Concerned Citizens for Nuclear Safety

Figures Supporting Report
by
Robert H. Gilkeson, Registered Geologist

on

Groundwater Monitoring Issues
at the
Los Alamos National Laboratory

Concerned Citizens for Nuclear Safety
Presentation to U.S. E.P.A. Region VI
Dallas, Texas

September 7, 2012

List of Figures to Robert H. Gilkeson, Registered Geologist, Presentation

Figure 10. Figure E-3.3-6. “Version 2 of the water-level contour map representative of the regional piezometric surfaces near MDA G; the map is based on February 2011 water levels measured in the deepest screens in the monitoring wells” *in* LANL MDA G CME-3.

Figure 11. Overlapping extents of 10 times Tier I SV contours for interpolated vapor plumes for TCA and TCE at MDA G based on fourth quarter FY2009 data. Plotted contour values shown are 423,000 ug / m^3 and 20,000 ug / m^3 for TCA and TCE, respectively.

Figure 12. Locations of high tritium surface-flux areas (three tritium hot spots) at MDA G during 1993-1994 survey.

Figure 13. North-south cross-section C-C’ showing the deep vertical volcanic vent at the east end of MDA G.

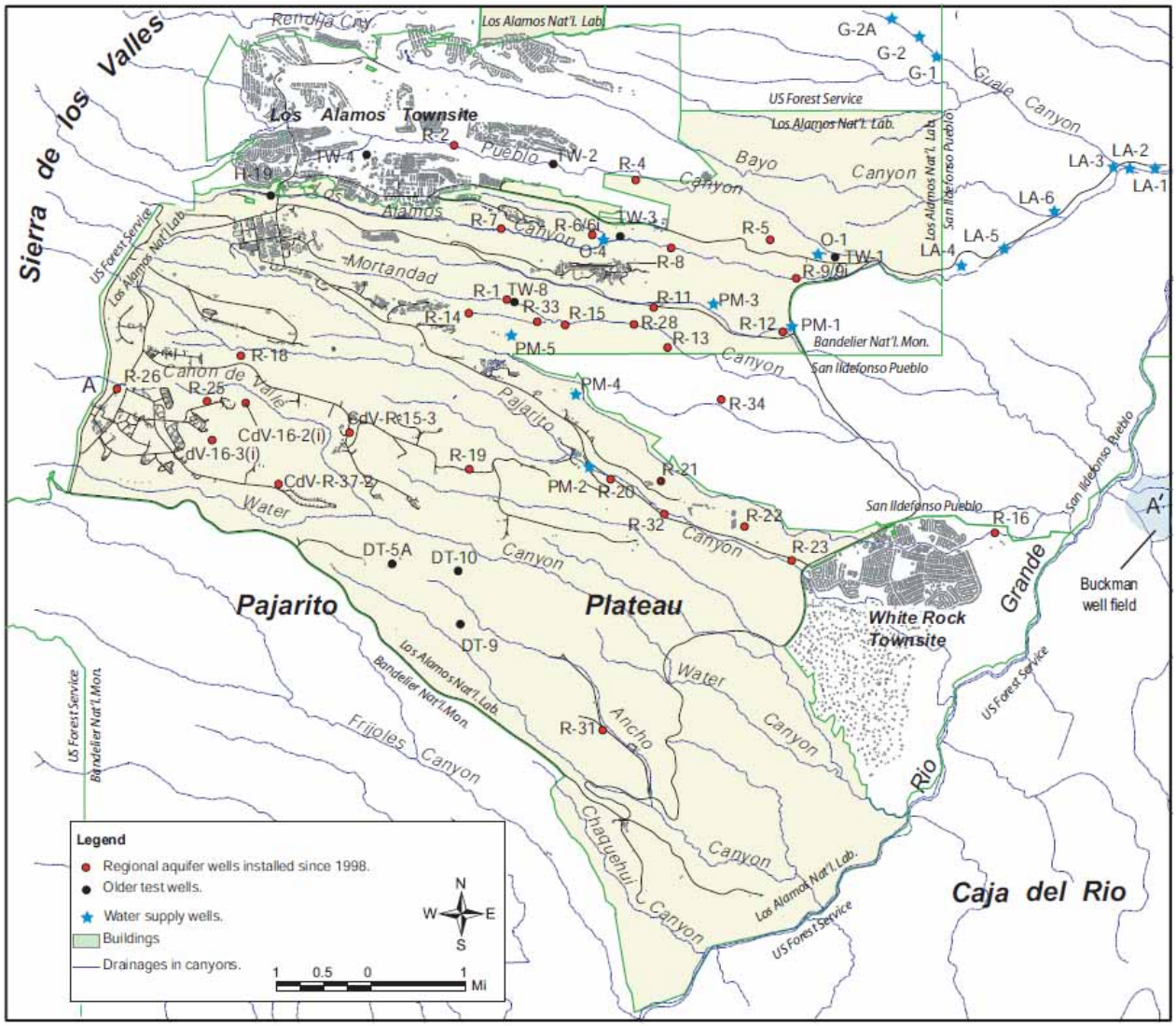
Figure 14. Schematic of the LANL Mud-Rotary Characterization Well R-16.

Figure 15. Schlumberger Borehole Geophysics Hydraulic Conductivity (Ksat) Log for the LANL Mud-Rotary Characterization Well R-16.

Figure 16. Table 4-5. “Examples of Organic and Inorganic Drilling Fluids used in Borehole Screen Intervals Drilled Primarily with Bentonite Mud” *in* LANL Well Screen Analysis Report – Revision 2 (May 2007).

Figure 17. Schematic of the pipe-based well screens installed in the LANL mud-rotary characterization wells.

Figure 1. Map showing the location of the 33 characterization wells installed for the LANL Hydrogeologic Workplan. The characterization wells are displayed with red dots.



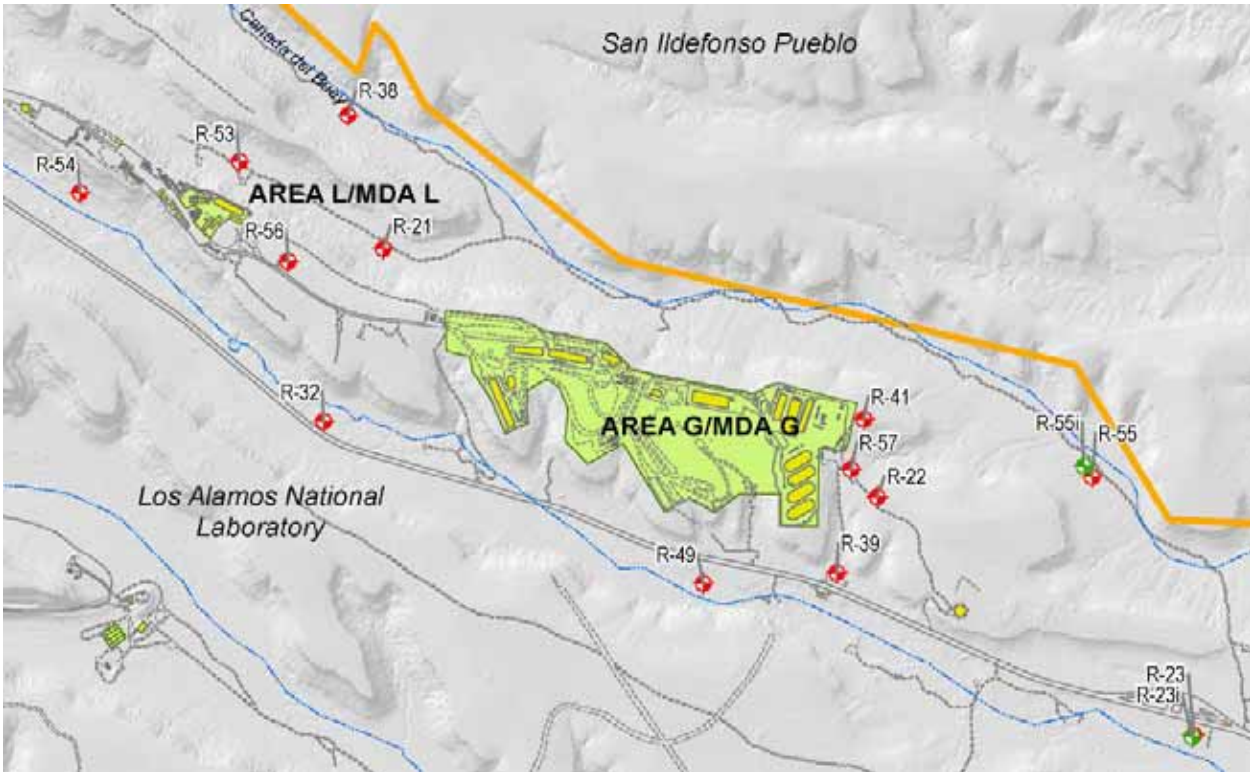
The NMED 2010 Response to Public Concerns on the LANL draft RCRA Renewal Permit stated on page 33 that the 33 characterization wells were not reliable monitoring wells as follows: “These wells were not installed for contaminant detection or groundwater monitoring. Therefore, these wells have limited relevance to groundwater protection goals set forth by the March 1, 2005 Consent Order”.

However, practically all of the characterization wells are now used as reliable monitoring wells. Six of the wells are used as reliable monitoring wells at MDA G. The five wells are R-16 (the only sentry well for the Santa Fe Buckman well field), R-20, R-21, R-22, R-23 and R-32. The six wells require replacement.

The eastern side of MDA G is located 500 ft west of well R-22 (see Figure 2). The distance from MDA G to the Buckman well field is ~4.25 miles.

The distance from the northern side of MDA G to the property of the Pueblo de San Ildefonso ranges from 700 ft to 1,500 feet.

Figure 2. The location of the two RCRA regulated unit waste disposal facilities Area G/MDA G and Area L/MDA L in Technical Area-54 (TA-54) at the Los Alamos National Laboratory. **Source:** Figure 2.3-3 in LANL 2011 MDA G CME-3.



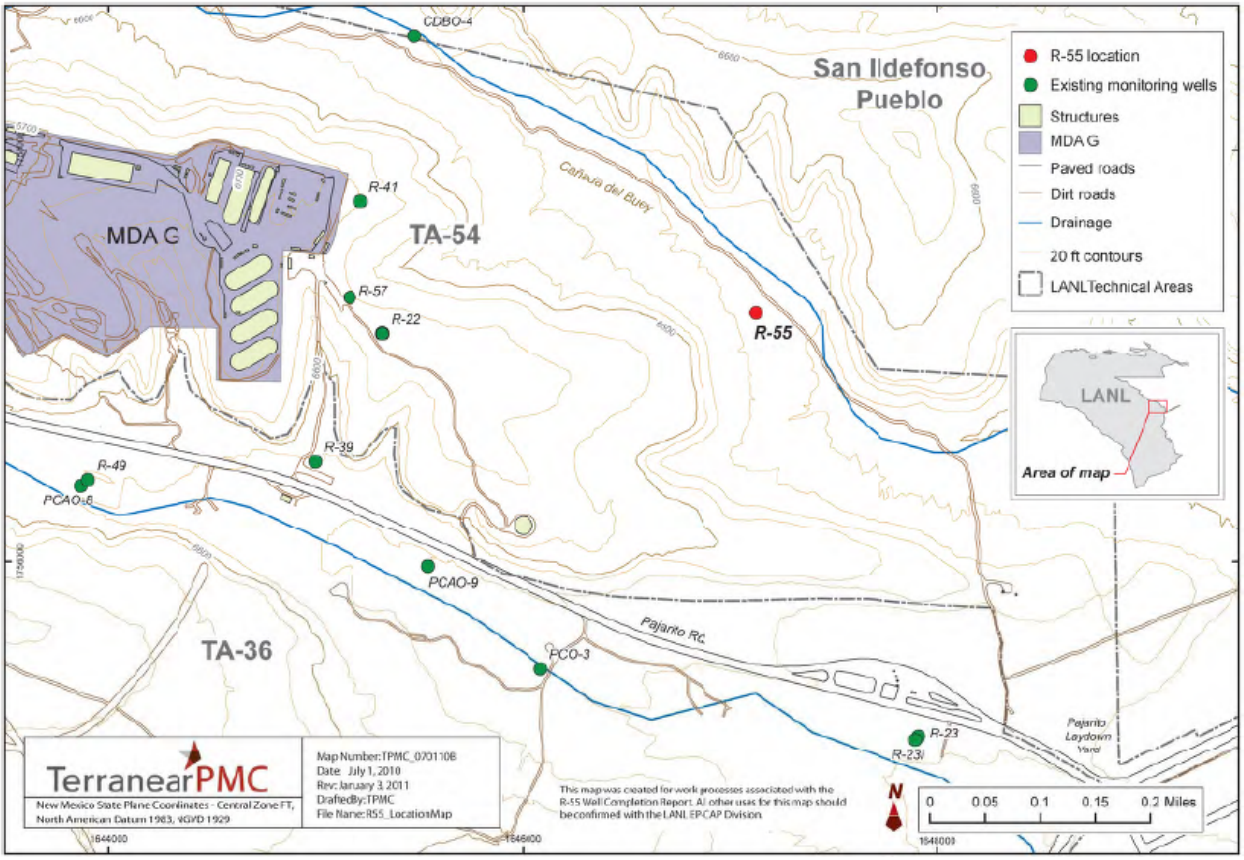
0 - - - - - - -I- - - - - - -I- - - - - - - 3,000 ft

The map shows the current networks of monitoring wells installed at MDA G and MDA L

The R-wells displayed with red dots are regional aquifer monitoring wells

The R-wells displayed with green dots are installed in perched zones of saturation.

Figure 3. The inadequate network of monitoring wells and characterization wells installed east and south of MDA G for knowledge of groundwater contamination in the regional aquifer. **Source:** Figure 1.0-1 *in* LANL Completion Report for Regional Aquifer Well R-55 January 2011 (LA-UR-11-0188)



- The defective monitoring wells in the regional aquifer are R-41, R-57, R-39, R-49 and R-55. The drilling methods were not careful to prevent harmful organic drilling fluids from flowing into the sampling zones of *all* seven wells. The water quality data show the wells are not reliable

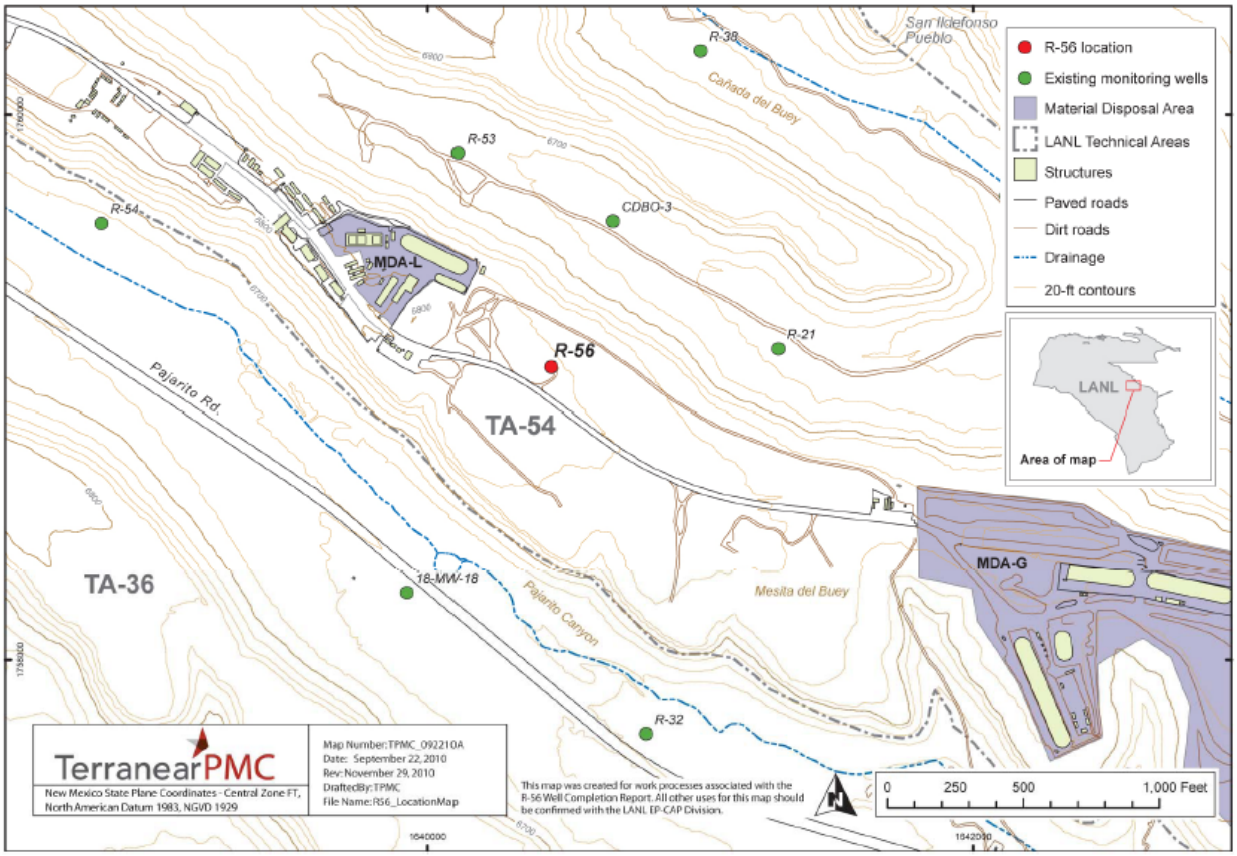
- The defective characterization wells in the regional aquifer are R-22 and R-23. The two wells were drilled with large quantities of organic drilling additives. Well R-23 was also drilled with large quantities of bentonite clay drilling muds. A contradiction is that the NMED assured the public the LANL characterization wells were not to be used as monitoring wells.

- The 2009 pumping test identified the need to replace well R-41 because the upper screen was dry and the lower screen was in a stagnant zone not in communication with the regional aquifer.

- The NMED April 1, 2011 Notice of Deficiency (NOD) for the MDA G CME-2 ordered LANL to install new monitoring wells near well R-41 because "if well R-41 is not hydraulically connected to the regional aquifer and the water table map in Figure E-2.3-1 [see flow map in Figure 5] represents actual groundwater flow regime, most of potential groundwater contaminants from MDA G might escape detection" [Emphasis supplied].

- A very serious issue is that LANL did not install the monitoring wells ordered by the NMED. Instead, the LANL 2011 MDA G CME-3 described well R-41 as a reliable monitoring well and no additional monitoring wells were needed at MDA G.

Figure 4. The inadequate network of monitoring wells (R-56, R-53 and R-38) and characterization wells (R-21 and R-32) installed west of MDA G for knowledge of background groundwater quality in the regional aquifer. **Source:** Figure 1.0-1 *in* LANL Completion Report for Regional Aquifer Well R-56 December 2010 (LA-UR-10-7289)

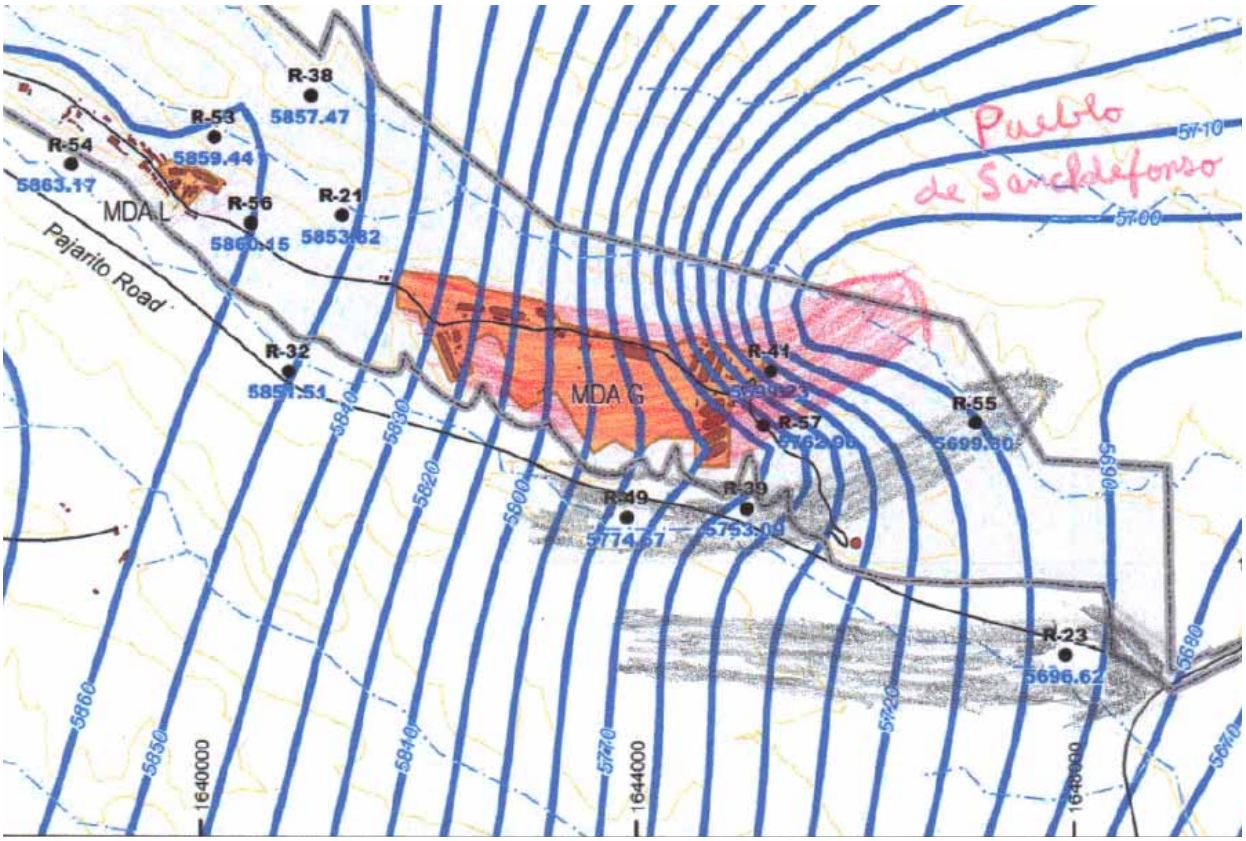


The defective monitoring wells in the regional aquifer required by the NMED for background water quality for the LANL 2011 MDA G CME-3 are R-38, R-53 and R-56. The drilling methods were not careful to prevent harmful organic drilling fluids from flowing into the sampling zones of *all* three wells. The water quality data show the wells are not reliable for background water quality for MDA G or for the detection of groundwater contamination from MDA L.

The defective characterization wells in the regional aquifer required by the NMED for background water quality for the MDA G CME are R-21 and R-32. The two wells were drilled with large quantities of organic drilling additives. Well R-32 was also drilled with large quantities of bentonite clay drilling muds. The NMED assured the public the LANL characterization wells were not to be used as monitoring wells.

There are no reliable monitoring wells for background water quality hydraulically upgradient of MDA G. There is a requirement for LANL to install a minimum of two monitoring wells for background water quality close to the western boundary of MDA G; one well at the water table of the regional aquifer and one well in the deeper highly productive river gravels.

Figure 5. Figure E-2.3-1 titled “The local contour map for the direction of groundwater flow at the water table of the regional zone of saturation below and in the vicinity of LANL MDA G” *in* 2010 LANL MDA G CME-2

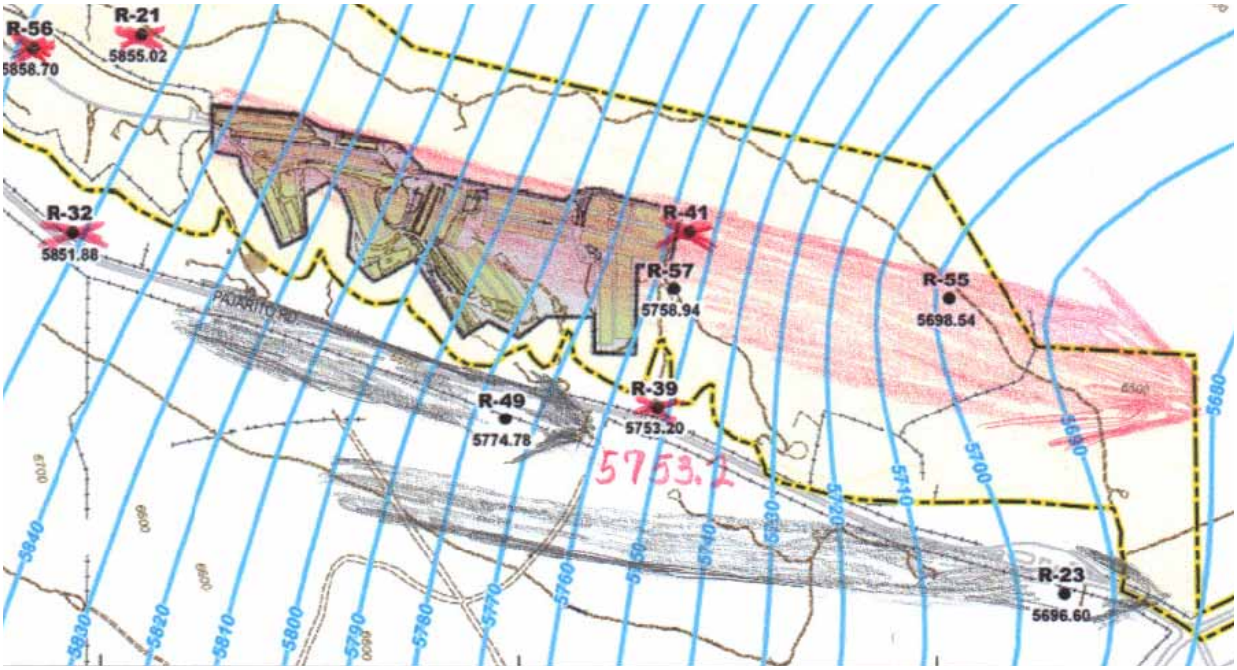


The NMED April 1, 2011 NOD for the MDA G CME-2 ordered LANL to install new monitoring wells near well R-41 because “if well R-41 is not hydraulically connected to the regional aquifer and the water table map in Figure E-2.3-1 represents actual groundwater flow regime, most of potential groundwater contaminants from MDA G might escape detection.”

A very serious issue is that LANL did not install the monitoring wells ordered by the NMED. Instead, the LANL 2011 MDA G CME-3 described the existing network of monitoring wells as follows:

“The monitoring wells located immediately downgradient of MDA G (R-41, R-57, R-49, and R-39) are screened in sections of the regional aquifer that appear to be the best locations for monitoring potential contaminants; therefore, no additional monitoring wells are necessary to complete the network.”

Figure 6. Figure E-3.3-2. "Version 1 of the water-level contour map representative of the regional water table near MDA G; the map is based on February 2011 water levels measured in the shallowest screens in the monitoring wells" *in* LANL 2011 MDA G CME-3.



The southeast direction of groundwater flow is incorrect for many reasons.

- The LANL "belief" that the dominant direction of groundwater flow was to the southeast was because of the mistake to use the deep water level measured in well R-39 as the water table of the regional aquifer.

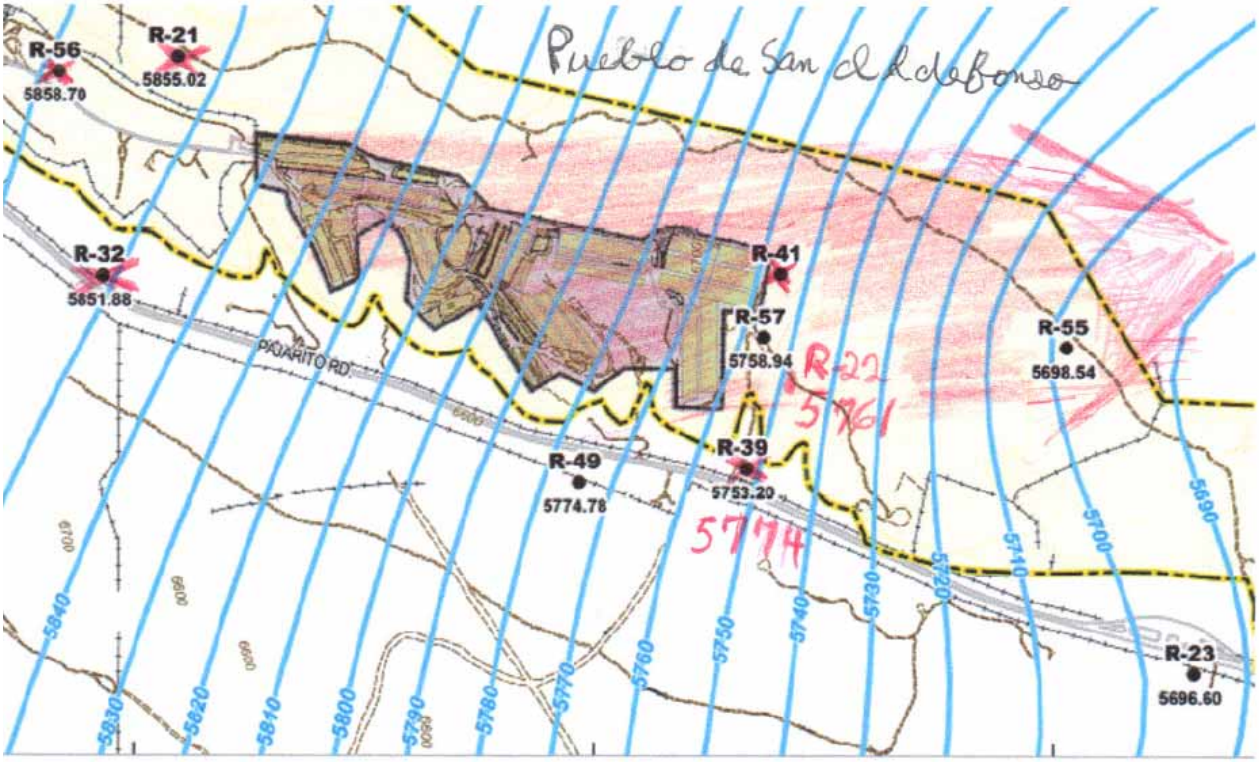
The red X on monitoring well R-39 is because the posted elevation of 5753.2 ft amsl represents the piezometric surface of the deeper productive aquifer. The LANL well R-39 completion report shows the correct elevation for the water table is 5774 ft amsl and greater than 20 ft higher than the elevation posted on the above map. The elevation of the water table at well R-57 is >15 ft lower than at well R-39 and the direction of groundwater flow at the water table beneath the eastern part of MDA G is not to the southeast but instead to the northeast.

The red X on monitoring well R-41 is because the pumping test determined this well does not monitor contamination at the water table or in the deeper productive aquifer zone. Well R-41 is not usable for any purpose and should have been replaced more than two years ago.

The red **X** on wells R-21 and R-32 are because the LANL MDA G CME-3 admitted the screens in the two wells were submerged too deep to measure the elevation of the water table.

The gray flow lines illustrate that even for the above incorrect flow scenario, monitoring well R-49 and mud-rotary characterization well R-23 are cross-gradient to the direction of groundwater flow at the water table below MDA G.

Figure 6A. Correction to groundwater flow in Figure 6. The red arrow shows the northeast direction of groundwater flow away from MDA G to the Pueblo de San Ildefonso and to the drinking water wells in the Santa Fe Buckman well field.



scale 0 - 5,000 ft

The elevation of the water table at the southeastern corner of MDA G is the level measured in the R-39 borehole at 5,774 ft amsl. The > 20-ft lower elevation posted above at 5753.20 ft was known to be incorrect because pumping tests determined that the well screen was installed in the deeper productive aquifer zone.

The water table elevations measured in wells R-39, R-22 and R-57 show that the direction of groundwater flow at the water table in the eastern sector of MDA G is to the northeast with a south to north decline below MDA G of ~20 ft.

Table E-3.1-1 in the CME-3 admits the screens in the two wells R-21 and R-32 are submerged too deep in the saturated zone to measure the elevation of the water table as follows:

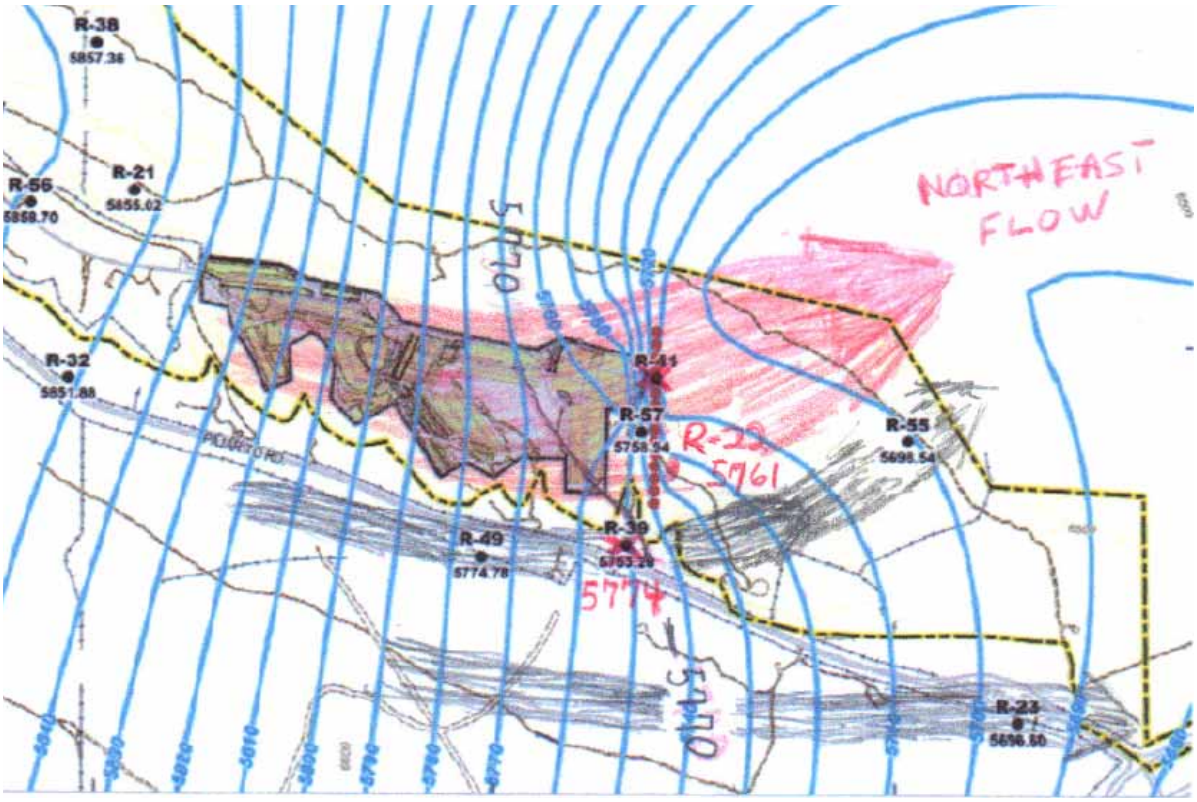
R-21 – "due to substantial [85-ft] submergence of the screen, the elevation of regional water table is expected to be higher than the observed water level."

R-32 – "due to substantial [70-ft] submergence of the screen, the elevation of regional water table is expected to be higher than the observed water level."

R-56 – the regional water table is located within the overlying Tb4 and its elevation is expected to be slightly higher than the observed water level;

The water level posted on the above map for characterization well R-23 may not be accurate for the water table of the regional aquifer because of the plugging action of the mud-rotary drilling method and the 42-ft submergence of the 57-ft long well screen.

Figure 7. Figure E-3.3-3. “Version 2 of the water-level contour map representative of the regional water table near MDA G; the map is based on February 2011 water levels measured in the shallowest screens in the monitoring wells” *in* LANL MDA G-CME-3.



scale 0 - 5,000 ft

- <u>There is great danger for travel of contaminated groundwater deep into the regional aquifer because of the north-south fault. The deep contamination is not monitored.</u>

- The red flow line shows that the groundwater contamination at the water table below MDA G flows away to the northeast to the Pueblo de San Ildefonso and to the Santa Fe drinking water wells in the Buckman well field without detection by most of the LANL monitoring wells.

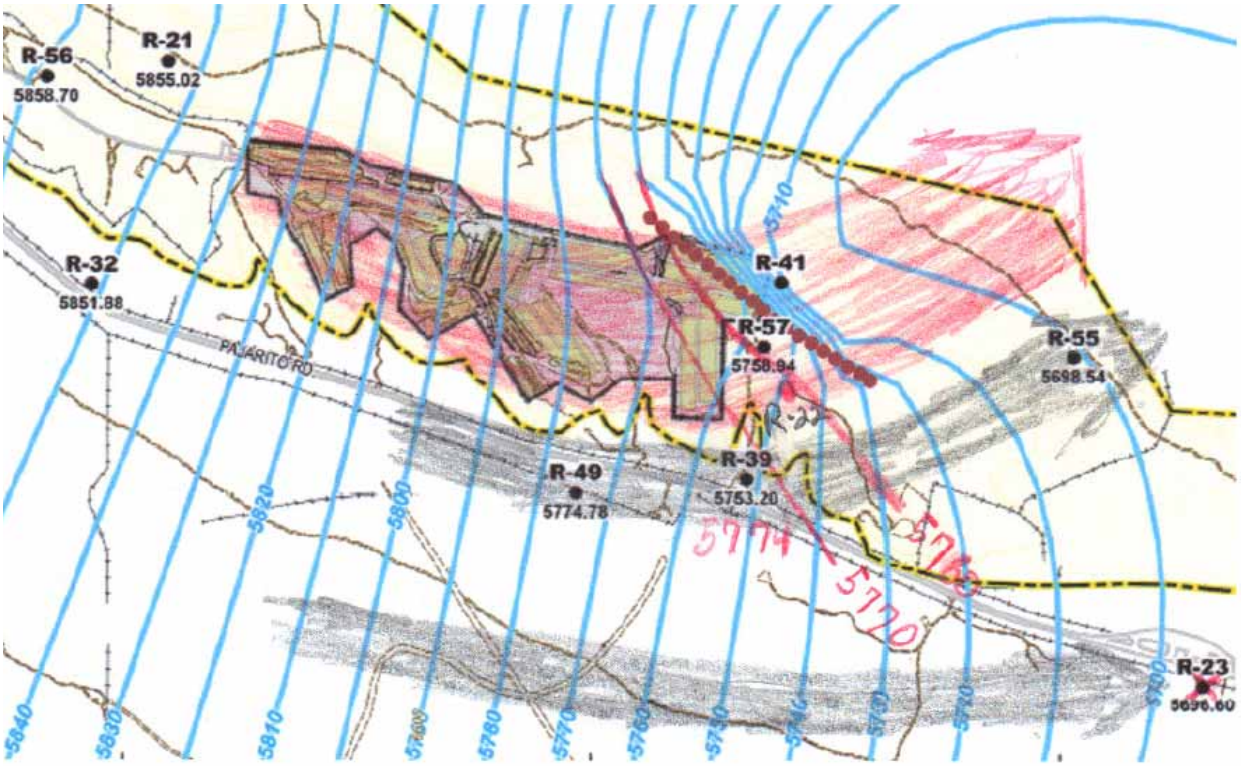
- The red X on monitoring well R-39 is because the pumping tests determined this well does not monitor contamination at the water table. See discussion above on Figure 6A.

- The red X on monitoring well R-41 is because the pumping test determined this well does not monitor contamination at the water table or in the deeper productive aquifer zone. Well R-41 is not u-sable for any purpose.

- The only wells located at the water table downgradient of MDA G are R-57 and R-22. Many RCRA contaminants were detected in R-22 in the early years. The well requires replacement. Well R-57 does not produce reliable and representative water samples because harmful organic drilling additives flowed into the sampling zone.

- The gray flow lines illustrate that monitoring wells R-49 and R-55 and mud-rotary characterization well R-23 are cross-gradient to the direction of groundwater flow at the water table below MDA G.

Figure 8. Figure E-3.3-4. “Version 3 of the water-level contour map representative of the regional water table near MDA G; the map is based on February 2011 water levels measured in the shallowest screens in the monitoring wells” *in* LANL MDA G CME-3.



scale 0 - 5,000 ft

<u>The northwest-southeast fault is probably a mistake because the geologic information shows the fault is located between wells R-57 and R-22. On the above map, both wells are located on the same side of the highly speculative fault.</u>

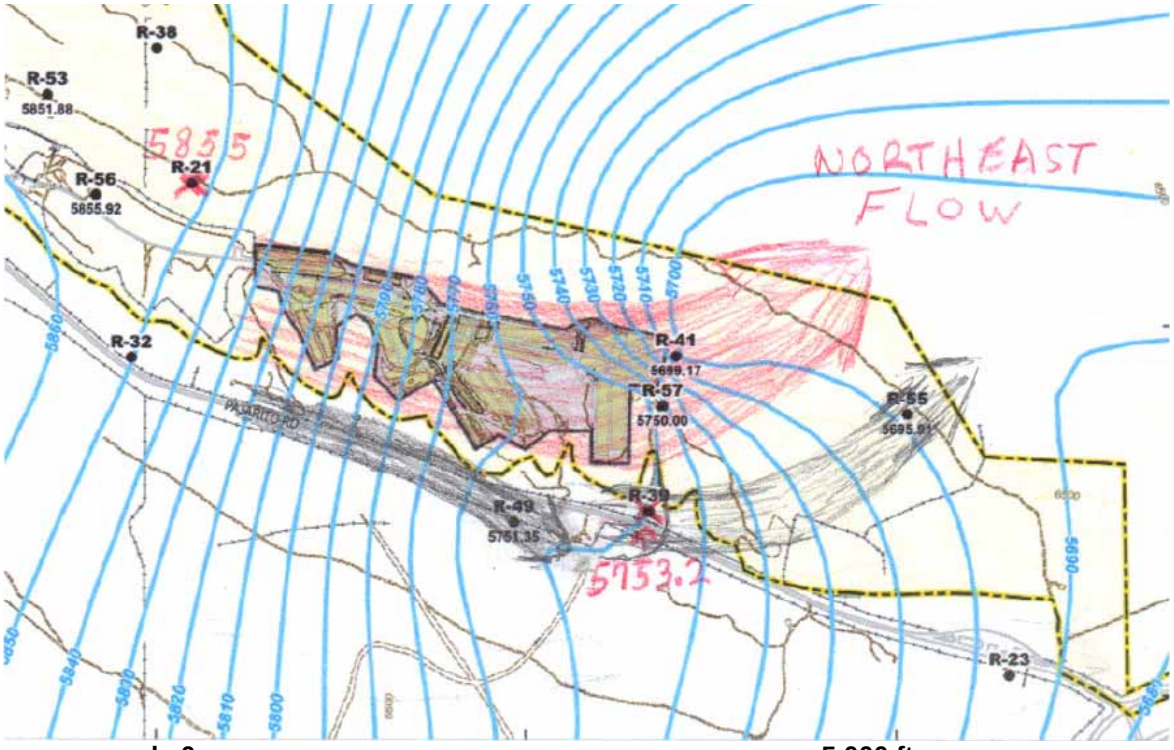
The red flow line shows that the direction of groundwater flow for contamination from MDA G is to the Pueblo de San Ildefonso and to the Buckman well field. The only monitoring wells along the flow of groundwater are wells R-57 and R-22 close to MDA G and well R-57 located 2,100 ft to the east of MDA G. The three wells are not reliable to detect groundwater contamination from MDA G because harmful organic drilling additives were allowed to flow into the sampling zones.

The red X on monitoring well R-39 is because the pumping tests determined this well does not monitor contamination at the water table. See discussion on Figure 6A.

The red X on monitoring well R-41 is because the pumping test determined this well does not monitor contamination at the water table or in the deeper productive aquifer zone. Well R-41 is not usable for any purpose.

The gray flow lines illustrate that monitoring wells R-49 and R-55 and mud-rotary characterization well R-23 are cross-gradient to the direction of groundwater flow at the water table below MDA G.

Figure 9. Figure E-3.3-5. “Version 1 of the water-level contour map representative of the regional piezometric surface [for the RCRA uppermost aquifer] near MDA G; the map is based on February 2011 water levels measured in the deepest screens in the monitoring wells” *in* LANL 2011 MDA G CME-3.



scale 0 - 5,000 ft

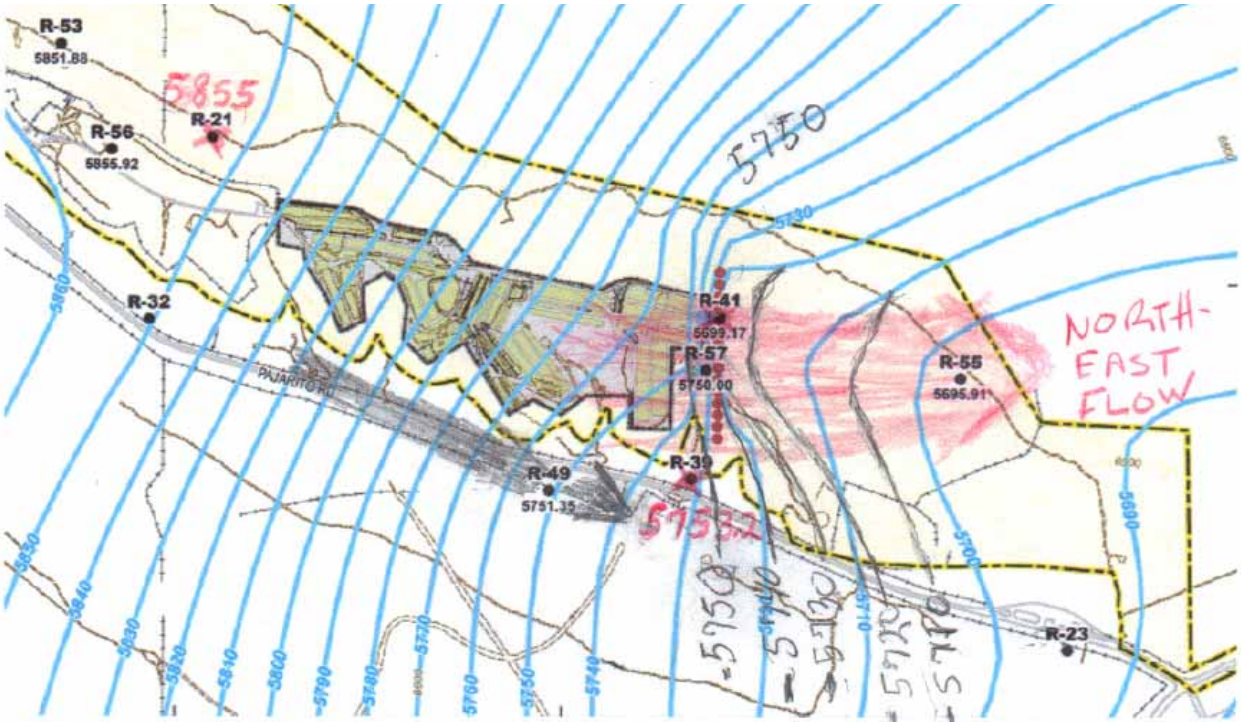
- <u>The red flow line shows the direction of groundwater flow in the productive aquifer zone is to the Pueblo de San Ildefonso and further to the Buckman well field.</u> The only monitoring wells along the flow of groundwater in the fast pathway productive aquifer are wells R-57 and R-41. The two wells are not reliable to detect groundwater contamination from MDA G because harmful organic drilling additives were allowed to flow into the sampling zones, In addition, the LANL well R-41 completion report admits well R-41 is installed in a stagnant zone not connected to the productive regional aquifer.

- The red X on monitoring well R-39 is because the pumping tests determined the water level measured in this well is not the water table, but instead the piezometric surface of the deeper productive aquifer. Well R-39 is not reliable to detect contamination because the screen is misplaced and the harmful drilling fluids were allowed to flow into the sampling zone.

- The red **X** on well R-21 is because the pumping tests determined this well is installed in the productive aquifer and not at the water table. The elevation posted on the map in red is the piezometric surface of the productive aquifer at well R-21.

- The gray flow line illustrates that monitoring wells R-49, R-39 and R-55 are cross-gradient to the direction of groundwater flow in the fast pathway aquifer zone below MDA G.

Figure 10. “Figure E-3.3-6. Version 2 of the water-level contour map representative of the regional piezometric surfaces near MDA G; the map is based on February 2011 water levels measured in the deepest screens in the monitoring wells” *in* LANL MDA G CME-3



- <u>There is great danger for travel of contaminated groundwater deep into the regional aquifer because of the north-south fault. The deep contamination is not monitored.</u>

- <u>The red flow line shows the direction of groundwater flow in the productive aquifer zone through the fault barrier is to the Pueblo de San Ildefonso and further to the Buckman well field.</u> The only monitoring wells along the flow of groundwater in the fast pathway productive aquifer are wells R-57 and R-55. The two wells are not reliable to detect groundwater contamination from MDA G because harmful organic drilling additives were allowed to flow into the sampling zones.

- The red X on monitoring well R-41 is because the pumping test performed when the well was installed in 2009 determined that the well was not reliable and required replacement. It is a very serious issue that the LANL 2011 MDA G CME-3 describes the defective well R-41 as a reliable monitoring well to detect groundwater contamination.

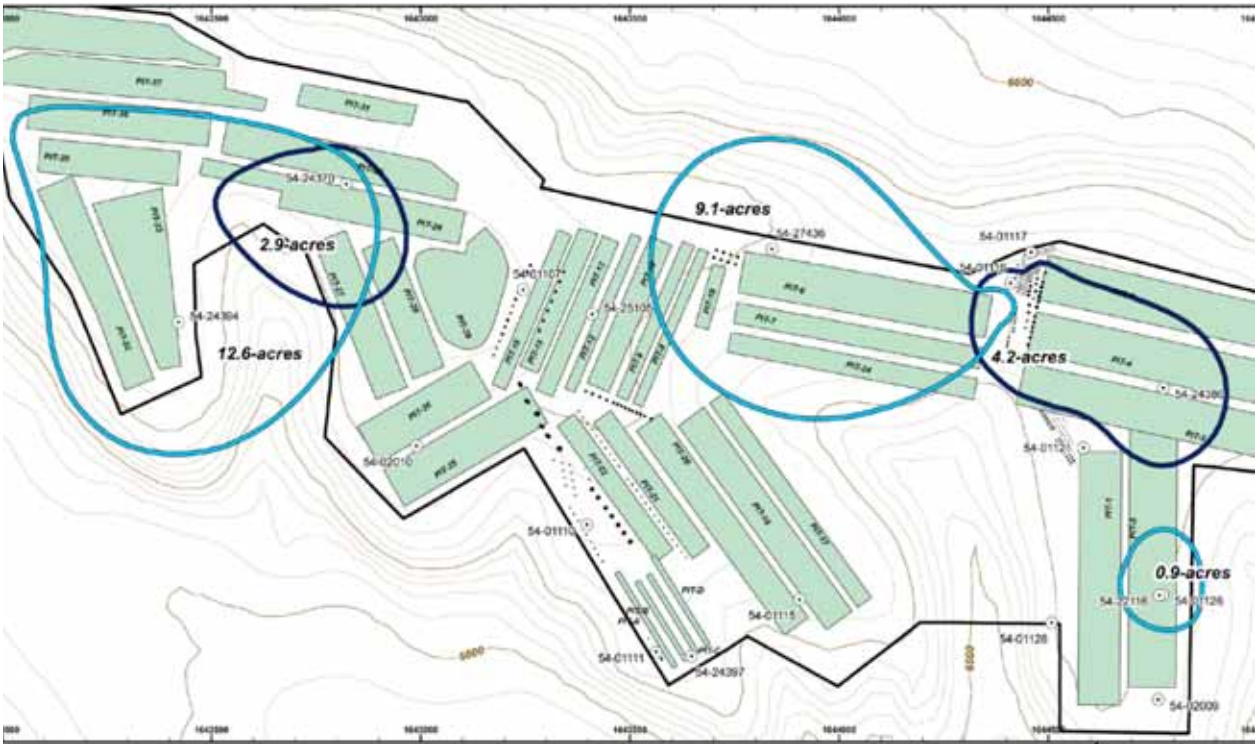
- The red X on monitoring well R-39 is because the water level measured in this well is the piezometric surface of the productive aquifer. See discussion on Figure 6.

- The red **X** on well R-21 is because the pumping tests determined this well is installed in the deeper fast pathway zone and not at the water table. The elevation posted on the map in red is the piezometric surface of the productive aquifer at well R-21.

- The gray flow line illustrates that well R-49 is cross-gradient to the direction of groundwater flow in the productive aquifer below MDA G.

Figure 11. Overlapping extents of 10 times Tier I SV contours for interpolated vapor plumes for TCA and TCE at MDA G based on fourth quarter FY2009 data. Plotted contour values shown are 423,000 µg/m^3 and 20,000 µg/m^3 for TCA and TCE, respectively.

Source: Figure C-3.1-5. "Overlapping extents of 10 times Tier I SV contours for interpolated vapor plumes for TCA and TCE at MDA G based on fourth quarter FY2009 data. Plotted contour values shown are 423,000 µg/m3 and 20,000 µg/m3 for TCA and TCE, respectively" *in* LANL 2011 MDA G CME-3.

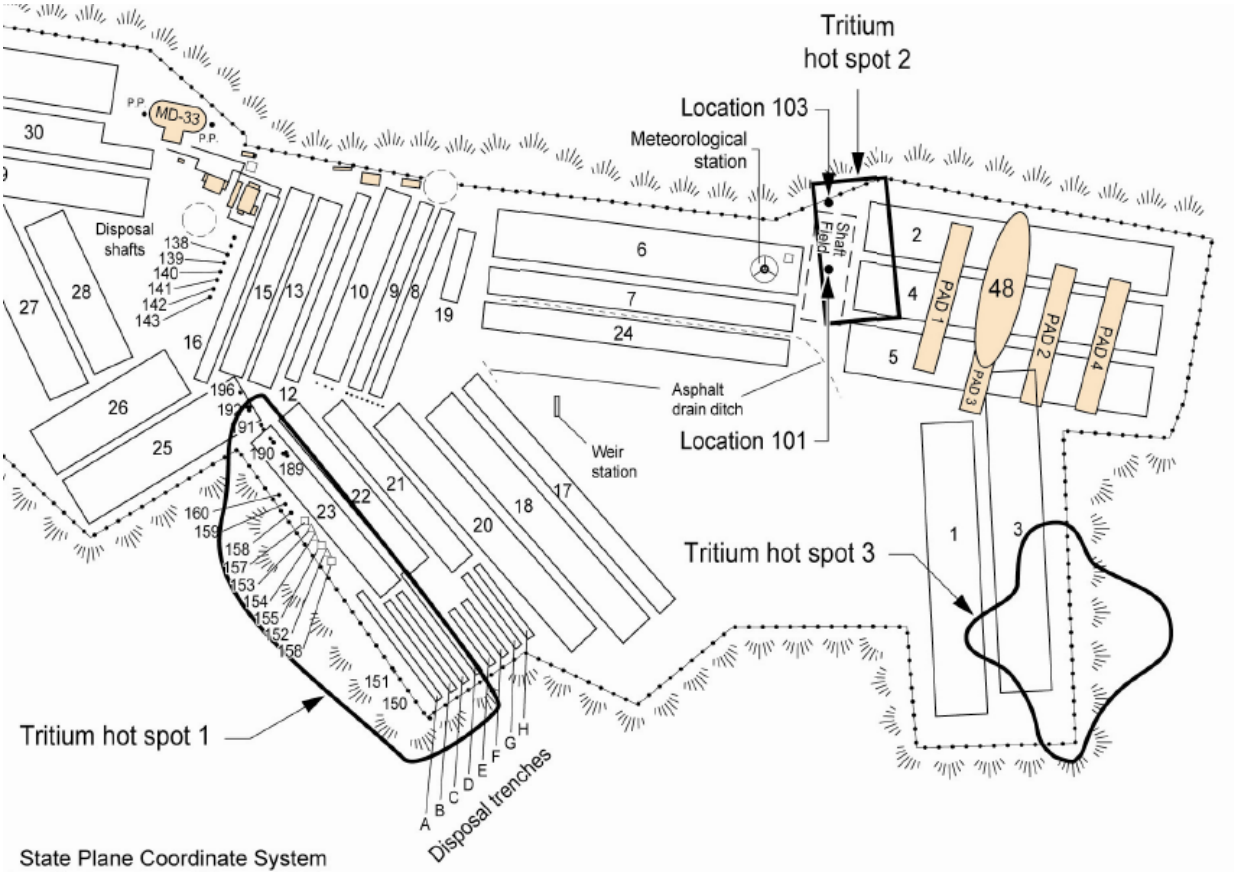


- The dark blue zones are large plumes of the solvent 111- trichloroethene (TCA) in the vadose zone that are predicted to cause contamination of the groundwater in the regional aquifer below MDA G.
- The light blue zones are large plumes of the solvent trichloroethene (TCE) in the vadose zone that are predicted to cause contamination of the groundwater in the regional aquifer below MDA G.
- The two eastern plumes have concentrations of TCA, TCE, 1,1-dichloroethene (1,1-DCE), and tetrachloroethene (PCE) at concentrations predicted to cause contamination of the groundwater in the regional aquifer below MDA G.

Note: Monitoring wells are not installed at appropriate locations close to the vapor plumes to investigate groundwater contamination with solvents in the regional aquifer. There is a special concern for the installation of monitoring wells along the northern and eastern side of MDA G because the direction of groundwater flow below and away from MDA G is to the northeast to the Pueblo de San Ildefonso and on to the Rio Grande and the Buckman well field.

Figure 12. Locations of high tritium surface-flux areas (three tritium hot spots) at MDA G during 1993–1994 survey

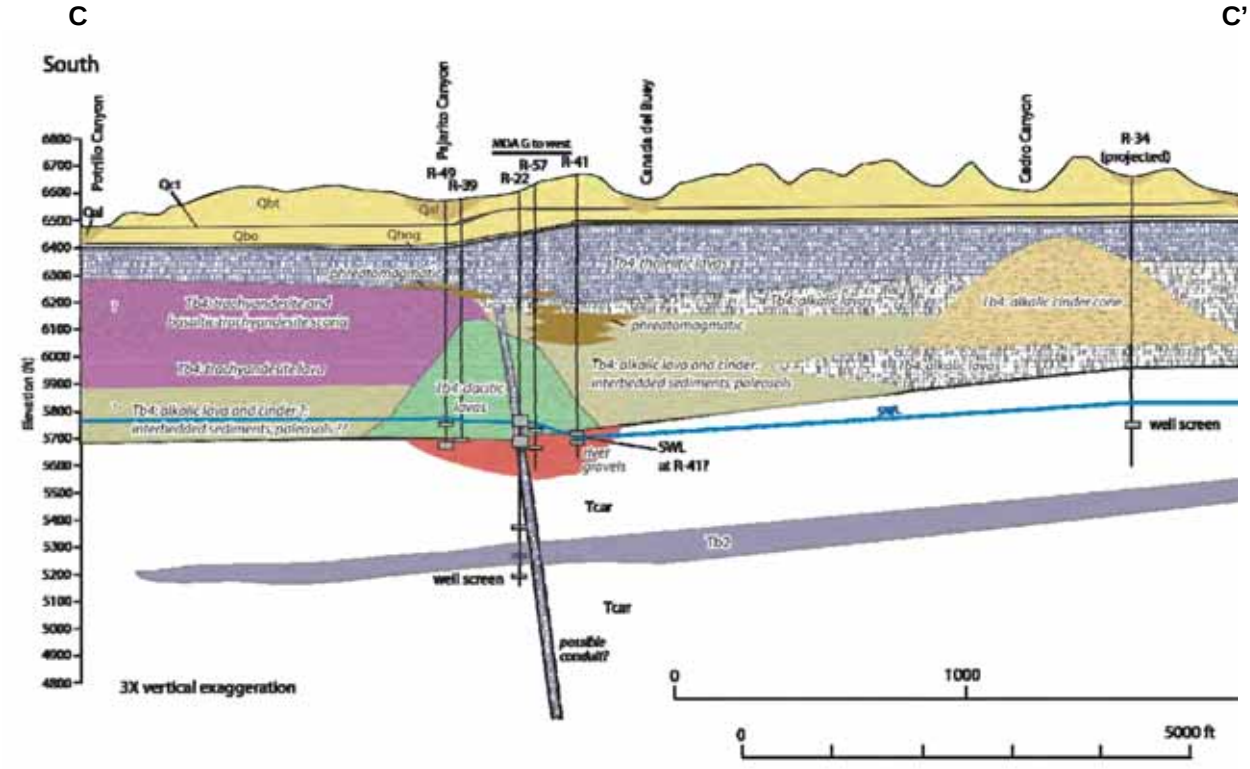
Source: Figure B-2.0-4. "Locations of high tritium surface-flux areas at Area G during 1993–1994 survey" *in* LANL 2011 MDA G CME-3.



Note: Monitoring wells are not installed at appropriate locations close to the three tritium hot spots to investigate groundwater contamination in the regional aquifer. There is a special concern for the installation of monitoring wells along the northern and eastern side of MDA G because the direction of groundwater flow is to the northeast to the Pueblo de San Ildefonso and on to the Rio Grande and the Buckman well field.

Figure 13. North-south cross-section C-C' showing the deep vertical volcanic vent at the east end of MDA G.

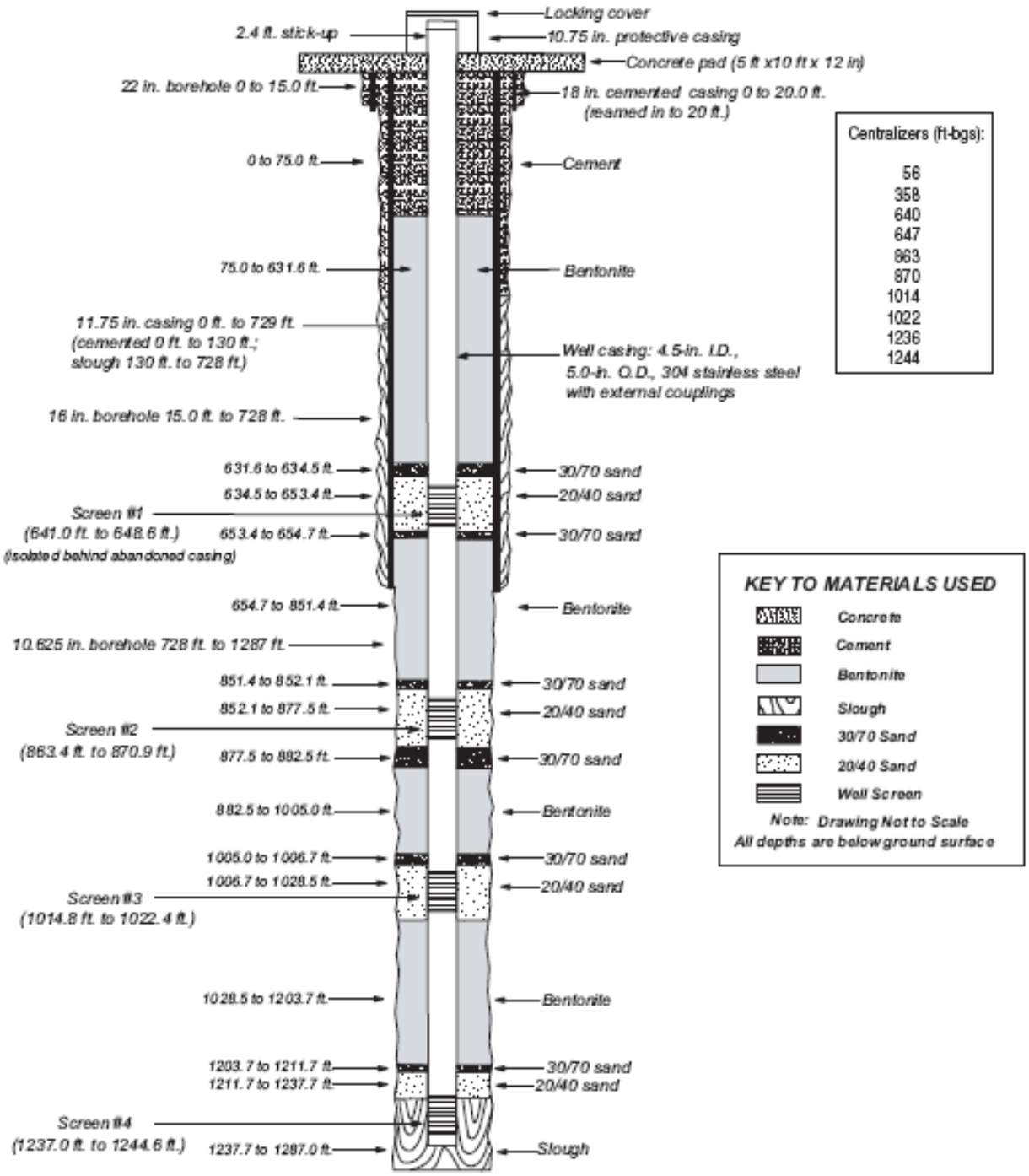
Source: Figure E-1.1-4. "North-south cross-section C-C' near east end of MDA G" *in* LANL 2011 MDA G CME Revision 2 (LA-UR-7868, Nov 2010).



Note: The above cross-section admits that the vertical vents that may be located below and close to MDA G are "possible conduits" for the travel of contaminated groundwater to a great depth in the regional aquifer. There are no monitoring wells to detect the deep groundwater contamination.

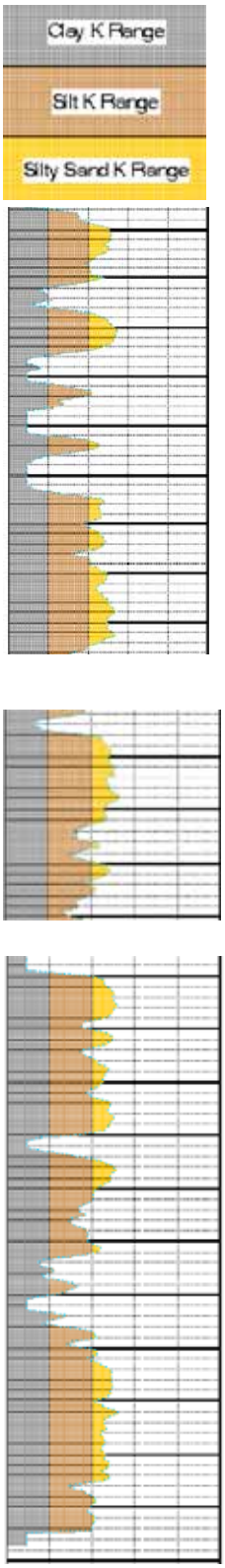
Figure 14. Schematic of the LANL Mud-Rotary Characterization Well R-16

Source: Figure 7.2-1 in LANL 2003 Characterization Well R-16 Completion Report



- Well R-16 was converted to produce groundwater from only screens #2 and #4.
- The two screens are invaded with bentonite clay drilling muds with strong properties to mask the detection of the LANL contaminants.
- Screen #4 is surrounded by bentonite clay slough because of mistakes in well construction.

Figure 15. Schlumberger Borehole Geophysics Hydraulic Conductivity (Ksat) Log For the LANL Mud-Rotary Characterization Well R-16.



.

- Screen #2, 863-871 ft – Installed across strata with a great range in permeability from clay to sand. Specific Capacity (SC) = 0.0902 gpm/min/ft with 49.2 ft of drawdown.

- 900 ft bgs

- Unmonitored aquifer strata from 904 to 935 ft bgs are the first thick layer of permeable strata below the Rio Grande

- 930 ft bgs

- 1000 ft bgs - Aquifer strata from 996 to 1,012 ft bgs have much higher Ksat than strata where Screen 3 was installed.

- Screen #3, 1015-1022 ft, Screen #3 was abandoned.

- 1030 ft bgs

- 1180 ft bgs

- Aquifer strata from 1180 ft to 1210 ft bgs have much higher Ksat than zones where Screens #3 and #4 were installed.

- 1210 ft bgs

- Screen #4, 1237-1245 ft – Installed across silty clay strata with low permeability, After well rehabilitation, the very low Specific Capacity = 0.020 gal/min/ft with 117.3 ft of drawdown

- Aquifer strata from 1250 ft to 1275 ft bgs have much higher Ksat than zone where Screen #4 was installed.

- 1280 ft bgs – The total depth of the R-16 borehole is 1287 ft bgs

Figure 16. “Table 4-5. Examples of Organic and Inorganic Drilling Fluids used in Borehole Screen Intervals Drilled Primarily with Bentonite Mud” *in* LANL Well Screen Analysis Report-Revision 2 (May 2007)

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.

Source: LANL Well Screen Analysis Report-Revision 2 (May 2007)

From the above figure:

Well No.	Bentonite (pounds)
- R-16 #2	2,530
- R-16 #4	5,312

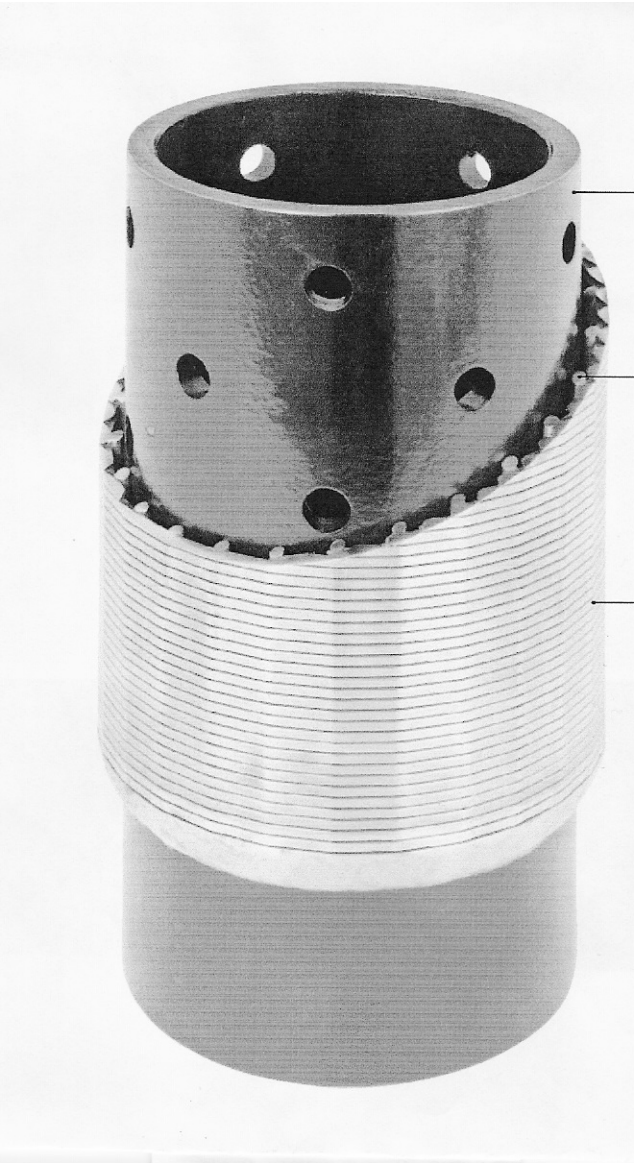
Note: Additional bentonite was in the slough sediments surrounding screen #4. See text for more information

Figure 17. Schematic of the pipe-based well screens installed in the LANL mud-rotary characterization wells.

Schematic of the pipe-based wire-wrap stainless steel well screens that are installed in the LANL multiple-screen monitoring wells R-14, R-16, R-20 and R-32 and in the single-screen monitoring well R-23. The drilling methods in all of the wells forced large quantities of bentonite clay drilling muds into the aquifer formations.

The original well development and the later well rehabilitation activities were only able to remove a small part of the bentonite clay from the screened intervals.

The hole pattern drilled into the 4.5 inch inside diameter pipe that is installed inside the wire-wrap screens are 0.5-in.-diameter holes on 1-in. centers, 168 holes per linear ft



The set of drill holes through the base pipe are > 17% 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.