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Date: May 27, 2005
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Mr. James Bearzi
NMED – Hazardous Waste Bureau
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Santa Fe, NM 87505-6303

SUBJECT: SUBMITTAL OF THE "PLAN TO DEMONSTRATE VALIDITY OF R-25 DATA"

Dear Mr. Bearzi:

Enclosed are two hard copies with CDs containing electronic copies of the "Plan to Demonstrate Validity of R-25 Data." This work plan fulfills the requirement in Section IV. B. 3.b.iii of the Consent Order to submit to the New Mexico Environment Department for review and approval a plan to demonstrate that data from regional well R-25 are valid and reliable. The work plan was prepared in accordance with the format required in the Consent Order.

If you have any questions, please contact John McCann at (505) 665-1091 (jmccann@lanl.gov) or Tom Whitacre at (505) 665-5042 (twhitacre@doeal.gov).

Sincerely,

David McInroy, Deputy Program Director
Environmental Remediation & Surveillance
Los Alamos National Laboratory

Sincerely,

David Gregory, Federal Project Director
Department of Energy
Los Alamos Site Office

DM/JM/jk

Enclosures: 1) Two hard copies – Plan to Demonstrate Validity of R-25 Data (ER2005-0256)
2) Two electronic copies – one in each binder (CDs)

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CERTIFICATION

CERTIFICATION BY THE ENVIRONMENTAL STEWARDSHIP– ENVIRONMENTAL REMEDIATION & SURVEILLANCE PROGRAM TECHNICAL REPRESENTATIVES

Document Title: **SUBMITTAL OF THE PLAN TO DEMONSTRATE VALIDITY OF R-25 DATA**

I certify under penalty of law that these documents and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violation.

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LA-UR-05-3217
May 2005
ER2005-0256

Plan to Demonstrate Validity of R-25 Data

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Prepared by the Environmental Stewardship Division–Environmental Remediation and Surveillance Program and Groundwater Protection Program

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LA-UR-05-3217
ER2005-0256

Plan to Demonstrate Validity of R-25 Data

May 2005

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EXECUTIVE SUMMARY

Regional characterization well R-25 is located in Technical Area 16, east of the presently inactive Building 16-260 Outfall. The well was sited to evaluate impacts on perched water and the regional aquifer from activities relating to manufacturing high explosives (HE) at Technical Area 16, particularly those related to past discharges from the outfall. The main contaminants of concern include HE compounds and their degradation products as well as barium and manganese. The suitability of the well for providing monitoring data has been questioned because of the concern that water quality in the screens may have been compromised by various aspects of the drilling, construction, and development history of this well.

Continued use of well R-25 is subject to provisions of the March 1, 2005, Compliance Order on Consent between the New Mexico Environment Department and the Department of Energy and University of California. The Compliance Order on Consent gives Los Alamos National Laboratory an opportunity to demonstrate to the New Mexico Environment Department that water quality data from well R-25 are, or will be, valid and reliable. This work plan responds to that opportunity.

Well R-25 was completed in June 1999 to a depth of 1942 ft. Nine screens were installed, separated from each other by blank steel casing. Four screens are located in intermediate perched zones (screens 1 to 4) and five screens tap the regional aquifer (screens 5 to 9). Outside the steel well casing, screens are isolated from one another by low-permeability backfill layers. Inside the well casing, screens were hydraulically isolated from each other by the installation of the Westbay multiple-port monitoring system and by the inflation of downhole packers in early October 2000. Water level data collected since then, and as recently as April 4, 2005, confirm continuous isolation of the screens from one another. Screen 3 in the intermediate perched zone does not currently provide water quality data that are representative of the formation because the interval has been dry since the first sampling event in December 2000. Screen 9 in the regional aquifer is nonfunctional for water level measurements and water quality sampling because of damage during construction. For the seven functional screens, up to seven sampling rounds of geochemical water quality data are available, spanning the period between November 2000 and September 2004. Essentially these data, particularly those for mobile constituents including tritium and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), can be considered monitoring of an inadvertent tracer test that began when the screens in R-25 were isolated from one another in October 2000 and that is continuing at the present time.

A linear relationship between measured concentrations of conservative chemical species such as RDX and tritium indicates that the uppermost perched zone is the most probable source of contamination detected in the lower screens. Contaminated water from this interval would have seeped into the cased well through screen 1 and mixed with standing water in the well. The contaminated water would then have flowed into the filter sand packs and the formation outside the lower screens whenever those screens were inundated by the standing water column in the well during development. This interflow would have continued until the Westbay packers were inflated to isolate the screens. Because screens 2, 3, and 4 appear to have remained above the standing water level in the open well prior to inflation of the packers, these screens were exposed only to minimal quantities of contaminants from the uppermost perched zone. This explanation accounts for the low concentrations of HE-related compounds in those intervals. In contrast, all screens in the regional aquifer showed significant initial concentrations of RDX, 2,4,6-trinitrotoluene (TNT), and other HE-related contaminants that subsequently have been decreasing in those intervals in a steady and consistent manner.

Three years after packer inflation, RDX concentrations in screens 5, 7, and 8 had declined to less than 3% of their initial concentrations. Screen 6 concentrations have declined more slowly, probably because of the low permeability of this screen based on evaluation of sediment samples collected from this section of the Puye Formation. The linear relationship between RDX concentrations and tritium activities over

time, and the absence of RDX degradation products in intervals below screen 1, indicate that the decrease in RDX in these screens is the result of flushing by native groundwater and not from degradation or sorption of RDX.

To evaluate the preceding conceptual model and demonstrate the extent to which contaminant data from well R-25 are, or will be, valid and reliable, five tasks are proposed in this work plan:

- Task 1: Resume water quality sampling from screens 1, 2, 4, 5, 6, 7, and 8 for 9 months to determine whether the observed re-equilibration trends continue.
- Task 2: Review water quality, water level, and rock-chemistry data sets and well drilling, well completion, and well development field logs for consistency with elements of the conceptual model presented above. This review includes previously conducted hydrotesting in this well.
- Task 3: Compare chemical and isotopic data from well R-25 screens with background levels for regional groundwater and for local perched zones.
- Task 4: Conduct a quality control check of the Westbay system and verify the integrity of the monitoring ports and packer seals.
- Task 5: Resume continuous monitoring of water levels in R-25 screens.

A report documenting the results of these tasks and demonstrating the validity of R-25 water quality data will be submitted to the New Mexico Environment Department in accordance with the schedule included in this work plan. The report will include a recommended decision regarding the continued operation of R-25.

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LIST OF ACRONYMS AND ABBREVIATIONS

2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene
AOC	area of concern
amsl	above mean sea level
bgs	below ground surface
COPC	chemical of potential concern
DNX	hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine
DOE	U.S. Department of Energy
ECR	Environmental Characterization and Remediation Group
ENV	Environmental Stewardship Division
ESP	Environmental Surveillance Program
HE	high explosive
HMX	high-melting explosive(s)
Laboratory	Los Alamos National Laboratory
LANL	Los Alamos National Laboratory
MNX	hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine

MP	measurement port
NMED	New Mexico Environmental Department
PCE	perchloroethylene
PRS	potential release site
QA	quality assurance
QC	quality control
QP	quality procedure
RDX	hexahydro-1,3,5,trinitro-1,3,5-triazine (research department explosive [cyclonite])
RPF	Records Processing Facility
SAPP	sodium acid pyrophosphate
SMO	Sample Management Office
SOP	standard operating procedure
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TDS	total dissolved solids
TNB	1,3,5-trinitrobenzene
TNT	2,4,6-trinitrotoluene (dynamite)
TNX	hexahydro-1,3,5-trinitroso-1,3,5-triazine
TOC	total organic carbon
UC	University of California
VOC	volatile organic compound
WQDB	Water Quality Data Base
WQH	Water Quality and Hydrology Group

1.0 INTRODUCTION

The objective of this work plan is to describe the approach by which Los Alamos National Laboratory (the Laboratory or LANL) will evaluate the suitability of regional aquifer characterization well R-25 for obtaining valid and reliable data relating to the distribution of contaminants of concern in the perched zones and the regional aquifer at this location.

This work plan responds to item 2 under Section IV.B.3.b.iii of the March 1, 2005, Compliance Order on Consent (hereafter, the Consent Order) between the New Mexico Environment Department (NMED) and the Department of Energy (DOE) and University of California (UC):

> The Respondents may prepare a plan to demonstrate to the Department that the water quality data from regional well R-25 are or will be valid and reliable. The plan shall be submitted to the Department within 90 days of the effective date of this Consent Order for Department approval, subject to the procedures of Section III.M of this Consent Order. If the Department determines that R-25 does not or will not produce valid and reliable data, the Respondents shall properly abandon R-25 and replace it at a location approved by the Department. (NMED 2005, 88207, p. 65)

Available data and information relating to water quality data for well R-25 are summarized in Section 2 below. This information is taken primarily from four Laboratory reports, updated as appropriate with water quality data that were collected after the reports had been prepared and that are contained in the Laboratory Water Quality Database (WQDB) (http://wqdbworld.lanl.gov/). This information provides the technical basis for the conceptual model presented in Section 3 to account for the evolving water chemistries observed in the screens of well R-25. Section 4 presents a proposed investigation for testing key elements of this conceptual model and thereby demonstrating the extent to which water quality data from well R-25 are, or will be, valid and reliable. Section 5 lists a proposed schedule with milestones and deliverables for this work activity.

An assessment report will be produced and provided to NMED as a result of this work plan. The report will present and summarize multiple lines of evidence, including (1) water quality and isotopic data for screens in well R-25, (2) water level data for screens in well R-25, and (3) water quality and isotopic data from other wells in settings similar to that of well R-25, relating to the suitability of well R-25 for its intended purpose.

Based on this assessment, one or more of the following decision options will be recommended for well R-25:

- no action (use as-is)
- restricted use of the well for collecting water quality and water level data (e.g., collect data only from certain screens)
- restricted use of water quality and water level data from certain screens (e.g., restrict data use to conservative species for screens still showing reducing conditions that are not representative of the formation)
- modification of the well for continued use, such as redevelopment of screens
- phase-out of the well (gradual transition to plug and abandon)
- immediate plug and abandon

2.0 REVIEW OF AVAILABLE INFORMATION

2.1 Well Location

Characterization well R-25 is located on the mesa above Cañon de Valle in the southwestern portion of the Laboratory, within Technical Area (TA) 16 (Figure 1). It was designed primarily to provide water quality, geochemical, hydrologic, and geologic information that would contribute to the understanding of the hydrogeologic setting beneath the Laboratory (Broxton et al. 2002, 72640, p. 1).

The well is downgradient of solid waste management units (SWMUs) and areas of concern (AOCs) at TA-16 where high explosives (HE), barium, boron, and other contaminants are present (LANL 1998, 59891, p. ES-3; LANL 2003, 77965, p. iv; LANL 2003, 85531, p. 25 and Appendix B, p. 1). The well was sited to evaluate the impacts on perched water and the regional aquifer from past HE-manufacturing activities at TA-16, particularly those related to discharges from the TA-16-260 Outfall. The outfall was in operation from 1951 until its deactivation in November 1996. Primary contaminants released to the drainage channel below the outfall were HE wastes and barium. Other chemicals of potential concern (COPCs) at TA-16 are metals and organic compounds.

2.2 Well Construction and Development

Details of the construction and development of well R-25 are described in the “Characterization Well R-25 Completion Report” (Broxton et al. 2002, 72640). Relevant information from that report is excerpted in this section. Appendix A of this report provides an abbreviated chronology of relevant construction and development events for well R-25. Figure A-1 presents the as-built well completion diagram for well R-25.

The R-25 borehole was drilled to a depth of 1942 ft using air-rotary drilling methods, beginning on July 22, 1998 (Broxton et al. 2002, 72640, p. 3). Advancement of drill casing was performed without fluids until 588 ft. Between 588 and 1427 ft, various combinations of water, bentonite, fibrous material (cellophane, MAG fiber, nylon), and TORKease were added for lubricity. From 1507.5 to 1547 ft, QUIK-FOAM and EZ-MUD Plus were also added for lubricity. The total volume of water used with these additives was 18,349 gal. (Broxton et al. 2002, 72640, Table 2.3-2).

Geologic strata encountered, in descending order, were the Tshirege Member of the Bandelier Tuff, tephras and volcaniclastic sediments of the Cerro Toledo interval, the Otowi Member of the Bandelier Tuff, and the Puye Formation (Broxton et al. 2002, 72640, p. ix). Groundwater occurrences included intermediate perched zones, first recognized at a depth of 747 ft within the Otowi Member (with a static water level of 711 ft) and extending into the Puye Formation, and the regional aquifer, first encountered at a depth of 1286 ft and continuous to the borehole total depth.

A stainless steel casing was installed with nine screens (Table 1). Screen lengths are 20.8 and 10.8 ft for screens 1 and 2 in the uppermost perched zone, and 10 ft for the deeper screens. Screens 3 and 9 were damaged during installation but were subsequently restored to partial usefulness. The repair of screen 3 involved plugging the former screen with Portland cement and Micro Matrix and then redrilling through this plug so that the Westbay sampling system could be deployed through the repaired screen (Broxton et al. 2002, 72640, p. 11 and Figure 3.2-2). The annular space outside each screen was filled with a sand pack with a length between 22 and 49 ft (Figure A-1). Screens and associated sand packs were isolated from one another with bentonite seals in the annular space between the outer well casing and the borehole wall.

Well screens were developed prior to installation of a Westbay multiport sampling system (Broxton et al. 2002, 72640, pp. 12–13). Well development involved pressure-washing each screen with a water solution

containing sodium acid pyrophosphate (SAPP) to remove residual concrete used in repairing screen 3. The pressure wash was followed by purging the wellbore, wire brushing and jetting the screens, and airlifting and pumping water from the bore. A submersible pump was used to target individual screens although no isolation packer was used for this operation. Starting with screen 4, the pump was moved down through screened intervals, and each interval was pumped until water quality parameters were optimized. These screens were then scrubbed, and the pump was again moved through the screen intervals. The Cerro Grande fire interrupted operations from mid-May 2000 through September 13, 2000. Pump development resumed in September and was immediately followed by installation of the Westbay casing components. A total of 192,000 gal. of water were removed during development operations following screen repair. Assuming a 5-in-inner-diameter casing and a saturated length of about 720 ft, the volume of standing water inside the casing would be about 734 gal. Therefore, the volume of water removed during this phase corresponds to about 260 well volumes.

HE compounds or degradation products were not detected in the thirteen core and cuttings samples collected from the R-25 borehole (Broxton et al. 2002, 72640, p. 51). This finding is consistent with the expectation that these compounds adsorb poorly onto the Bandelier Tuff and Puye Formation because of the near absence of solid organic matter (<0.05 wt%) (Broxton et al. 2002, 72640, p. 51 and Appendix H). The absence of HE in the core is probably also because R-25 was drilled in a clean area with no near-surface source of HE.

2.3 Water Level Data

Immediately following well development, the Westbay MP55 System component was installed (Broxton et al. 2002, 72640, pp. 13–14). System components include measurement ports, pumping ports, and packers. Lowering of the casing components to their target positions was completed on September 28, 2000. Packers were inflated in sequence, beginning with the lowermost, from September 29 to October 2, 2000.

Figure 2a shows the hydraulic head profiles in well R-25 from the installation of the Westbay system through April 5, 2005 (Koch 2005, 88506, Figure 2-1). To obtain these profiles, pressure measurements were combined with port elevation to ascertain an equivalent elevation of water above sea level. If a head measurement falls on the atmospheric line, it indicates no overlying water column at that point. Head measurements that fall along a vertical line indicate hydrostatic conditions with no change in total head with depth. Total head is the sum of the pressure head (i.e., depth of overlying water column) and elevation.

Head measurements at screens 1, 4, and 5 (Figure 2a) indicate that the measurement port at each screen is overlain by only a small water column and that each screen is near the top of individual saturated zones. The trend of measurements indicated by screens 1 and 2 shows that they may lie within the same saturated zone, within which hydraulic head decreases with depth. The same conclusion applies to screens 6, 7, and 8, which evidently lie within the same saturated zone (the regional aquifer) as screen 5. The measurements in these four screens show that head decreases with depth. The initial head measurement at screen 3 indicates little or no overlying water and suggests that no perched zone is present at that screen.

The hydraulic head profile (Figure 2a) and supporting water level data indicate that, since the Westbay system was installed, each screen in the well has maintained different and unique hydraulic heads in a setting of significant head gradients throughout the total depth of well R-25 (Figure 2b) (Koch 2005, 88506, p. 16). These consistent trends indicate that screens in the well are not in direct hydraulic communication either through the well annulus or through the Westbay packers inside the well. The data

indicate that the annular materials provide a sufficient seal between screen zones and that the Westbay packers are effectively isolating each screen zone within the well. Thus, direct leakage or communication of groundwater between zones as a result of the well installation does not appear to be occurring.

Koch (2005, 88506) evaluated the water level responses of each interval, as summarized in the rest of this section. Some of the apparent data outliers plotted in Figures 2b, 3a, and 3b may be attributed to the limited accuracy of the equipment used. According to the Environmental Stewardship–Water Quality and Hydrology (ENV-WQH) standard operating procedure (SOP) SOP-016.4, "Pressure Transducer Installation, Removal, and Maintenance," the accuracy of a pressure transducer is ± 0.1% of its full-scale reading, such that transducer measurements obtained using the Westbay groundwater sampling tool may have measurement errors up to 2.3 ft (1 psi) because of the high pressure rating of the transducer (1000 psi) (Koch 2005, 88506, p. 10).

Screens 1 and 2 have similar water level trends through time and appear to represent different horizons within the same intermediate perched zone (Figure 3a) (Koch 2005, 88506, p. 16). This interpretation is consistent with the geologic log that reported continuously wet core throughout this depth (Broxton et al. 2002, 72640, p. 45). Initially rising water levels in screen 1 (Figure 3a) may reflect equilibration of the uppermost perched zone after inflation of the Westbay packers to seal off the intervals (Koch 2005, 88506, pp. 8 and 13). The head gradient between screens 1 and 2 has stayed in the range of 0.27 to 0.30 ft/ft since October 4, 2000.

The initial head for screen 3 plots on the atmospheric pressure line (Figure 2a), which indicates the absence of an overlying column of water at the measurement port (Koch 2005, 88506, pp. 8, 12, and 19). In addition, the water level in this interval never recovered after a water sample was collected in November 2000. This screen is not functional for collecting water quality data representative of the formation because of the repairs performed at this screen interval.

The water level trend through time shown by screen 4 is distinct from the trends shown by screens 1 and 2 in the uppermost perched zone as well as from the trend shown by screen 5 at the top of the regional aquifer (Figures 3a and 3b) (Koch 2005, 88506, p. 8). This difference supports the conclusion that screen 4 lies near the top of a separate perched zone. The initial water level at screen 4 was about 15 ft above the top of the screen and about 21 ft above the level of the measurement port, indicating a perched zone of significant thickness.

Screen 5 is located slightly below the top of the regional aquifer, which occurs about 19 ft above the top of the screen and about 27 ft above the measurement port (Figures 2a and 2b) (Koch 2005, 88506, pp. 8–9). Initial declining water levels in screen 5 (Figure 3b) likely represented the dissipation of a small groundwater mound formed near the top of the regional aquifer when the well was open to all screens prior to Westbay installation.

Hydraulic heads at screens 6, 7, and 8 decrease with depth and are less than that in screen 5, indicating a significant head gradient within this part of the regional aquifer (Figure 2a and 2b). The initial head difference between screens 5 and 8 was 83.77 ft over a distance of 492.6 vertical ft, for an average head gradient of 0.17 ft/ft (Koch 2005, 88506, p. 8–9). Screen 6 shows the least amount of fluctuation in water levels over time, and the trend is unlike those of adjacent screens (Figure 3b) (Koch 2005, 88506, p. 12). This characteristic probably indicates a low-permeability ("tight") interval. This interpretation is supported by the lack of success of slug-injection testing at R-25; the screens would not accept the injected water (Broxton et al. 2002, 72640, p. 48; Koch 2005, 88506, p. 20). Similarly, at regional well R-26, located about 1.5 km (0.9 mi) upgradient of R-25, aquifer tests indicated an average hydraulic conductivity of 0.0022 ft per day (Kleinfelder 2005, 87846, p. 24). This field value is the lowest yet determined for the regional aquifer in the Puye Formation and more than two orders of magnitude less than the value of

0.25 ft/day determined for this part of the formation (fanglomerates) where it was encountered by screen 5 of regional well CdV-R-15-3, about 1.5 mi downgradient from R-25 (Kopp et al. 2002, 73179, p. 28). A lowering of piezometric pressures in screen 8 during some groundwater sampling events may indicate another low-permeability screen interval (Figure 3b) (Koch 2005, 88506, p. 12).

Data from screen 9 (not included in this work plan) show a significantly lower water level than observed in screen 8 and a high hydraulic gradient between those two screens of 2.4 ft/ft, compared to 0.17 ft/ft above screen 8 (Koch 2005, 88506, p. 9). The construction and repair history of screens 3 and 9 probably disrupted the reliability of this screen, and measurements from port 9 are likely not representative of the formation (Koch 2005, 88506, p. 19).

Water levels have decreased in all of the monitored screens since installation of the Westbay system (Figures 3a and 3b) (Koch 2005, 88506, p. 19). The largest declines, exceeding 10 ft, have occurred in the two deepest functioning screens (7 and 8) within the regional aquifer. Screen 6 has shown the smallest decrease, with a drop of only 1 ft, possibly because of a lower permeability than in other screens. The reasons for the decline could reflect changing recharge conditions.

2.4 Selected Chemical Data

Longmire (2005, 88510, Section 5) presents analytical results for water samples collected during four characterization sampling events at well R-25. These events occurred in November and December 2000, May 2001, August 2001, and February 2002. The objectives of the characterization work were to evaluate the extent to which the well R-25 groundwater samples are representative of in situ conditions and to determine whether contaminants are present in the intermediate perched zones and in the regional aquifer in the vicinity of the well. Three surveillance sampling events occurred following the conclusion of the characterization phase; these events took place in August 2002, December 2003, and August 2004 (ESP 2004, 83635; ESP 2004, 88421; WQDB: http://wqdbworld.lanl.gov/).

This section summarizes some of the major findings presented in recent Environmental Surveillance reports (ESP 2004, 83635, pp. 130–134; ESP 2004, 88421, pp. 124–128) and in Longmire (2005, 88510). Contaminant concentrations for the four characterization sample suites were below water quality standards and health advisory limits, except those for RDX, TNT, dissolved and total iron, dissolved and total nickel, and total manganese (Longmire 2005, 88510, Section 5). Other contaminants occurring in concentrations above detection levels in characterization samples included octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (high-melting explosive or HMX), HE degradation products, volatile organic compounds, trace metals, barium, nitrate, perchlorate, and tritium (Table 2). Observed trends for some of the conservative contaminant species that were above detection limits in the initial sampling suites are summarized below. An evaluation of trends for the remaining constituents of concern will be addressed in a task to be conducted under an approved work plan (Task 2 in Section 4).

2.4.1 High Explosives and Their Degradation Products

RDX was initially present at detectable concentrations in every screen, including screen 3 in November 2000 (the screen has been dry since then). Initial concentrations ranged from 5 to 65 µg/L, with the highest level in screen 1, the second highest in screen 8 (28 µg/L), and the lowest in screen 3. Since then, however, the concentration of RDX has steadily and sharply declined in all screens except screen 1, where its level has remained elevated and variable (Figure 4). Following three years of re-equilibration, RDX concentrations from the most recent sampling round dropped over an order of magnitude from the initial concentrations for screens 2, 5, 6, 7, and 8. (An unusually high detection limit of 12.5 µg/L for the most recent sample from screen 4 obscured the extent of decrease.)

TNT was initially present in 6 screens at detectable concentrations ranging from 0.36 to 4.3 µg/L, with the highest concentration in screen 1, the next two highest levels in screen 7 (2.2 µg/L) and screen 8 (2.0 µg/L), and the lowest concentration in screen 3. TNT has not been detected in screens 2 or 5, nor has it been detected in screen 4 since the first sampling round in November 2000. In screen 1, TNT concentrations have largely paralleled the temporal variations in RDX concentrations. As with RDX, TNT concentrations from the most recent sampling round were about an order of magnitude less than initial concentrations for screens 7 and 8 and about 21% of initial concentrations for screen 6. However, TNT also tends to sorb more than does RDX onto organic carbon and clays (Broxton et al. 2002, 72640, Appendix H; Longmire 2005, 88510, Section 5). The extent to which sorption may have contributed to the decrease in TNT concentrations has not been fully evaluated.

HMX was initially detected in 6 of the 8 screens at concentrations spanning a range from 2.8 to 4.9 µg/L. The upper limit may have extended as high as 10 µg/L, which was the unusually high detection limit that applied to the initial sample from screen 1. Aside from screen 1, the two highest HMX concentrations were measured in screen 3 (4.9 µg/L) and screen 8 (4.1 µg/L). HMX was not detected in screen 4 (< 1 µg/L), nor was it detected in screen 2 after the first round. Similar to RDX and TNT, HMX concentrations have steadily decreased in the screens tapping the regional aquifer. Concentrations were about an order of magnitude less than initial values for screens 5, 7, and 8, and about 20% of initial concentrations for screen 6.

RDX degradation products include hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine (DNX), hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine (MNX), and hexahydro-1,3,5-trinitroso-1,3,5-triazine (TNX). Analyses of these constituents appear to be available only for waters collected from 5 screens in August 2001 and from all screens in February 2002 because of analytical method development. None of these degradation products were detected (< 0.5 µg/L) except in the sample collected from screen 1 in February 2002, in which DNX, MNX, and TNX were detected at 0.15 µg/L, 0.27 µg/L, and 0.23 µg/L, respectively.

TNT degradation products include 4-amino-2,6-dinitrotoluene (4-ADNT) and 2-amino-4,6-dinitrotoluene (2-ADNT). Both of these products were initially present at detectable levels in all screens for 4-ADNT, at levels ranging from 0.6 to 4.5 µg/L, and in all screens, except screen 3, for 2-ADNT, at levels ranging from 0.49 to 8.0 µg/L. Screens 1, 7 and 8 had the highest initial concentrations. 4-ADNT and 2-ADNT were not detected in screens 2 or 4 after the first sampling round, and decreased below detection levels in screen 5 by the most recent sampling round. In screens 6, 7, and 8, concentrations had decreased by about an order of magnitude from their initial concentrations.

2.4.2 Tritium

Tritium was present at detectable activities in every sample from every screen, including screen 3. Initial activities ranged from 26 to 139 pCi/L, with the highest activity in screen 2, the second highest in screen 1 (67 pCi/L), and the lowest in screen 6. Tritium activities have steadily declined in the regional aquifer screens but have remained elevated and slightly variable in screen 1 at the top of the intermediate perched zone (Figure 5). The tritium activity in screen 5 dropped to 17 pCi/L for the second sampling round (60% of its initial activity), and remained fairly constant at about 16 pCi/L in the last three sampling suites. Following three years of flushing by native groundwater, tritium activities from screens 7 and 8 dropped to less than 3% of their initial values. Tritium activities in screen 6 have also dropped steadily but more slowly, declining to 14% of its initial activity as of December 2003. In effect, this situation has provided a field-scale, multilevel, multitracer study under natural hydraulic gradient conditions.

Although tritium activities in well R-25 are far below regulatory concern, this constituent is valuable as a conservative tracer of water movement and origins. Tritium activities plotted against RDX concentrations

show linear correlations that support the contention that RDX is also conservative in this environment (Figure 6a). For the screens in the regional aquifer, the correlation indicates mixing of regional groundwater with water from the top of the uppermost perched zone (screen 1). Water from screen 4 falls on a separate but parallel mixing line (Figure 6b), suggesting no direct connection (i.e., no fast path) with the uppermost perched zone at screen 1.

TNT also shows a linear correlation with tritium in the regional aquifer, although the relationship is weaker than for RDX because about half the samples were below detection for TNT.

The conservative behavior of RDX and tritium, and their gradual but steady approach to reproducible concentrations over time in the screens completed in the regional aquifer, may be used to estimate the extent to which concentrations of dissolved species have approached conditions that are representative of the formation (Figure 7). RDX concentrations and tritium activities both indicate that waters in screens 5, 7, and 8 have nearly attained this condition, at least for conservative species, while screen 6 may require a couple more years to do so.

2.4.3 Trace Metals

Various trace metals such as total and dissolved iron, manganese, nickel, strontium, and uranium are not representative of predrilling conditions in some intervals because of the lingering effects of residual chemicals such as EZ-MUD plus used during well construction (Longmire 2005, 88510, Sections 5.1 and 5.3.3). Dynamic oxidation/reduction conditions exist in some intervals from the breakdown or dissociation of organic drilling chemicals. Elevated levels of iron and manganese suggest that reducing conditions have probably dissolved solid ferric (oxy)hydroxide ($FeOH_3$) and manganese dioxide (MnO_2) and converted these two metals to their more soluble reduced forms, Fe(II) and Mn(II). Dissolution of these mineral phases would release ions into solution that had coprecipitated with those phases (such as nickel) or that had adsorbed onto their surfaces (such as strontium or uranium). However, these drilling impacts on screen water quality should diminish with time, as the intervals return to the oxidizing conditions that prevail in the adjacent formations.

In contrast with the trace metals discussed above, it is conceivable that boron concentrations are elevated above natural background levels (which are generally less than 60 µg/L) in the uppermost perched zone as a result of infiltration of TA-16 effluents (ESP 2004, 88421, p. 128). Because it is stable as the neutral dissolved species $B(OH)_3$ below pH 9 at 25°C (Longmire 2005, 88510, Section 5.1), boron should behave conservatively in the sampled intervals. In fact, its concentrations show linear relationships with RDX and tritium in the regional aquifer screens (plots not included in this work plan). Like RDX and tritium, boron concentrations are within the range of natural background levels in screens 6, 7, and 8 but remain elevated in screens 1, 2 and 5.

2.4.4 Water Chemistry for Screen 3

About 5.5 L of water were collected from screen 3 during the first round of sampling on December 1, 2000. The highly alkaline pH of 11.67 and chemical composition of the water sample clearly show the influence of the Portlandite cement used to repair the screen (Longmire 2005, 88510, Section 5.1, Tables 4.2-1c and 5.1-3). No additional samples have been collected because the water level never recovered after this first round. Screen 3 is considered to be nonfunctional for collecting water quality samples.

2.4.5 Phosphorus

Phosphorus was introduced into screen intervals in well R-25 when the screens were pressure-washed with SAPP in early December 1999. The solution strength was not indicated in any available written report but can be estimated by assuming that 100 lb of SAPP were added to each 300-gal. batch of the cleaning solution (David Schafer, personal communication, April 14, 2005; Mark Everett, personal communication, May 17, 2005). This recipe yields a concentration of 7600 mg/L of phosphorus, and 5600 mg/L of sodium. The application rate was about one mixing tank of solution per screen. Some would have escaped to the bottom of the cased well and could have been removed during pumping development, but much of the cleaning solution would have passed through the screens into the filter sand packs. An unknown portion would have entered the formation, particularly if the screen were later submerged by standing water in the cased well. Solution that entered the filter sand pack or formation would be expected to flush out slowly, as a function of the groundwater flow rate through that screen.

This reconstruction of events is supported by the phosphorus concentrations measured in each screen (Figure 8). Screens 1 and 4 in intermediate perched zones had the lowest phosphorus concentrations (except for a spurious spike in screen 4 during the last sampling round). Screens 7 and 8 also had very low initial phosphorus concentrations (about 1 mg/L), which have steadily decreased and now possibly represent background levels. Screen 2 shows relatively high and erratic phosphorus concentrations (10 to 20 mg/L). The flow rate through the formation at screen 2 is apparently so slow that a very long time will be required to flush the residual phosphorus out of the interval. The tightness of the formation at screen 6 also limits the rate at which it can be flushed.

3.0 CONCEPTUAL MODEL

The major features of a conceptual model to account for the water quality trends observed in the screens in well R-25 are described below. The discussion follows the premise that the process by which groundwater returns to predrilling conditions proceeds through predictable phases. As a result, an individual screen may have returned to predrilling conditions for some parameters but not for others, e.g., because of slower flow rates or reaction rates. The major phases of re-equilibrium through which the R-25 screens are proceeding include, approximately in order of occurrence, the following:

- return to negligible levels of suspended particulates (turbidity)
- return to predrilling water levels
- return to predrilling concentrations of conservative species (i.e., constituents that are not affected by redox conditions, do not sorb, do not degrade, and do not react or form nonconservative complexes with other species present in the interval)
- degradation of residual organic constituents introduced with drilling fluids
- return to predrilling concentrations of other nonconservative constituents.

3.1 Contamination of Screen Intervals below Screen 1

As a result of the long delays in well completion caused by the repair of screens 3 and 9 and by the Cerro Grande fire, screen intervals 5 to 9 were subjected to standing water in the cased borehole for about 16 months, until the intervals were finally isolated at the end of September 2000. For those 16 months, water from intermediate perched zones continually seeped down the casing walls to mix with standing water in the cased well. The sustained concentrations of HE compounds in water from screen 1 and the

steadily decreasing contaminant concentrations in water from the other screens over the past few years indicate that screen 1 was the primary pathway by which contaminants were transported from the uppermost perched zone to those other screens. The composite water level during this time is not indicated in any of the available published reports but a lower bound can be estimated based on the water level of 1224 ft bgs (6292.1 ft amsl) measured immediately prior to inflation of the Westbay packers. This water level is about 40 ft higher than the top of the regional aquifer after packer inflation and 29 ft below screen 4. Contaminated water from the cased well would have flowed continuously into the relatively high-porosity (about 30%) filter sand packs and would have diffused into the formation from which it could not be readily removed during pumping development of the screens. Even if screens 2, 3, and 4 were never inundated by the standing water in the well, small quantities would have entered those screens as the water seeping from screen 1 trickled down the 10-ft screen sections. Because contamination was detected in screening samples collected from the cased borehole during drilling (Broxton et al. 2002, 72640, pp. 56–64), contamination of the deeper zones could also have occurred during drilling.

3.2 Re-equilibration of Water Levels

Once the Westbay packers were inflated in October 2000, thereby isolating the screens from one another, water levels and chemical compositions in each screen began to re-equilibrate with the surrounding formation. Screens in the intermediate perched zones initially showed water level increases as formation water recovered and moved back into the partially desaturated volume adjacent to the well at each of these screens (Koch 2005, 88506, p. 13). In contrast, screen intervals in the regional aquifer initially showed water level decreases from dissipation of the localized groundwater mound that formed at the top of the regional aquifer around the well while the well was open to all screens (Koch 2005, 88506, p. 13). All functioning screens should now be fully equilibrated with water level conditions representative of the adjacent formation.

3.3 Re-equilibration of Water Chemistries

Conservative species such as tritium, perchlorate, chloride, boron, and RDX are expected to be the first to recover from the disturbances caused by well drilling, construction, and development. The concentrations of these species are not affected by any chemical interactions between residual drilling materials and the groundwater. The rate at which these conservative species return to ambient predrilling concentrations depends upon several factors:

- the magnitude of the difference in the chemical concentration in the introduced water and in the formation water
- the extent to which the introduced water penetrated the formation adjacent to the screen
- the time period during which introduced constituents diffused into the formation porespaces
- the groundwater flow rate through the screen, which is primarily a function of the hydraulic gradient and hydraulic conductivity of the geologic formation, both of which may vary with formation depth

Water samples collected from screens 1, 7, and 8 are the least impacted by residual chemicals introduced during well construction and completion, based on the observed distribution of major ions and trace elements (Longmire 2005, 88510, Section 5.3). These screens, as well as screen 5, appear to be approaching predrilling conditions for conservative species. The amount of time required for each screen in well R-25 to completely re-equilibrate with groundwater is not presently known and is dependent on

hydraulic properties of the Puye Formation and reactivity of materials used during well construction. The conservative contaminants relevant to well R-25, including tritium, RDX, TNT, boron, and perchlorate, are not affected by materials used during well construction, based on six rounds of samples collected to date.

A slower rate of recovery is expected for those constituents that are nonconservative in their behavior. These include constituents that participate in redox reactions; sorb onto surfaces of minerals, colloids, or organic matter; degrade; react with other constituents to form complexes or colloids; and precipitate or dissolve from mineral phases. In R-25, indicators used to track the extent of disequilibrium include concentrations of total organic carbon (TOC), sulfate, nitrate, ammonia, redox-sensitive trace metals such as iron and manganese, phosphorus, and indicators of bentonite clay such as chloride, strontium, sodium, and uranium. An examination of temporal trends for each of these indicators in R-25 screens indicates that some nonconservative constituents require more time to attain predrilling conditions. Analyses of water samples collected from screens 4 and 6 indicate that residual chemicals are still being slowly flushed out of these intervals. Screen 2 is the slowest interval to return to predrilling water quality conditions, as indicated most markedly by elevated concentrations of sodium and phosphorus introduced by the use of SAPP to clean the screens prior to well development.

Several trace metals are notable exceptions to the above general statements about re-equilibration of screen intervals with in situ groundwater chemistries. In particular, metals such as total and dissolved iron, manganese, nickel, strontium, and uranium do not appear to be representative of predrilling conditions in some of the intervals. Elevated concentrations of some of these metals are believed to result from the temporary reducing environment created as an artifact of well construction, as described in Section 2.4.3 (ESP 2004, 88421, p. 128; Longmire 2005, 88510, Sections 5.3 and 7). However, trends for these species must be evaluated carefully because of the variability in analytical detection limits and ambiguities introduced by comparison of data obtained on filtered and nonfiltered samples.

3.4 Assessment of Sampling Port Suitability

Several independent lines of evidence support the case that well R-25 provides useful information despite the circumstances summarized in Sections 3.1 through 3.3:

- Water level profiles show that the hydraulic head always decreases with depth (Figure 2), which is consistent with the well being within a recharge zone on the Pajarito Plateau.
- Water level profiles show no direct hydrologic connection or pathway exists between screens. If there were, then the connected screens would have similar hydraulic heads (Figure 2) (Koch 2005, 88506, p. 2 and 16).
- Pressure data collected on April 4, 2005, from screen 3 show the presence of water in the screen 3 sump, which confirms that the packer below screen 3 is holding and the Westbay system does not provide any pathway from the uppermost perched zone (screens 1 and 2) to a lower perched zone (screen 4) or to the regional aquifer (Koch 2005, 88506, p. 16).
- The source of HE contamination in all screens appears to have been water from the uppermost perched zone (Longmire 2005, 88510, Figure 5.1-7) seeping into the cased borehole and mixing with water from other intervals during well drilling, construction, and development. The conceptual model posits that the contaminated water moved into the filter sand packs and formation next to the screens. The screens are now slowly being flushed out by native water. Evidence for this conceptual model includes linear mixing lines between conservative species in the various screens, with water from the uppermost perched zone and regional groundwater being the mixing endmembers.

- All intervals below screen 1 show a reduction in RDX concentrations in a consistent manner (Figure 4) (Longmire 2005, 88510, Figure 5.1-7). Screens 5, 7, and 8 have been flushed of over 97% of their residual RDX contamination (Figure 7). Screen 6 is cleaning up more slowly because of the tightness of the formation in this interval; about 10% of the initial RDX contamination was still present during the last sampling round (December 2003). The tightness in screen 6 is also evident from the flat water level response for this interval (Figure 3b) (Koch 2005, 88506, p. 12).
- Decreases in RDX concentrations result from the flushing of the formation/filter pack outside the screens by native water and are not attributable to RDX degradation or sorption (Longmire 2005, 88510). Strong supporting evidence is provided by (1) the linear relationship between RDX concentrations and tritium activities over time (Figures 6 and 7), and (2) the absence of degradation products of RDX, which include MNX, DNX, and TNX, in the regional aquifer screens at well R-25.

These considerations demonstrate that screens 1, 2, 4, 5, 6, 7, and 8 provide water quality data that are representative of natural formation conditions for the main constituents of concern at R-25, which include HE-related compounds, boron, perchlorate, barium, nitrate, tritium, and volatile organic compounds (VOCs). It appears that all screens have already reached or are approaching equilibrium with predrilling concentrations of conservative species (e.g., RDX, boron, perchlorate, and tritium). However, for nonconservative species, the screens are approaching equilibrium more slowly. Hence, until re-equilibration is achieved for all constituents of interest, water quality data from R-25 need to be evaluated for reliability and representativeness on an analyte-by-analyte basis.

4.0 PROPOSED INVESTIGATION

To test the conceptual model described above and to demonstrate the extent to which contaminant data from individual screens in well R-25 are or will be valid and reliable, the following tasks are proposed.

4.1 Task 1. Collection of Samples for Water Quality Analysis

Sampling of Well R-25 (screens 1, 2, 4, 5, 6, 7, and 8) will be conducted twice a year for the analytical suites specified below. All work will be conducted under the Environmental Stewardship–Environmental Characterization and Remediation (ENV-ECR) Quality Assurance (QA) Program. Samples will be collected under controlled conditions by ENV-WQH personnel and documented following the ENV-ECR SOP-06.32, “Multi-level Groundwater Sampling of Monitoring Wells: Westbay MP System,” including the applicable quality procedures (QPs) and SOPs cited in that procedure. Samples will be transmitted to the ENV-ECR Sample Management Office (SMO) for shipping to analytical test laboratories on the ENV-ECR qualified suppliers list. Data will be received by the SMO and provided to the project team leader for this work plan.

The following analytical suites will be requested:

- field measurements (pH, specific conductance, temperature, dissolved oxygen, turbidity, alkalinity, pressure of zone)
- general inorganics
- perchlorate
- metals (filtered and nonfiltered samples)
- modified high explosive suite (includes HE degradation products)
- VOCs

- tritium (low-level tritium)

Reporting for Task 1: Data will be reported in the WQDB (http://wqdbworld.lanl.gov/) and will also be included in a report to demonstrate the validity of R-25 data, which is to be submitted to NMED in accordance with the schedule presented in Section 5. Applicable records will be submitted to the Records Processing Facility (RPF) following ENV-ECR QP-4.4 "Record Transmittal to the Records Processing Facility."

4.2 Task 2. Evaluation of Data for Consistency with Conceptual Model

A systematic evaluation will be conducted of chemical, isotopic, and water level data for well R-25, along with daily field logs for the construction and development phases, to assess consistency with the preliminary conceptual model and the interpretation proposed in this work plan. The task expands the approach described in Section 3 by including additional analytes and characteristics that are relevant for R-25, and by providing more complete documentation of data and information and explicit substantiation of underlying assumptions. Key hypotheses of the conceptual model to be evaluated are listed below.

Hypothesis 1: The uppermost perched zone was the primary source of contaminants detected in screens in the regional aquifer at R-25. HE contamination was introduced from this perched zone to screens in the regional aquifer (screens 5 to 8) when the wellbore was open to screen 1 during well construction and development.

Evaluation criteria: Provide documentation to verify the following:

- The best correlation coefficients for tritium versus RDX, chloride versus RDX, sodium versus chloride, and sodium and potassium versus magnesium and calcium for screens in the regional aquifer are obtained when the mixing endmembers are assumed to be the top of the intermediate perched zone (as represented by screen 1) and native groundwater (as represented by the most recently measured water chemistries for screens 5 to 8, respectively). Correlation coefficients for any other physically reasonable contaminated mixing endmember (if any) are significantly less than those obtained for screen 1.

- Screen 1 contributed water to standing water in the open borehole during a period when screens 5 to 8 were exposed to the standing water. A bounding estimate can be provided of the quantity of water contributed.

- Screens 2, 3 and 4 contributed smaller quantities of water to standing water in the open borehole than did screen 1 during a period when at least one screen interval in the regional aquifer was exposed to the standing water.

- The hydraulic head in the open borehole exceeded the heads in screens 5 to 8 when these screens were exposed to standing water containing some proportion of water from screen 1.

- HE compounds or degradation products were not detected in the thirteen core and cuttings samples collected from the R-25 borehole.

- Water quality data for contaminants detected in groundwater screening samples while drilling the R-25 borehole (Broxton et al. 2002, 72640, Appendix G) are consistent with a derivation from the uppermost perched zone.

Hypothesis 2: No water in the wellbore entered the formation at screens 2, 3, or 4 because these intervals were always above the standing water level in the wellbore during periods when the well was open. Hence, there would not have been any gradient to force water into the formation.

Evaluation criteria: Provide documentation that standing water levels measured in R-25 after the well was drilled into the regional aquifer were less than the port elevations for screens 2, 3, and 4.

Hypothesis 3: Decreases in RDX and TNT in screens below screen 1 are the result of the natural flushing of the contaminants introduced during well construction and development.

Evaluation criteria: Provide documentation for the conservative (i.e., nonsorbing, nondegrading) behavior of RDX and TNT under the environmental conditions present in the regional aquifer at R-25. Provide documentation that no significant concentrations of degradation products for RDX or TNT are observed above those levels expected for mixing with contaminated water from screen 1 in accordance with Hypothesis 1.

Hypothesis 4: Residual concentrations of phosphorus above background levels can be attributed to the use of SAPP to clean the screens.

Evaluation criteria: Provide documentation that the volumes and concentrations of SAPP applied to each screen are consistent with the measured phosphorus concentrations in water from the screen interval.

Hypothesis 5: Stabilization of tritium activities and chloride concentrations can be used as indicators of the attainment of predrilling concentrations of RDX and other conservative constituents of concern in screens 5 to 8 in the regional aquifer.

Evaluation criteria: Tritium activities and chloride concentrations will be considered to have attained predrilling levels at a given screen interval when two consecutive analyses, collected at least six months apart, fall within one standard deviation of one another. The acceptability of using tritium and chloride as tracers of RDX will be demonstrated by the response to evaluation criteria for Hypothesis 2.

Hypothesis 6: Concentrations and transport properties of the main constituents of concern (Table 2) are not affected to a significant extent by any residual chemical or physical artifact of the well construction and development history for the screens in which they are detected or expected to be present.

Evaluation criteria: Provide documentation that supports the predominantly recalcitrant (nonsorbing, nondegrading) behaviors of RDX, TNT, and their degradation products (to the extent that these products are present) under the environmental conditions present in the regional aquifer at R-25.

Reporting for Task 2: The results of this evaluation will be included in a report to demonstrate the validity of R-25 data, which is to be submitted to NMED in accordance with the schedule presented in Section 5. Applicable records will be submitted to the RPF following ENV-ECR QP-4.4.

4.3 Task 3. Comparison of Chemical Data against Background Levels

Chemical and isotopic data for the regional aquifer and overlying perched zones at well R-25 will be compared with background levels, as determined in the “Groundwater Background Investigation Report” required by Section IV.A.3.d in the Consent Order (NMED 2005, 88207), and from local wells, as appropriate and available. The statistical comparison will provide the basis for evaluating the extent to which the data for R-25 screens represent a return to predrilling conditions.

Evaluation criteria: For each screen interval, analyses of major ions (sodium, potassium, magnesium, calcium, chloride, sulfate), characteristic major ion ratios, tritium, and field measurements of carbonate alkalinity, and pH in samples collected at least three months apart are within two standard deviations of one another (for samples from the same interval) and are within the range of background concentrations of these constituents measured in regional perched water and groundwater.

Note: The schedule for completion of task 3 will depend upon the collection and analysis of new samples from R-25 screens, as proposed in Task 1.

Reporting for Task 3: The results of this evaluation will be included in a report to demonstrate the validity of R-25 data, which is to be submitted to NMED in accordance with the schedule presented in Section 5.

4.4 Task 4. Evaluation of Westbay Multi-port System

The Westbay Multi-port monitoring system will be further evaluated by reviewing existing pressure data and by obtaining additional pressure data from measurement ports (MP) located in quality assurance (QA) zones, as well as by further evaluation of pressure data from measurement ports by Westbay personnel. The evaluation will include a review of applicable QA and quality control (QC) measurements and verification of the integrity of the packers.

Reporting for Task 4: This task is included in the “Draft 2005 Groundwater Level Monitoring Plan and Field Implementation Plan for the Groundwater Level Monitoring Project.” The results of this evaluation will be included in a report to demonstrate the validity of R-25 data, which is to be submitted to NMED in accordance with the schedule presented in Section 5.

4.5 Task 5. Resumption of Continuous Monitoring of Water Levels in Screens 1 through 8

The transducer string for continuous water level monitoring will be reconfigured to incorporate monitoring at MP3B instead of MP3A to monitor the water present in the sump at screen 3 and to detect any changes in water level that might indicate the presence of formation water in the screen or the failure of the packer system below screen 3. The transducer string will be installed as soon as reconfiguration changes have been made, and screens 1 through 8 will be monitored continuously. The transducer string will be reinstalled after each groundwater sampling event.

Reporting for Task 5. This task is included in the “Draft 2005 Groundwater Level Monitoring Plan and Field Implementation Plan for the Groundwater Level Monitoring Project.” As presented in the monitoring plan, water level monitoring data from R-25 intervals will be reported via the WQDB (http://wqdbworld.lanl.gov/). Data acquired under this task will be included in a report to demonstrate the validity of R-25 data, which is to be submitted to NMED in accordance with the schedule presented in Section 5.

5.0 SCHEDULE AND DELIVERABLES

The schedule in Table 3, “Schedule of Milestones and Deliverables,” becomes effective after the Laboratory has received a written notice from NMED signifying its approval of this work plan. If the Department sends a notice of disapproval or directions to modify this work plan, then the schedule shall not go into effect until approval has been obtained of the resubmitted work plan.

All work under this work plan will be performed under the ENV-ECR QA Program.

6.0 REFERENCES

The following list includes all documents cited in this plan. Parenthetical information following each reference provides the author, publication date, and ER ID number. This information is also included in text citations. ER ID numbers are assigned by the ENV-ERS Program Records Processing Facility (RPF) and are used to locate the document at the RPF.

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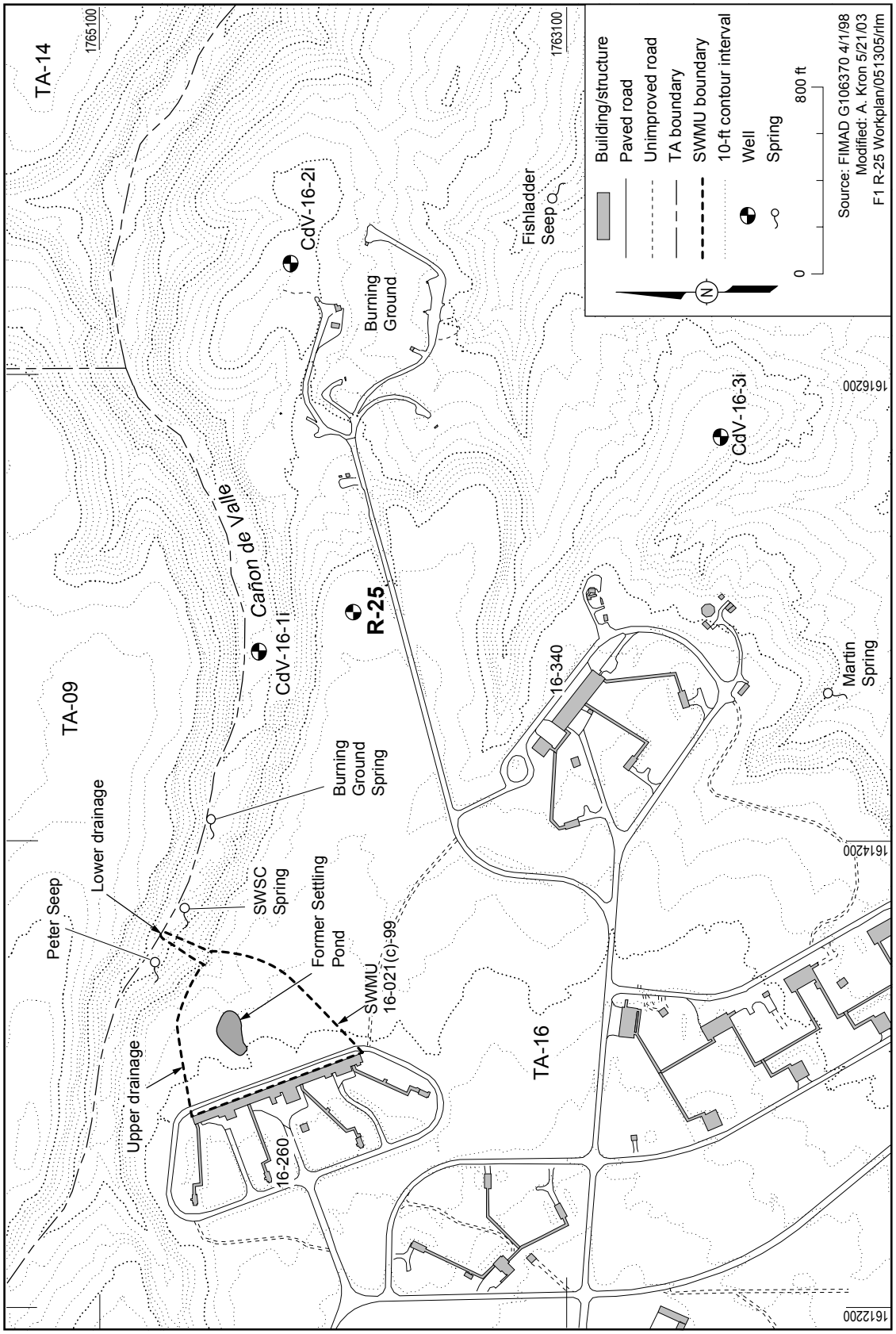

Figure 1. Location of well R-25 and associated physical features

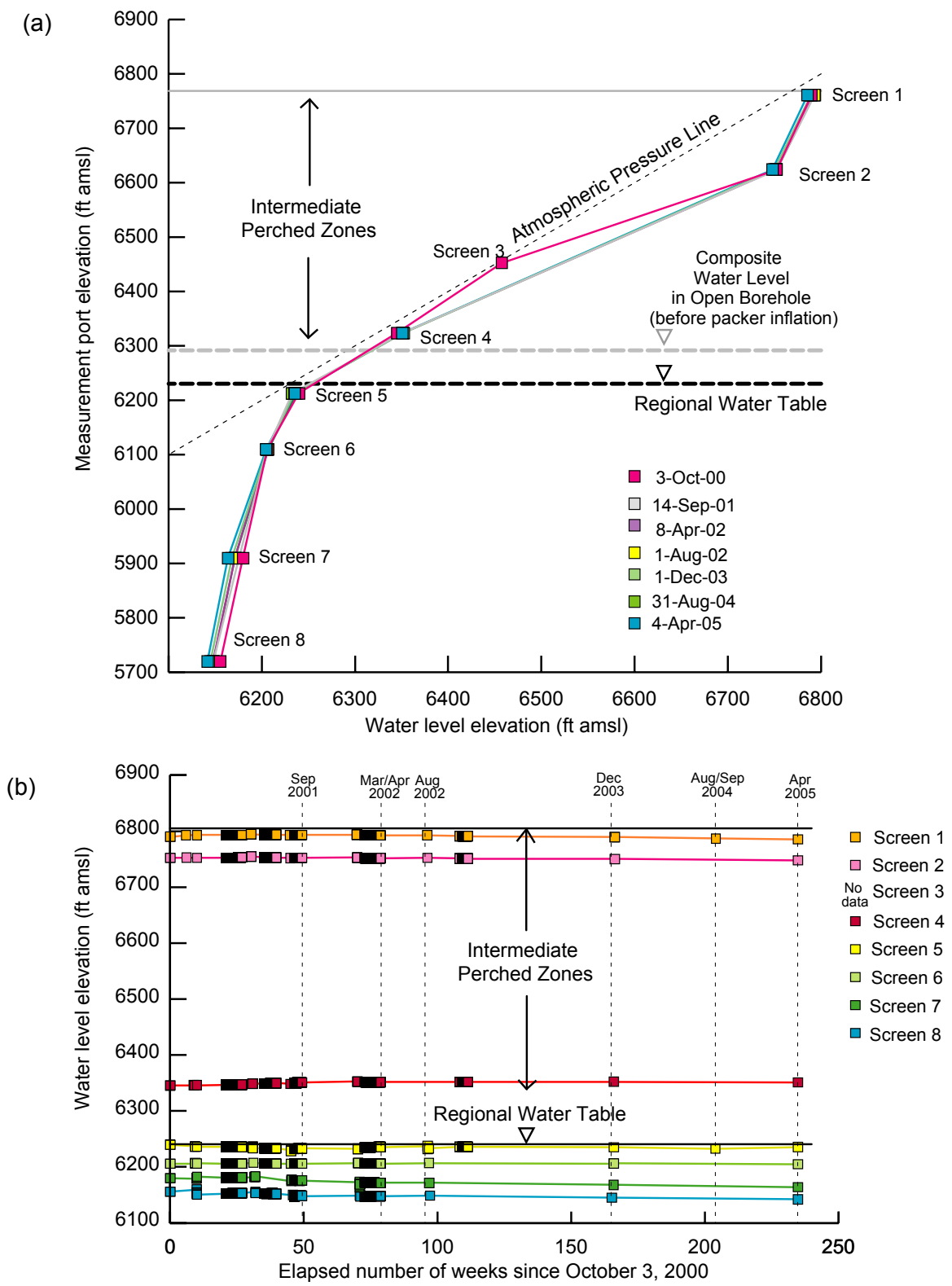

Figure 2. Water level elevations in well R-25, October 2000 to April 2005: (a) depth profiles for each sampling round and (b) temporal profiles for each screen interval (water level data from Koch 2005, 88506, and WQDB)

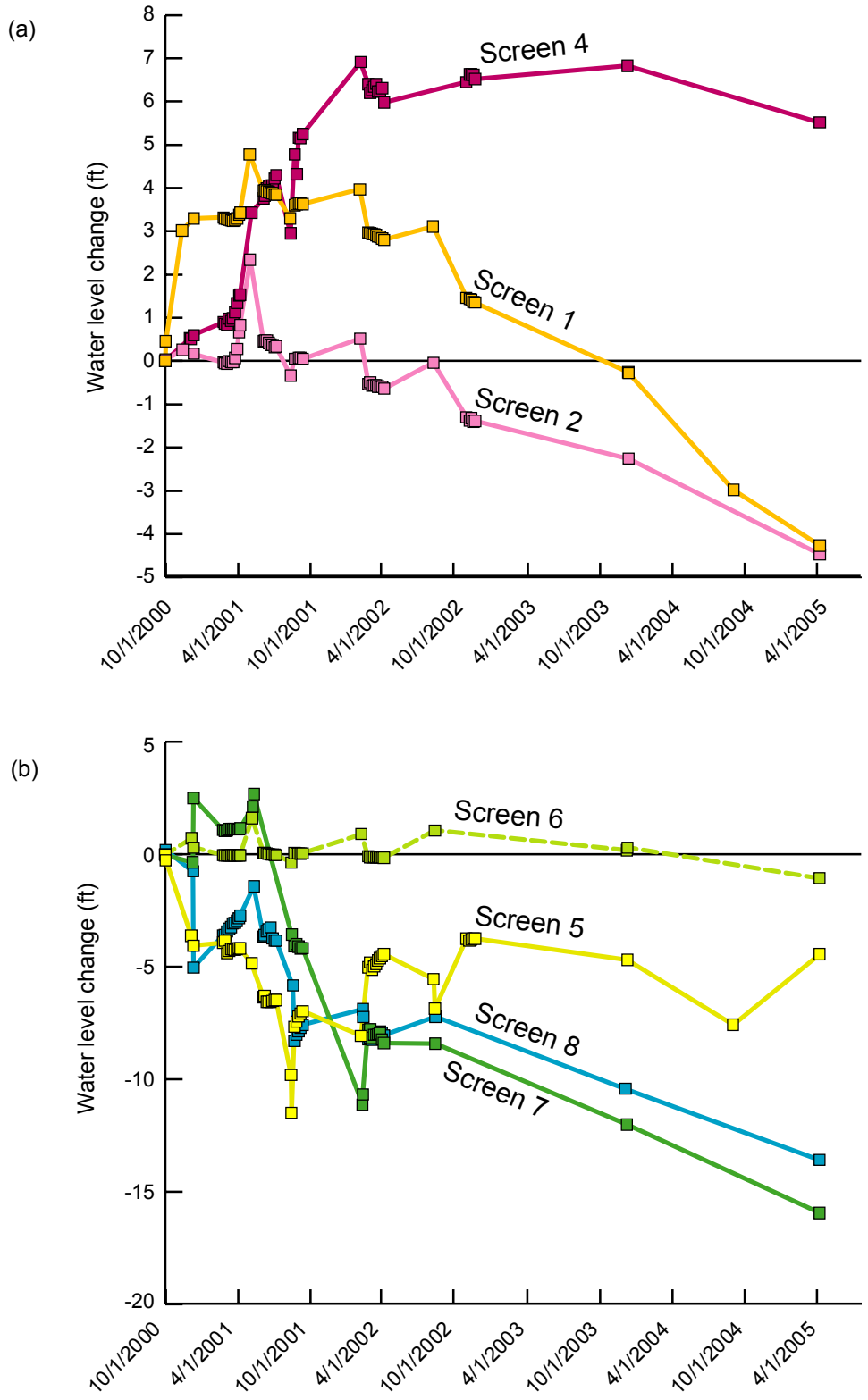

Figure 3. Water level elevations in well R-25 screen intervals, normalized to initial level measured October 3, 2000: (a) intermediate perched zones and (b) regional aquifer (water level data from Koch 2005, 88506, and WQDB)

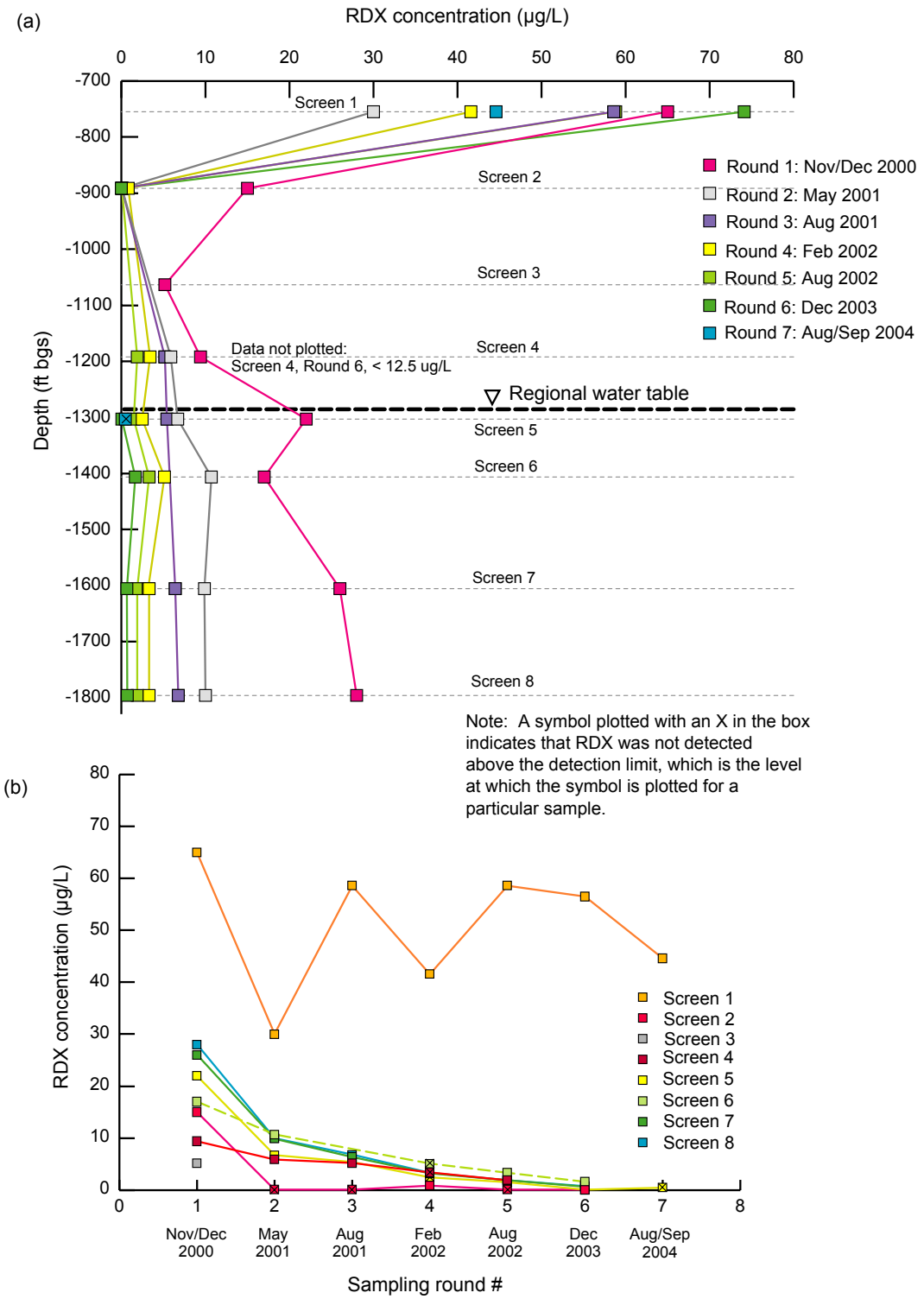

Figure 4. RDX concentrations in well R-25, November 2000 to September 2004: (a) depth profiles for each sampling round and (b) temporal profiles for each screen interval (data from WQDB)

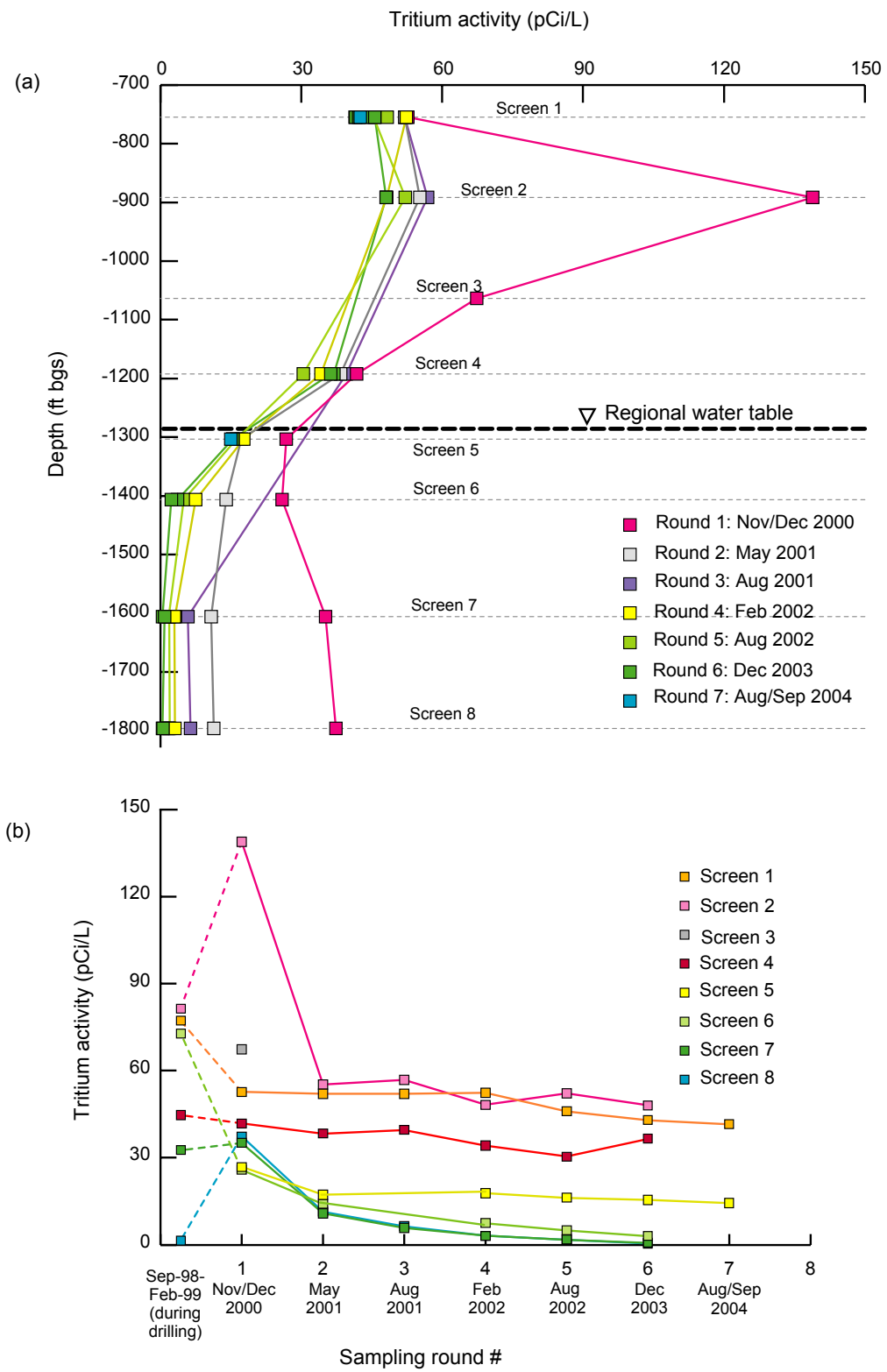

Figure 5. Tritium activities in well R-25, November 2000 to September 2004: (a) depth profiles for each sampling round and (b) temporal profiles for each screen interval (data from WQDB)

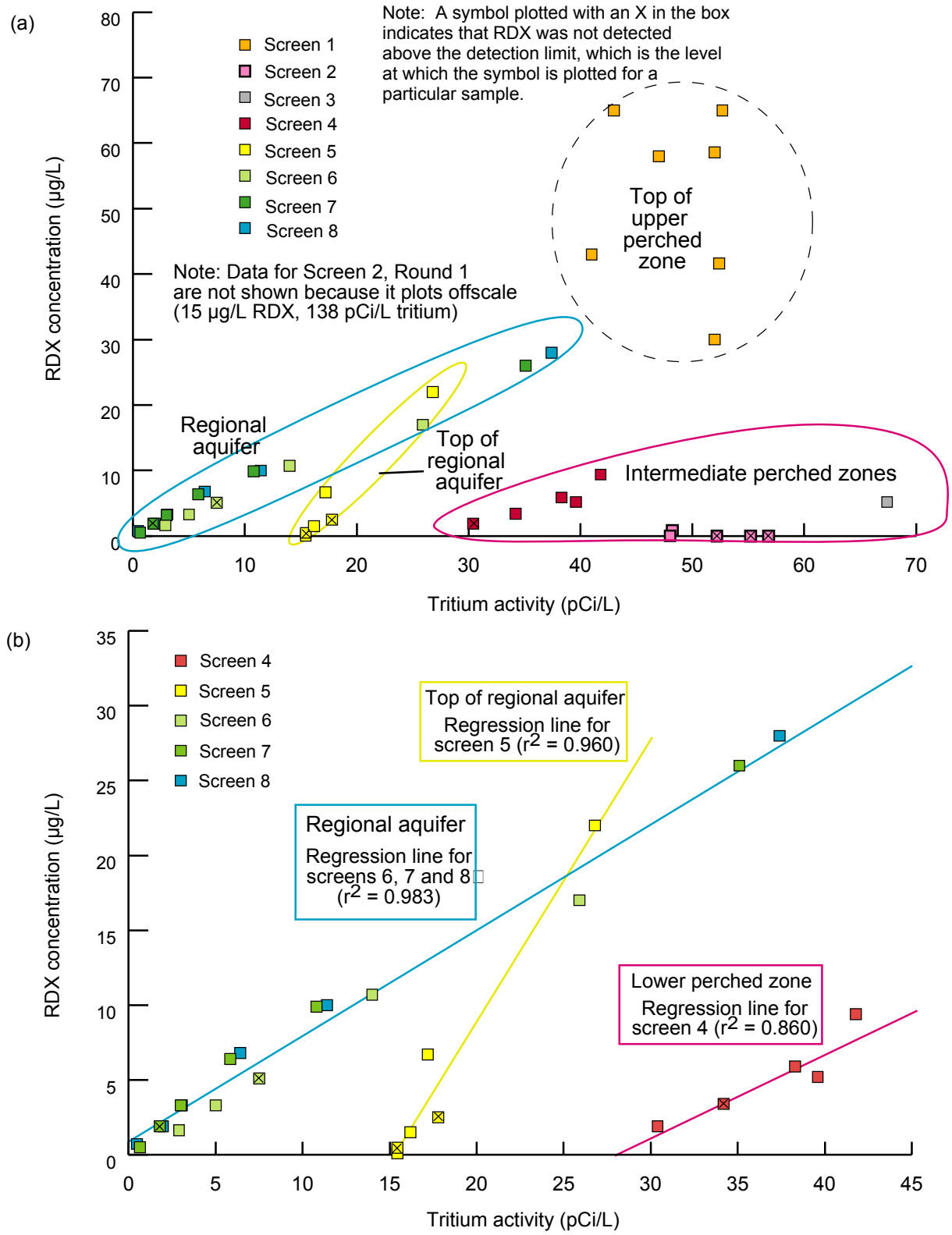

Figure 6. Tritium activities versus RDX concentrations in well R-25: (a) all screen intervals and (b) expanded plot for screens 4 to 8, with regression lines (data from WQDB)

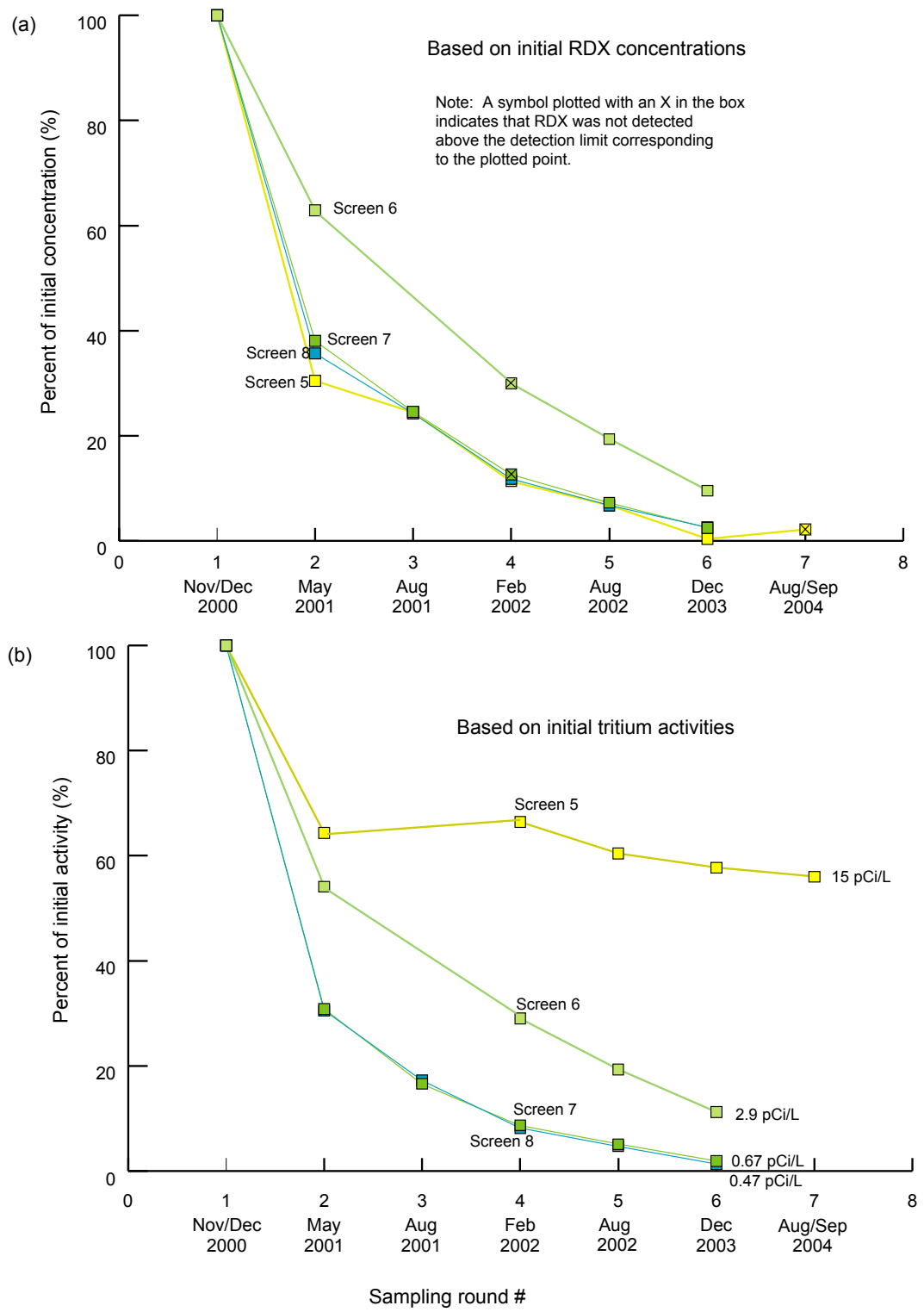

Figure 7. Residual contamination in screens in the regional aquifer at well R-25 based on: (a) decrease from initial RDX concentrations and (b) decrease from initial tritium activities (calculated from WQDB data)

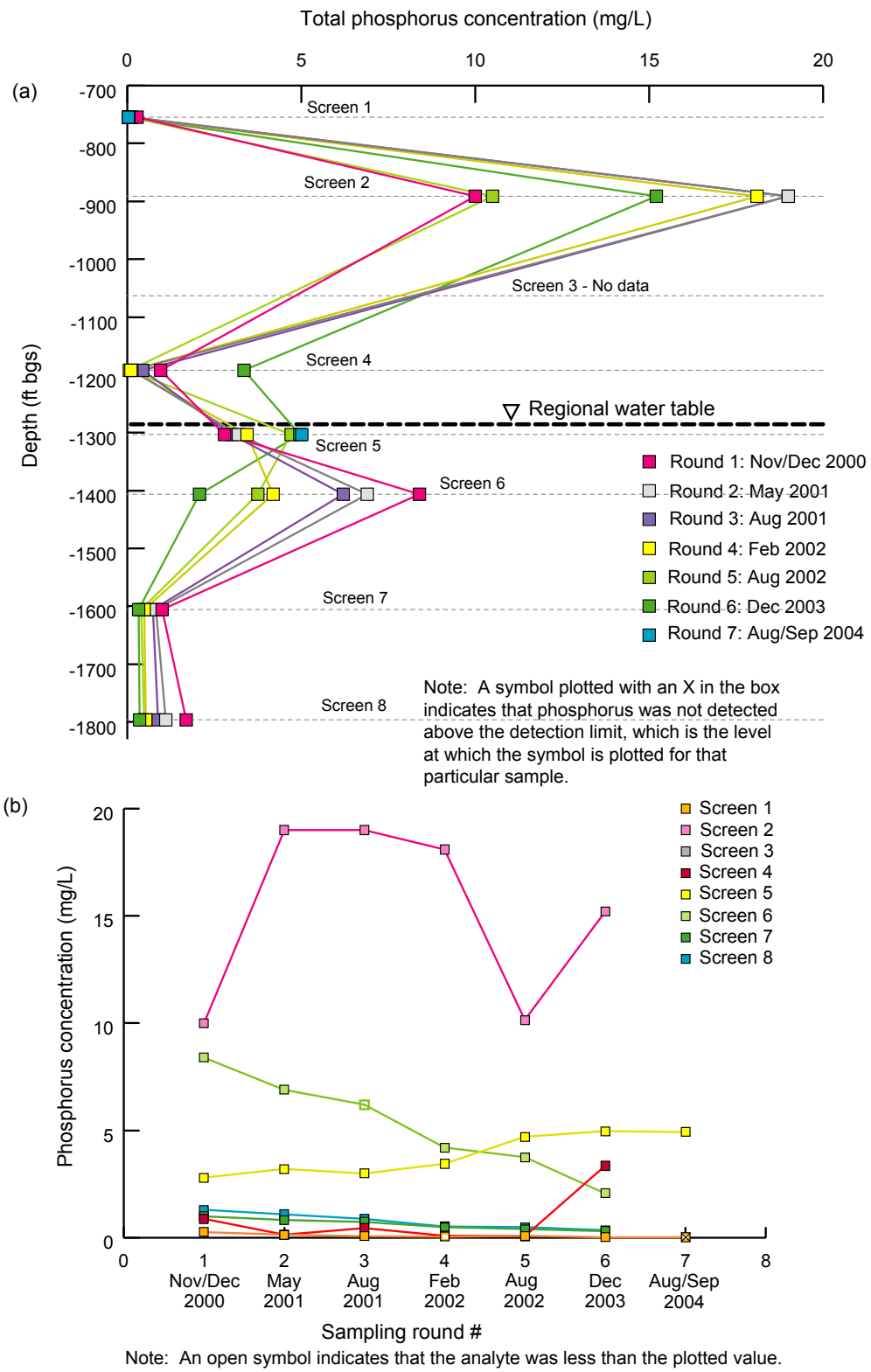

Figure 8. Phosphorous concentrations in well R-25, November 2000 to September 2004: (a) depth profiles for each sampling round and (b) temporal profiles for each screen interval (data from WQDB)

Table 1
Well R-25 Screens

Screen #	Screen Interval[a] (ft)	Screen Length (ft)	Sand Pack Length (ft)	Sump Volume[b] (L)	Geologic setting	Hydrologic Setting
1	737.6–758.4	20.8	36	32	Otowi Member	Uppermost perched zone
2	882.6–893.4	10.8	40	38	Puye Formation	Intermediate perched zones
3	1054.6–1064.6	10	30	72	Puye Formation	
4	1184.6–1194.6	10	22	36	Puye Formation	
5	1294.7–1304.7	10	24	39	Puye Formation	Regional water table
6	1404.7–1414.7	10	30	18	Puye Formation	Regional aquifer
7	1604.7–1614.7	10	30	18	Puye Formation	
8	1794.7–1804.7	10	32	17	Puye Formation	
9	1894.7–1904.7	10	49	N/A [c]	Puye Formation	

Source: Broxton et al. 2002, 72640, Figure 3.2-1 and Appendix B

[a] Depths are reported relative to the well R-25 brass cap ground elevation of 7516.1 ft (Broxton et al. 2002, 72640, Table 4.1-1).

[b] Volume of fluid in the sump area between the Westbay casing and the stainless-steel casing and below the bottom of the screen and the top of the next lower Westbay packer.

[c] Screen 9 is blocked by sediment.

N/A = Not applicable

Table 2
Main Constituents of Concern at Well R-25

Category	Constituent
High explosives and associated degradation intermediates	RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) RDX intermediate degradation products: • MNX (hexahydro-1-nitroso-3,5-dinitro-1,3,5-triazine) • DNX (hexahydro-1,3-dinitroso-5-nitro-1,3,5-triazine) • TNX (hexahydro-1,3,5-trinitroso-1,3,5-triazine) TNT (2,4,6-trinitrotoluene) TNT intermediate degradation products • 2-ADNT (2-amino-4,6-dinitrotoluene) • 4-ADNT (4-amino-2,6-dinitrotoluene) HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) 2,4-Dinitrotoluene TNB (1,3,5-trinitrobenzene)
Chlorinated solvents	PCE (perchloroethylene, also known as tetrachloroethylene) TCE (trichloroethylene, also known as trichloroethene)
Other Volatile Organic Compounds (VOCs)	Acetone Chlorobenzene Toluene
Other inorganic constituents*	Boron Nitrate Perchlorate Tritium

Sources: Longmire 2005, 88510, Section 5.3; ESP 2004, 88421, pp. 124–128.

* In addition, various trace metals such as total and dissolved iron, manganese, nickel, strontium, and uranium do not appear to be representative of predrilling conditions in some of the intervals for reasons discussed in Section 2.4.3.

Table 3
Schedule of Milestones and Deliverables

Elapsed time since receipt of approval notice	Milestone or Deliverable
1 month	Milestone 1: Establish sample collection and analytical protocols and identify applicable program requirements for semi-annual collection of water samples from screens 1, 2, 4, 5, 6, 7, and 8 (Task 1) Note: Water quality data will be reported in the Water Quality Database.
2 months	Milestone 2: Complete compilation of existing chemical analyses, water level measurements, and relevant information from field logs (Task 2)
3 months	Milestone 3: Collect first semiannual suite of water samples from R-25 (Task 1)
6 months	Milestone 4: Complete assessment of existing information for consistency with the elements of the conceptual model (Task 2)
9 months	Milestone 5: Collect second semiannual suite of water samples from R-25 (Task 1)
11 months	Milestone 6: Complete comparison of chemical and isotopic data for R-25 against background levels for intermediate perched zones and regional groundwater. Based on the comparison, provide estimates of the extent to which water from each screen has returned to predrilling conditions for all main constituents of concern (Task 3)
12 months	Milestone 7: Submit a report to demonstrate the validity of R-25 data for formal internal peer review following ENV-ECR QP-3.5, “Peer Review Process.” Report contents will include results of the evaluations for Tasks 1–4, along with a summary and preliminary interpretation of any water level data collected for R-25 under Task 5.
14 months	Deliverable: Submit a report to demonstrate the validity of R-25 data to NMED.

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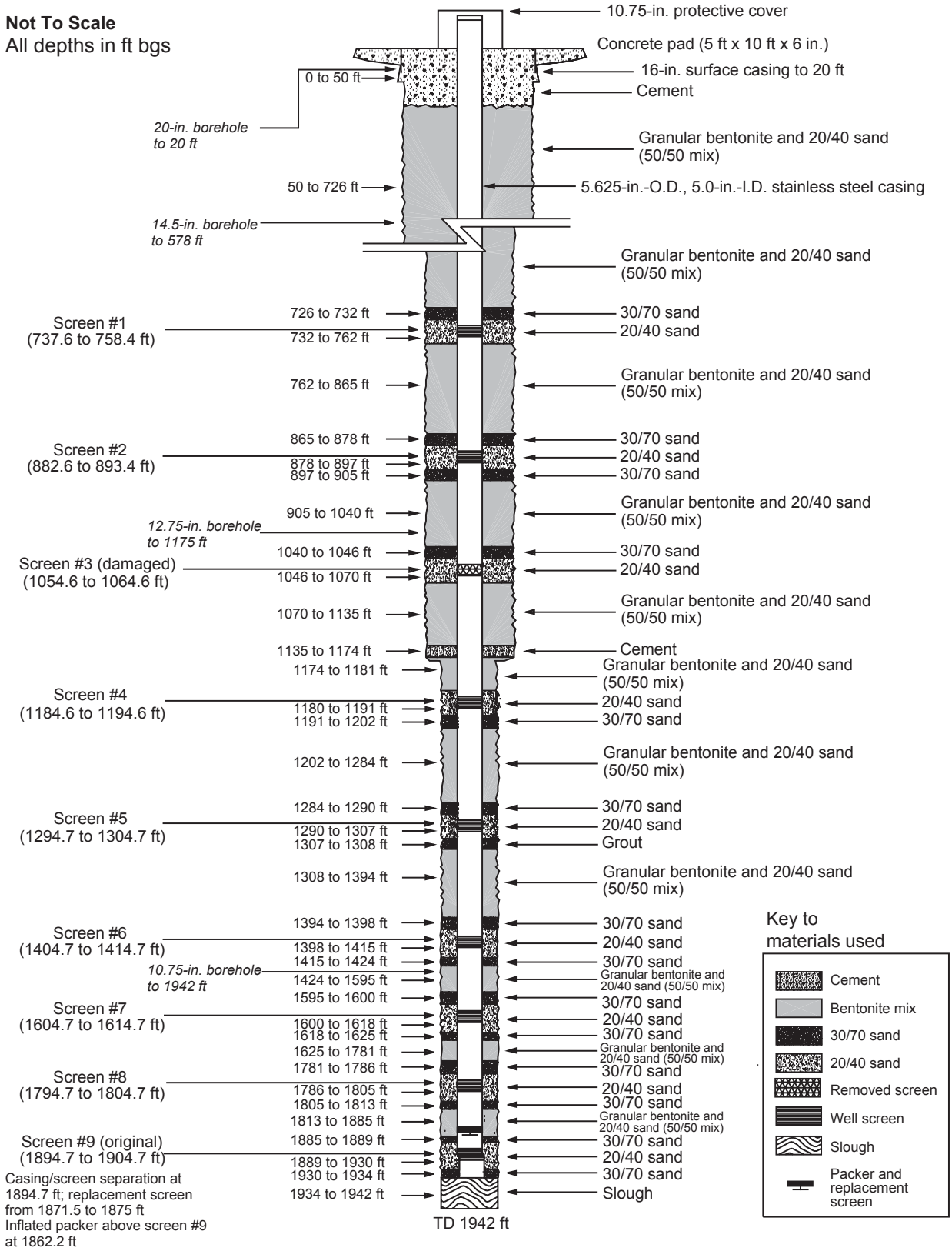
Appendix A

Construction, Development and Water Quality Sampling Chronology for R-25



Note: The screen intervals list the footages of the pipe perforations, not the tops and bottoms of screen joints.

Figure A-1. As-built well-completion diagram of well R-25 (Broxton et al. 2002, 72640, Fig. 3.2-1)

Table A-1
Construction, Development and Water Quality Sampling Chronology for R-25

Date	Elapsed Time (Months)	Event Description
July 28, 1998	0	Began drilling R-25
September 22, 1998	1.8	At 588 ft, first use of drilling fluids (water, bentonite and TORKease); use was necessitated by stuck casing
September 28, 1998	2.0	At 711 ft, reached top of uppermost perched zone
September 30 to December 3, 1998	2.0 - 4.2	Collected water samples for screening purposes during drilling, by bailing water from uppermost perched zone (747, 867 and 1047 ft) and wet/dry zone (1137 and 1184 ft). RDX, HMX, TNT and/or breakdown products detected in all samples, with highest concentrations in uppermost perched zone (867 and 1047 ft)
December 15, 1998	4.6	At 1217 ft, last use of TORKease (cumulative use, 62 gal.)
December 16, 1998	4.6	At 1286 ft, reached the top of the regional aquifer
December 18, 1998	4.7	Collected first groundwater sample from top of regional aquifer, by bailing water from 1286 ft. No HE compounds detected.
January 7, 1999	5.4	Collected groundwater sample 2 at 1407 ft. RDX, HMX, and TNT levels similar to those in uppermost perched zone
January 13, 1999	5.6	Collected groundwater sample 3 at 1507 ft. RDX is the only HE compound detected.
January 19, 1999	5.7	At 1507.5 ft, first use of QUIK-FOAM (to help clean out hole)
January 20, 1999	5.7	At 1507.5 ft, first (and only) use of MF-1 flocculant (1-lb) (to permit use of video logging)
January 28, 1999	6.0	At 1507.5 ft, first (and only) use of EZ-MUD plus(0.5 gal)
February 2, 1999	6.2	At 1547 ft, last use of QUIK-FOAM (cumulative use, 5.35 gal); no other drilling fluid assist after this date
February 3 – 23, 1999	6.2 – 6.9	Collected groundwater samples. RDX, HMX, TNT, and HE breakdown products detected in samples from 1607 and 1940 ft. RDX is the only HE compound detected in sample from 1867 ft. No HE compounds detected in samples from 1747 and 1938 ft
February 24, 1999	6.9	At 1942 ft, reached Total Depth (TD)
February 26, 1999	7.0	At 1942 ft, collected last groundwater sample; RDX, TNT, and HE breakdown products detected.
March 3, 1999	7.3	Finished running stainless steel casing to final depth of 1934 ft bgs
March 10, 1999	7.4	Began backfilling well annulus with granular bentonite and sand; transport fluid for bentonite seal included retardant (Catalyst) from bottom of hole up to 1026 ft
March 26, 1999	7.9	Backfilled well annulus up to 1191 ft
March 28, 1999	8.0	Inflated packer inside well casing at 1206 ft
April 7, 1999	8.3	Dropped dual tremie (A and BQ) rods down annulus when preparing to air lift or water lift a surplus amount of grout/sand pack from the top of screen 4. The BQ (2-3/16-in OD) rod penetrated annular materials to a depth of about 1860 ft (between screens 8 and 9). The A rod (1-3/16-in OD) penetrated to a depth of 1584 ft (between screens 6 and 7).
April 11, 1999	8.4	Pulled out packer, pumped out about 1 pint of Puye-like sand from inside well casing.

Date	Elapsed Time (Months)	Event Description
April 12, 1999	8.5	Reset packer inside well casing at 1107 ft
April 16, 1999	8.6	Removed packer. Tagged top of slough inside well at 1893.5 ft
April 21, 1999	8.8	Open-hole water level at 1216 ft bgs. Used neutron log to identify intervals of possible bridging in annular fill based on high water content: 1250-1256, 1398-1404, 1444-1446, 1668-1672 ft.
May 2, 1999 to May 11, 1999	9.1 - 9.4	Began well development activities. Purged lower part of well below screen 3 interval by introducing 900 gal water into well and removing 1200 gal.
		Partially developed screen 8 by airlifting 39,000 gal of water from the cased interval between screens 8 and 9.
		Partially developed screen 2 by airlifting 500 gal from a depth corresponding to screen 2
May 17, 1999	9.6	Finished fishing out dropped tremie lines. Recovered all but the lower 52 ft of 1-in (A) tremie rod (1532- to 1584-ft depth). Unrecovered piece of A rod is located in bentonite between screens 6 and 7 and should be isolated from groundwater. The displacement of bentonite by the dropped tremies is expected to heal naturally as the bentonite hydrates and fills any voids. Possible mixing of bentonite into the sand packs around screens 4, 5, 6, 7, and 8 does not appear to be a significant issue. Inflated packer at 1200 ft.
May 25, 1999	9.9	Completed backfilling well annulus to 4 ft bgs; transport fluid was municipal water from 1026 ft up to 610 ft
May 27, 1999	10.0	Air-lifted to develop screen 2; producing 1 to 1.5 gal./min.
June 2, 1999	10.2	While using camera to fish for dropped skillet pin, discovered that screen 3 is collapsed.
June 5, 1999	10.2	Set packer at 910 ft (below screen 2); demobilized. (End of operations phase.)
August 22, 1999 to November 19, 1999	12.8 – 15.7	Began screen 3 repair by setting detachable packer to 1091 ft (i.e., several ft below screen 3 interval). Added sand layer above packer to protect it from cementing that would follow. Repaired screen 3 by plugging former screen interval with Portland cement/Micro Matrix plug, and then redrilling through plug so that the Westbay sampling system could be deployed through the repaired screen. Finished screen repair by fishing out detachable packer.
November 21, 1999	15.8	Video confirmation of casing separation and offset at top of screen 9 at 1894.7 ft
November 30, 1999	16.1	Added 20/40 sand inside well casing, from top of existing annular materials below screen 9, to the depth at which the casing had separated, and then filled screen 9 and sump below to a depth of 1875.5 ft. This included 19.2 ft within the casing above the separation.
December 1, 1999	16.1	Installed permanent packer at 1862.2 to 1865.0 ft to hydraulically isolate the lowermost part of the well. The packer has a stainless steel replacement screen below it, which is set between 1871.5 and 1875.0 ft.
December, 1999	16 – 17	Pressure-washed screens 1, 2, 4, 5, 6, 7, and 8 with a water solution containing sodium acid pyrophosphate (SAPP).
January 18, 2000	17.7	Scrubbed screens 1 and 2 with a wire brush; jetted all screens except 3 and 9.
January 19 to February 3, 2000	17.7 – 18.2	Purged well by pumping from 1760 ft.

Date	Elapsed Time (Months)	Event Description
April 13, 2000	20.5	Scrubbed screens 1 and 2. Airlifted water from about 1850 ft. Used submersible pump to pump from screen intervals 4, 5, 6, 7, and 8 in sequence
May 4, 2000	21.2	Scrubbed lower screens (4 to 8). Moved submersible pump through screen intervals as before
May 5, 2000	21.2	Operations interrupted by Cerro Grande Fire
September 13, 2000	25.6	Continued pump development. Cumulative volume of water removed following screen repair was 192,000 gal.
September 28, 2000	26.1	Open-hole water level at 1224 ft bgs
September 29 to October 2, 2000	26.2	Inflated packers to isolate screen intervals
November 14 to December 12, 2000	28	Characterization round 1 for samples from screen intervals 1 to 8
May 3 – 14, 2001	33	Characterization round 2 for samples from screen intervals 1 to 8 (excluding 3)
August 13 – 20, 2001	36	Characterization round 3 for samples from screen intervals 1 to 8 (excluding 3)
February 2 – 13, 2002	42	Characterization round 4 for samples from screen intervals 1 to 8 (excluding 3)
August 7 – 14, 2002	48	Round 5 for samples from screen intervals 1 to 8 (excluding 3)
December 4 – 11, 2003	64	Round 6 for samples from screen intervals 1 to 8 (excluding 3)
August 31 and September 1, 2004	73	Round 7 for samples from screen intervals 1 and 5

Source: Broxton et al. 2002 (72640); WQDB: http://wqdbworld.lanl.gov/; personal communication with D. Broxton, D. Larssen, and D. Schafer, April 2005.