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Plugging and Abandonment Summary Report for Well MCOBT-4.4

Los Alamos
NATIONAL LABORATORY
EST.1943

Prepared by the Environmental Programs Directorate

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September 2009

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EXECUTIVE SUMMARY

This report describes the methods Los Alamos National Laboratory (LANL or the Laboratory) used to plug and abandon groundwater-monitoring well MCOBT-4.4. Well MCOBT-4.4 was located in Mortandad Canyon, Los Alamos, New Mexico, in Technical Area 05 (TA-05) of the Laboratory.

Well MCOBT-4.4 was plugged and abandoned at the direction of the New Mexico Environment Department because of a leakage concern and because the perched-groundwater interval that was monitored by MCOBT-4.4 was thin and did not produce sufficient water for sampling. Water levels had been steadily declining since MCOBT-4.4 was installed in 2001, and the well was insufficient to obtain samples for the past 2 yr. In 2004, monitoring well MCOI-4 was installed 70 ft to the northwest of MCOBT-4.4 to replace MCOBT-4.4.

Plugging and abandonment activities at well MCOBT-4.4 occurred from June 14 to July 29, 2009, using a Foremost DR-24HD drill rig and ancillary equipment. After the dedicated sampling system was removed and before the well was plugged and abandoned, the well was bailed. Before overdrilling activities began, the 5-in.-outside-diameter (O.D.) stainless-steel casing was pressure-grouted with high-solids bentonite grout from the bottom with a tremie pipe.

The 10 ¾-in. surface casing, which remained in the borehole from drilling activities, was overdrilled with 12-in. drill casing. The 10 ¾-in. surface casing was removed along with the upper portion of 5-in.-O.D. stainless-steel well casing after which 8-in. casing was advanced from 0 to 545 ft below ground surface over the remaining 5-in. well casing. All the 5-in.-O.D. stainless-steel well casing and both strings of drill casing were removed from the borehole. To clean out the remaining annular fill, the borehole was reamed with an 11 7/8-in. tricone bit. The MCOBT-4.4 borehole was grouted to ground surface on July 29.

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1.0 INTRODUCTION

This report summarizes the methods Los Alamos National Laboratory (LANL or the Laboratory) used to plug and abandon groundwater-monitoring well MCOBT-4.4. Well abandonment was consistent with the requirements and guidelines in Sections IV.B.1.b.v and X.D (Well Abandonment) of the Compliance Order on Consent (the Consent Order) and the work plan to plug and abandon well MCOBT-4.4 (LANL 2009, 106290) that was approved by the New Mexico Environment Department (NMED) (2009, 106232).

2.0 BACKGROUND

Well MCOBT-4.4 was located in Mortandad Canyon, Los Alamos, New Mexico, in Technical Area 05 (TA-05) of the Laboratory. The well was installed in 2001 using air-rotary, dual-rotation, reverse-circulation drilling methods. The well location is shown in Figure 2.0-1. Well MCOBT-4.4 was a single-screen well and was constructed as follows (Broxton et al. 2002, 076006):

- 0 to 130 ft below ground surface (bgs): 13 3/8-in.-outside-diameter (O.D.) steel casing. (Note: during over-drilling activities, 10 ¾-in. casing was found to be located from 0 to 11.5 ft bgs. The 13 3/8-in.-O.D. casing was not present. Careful review of the original field logbook indicated that the 13 3/8 in. casing was withdrawn from the borehole during well construction.)
- 0 to 545 ft bgs: 5-in.-O.D./4.5-in.-inside-diameter (I.D.) stainless-steel casing with a bentonite chip seal from 68 to 474 ft bgs.
- 485 to 524 ft bgs: 5.5-in.-O.D. pipe-based stainless-steel screen with a secondary filter pack (30/70 sand) from 474 to 476.8 ft bgs and a primary filter pack (20/40 sand) from 476.8 to 527 ft bgs.

2.1 Well History

Well MCOBT-4.4 was drilled and installed in June and July 2001 (Broxton et al. 2002, 076006). The well was installed to monitor a thin perched groundwater zone located in the Puye Formation above the Cerros del Rio basalt. Drilling was performed using a Foremost DR-24 dual-rotary drill rig equipped with reverse circulation drilling rods, tricone bits, downhole-hammer bits, and support equipment. Drilling fluids consisted of air and municipal water mixed with QUIK-FOAM (a surfactant) and EZ-MUD (a polymer), used as needed to improve borehole stability, minimize fluid loss, and facilitate cuttings removal from the borehole.

Well MCOBT-4.4 was installed on July 2, 2001, to a total depth (TD) of 545 ft bgs with one screened interval (Figure 2.1-1). The well design was based on a static water level that was measured at 493 ft bgs above an inflatable packer in the open borehole, the interpretation of a possible water-producing zone (516 to 524 ft bgs) that was identified by geophysical logs and the presence of a massive basalt zone (522.5 to 535 ft bgs) that was considered a possible perching layer. The screened interval was set from 485.4 ft to 524 ft bgs within the intermediate-depth perched groundwater zone.

Well development activities at MCOBT-4.4 were conducted from July 9 to July 12, 2001. Approximately 1825 gal. of water was bailed, and 75 gal. of water was pumped from the well during development. Following well development, the static water level declined in the well. Before the installation of the dedicated sampling system, a downhole video survey was run inside the well casing to view the water level and integrity of the screen. The video survey indicated the static water level had dropped from 493 to 519 ft bgs and water was entering the screen at 497 ft bgs.

After discussions with NMED, it was determined that the perching layer that was screened in well MCOBT-4.4 could have been breached by the well's filter pack, causing the water to drain. In 2004, well MCOBT-4.4 was replaced by well MCOI-4, which was installed 70 ft to the northwest. Water levels from MCOI-4 are about 4 ft higher than those from MCOBT-4.4. Replacement well MCOI-4 has consistently provided groundwater samples during regularly scheduled sampling events.

2.2 Rationale for Plugging and Abandonment

Well MCOBT-4.4 was plugged and abandoned at the direction of NMED for the following reasons: (1) the perched zone sampled was thin and did not produce enough water to generate extensive flow during development; (2) water levels had been steadily declining since MCOBT-4.4 was installed, and the well was insufficient to collect samples for the past 2 yr; and (3) the filter pack may have provided a pathway for perched intermediate groundwater to enter the Cerros del Rio basalt.

3.0 SCOPE OF ACTIVITIES

The scope of activities is discussed below.

3.1 Plugging and Abandonment Design and Approach

Before abandonment, the well was gamma logged and a video survey was conducted to document present and final conditions. The results of the gamma and video logging from well MCOBT-4.4 are detailed below. To plug and abandon well MCOBT-4.4, the screened interval and the well casing were pressure-grouted before overdrilling activities were conducted.

After the 5-in.-O.D. stainless-steel well casing and screened interval were grouted, the 10 ¾-in. surface casing was overdrilled with a Foremost DR-24HD drill rig and 12-in. flush-welded drill casing. The 10 ¾ in. surface casing and the upper portion of the 5-in.-O.D. stainless-steel well casing were removed from the borehole before the remaining 5-in. well casing was overdrilled. The 12-in. drill casing was then used as a guide for overdrilling the 5-in.-O.D. stainless-steel well casing with 8-in. flush-welded drill casing.

The borehole was advanced using 8-in. casing to a TD of 545.54 ft bgs. Before the 8-in. drill casing was extracted from the borehole, the remaining 5-in. well casing was fished out of the borehole using 3-in. pipe. After the 8-in. casing was removed from the borehole, it was reamed using an 11 7/8-in. tricone bit to a TD of 548 ft bgs. The borehole was reamed to clean out the remaining annular fill, including filter-pack sand. After it was reamed, the borehole was pressure-grouted from bottom to top via tremie pipe.

3.2 Borehole Logging

Well MCOBT-4.4 was video and gamma logged before well abandonment to document present and final conditions.

3.2.1 Video Logging

A downhole video camera was run in well MCOBT-4.4 on June 21 to document screen conditions, confirm depth of the well screen, and measure the composite static water level before plugging and abandonment. The Laboratory's geophysical trailer and camera were used to complete this logging. Ground surface (top of concrete pad) was used as the datum for all video depth measurements. The

video of June 21 confirmed a screen depth consistent with well construction records (482.8 to 524.7 ft) (Broxton et al. 2002, 076006). Static water level was noted at approximately 524.2 ft, approximately 6 in. above the base of the screen. The video survey was terminated at a depth of 527.75 ft. within the well sump. A cement coating was noted in the upper part of the well; this finding was consistent with the well construction records that documented the loss of cement inside the well during initial construction. With the exception of occasional flakes of cement, the perforations and outer screen appeared clean and open. There was no indication of groundwater recharge entering the well above the observed static water level.

The video log from well MCOBT-4.4 is presented in Appendix A (on DVD).

3.2.2 Geophysical Logging

Geophysical logging was conducted before plugging and abandonment activities in order to document well conditions. The log is shown in Figure 3.2-1. The gamma-log profile corresponds well with the filter-pack depths shown in the well-construction diagram (Figure 2.1-1).

3.3 Plugging and Abandonment

Plugging and abandonment activities included mobilization, dedicated sampling system removal, downhole video logging, pressure-grouting the well casing, overdrilling, reaming, pressure-grouting the borehole, surface completion, and demobilization. All activities were performed following appropriate standard operating procedures (SOPs) and Laboratory-approved health and safety documents. Well MCOBT-4.4 was plugged and abandoned in accordance with the NMED-approved work plan (LANL 2009, 106290).

3.3.1 Field Activities

Well MCOBT-4.4 was plugged and abandoned from June 14 to July 29, 2009. Mobilization of a workover rig and ancillary equipment to the well site was performed on June 14. Following a field management, operations, and verification (MOV) that included inspection of heavy equipment, the dedicated sampling system was removed from the well. A groundwater-level measurement of 524.37 ft bgs was recorded on June 14.

On June 21, a groundwater-level measurement of 523.99 ft bgs was recorded. The well was then bailed four times. The first bailing effort removed approximately 12 gal. of water; the last three bailing attempts did not remove any water. The groundwater level measurement after bailing was 538.41 ft bgs. By June 23, the water level had returned to approximately 524 ft bgs, which was the prebailing level.

Mobilization of the dual-rotary drill rig and ancillary equipment was performed on June 24. A groundwater-level measurement of 524.06 ft bgs was recorded. The 10 ¾-in. protective casing at the surface was removed to stage the drill rig over the well. When the 10 ¾-in. protective casing was removed, it was observed that the 10 ¾-in. casing was the surface casing and that the 13 3/8-in. surface casing noted in the well completion diagram (Figure 2.1-1) was not present. Minor excavation at the wellhead and subsequent drilling activities provided no evidence that the 13 3/8-in. casing was present. Furthermore, careful review of the original field logbook indicated that the 13 3/8 in. casing was withdrawn from the borehole during well construction.

Following a second MOV on June 28, the 5-in.-O.D. stainless-steel casing was pressure-grouted with high-solids bentonite grout. The volume and type of abandonment materials used are presented in

Table 3.3-1. The well was grouted in place to reduce any risk of failing to seal the screen and filter-pack interval if overdrilling should have broken and/or separated the well casing. After the 5-in. well casing was pressure-grouted, 12-in. flush-welded drill casing was used to overdrill the 10 ¾-in. surface casing. Circulation of cuttings was accomplished using air, municipal water, and drilling additives. The volume and type of drilling materials used are presented in Table 3.3-2. At 65 ft bgs, the 10 ¾-in. surface casing and 5-in. well casing started to rotate with the 12-in. drill casing. The 12-in. drill casing was removed in an attempt to pull out the 5-in. well casing. The 5-in. well casing was pulled upward but would not come out of the borehole. A downhole video log was run to determine if a break had occurred, but the standing water in the hole was not clear enough to view either the 10 ¾-in. surface casing or the 5-in. well casing. After the video camera was removed from the borehole, the 10 ¾-in. and 5-in. casings were again pulled upward simultaneously. A total of 11.5 ft of 10 ¾-in. surface casing and 54 ft of 5-in. well casing was removed from the borehole.

The downhole video camera was again run into the borehole to identify where the 10 ¾-in. surface casing and 5-in. well casing had separated. However, for a second time the cloudy water in the borehole prevented the identification of either the 10 ¾-in. casing or the 5-in. well casing. On July 8, the 12-in. drill casing was advanced to 69 ft bgs. At 69 ft bgs overdrilling was suspended to rerun the camera. The camera inspection indicated that the top of the 5-in. well casing was at about 48 ft bgs, and there was no indication of any remaining 10 ¾-in. casing.

From July 9 to July 15, the 5-in. well casing was overdrilled with 8-in. flush-welded drill casing. The 12-in. drill casing was left in place as a guide for overdrilling the stainless-steel well. The cutting shoe on the bottom of the 8-in. drill casing string was 12-in.-O.D. The larger diameter cutting shoe was designed to fit inside the 12-in.-diameter casing in place and open the hole to original diameter. On July 9, the 8-in.drill casing was installed in the borehole to begin overdrilling the 5-in. well casing. Initially circulation of drill cuttings was good from 65 to 83 ft bgs but deteriorated with depth. From 83 to 116.5 ft bgs, circulation of drill cuttings was regained after N-SEAL, a drilling additive, was added to the drilling-fluid mixture of drilling mud, air, and municipal water. From 116.5 to 175 ft bgs, lost circulation was encountered even with the addition of N-SEAL. From 175 to 257.1 ft bgs, lost-circulation material (inert drilling paper) was added to the drilling-fluid mixture without N-SEAL, but circulation was not regained. From 257.1 to 545.6 ft bgs (TD), circulation remained lost. No additives were introduced to the drilling-fluid mixture of air and municipal water from 257.1 to 545.6 ft bgs.

On July 15, the top of the 5-in. casing was physically measured at 71 ft bgs, 23 ft lower than previously documented via video logging. Four attempts were made with an overshot tool to latch onto the 5-in. well casing, but all four attempts were unsuccessful. On July 16, 3-in. tremie pipe was installed into the 5-in. well casing. The 3-in. tremie pipe was capped on the end, and holes were cut into the sides of the lowest pipe joint. Four bags of 10/20 sand and 100 gal. of water were tremied through the 3-in. pipe, which sand-locked the 3-in. pipe into the 5-in. well casing.

From July 16 to July 19, the remaining 5-in. well casing, 8-in. drill casing, and 12-in. drill casing were removed from the borehole. The 0.010-in. slot wire-wrapped pipe-based screen was observed to be completely sealed by the high-solids bentonite grout used initially to plug the MCOBT-4.4 well before overdrilling activities were conducted.

On July 23, either an obstruction or dense drilling fluid was measured at approximately 65 ft bgs. After some discussion, it was decided that to plug the hole sufficiently, the borehole should be reamed and then plugged with bentonite chips. The borehole was reamed with an 11 7/8-in. tricone bit from 65 to 548 ft bgs. Circulation of cuttings was accomplished using air, municipal water, and drilling additives. The volume and type of drilling materials used are presented in Table 3.3-3. The tricone bit was tripped out after reaming, and the string of drill rods was reinstalled to TD for pressure-grouting activities.

A tag line was lowered into the drill rods to measure TD before the borehole was abandoned. The tag line measurement indicated drilling mud was present inside the drill rods to approximately 100 ft bgs. Water was introduced into the drill rods to force the material out. Ten bags of 3/8-in. bentonite chips were added as the rods were slowly raised from the borehole TD. However, the 3/8-in. bentonite chips eventually bridged and plugged the drill rods, and the drill rods were removed from the borehole. Approximately 6.7 ft^3 of bentonite chips was installed before the rods were plugged. The process of installing the chips through and into the dense drilling fluids at the bottom of the hole was problematic. Abandonment of the hole was then completed using cement grout.

On July 27, BQ core pipe was installed as tremie pipe, and a slurry of Portland cement, Baroid IDP-381, and water was used to pressure-grout the borehole. From July 27 to July 29, approximately 3150 gal. of cement grout was used to plug the borehole from 540 ft bgs to ground surface. The volume and type of abandonment materials used are presented in Table 3.3-4.

Pressure was achieved in two forms: via a pneumatic pump during emplacement and via hydrostatic head for forcing the grout into the formation. A pneumatic diaphragm pump was used to deliver the grout from mixing drums at ground surface to the bottom of the well in a 2-in. tremie pipe. Twenty-foot pipe sections were removed as the operation progressed based on theoretical volume calculations. Pumping the grout in nearly one continuous lift built a column of grout inside the borehole that ensured continuous head pressure.

The addition of Baroid IDP-381 helped ensure a thorough plugging operation. IDP-381 is a cement-curing retardant that enhances the cement's flow properties and improves its bonding characteristics. Small samples of the cement used at MCOBT-4.4 indicated that the cement's actual set time was between 24 and 36 h.

3.3.2 Completion

Once the well was cement-grouted to ground surface, a 2-ft × 2-ft concrete surface pad was installed (Figure 3.3-1). A brass marker was surveyed during well completion in accordance with Section IX.B.2.f of the Consent Order, which states that pertinent structures may be located horizontally with a global-positioning system to within 0.5 ft. The surveyed location is recorded in the as-built figure in the well completion report (Broxton et al. 2002, 076006). Because this information is available, no new survey of the abandoned well is planned.

4.0 POSTABANDONMENT ACTIVITIES

Postabandonment activities are described below.

4.1 Well Site Restoration

Site restoration activities will include removing drilling fluids and cuttings from the pit, removing the polyethylene pit liner, removing the containment area berms, and backfilling and regrading the containment area, as appropriate.

4.2 Waste Management

Contact waste, circulation fluids, drill cuttings, and decontamination water were generated during the plugging and abandonment of well MCOBT-4.4. The Laboratory excavated the concrete surface pad,

leaving the rubble to be recycled with the other contact waste, which included the dedicated sampling system, surface casing, and well casing. All contact waste will be recycled by the Laboratory.

Circulation fluids and drill cuttings were produced from overdrilling. Decontamination water was generated from decontaminating the stainless-steel well casing after it was removed from the borehole. All fluids and cuttings were placed into the drill pit. Circulation fluids, drill cuttings, and decontamination water are expected to be land-applied after a review of associated analytical results per the waste characterization strategy form, SOP-010.0, Land Application of Groundwater, and ENV-RCRA SOP-011.0, Land Application of Drill Cuttings.

No excess cement grout was generated during the plugging and abandonment of Well MCOBT-4.4.

5.0 DEVIATIONS FROM PLANNED ACTIVITIES

- The use of 12-in. drill casing was not planned but was necessitated by the unexpected existence of 10 3/4-in. casing extending to approximately 12 ft bgs.
- Reaming the borehole after the stainless-steel well casing removal was not planned. Given the lack of circulation during overdrilling activities and concerns about the condition of the borehole, reaming was determined to be the best solution for an effective abandonment.

5.1 NMED-Approved Modifications to Work Plan

The Laboratory sought, and was granted, permission to abandon the borehole with bentonite chips instead of cement grout to minimize fugitive grout impacting nearby wells. Conditions in the bottom of the borehole and fluid densities found in the borehole made it impossible to emplace bentonite chips. The borehole was abandoned as originally planned with cement grout.

6.0 SUMMARY

Well MCOBT-4.4 was plugged and abandoned in accordance with the NMED-approved work plan (LANL 2009, 106290). Before overdrilling activities were conducted, the well casing was grouted with high-solids bentonite grout. The surface casing was overdrilled with 12-in. flush-welded drill casing. The surface casing was extracted, along with a portion of the well casing. The remaining well casing was then overdrilled with 8-in. flush-welded casing, and the well casing was extracted. The 8-in. and 12-in. casings were removed, and the borehole was reamed with an 11 7/8-in. tricone bit. The borehole was plugged and abandoned from bottom to top via tremie pipe with a mixture of Portland Type I/II/V cement, Baroid IDP-381 cement additive, and municipal water.

7.0 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. This information is also included in text citations. ER IDs 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 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.

Broxton, D., D. Vaniman, P. Longmire, B. Newman, W. Stone, A. Crowder, P. Schuh, R. Lawrence, E. Tow, M. Everett, R. Warren, N. Clayton, D. Counce, E. Kluk, and D. Bergfeld, December 2002. "Characterization Well MCOBT-4.4 and Borehole MCOBT-8.5 Completion Report," Los Alamos National Laboratory report LA-13933-MS, Los Alamos, New Mexico. (Broxton et al. 2002, 076006)

LANL (Los Alamos National Laboratory), June 2009. "Interim Measures Work Plan for the Plugging and Abandonment of Intermediate Groundwater Well MCOBT-4.4," Los Alamos National Laboratory document LA-UR-09-3511, Los Alamos, New Mexico. (LANL 2009, 106290)

NMED (New Mexico Environment Department), June 22, 2009. "Approval of Interim Measures Work Plan for Plugging and Abandonment of Intermediate Monitoring Well MCOBT-4.4," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2009, 106232)

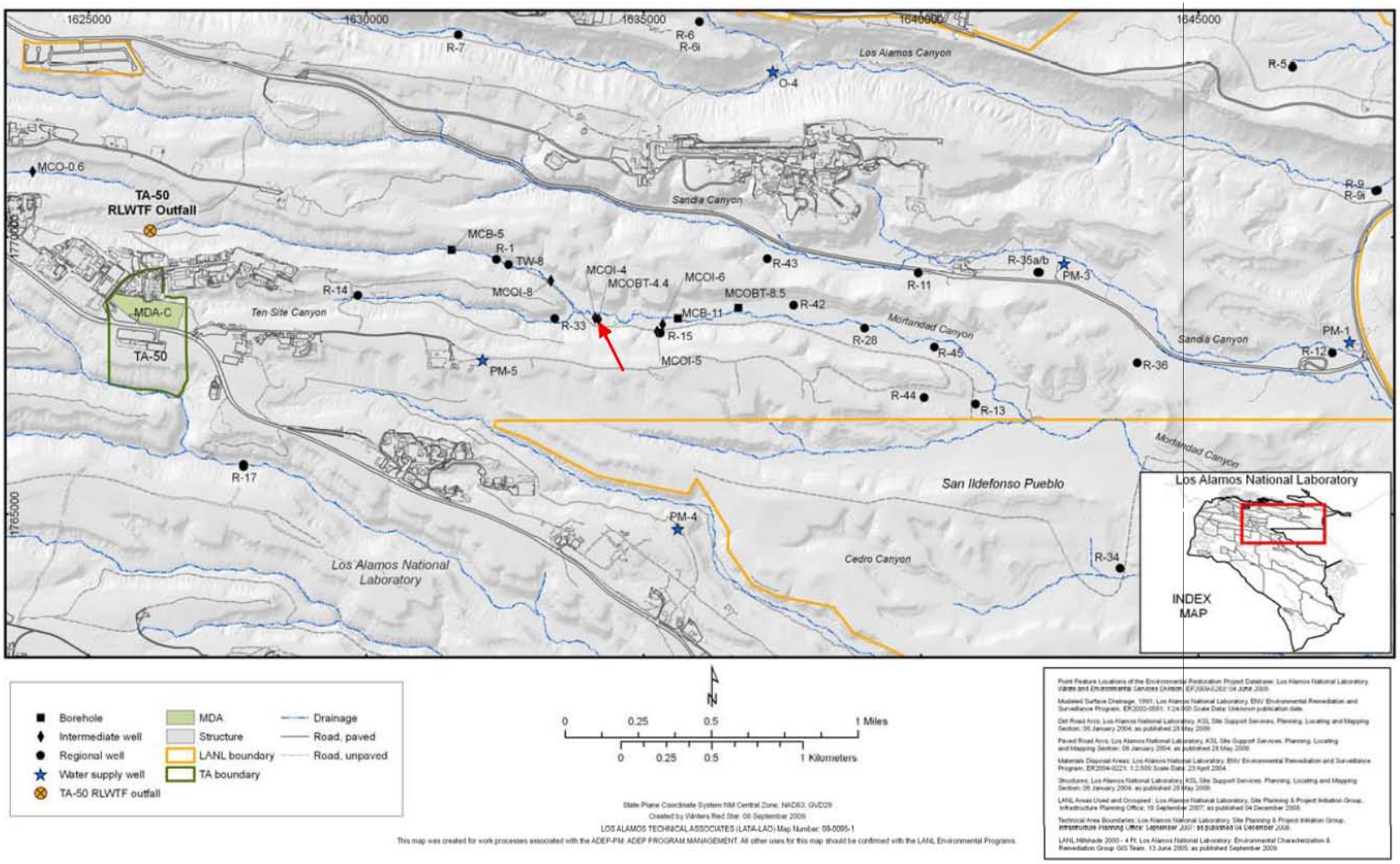

Figure 2.0-1 Location of well MCOBT-4.4

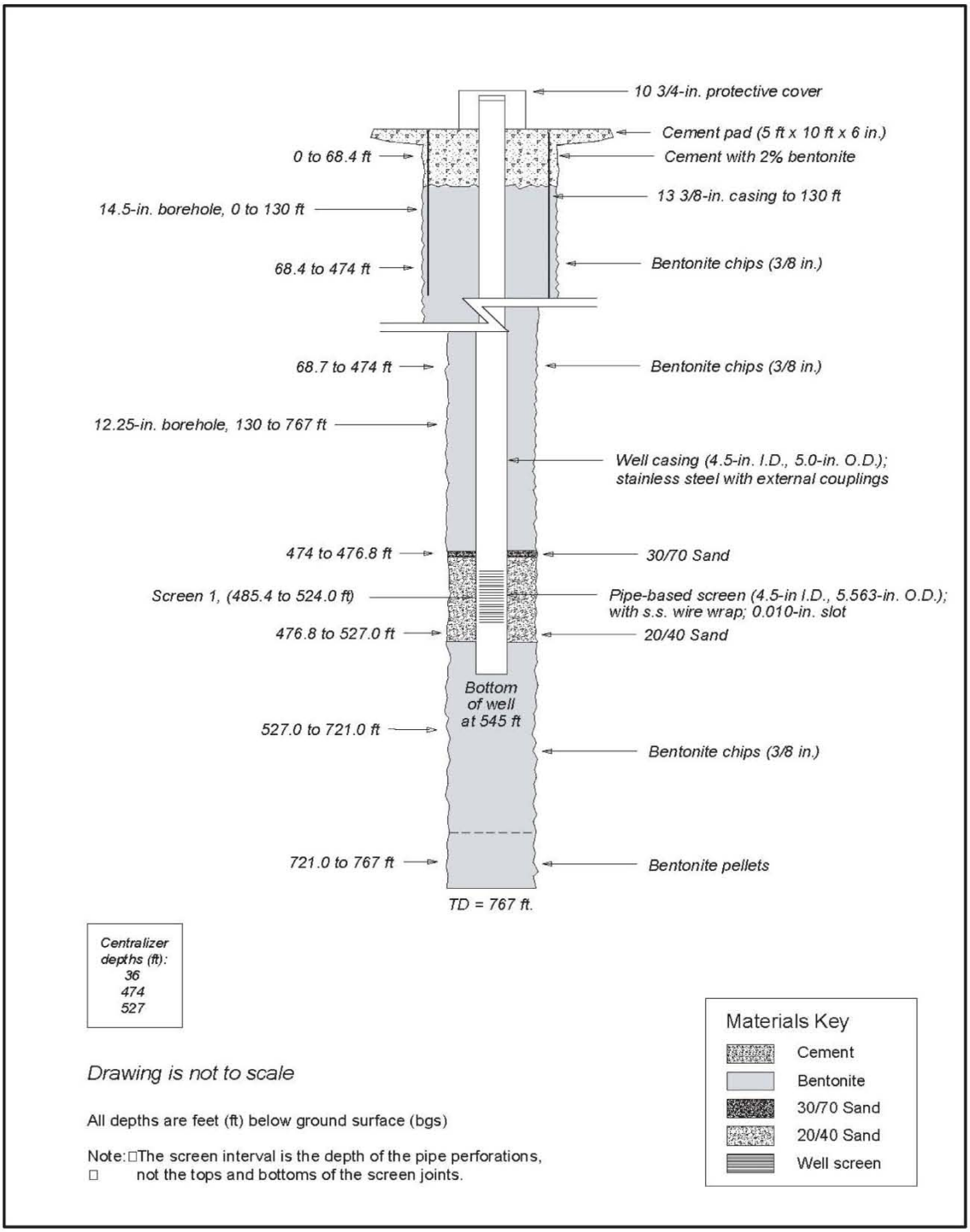

Figure 2.1-1 Monitoring well MCOBT-4.4 well-construction diagram (Broxton et al. 2002, 076006)

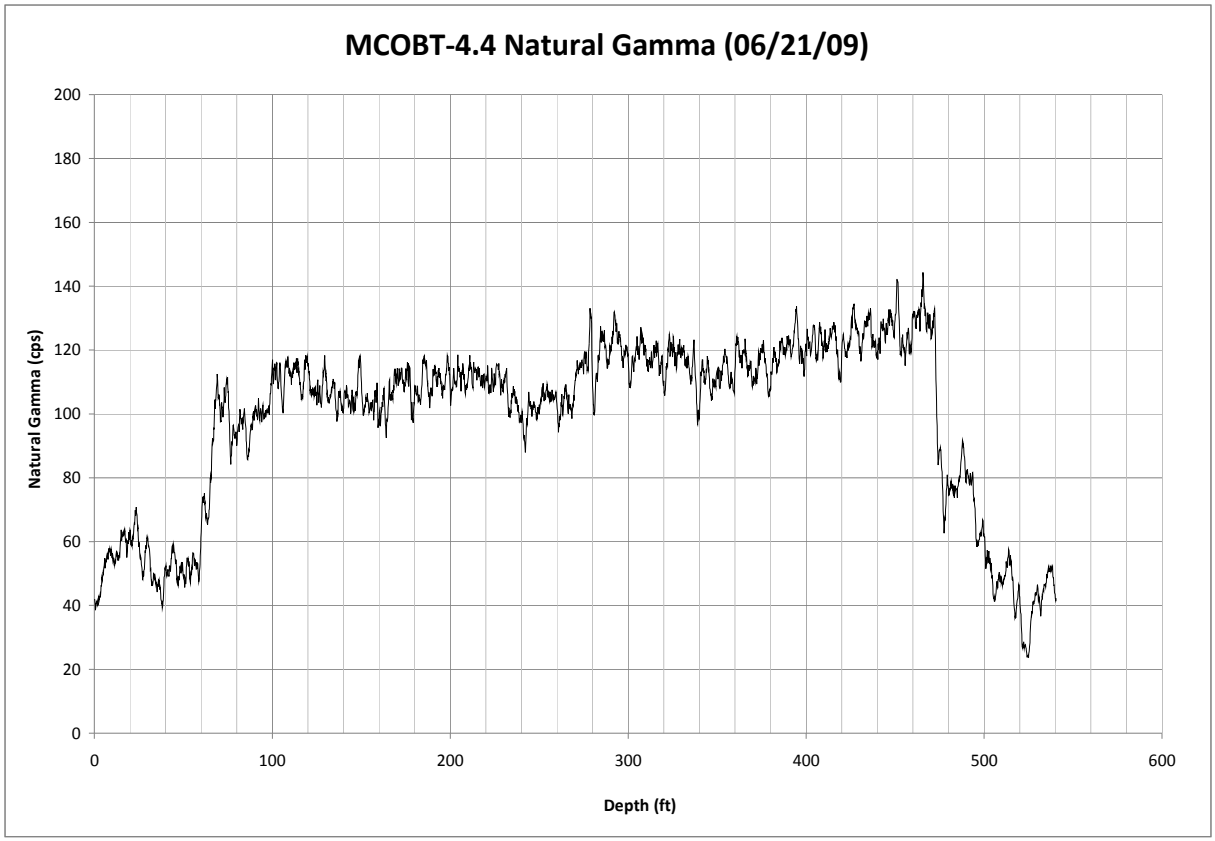

Figure 3.2-1 Gamma log of June 21, 2009

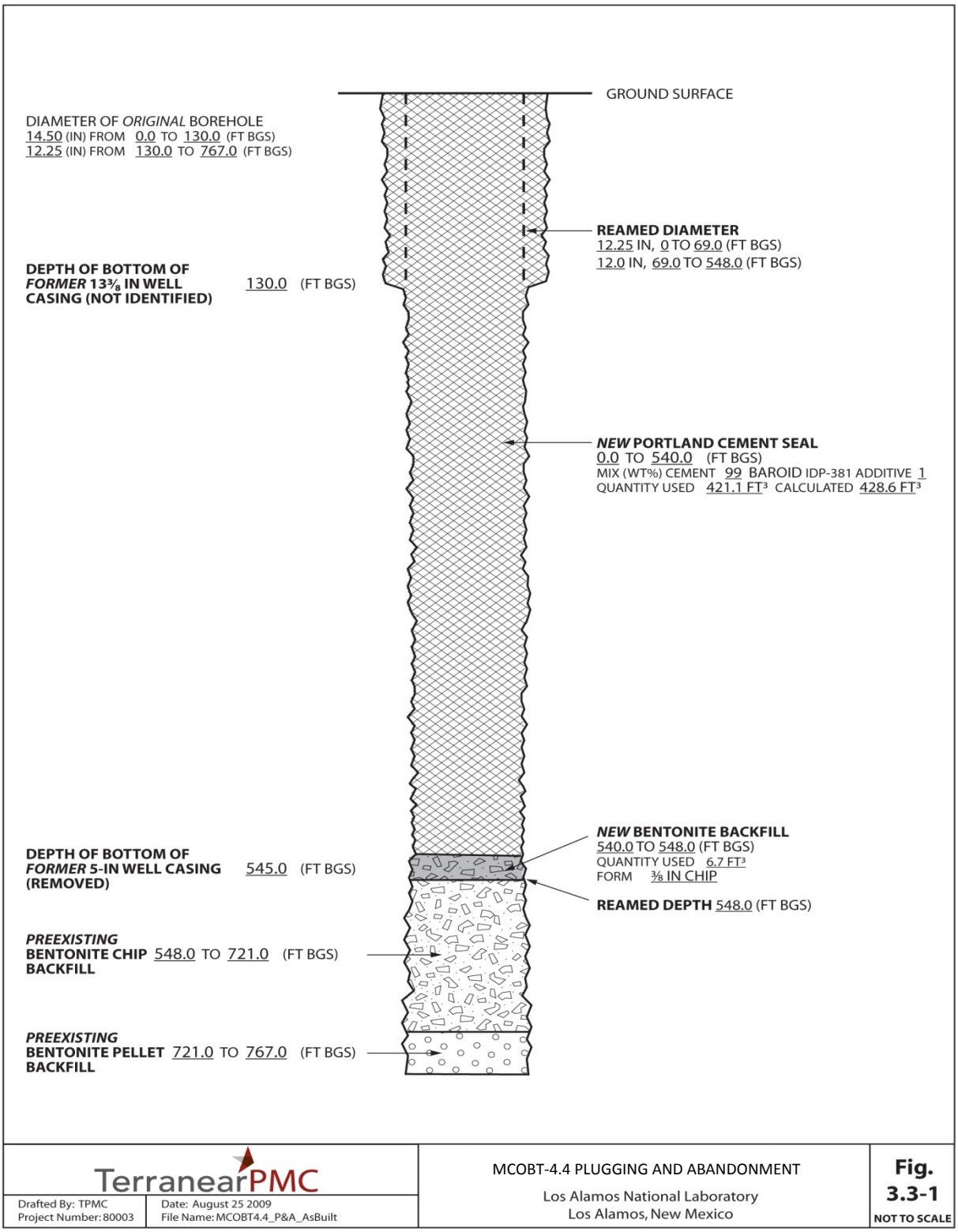

Figure 3.3-1 Diagram of monitoring well MCOBT-4.4 after plugging and abandonment

Table 3.3-1
Quantity and Materials Used To Grout Inside Well MCOBT-4.4 Casing

Date	Depth Interval (ft bgs bottom to top)	Quantity High-Solids Bentonite Grout (lb)	Quantity Municipal Water (gal.)	Calculated Volume (gal.)	Actual Volume (gal.)
6/28/2009	545–surface	1200	480	448.43	538.56

Table 3.3-2
Quantity and Materials Used To Overdrill Well MCOBT-4.4

Date	Depth Interval (ft bgs bottom to top)	Quantity EZ-MUD Stabilizer (lb)	Quantity N-SEAL (lb)	Quantity Drilling Paper (ft^3)	Quantity Municipal Water (gal.)
6/29/2009	55.00–surface[a]	10	0	0	5000
7/8/2009	69.05–surface[b]	20	0	0	1000
7/9/2009	116.51–69.05[c]	25	630	0	4500
7/10/2009	175.00–116.51	20	2250	0	10,000
7/11/2009	196.85–175.00	0	0	147.98	8000
7/12/2009	275.09–196.85	0	0	215.9	10,000
7/13/2009	343.12–275.09	0	0	0	9000
7/14/2009	504.13–343.12	0	0	0	32,000
7/15/2009	545.54–504.13	0	0	0	12,000
Total		**75**	**2880**	**363.88**	**91,500**

[a] Overdrilled 10 ¾-in. surface casing with 12-in. drill casing.

[b] Readvanced 12-in. drill casing.

[c] Overdrilled 5-in. well casing with 8-in. drill casing from 65 to 545.54 ft bgs. Lost circulation at 83 ft bgs. Regained circulation from 83 to 116.51 ft bgs by adding N-SEAL. Lost circulation again from 116.51 to 545.54 ft bgs.

Table 3.3-3
Quantity and Materials Used To Ream MCOBT-4.4 Borehole

Date	Depth Interval (ft bgs bottom to top)	Quantity EZ-MUD PLUS Polymer Emulsion (gal.)	Quantity Wyo-Ben HYDROGEL Bentonite (50-lb bags/total lb)	Quantity Drilling Paper (ft^3)	Quantity Municipal Water Used (gal.)
7/24/2009	548.00–surface*	6	39/1950	64.3	13,150

* 9000 gal. of water used during overdrilling and 4150 gal. of water used to displace mud/cuttings from inside the drill rods.

Table 3.3-4
Quantity and Materials Used To Plug and Abandon MCOBT-4.4 Borehole

Date	Depth Interval (ft bgs bottom to top)	Quantity 3/8-in. Bentonite Chips (lb)	Quantity Portland Type I/II/V Used (lb)	Quantity Municipal Water (gal.)	Quantity Baroid IDP-381 Used (lb)	Calculated Volume Cement Grout (gal.)[a]	Actual Volume Cement Grout (gal.)
7/26/2009	548–540	500	—[b]	500	—	47.27	50.12
7/27/2009	540–390	—	4512	420	24	886.38	600
7/28/2009	390–6	—	18,048	1680	192	2283.27	2400
7/29/2009	6–surface	—	1128	105	12	36.80	150
Total		**500**	**23,688**	**2705**	**228**	**3253.72**	**3200.12**

[a] Calculated volumes are based on the following dimensions: 0–69 ft—12.25-in. borehole; 69–548 ft—12.00-in. borehole.

[b] — = Not applicable.

Appendix A

Video Log of June 21, 2009
(on DVD included with this document)