Addendum to the "Evaluation of the Suitability of Wells Near Technical Area 16 for Monitoring Contaminant Releases from Consolidated Unit 16-021(c)-99, Revision 1"

1.0 CALCULATIONS AND DISCUSSION BEARING ON THE REHABILITATION OF CdV-R-37-2

This addendum to the "Evaluation of the Suitability of Wells Near Technical Area 16 for Monitoring Contaminant Releases from Consolidated Unit 16-021(c)-99, Revision 1" (LANL 2007, 098548) presents additional information bearing on the potential rehabilitation of CdV-R-37-2, including a discussion of the geology and hydrology near this well, an update of well network efficiency calculations relevant to the well, and a discussion of lateral and vertical dispersivity near the well.

1.1 Geologic and Hydrologic Constraints

It appears unlikely a screen near the regional water table at or near CdV-R-37-2 will produce sufficient water for sampling. Screen 2 of CdV-R-37-2 straddles the regional water-table (the water-table elevation is approximately 5 ft below the top of screen 2) (Table 4.2-1); the top of screen 3 is approximately 160 ft below the regional water-table (Table 3.4-2) (LANL 2007, 098548). Although both screens are within the same hydrostratigraphic unit (Tschicoma dacites), screen 2 is located in a relatively massive portion of the dacite flow that is characterized by low permeability. According to the geophysical logs, the interval from 1075 to 1365 ft below ground surface (including screen 2) has a lower porosity than the zone where screen 3 is installed, which appears to be a rubbly section of dacite. These observations suggest monitoring near CdV-R-37-2 may be difficult. The hydrogeology and the location of the screen also pose challenges to successfully rehabilitating this screen, which currently has poor geochemical performance. However, because of advection, the lower permeability of dacites straddling the water table creates the potential for downward diversion of any plume near CdV-R-37-2. In addition, the borehole log data suggest that screen 3 is probably the uppermost producing zone at the CdV-R-37-2 location, and contaminant fluxes are probably most significant in such a producing zone.

The existing data also indicate that the water table at CdV-16-3(i) is within a low-permeability portion of the Tschicoma dacites. This low-permeability zone probably represents the massive interior of an areally extensive lava flow that, at a minimum, extends as far east as CdV-R-37-2. Therefore, it is unlikely a producing zone at the top of the regional aquifer, close to the regional water table, could be found and successfully sampled in the vicinity of CdV-R-37-2 and CdV-16-3(i).

1.2 Update to Network Efficiency Calculations

Updated network efficiency calculations are provided in revised Tables E-5.0-1 through E-5.0-3 of this addendum. Along with calculations originally presented, these tables present calculations of the well network efficiency without well CdV-R-37-2, without well CdV-16-3(i), and without both of these wells.

Key points related to this revised analysis include the following.

- Neither CdV-R-37-2 nor CdV-16-3(i) is important for detecting release from a Cañon de Valle source; the network efficiencies are greater than 95% for all of these scenarios. Cañon de Valle is hypothesized to be the major source of contaminants in the deep perched and regional aquifers at Technical Area 16 (TA-16) (as much as 80% of contaminant mass is expected to be from this source area).

- CdV-R-37-2 is important for detecting releases from S-Site (Martin) Canyon sources; if this well is excluded, the network efficiencies are likely to be less than 95% protective of PM-2 in an S-Site Canyon-sourced release.
- CdV-16-3(i) is important for protecting PM-1 and PM-3 from contamination in an S-Site Canyon release scenario.

There is significant uncertainty in the regional water table map near CdV-16-3(i). Refinement of the water table map, particularly if the head gradients trend to the north, would decrease the importance of CdV-R-37-2 and possibly increase the importance of the new well CdV-R-15-1 for protecting drinking-water wells from releases at S-Site Canyon. The well network efficiency calculations will be updated using the water-level data obtained from the new well at CdV-16-3(i) and at the new well location (CdV-R-15-1).

1.3 Lateral and Vertical Dispersivity

It is possible to estimate the lateral and vertical dispersion of a plume migrating through the regional aquifer. In the analysis, it is assumed that (1) the groundwater fluxes downgradient from the source are similar to the fluxes near the source (i.e., the flow is uniform flow and no large-scale diversion/channeling of the groundwater flow occurs); (2) contaminant source is at a point and instantaneous; and (3) longitudinal and transverse dispersivities are on the order of 1/10 and 1/100 of the traveled distance, respectively. The ratios are considered typical for the scale of simulated contamination transport and type of medium heterogeneity (Freeze and Cherry 1979, 088742, Chapter 9; Neuman 1990, 090184).

To estimate the size of the plume, a scaling parameter σ is calculated:

$$\sigma = \frac{1}{3}\sqrt{2\lambda L}$$

where λ is dispersivity (longitudinal or transverse) and *L* is the distance of the center of the plume from the source location. The parameter σ defines the standard deviation of the spatial plume dispersion. Typically 68.3%, 95.4%, and 99.7% of contaminant mass are within 1σ, 2σ, and 3σ distances from the center of the plume, respectively (Freeze and Cherry 1979, 088742, Chapter 9). These calculations are based on assumptions for unbounded flow domain and normal spatial distribution of the contaminant plume mass.

The potential plume sizes resulting from longitudinal and transverse dispersion are calculated using the above formula. The computed plume sizes define a portion of the plume that will contain a given fraction of the plume mass. For example, a plume that migrated for 2000 m (the approximate distance between the S-Site area and CdV-R-37-2) is expected to have a longitudinal size (along the flow path) of about 300, 600, and 900 m containing 68.3%, 95.4%, and 99.7%, respectively, of the plume mass. The transverse size (perpendicular to the flow direction) is expected to be about 100, 200, and 300 m containing 68.3%, 95.4%, and 99.7% of plume mass, respectively. Since the flow medium is expected to be vertically anisotropic, the vertical transverse dispersion is expected to be further subdued. For an anisotropic ratio of 0.1, the vertical plume size is calculated to be on the order of 10, 20, and 30 m containing 68.3%, 95.4%, and 99.7% of the plume mass, respectively. The above calculations assume that the flow domain is bounded by the water table (i.e., the regional contaminant flow is confined by the water table). Because the properties of the medium are not known, the vertical dispersion of the plume may range between 30 and 300 m (99.7% of the plume mass). It is important to note that most of the contaminant mass is expected to be in the center of the plume, and the concentrations at the plume fringes could be orders of magnitude lower.

The distance between the top two screens in the regional aquifer at CdV-R-37-2 is 140 ft (~45 m). The distance between the filter packs associated with the two screens is slightly shorter (about 120 ft or 40 m). The vertical dispersion of the plume at CdV-R-37-2 is expected to be between 90 and 900 ft (~30 and 300 m). Because of the low-permeability dacitic unit near the regional water table (discussed above), the vertical dispersion at CdV-R-37-2 is expected to be somewhat higher. Therefore, screen 3 is expected to detect contaminants although it is substantially below the water table. Potential flow paths are not expected to occur through the low-permeable zone above screen 3.

2.0 SUMMARY AND CONCLUSIONS

The water table screen (screen 2) at CdV-R-37-2 and the hydrostratigraphic unit at the water table at CdV-16-3(i) are located within an impermeable dacitic formation. It may be difficult to install a producing well that can be developed properly in such a geologic unit. The impermeable zone between the two wells may be spatially extensive. Targeting the uppermost producing zones below the water table and within the dacites may be a more effective approach.

The borehole logs and water-level data collected during future CdV-16-3(i) and new well (CdV-R-15-1) drilling may provide better information to explain the medium heterogeneity of Tschicoma dacites and will help refine the model of local hydrologic gradients at the regional water table. Network efficiencies will be recalculated following drilling of each of these wells. A final decision on whether to attempt to rehabilitate screen 2 of CdV-R-37-2 or to drill a well downgradient of the dacites (but upgradient of R-27) should be contingent on these new calculations of network efficiency.

3.0 REFERENCES

The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.

Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau; the U.S. Department of Energy–Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.

Freeze, R.A., and J.A. Cherry, January 1979. *Groundwater*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey. (Freeze and Cherry 1979, 088742)

LANL (Los Alamos National Laboratory), October 2007. "Technical Area 54 Well Evaluation and Network Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-07-6436, Los Alamos, New Mexico. (LANL 2007, 098548)

Neuman, S.P., August 1990. "Universal Scaling of Hydraulic Conductivities and Dispersivities in Geologic Media," *Water Resources Research,* Vol. 26, No. 8, pp. 1749-1758. (Neuman 1990, 090184)

Table E-5.0-1
Efficiency for the Regional Monitoring Network to Detect Plumes Originating at Cañon de Valle Source Area before Being Observed at the Water-Supply Wells for the Case of Water-Table Model 1

O-1	O-4	PM-1	PM-2	PM-3	PM-4	PM-5	Comment
1	1	1	0.976	1	0.987	1	All wells
0.997	0.943	0.958	0.898	0.93	0.903	0.912	Only CdV wells
0.999	0.991	0.976	0.949	0.974	0.964	0.977	Only CdV wells and R-18
1	1	0.999	0.994	0.999	0.994	0.999	Only CdV wells and R-18, R-17, R-19
1	1	0.999	0.995	0.999	0.994	0.999	Only CdV wells and R-18, R-17, R-19, R-27
1	1	1	1	0.999	1	1	Only CdV wells, R-18 and a new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, R-18, new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, CdV-R-37-2, R-18, new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, CdV-16-3i, R-18, new well

Note: Rows shaded in yellow represent new calculations.

Table E-5.0-2
Efficiency for the Regional Monitoring Network to Detect Plumes Originating at Cañon de Valle Source Area before Being Observed at the Water-Supply Wells for the Case of Water-Table Model 2

O-1	O-4	PM-1	PM-2	PM-3	PM-4	PM-5	Comment
1	1	1	0.951	1	0.969	1	All wells
0.998	0.935	0.921	0.785	0.896	0.817	0.872	Only CdV wells
0.999	0.993	0.973	0.917	0.974	0.949	0.985	Only CdV wells and R-18
1	1	0.993	0.984	0.997	0.989	1	Only CdV wells and R-18, R-17, R-19
1	1	0.998	0.996	0.999	0.996	1	Only CdV wells and R-18, R-17, R-19, R-27
1	1	0.995	0.98	0.998	0.994	0.999	Only CdV wells R-18, and a new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, R-18, new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, CdV-R-37-2, R-18, new well
1	1	1	0.999	1	1	0.999	Only CdV-R-15-3, CdV-16-3i, R-18, new well

Note: Rows shaded in yellow represent new calculations.

Table E-5.0-3
Efficiency for the Regional Monitoring Network to Detect Plumes Originating at S-Site (Martin Spring) Canyon Source Area before Being Observed at the Water-Supply Wells for the Case of Water-Table Model 1

O-1	O-4	PM-1	PM-2	PM-3	PM-4	PM-5	Comment
1	1	1	0.998	1	1	1	All wells
1	1	1	0.996	1	1	1	Only CdV wells
1	1	1	0.996	1	1	1	Only CdV wells and R-18
0.997	0.995	0.924	0.775	0.965	0.938	1	Only CdV-R-15-3, R-18, new well
1	1	1	0.999	1	1	1	Only CdV-R-15-3, CdV-R-37-2, R-18, new well
0.999	0.999	0.962	0.86	0.987	0.974	1	Only CdV-R-15-3, CdV-16-3i, R-18, new well

Note: Rows shaded in yellow represent new calculations.