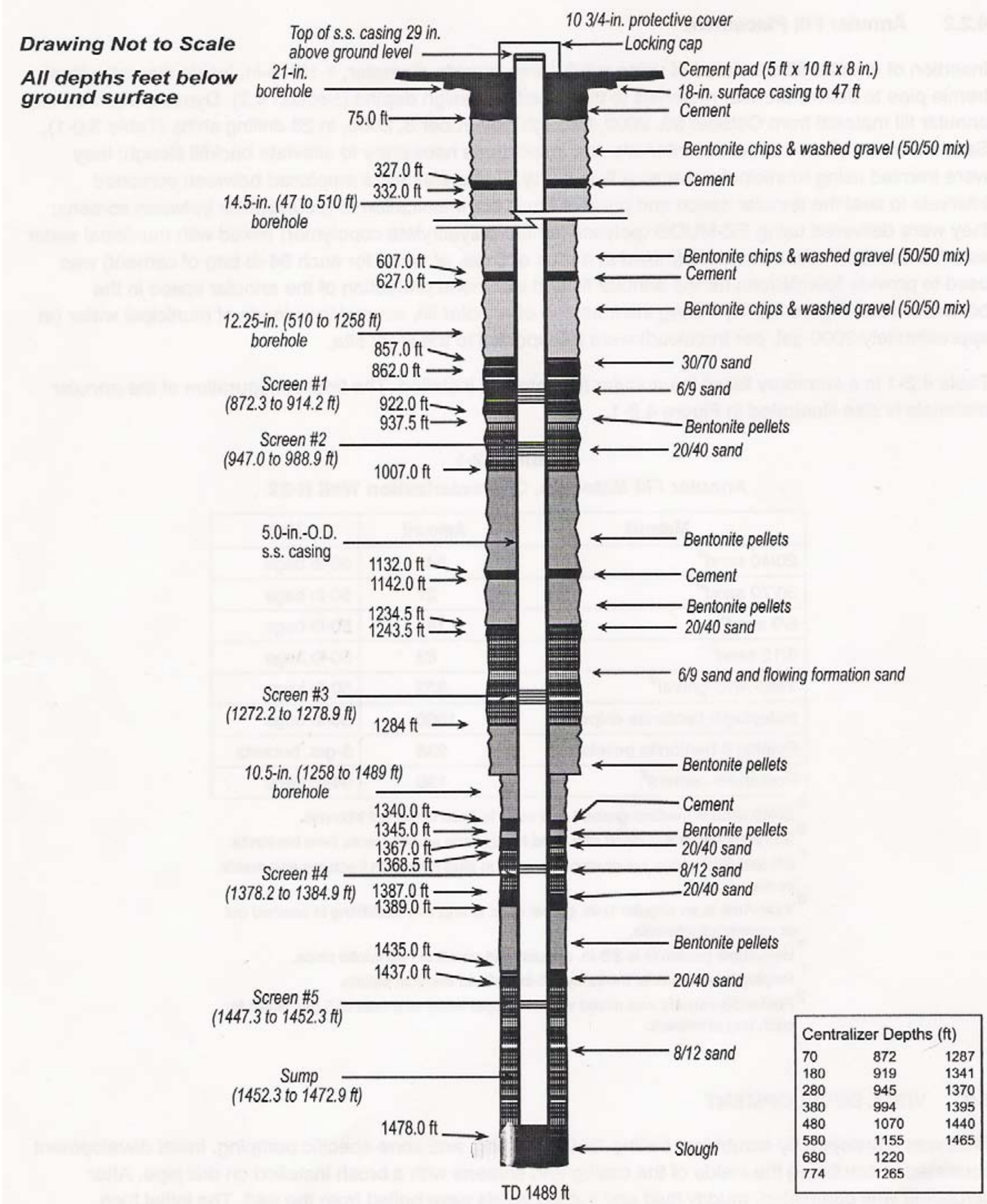
Figure 1. The locations of LANL characterization wells R-22 and R-23 east of the LANL 63-acre landfill and waste dump Area G/MDA G.



scale 0 - - - - - - - - 1000 feet

- **The orange line north of MDA G marks the boundary of LANL with the San Ildefonso Pueblo.**
- **Wells R-22 and R-23 are installed in the regional aquifer to monitor groundwater contamination from MDA G. The distances from the eastern boundary of MDA G to wells R-22 and R-23 are 500 feet and 3,300 feet, respectively.**
- **The direction of groundwater flow at the water table below MDA G is from west to east toward the Rio Grande. The travel time for contaminated groundwater in the permeable aquifer strata below MDA G below MDA G to reach wells R-22 and R-23 is not known because of insufficient characterization of the geology below and away from MDA G.**
- **The many mistakes in the location, drilling, well construction, misplaced well screens and improper sampling methods prevent the wells R-22 and R-23 from producing reliable and representative water samples for the detection of groundwater contamination from MDA G.**

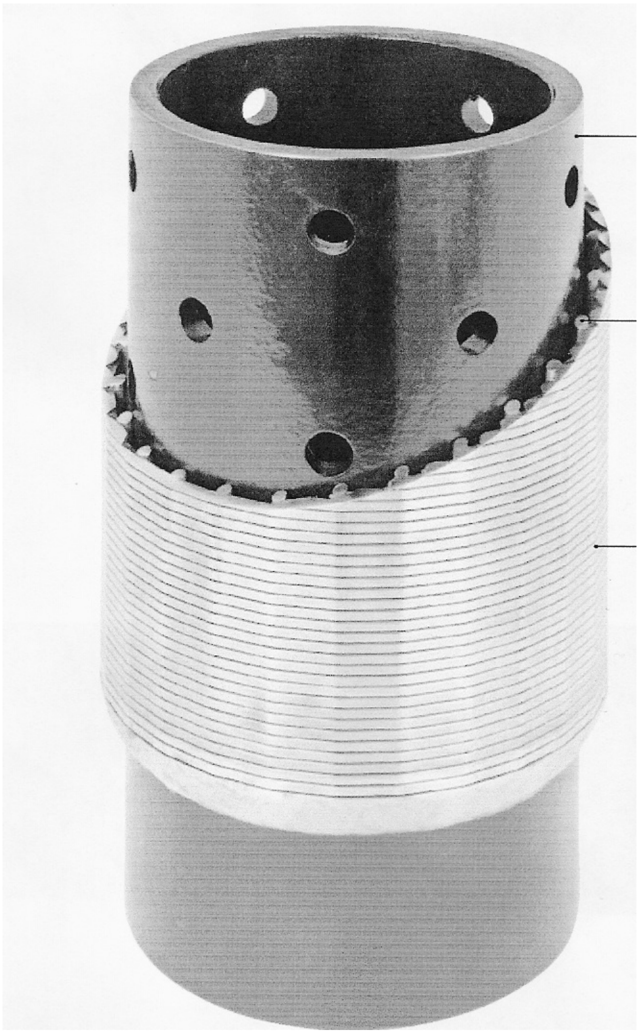
Figure 2. The as-built construction of LANL characterization well R-22.



Note: 1. The screen interval lists the footage of the pipe perforations, not the top and bottom of screen joints.
2. Pipe-based screen: 4.5-in. I.D., 5.563-in. O.D. 304 stainless steel with s.s. wire wrap: 0.010-in. slot.

Source for Figure 2: LANL Characterization Well R-22 Completion Report, (LA-13893-MS, February 2002).

Figure 3. Schematic of the pipe-based wire-wrap stainless steel well screen installed in many of the LANL characterization well R-22.



- The pipe-based screens in LANL characterization well R-22 are constructed with 84 holes drilled through the base pipe per linear foot of screen. The drill holes have a diameter of 0.375 inches.
- The surface area of the holes drilled through the base pipe is only 5% of the surface area of the well screen.
- The restrictive design of the pipe-based screens prevented the original well development activities from removing the organic drilling additives from the five screened intervals in well R-22.
- The restrictive design of the pipe-based screens will prevent the rehabilitation activities in the R-22 PLAN from removing the new mineralogy created by the organic drilling additives and the bentonite clay grout contamination from screen #3 in well R-22.