ERID-206327

LA-UR-11-5179
September 2011
EP2011-0286

Bandelier Tuff Unit 4 Background Study Report

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

EP2011-0286

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September 2011

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EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) has completed a study of background concentrations of inorganic chemicals and naturally occurring radionuclides in cooling unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4). Results of previous environmental investigations involving analysis of Qbt 4 samples have indicated that background concentrations of some metals in Qbt 4 may be higher than the background values (BVs) used for Bandelier Tuff units 2, 3, and 4 (Qbt 2, 3, 4). If so, use of these BVs might not be appropriate for determining whether concentrations of metals in Qbt 4 are naturally occurring or the result of contamination.

The background study consisted of collecting samples of unweathered Qbt 4 from locations not impacted by Laboratory operations and submitting these samples for laboratory analysis of inorganic chemicals and naturally occurring radionuclides. These results show that background concentrations of these constituents in unweathered Qbt 4 do not exceed the Qbt 2, 3, 4 BVs. The study also characterized the depth of weathering of Qbt 4 at all sample locations. Based on these results, previously collected samples of Qbt 4 that exceeded BVs were likely collected from weathered tuff, which explains the elevated concentrations of inorganic chemicals in the samples.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the U.S. Department of Energy (DOE) and managed by Los Alamos National Security, LLC. The Laboratory is located in north-central New Mexico approximately 60 mi northeast of Albuquerque and 20 mi northwest of Santa Fe. The Laboratory site covers 40 mi^2 of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing perennial and intermittent streams running from west to east. Mesa tops range in elevation from approximately 6200 to 7800 ft above sea level.

The Laboratory is participating in a national effort by DOE to clean up sites and facilities. The goal of the Laboratory's effort is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve this goal, the Laboratory is currently investigating sites potentially contaminated by past Laboratory operations. The sites under investigation are designated as either solid waste management units (SWMUs) or areas of concern (AOCs).

As part of the SWMU and AOC investigation process, the Laboratory uses background values (BVs) for inorganic chemicals and naturally occurring radionuclides in various geologic units to determine the extent of contaminant releases and to identify chemicals of potential concern (COPCs). The BVs for inorganic chemicals presently used by the Laboratory were determined from statistical analysis of background data sets for soil, sediment, and rock units (LANL 1998, 059730). Data from the recent investigation of SWMUs and AOCs at Technical Area 49 (TA-49) (LANL 2010, 109319) indicated BVs used for cooling unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4) may not be representative of background for this unit. The BVs used for Qbt 4 are composite values based on pooled background data from unweathered samples collected from cooling units 2 and 3 (Qbt 2 and Qbt 3) and Qbt 4. The investigation results from TA-49, which had a high number of Qbt 4 samples, indicated that the composite BVs for Qbt 2, Qbt 3, and Qbt 4 (Qbt 2, 3, 4) may be lower than the actual background concentrations for many inorganic chemicals in Qbt 4. In the response to the notice of disapproval for the investigation report for TA-49 sites outside the nuclear environmental site (NES) (LANL 2010, 110654.4), the Laboratory indicated that it would conduct a background study for Qbt 4. In the approval with modifications for this response, the New Mexico Environment Department (NMED) directed the Laboratory to submit a work plan to determine background concentrations of inorganic chemicals in Qbt 4 (NMED 2010, 110859). This work plan was submitted by the Laboratory in December 2010 ((LANL 2010, 111504) and approved by NMED in January 2011 (NMED 2011, 111680).

The Qbt 4 background study described in this report was undertaken to collect samples of unweathered Qbt 4 from a variety of unimpacted locations across the Laboratory and to determine background concentrations of inorganic chemicals and naturally occurring radionuclides with analytical methods currently being used to implement the Compliance Order on Consent. These results can be compared with Qbt 2, 3, 4 BVs to determine if they are different than these BVs.

This report describes the Qbt 4 background study conducted in accordance with the approved work plan and presents the results of the study. Section 2 provides background information related to the study. Section 3 identifies the scope of activities implemented during the study, and section 4 presents the results of the study. Conclusions are presented in section 5. References cited in this report and data sources for maps are provided in section 6. Appendix A contains acronyms and abbreviations and metric conversion tables. Appendix B describes the field methods used during the study. Borehole logs are presented in Appendix C, and management of investigation-derived waste (IDW) is described in Appendix D. Appendix E describes the analytical program and data quality. Analytical data are presented in Appendix F (on CD included with this document).

2.0 BACKGROUND

2.1 Development of Current BVs

The BVs for soil, sediment, and rock currently in use by the Laboratory were developed in 1998 (LANL 1998, 059730). The BVs were developed by collecting a statistically significant number of samples of the various media and analyzing these samples for inorganic chemicals, naturally occurring radionuclides, and radionuclides associated with atmospheric fallout from nuclear testing. The analytical data were used to statistically calculate the BVs and fallout values.

Tuff samples for the 1998 background study were collected on and next to Laboratory property at locations not impacted by releases from SWMUs and AOCs or other Laboratory operations. Samples were typically collected in vertical stratigraphic sections on canyon walls at a nominal spacing of 5 m or at major changes in lithology. Tuff samples were analyzed for inorganic chemicals using then-current U.S. Environmental Protection Agency (EPA) analytical methods (except for cobalt, which was analyzed using neutron activation instead of the EPA analytical method).

The results of the sample analyses were divided into three groups: the upper Bandelier Tuff, which consisted of units Qbt 2, Qbt 3, and Qbt 4; the middle Bandelier Tuff, which consisted of unit Qbt 1v; and the lower Bandelier Tuff, which consisted of units Qbt 1g, Qct, and Qbo. The upper Bandelier Tuff group was intended to be used for making background comparisons for samples from shallow boreholes (less than 50 ft) into the Bandelier Tuff from mesa-top locations (LANL 1998, 059730, p. 38). The other groups were intended to be used for background comparisons in deeper boreholes. The BV for each inorganic chemical was calculated as the upper tolerance limit (UTL) of the background distribution. The UTLs were calculated by one of four methods selected based on the statistical distribution of the data (LANL 1998, 059730). For three inorganic chemicals in the upper Bandelier Tuff group (antimony, selenium, and silver), the frequency of detection was too low to calculate a UTL, and the analytical detection limit was used as the BV.

2.2 Results from TA-49 Investigations

The data set for the investigations of SWMUs and AOCs inside the NES at TA-49 includes the results of 93 Qbt 4 samples for target analyte list (TAL) metals analysis. Two of these samples were collected from the surface interval (0.0 ft to 0.5 ft below ground surface [bgs]), 45 were from a shallow subsurface interval (0.5 ft to 1.5 ft bgs), and 46 were from deeper subsurface intervals (1.5 ft to 80 ft bgs). These data were compared with BVs as part of the process of determining whether the extent of contamination had been defined. These comparisons showed multiple inorganic chemicals consistently above the Qbt 2, 3, 4 BVs. Specifically, 11 inorganic chemicals (aluminum, arsenic, barium, calcium, cobalt, copper, lead, manganese, nickel, selenium, and vanadium) typically exceeded the Qbt 2, 3, 4 BVs and frequently exceeded the maximum concentration from the background data set (LANL 2010, 110656.17, p. 14). Of the 47 surface and shallow subsurface Qbt 4 samples, all but 1 sample had 2 or more inorganic chemicals detected above the Qbt 2, 3, 4 BV.

To determine whether these results were indicative of possible site contamination, a geochemical evaluation was conducted. Scatter plots of the Qbt 4 data were prepared for the 11 inorganic chemicals consistently detected above the Qbt 2, 3, 4 BVs using aluminum as a reference element (iron was used as the reference metal for aluminum). Aluminum and iron were used as reference metals because they are known to be naturally present at high concentrations in Qbt 4. With few exceptions, the scatter plots showed linear correlations between the reference metals and the metals of interest, including results above the Qbt 2, 3, 4 BVs and the maximum concentration from the background data set (LANL 2010, 110656.17, p. 15). The strong linear correlation between the reference metals and trace metals indicates that most of the inorganic chemicals detected above the Qbt 2, 3, 4 BVs are not associated with site contamination but rather are naturally occurring. Relatively few results appeared to represent potential site contamination, i.e., outliers above the correlated values.

3.0 SCOPE OF ACTIVITIES

This section describes the investigation activities conducted during April and May 2011 in accordance with the approved background study work plan (LANL 2010, 111504; NMED 2011, 111680). Activities included drilling 10 boreholes and collecting samples of unweathered Qbt 4 for laboratory analysis.

The standard operating procedures (SOPs) used during the background study are listed in Table B-1.0-2 in Appendix B. Details of the field methods used during the background study are presented in Appendix B, along with all deviations from the approved work plan.

3.1 Premobilization Activities

Site setup for field activities was initiated on April 26, 2011. Site setup activities included onsite housekeeping and inspections, obtaining all supporting documentation and equipment required for the project, briefing on the integrated work document, and the establishment of a work zone at the first borehole. Before mobilization, the drill rig was given a safety inspection offsite.

3.2 Geodetic Surveys

Before mobilization, the preliminary sampling locations specified in the investigation work plan (LANL 2010, 111504) were inspected by members of the project team to establish final sample locations. Locations were selected based on such considerations as ease of access by a drill rig and interference with underground or overhead utilities. Final locations were then marked with a stake.

Geodetic surveys of sampling locations were conducted using a Trimble GeoXT handheld global positioning system. The surveyed coordinates for all sampling locations are presented in Table 3.2-1.

3.3 Field Screening

Field screening for radionuclides and organic vapors was performed in accordance with the approved investigation work plan (LANL 2010, 111504; NMED 2011, 111680) to support on-site health and safety requirements. All field-screening measurements are summarized in Table 3.3-1.

3.4 Borehole Drilling and Subsurface Sampling

During the Qbt 4 background study 30 subsurface tuff samples were collected from 10 locations in TAs-06, -14, -16, -49, -58, -67, and -69 (Figure 3.4-1). Table 3.4-1 presents a summary of the samples collected and analyses requested for each borehole.

Boreholes were advanced using a hollow-stem auger drill rig, and samples were collected using a core barrel. Continuous core was collected from each borehole. Core was inspected and lithologically logged by a qualified geologist. The top of the unweathered tuff was identified, and three samples were collected from the top 10 ft of the unweathered tuff profile. Field quality control (QC) samples consisted of field duplicates (FDs) and field rinsates (FRs) (equipment blanks). These samples were collected at a frequency of 10%. Samples collected from each borehole are described below. Table 3.4-2 presents a summary of the borehole total depth (TD), the depth to the top of bedrock (i.e., Qbt 4), and the depth to the top of unweathered tuff.

- Three tuff samples were collected at TA-06 borehole location 06-614310 from 4–5.5 ft, 8.5–10 ft, and 13–14.5 ft bgs. The top of unweathered tuff was determined to be at 4 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-14 borehole location 14-614311 from 6.5–7.5 ft, 12.5–13.5 ft, and 18–20 ft bgs (see deviations in Appendix B). The top of unweathered tuff was determined to be at 6.5 ft bgs by on-site geologists. Quality assurance/quality control (QA/QC) samples (one FD and one FR) were also collected at this location.
- Three tuff samples were collected at TA-16 borehole location 16-614312 from 6–7 ft, 10.5–11.5 ft, and 15–16 ft bgs. The top of unweathered tuff was determined to be at 6 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-49 borehole location 49-614313 from 3.5–5 ft, 8–9.5 ft, and 12.5–14 ft bgs. The top of unweathered tuff was determined to be at 3.5 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-49 borehole location 49-614314 from 7–8.5 ft, 11.5–13 ft, and 16–18 ft bgs. The top of unweathered tuff was determined to be at 7 ft bgs by on-site geologists. QA/QC samples (one FD and one FR) were also collected at this location.
- Three tuff samples were collected at TA-49 borehole location 49-614315 from 25–26 ft, 29.5–30.5 ft, and 34–35 ft bgs. The top of unweathered tuff was determined to be at 25 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-49 borehole location 49-614395 from 2.2–3.2 ft, 6.7–7.7 ft, and 11.2–12.2 ft bgs. The top of unweathered tuff was determined to be at 2.2 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-58 borehole location 58-614316 from 7–8.5 ft, 11.5–13 ft, and 16–17.5 ft bgs. The top of unweathered tuff was determined to be at 7 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-67 borehole location 67-614317 from 6.5–7.5 ft, 10–11 ft, and 15.5–16.5 ft bgs (see deviations in Appendix B). The top of unweathered tuff was determined to be at 6.5 ft bgs by on-site geologists.
- Three tuff samples were collected at TA-69 borehole location 69-614302 from 7–8.5 ft, 11.5–13 ft, and 16–18 ft bgs. The top of unweathered tuff was determined to be at 7 ft bgs by on-site geologists. QA/QC samples (one FD and one FR) were also collected at this location.

Per the approved investigation work plan (LANL 2010, 111504; NMED 2011, 111680), all samples were submitted for laboratory analyses of the following: TAL metals, total cyanide, nitrate, perchlorate, isotopic thorium, and isotopic uranium. Samples from each borehole location were also collected and submitted to an on-site laboratory operated by the Laboratory's Earth and Environmental Sciences (EES) Division for total metals analysis using x-ray fluorescence (XRF). Core material was stored and labeled in a core box for curating and archiving.

3.5 Borehole Abandonment

All 10 hollow-stem auger boreholes were abandoned following the collection of samples. Boreholes were abandoned in accordance with SOP 5034, Monitoring Well and Borehole Abandonment, by backfilling with 3/8-in. bentonite chips to within 1 ft of the surface. The remainder of each boring was filled with Portland Type I/II cement to surface grade.

3.6 Equipment Decontamination

All field equipment that had the potential to contact contaminated environmental media (e.g., spilt-spoon core barrel, sampling scoops, and bowls) was decontaminated between sample collection and between sampling locations to prevent cross-contamination of samples and sampling equipment.

3.7 IDW Management

Approximately 3.2 yd^3 of IDW was generated during the Qbt 4 background study and included: (1) drill cuttings and (2) contact waste (e.g., contaminated personal protective equipment [PPE]). All wastes generated were managed in accordance with the IDW management plan in the approved work plan (LANL 2010, 111504; NMED 2011, 111680).

Before field activities began, a waste characterization strategy form (WCSF) was prepared, reviewed, and approved by the Laboratory. The WCSF provided information on IDW characterization, management, and containerization, and expected waste volumes. The WCSF is presented as Attachment D-1 to Appendix D.

All IDW was characterized as specified in the WCSF. Drill cuttings met the criteria for land application and were disposed of accordingly. Contact IDW included PPE (gloves), paper towels, and disposable sampling supplies. Such waste was containerized as “Green is Clean” and stored for disposal at TA-54.

3.10 Deviations from Approved Work Plan

Deviations to the approved investigation work plan (LANL 2010, 111504; NMED 111680) consisted of adjustments to sampling intervals based on conditions observed in the field. In addition, BVs were not calculated using Qbt 4 data as specified in the work plan. These deviations are described in Appendix B.

4.0 RESULTS

4.1 Results of Analysis of Qbt 4 Samples

4.1.1 Inorganic Chemicals

The results of inorganic chemical analysis of Qbt 4 background study samples are presented in Table 4.1-1. Concentrations of inorganic chemicals detected above Qbt 2, 3, 4 BVs or not detected and having detection limits above Qbt 2, 3, 4 BVs are presented in Table 4.1-2. As seen in Tables 4.1-1 and 4.1-2, relatively few results were above BVs. Arsenic was detected above the Qbt 2, 3, 4 BV in three samples from two locations. Calcium, iron, and manganese were detected above Qbt 2, 3, 4 BVs in one sample each. Lead was detected above the Qbt 2, 3, 4 BV in three samples from three locations. Antimony and selenium were not detected but had detection limits above Qbt 2, 3, 4 BVs in all 30 samples. BVs have not been established for nitrate or perchlorate. Nitrate was detected in nine samples from six locations, and perchlorate was detected in nine samples from five locations.

The results of major element analysis by XRF are presented in Table 4.1-3. With one exception, these results are indicative of Qbt 4. Sample RE67-11-9819 collected from 15.5–16.5 ft bgs at location 67-614317 shows relatively higher silica and lower aluminum, calcium, and titanium than the other samples. This major element signature is indicative of Qbt 3 rather than Qbt 4. Although logged in the field as Qbt 4, the media code for this sample, which was collected immediately beneath a surge bed, was revised to Qbt 3 based on the XRF results.

The results of trace element analysis by XRF are presented in Table 4.1-4. With the exception of copper, which has an XRF detection limit near background, XRF results are all higher than the results using EPA SW-846 methods (acid extraction followed by analysis using inductively coupled plasma emission spectroscopy or inductively coupled plasma mass spectroscopy). XRF yields higher results because it measures the total metal present in the sample, whereas the EPA method measures only the fraction of metal dissolved by the extraction procedure.

4.1.2 Naturally Occurring Radionuclides

The results of radionuclide analysis of Qbt 4 background study samples are presented in Table 4.1-5. Concentrations of radionuclides above Qbt 2, 3, 4 BVs are presented in Table 4.1-6. Uranium-235/236 was detected above the Qbt 2, 3, 4 BV in one sample and was the only radionuclide detected above Qbt 2, 3, 4 BVs.

4.2 Depth of Weathering

At each sampling location, continuous core was collected from the ground surface to the TD of the borehole. The core was inspected by a subcontract geologist and a geologist from the Laboratory's EES Division to identify the zone of weathering. Borehole logs are presented in Appendix C and the zone of weathered Qbt 4 is identified on the logs. The depths to the top of the unweathered Qbt 4 are presented in Table 3.4-2 and range from 2.2 ft bgs to 25 ft bgs.

5.0 CONCLUSIONS

The results of the analysis of unweathered Qbt 4 samples indicate that background concentrations of TAL metals, thorium isotopes, and uranium isotopes do not exceed Qbt 2, 3, 4 BVs. A previous study had shown bulk rock chemical compositions (i.e., the results of XRF analyses) of Qbt 4 (based on data from borehole 49-2-700-1 at TA-49) to be significantly different from other units of the Tshirege Member of the Bandelier Tuff (Stimac et al. 2002, 073391). The results of the current study, however, are based on acid extraction methods rather than XRF analysis. This difference in analytical methods accounts for the differences in observed results.

Many of the samples from the TA-49 inside NES investigation that exceeded BVs but appeared to be background based on scatter plot analyses were collected from shallow depths (e.g., 1.5 ft bgs). Based on the depth of weathering observed during the current study, the TA-49 inside NES samples were likely collected in weathered Qbt 4. Further, inspection of material excavated from several of these inside NES sample locations by a geologist during preparation of the TA-49 inside NES Phase II investigation work plan indicated that the material sampled may have been highly weathered tuff (LANL 2011, 201570, p. 12). Weathered tuff will contain higher concentrations of clay minerals, iron oxyhydroxides, and organics than unweathered tuff, which will concentrate major and trace elements (Longmire et al. 1995, 052227). Therefore, concentrations of many major and trace elements will be higher in weathered tuff than in unweathered tuff. The effects of weathering would explain the concentrations of certain metals above BVs, which appear to be background based on scatter plots. The TA-49 inside NES investigation shallow samples were collected using hand augers, making it difficult to ascertain the degree of weathering. During the Phase II investigation of TA-49 sites inside the NES, core samples will be collected using a drill rig at some of the previous sample locations where metals were detected above BV in order to determine the degree of weathering of Qbt 4 at the sampled depths.

Based on the results of this study, the current Qbt 2, 3, 4 BVs are appropriate for comparison with analytical results from unweathered Qbt 4 for the purpose of defining extent and identifying COPCs. These BVs are not appropriate for comparison with analytical results from weathered Qbt 4. Development of BVs for weathered tuff would be difficult because of the variability of weathering effects and degree of weathering. The concentrations of inorganic chemicals and naturally occurring radionuclides in weathered tuff should, however, be bounded by soil BVs since soil represents a very high degree of weathering.

6.0 REFERENCES AND MAP DATA SOURCES

6.1 References

The following list includes all documents cited in this plan. 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.

LANL (Los Alamos National Laboratory), September 22, 1998. "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847, Los Alamos, New Mexico. (LANL 1998, 059730)

LANL (Los Alamos National Laboratory), May 2010. "Investigation Report for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary," Los Alamos National Laboratory document LA-UR-10-3304, Los Alamos, New Mexico. (LANL 2010, 109319)

LANL (Los Alamos National Laboratory), September 2010. "Response to the Notice of Disapproval for the Investigation Report for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary," Los Alamos National Laboratory document LA-UR-10-6035, Los Alamos, New Mexico. (LANL 2010, 110654.4)

LANL (Los Alamos National Laboratory), September 2010. "Investigation Report for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary, Revision 1," Los Alamos National Laboratory document LA-UR-10-6032, Los Alamos, New Mexico. (LANL 2010, 110656.17)

LANL (Los Alamos National Laboratory), December 2010. "Work Plan for Determining Background Concentrations of Inorganic Chemicals in Unit 4 of the Bandelier Tuff," Los Alamos National Laboratory document LA-UR-10-8111, Los Alamos, New Mexico. (LANL 2010, 111504)

LANL (Los Alamos National Laboratory), March 2011. "Phase II Investigation Work Plan for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary," Los Alamos National Laboratory document LA-UR-11-1818, Los Alamos, New Mexico. (LANL 2011, 201570)

Longmire, P.A., D.E. Broxton, and S.L. Reneau (Eds.), October 1995. "Natural Background Geochemistry and Statistical Analysis of Selected Soil Profiles, Sediments, and Bandelier Tuff, Los Alamos, New Mexico," Los Alamos National Laboratory document LA-UR-95-3486, Los Alamos, New Mexico. (Longmire et al. 1995, 052227)

NMED (New Mexico Environment Department), September 22, 2010. "Approval with Modifications, Investigation Report for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary, Revision 1," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2010, 110859)

NMED (New Mexico Environment Department), January 12, 2011. "Notice of Approval, Work Plan to Determine Background Concentrations in Unit 4 of the Bandelier Tuff," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 111680)

Stimac, J.A., D.E. Broxton, E.C. Kluk, S.J. Chipera, and J.R. Budahn, July 2002. "Stratigraphy of the Tuffs from Borehole 49-2-700-1 at Technical Area 49, Los Alamos National Laboratory, New Mexico," Los Alamos National Laboratory report LA-13969, Los Alamos, New Mexico. (Stimac et al. 2002, 073391)

6.2 Map Data Sources

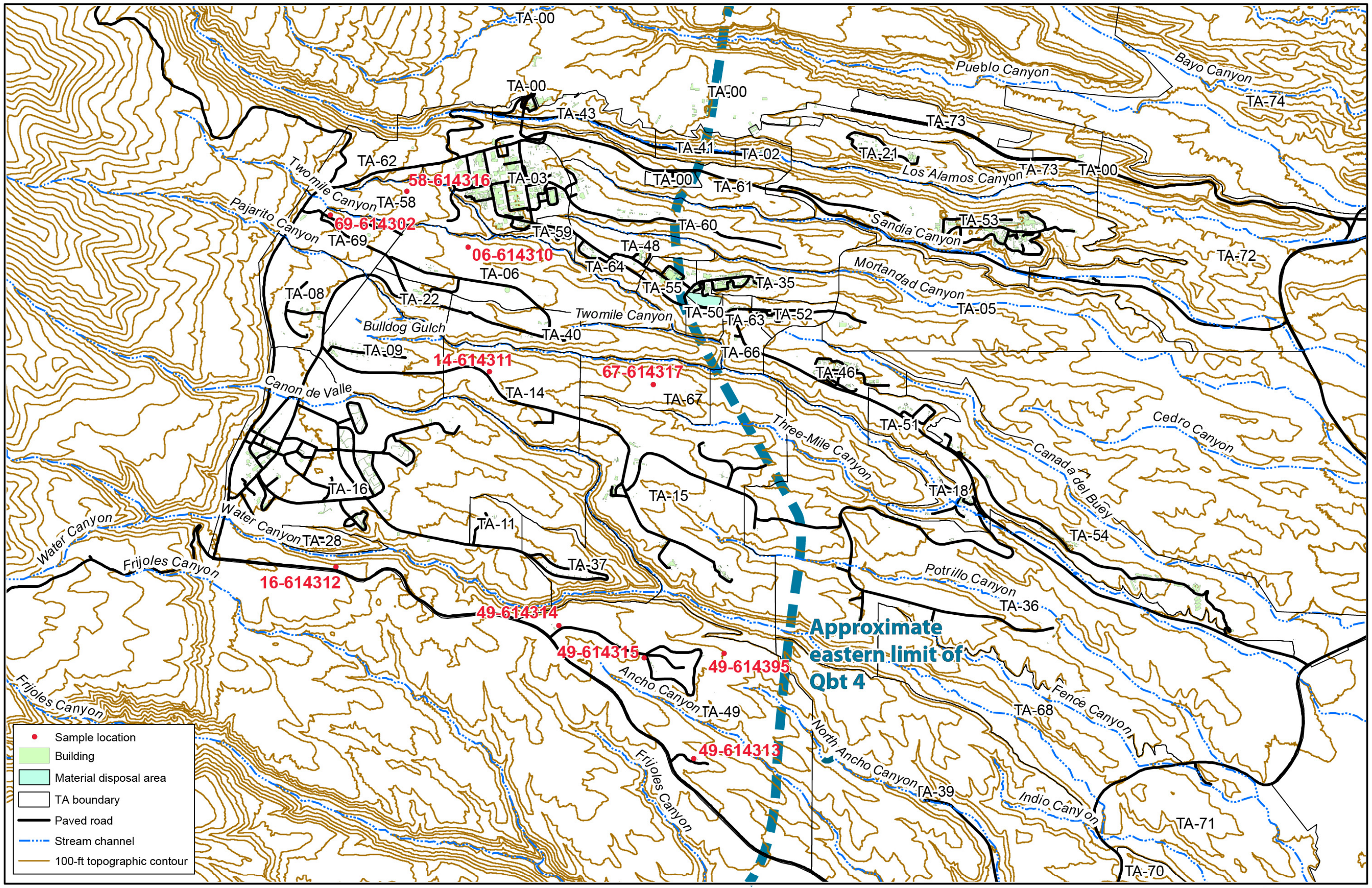
Point Feature Locations of the Environmental Restoration Project Database; Los Alamos National Laboratory, Waste and Environmental Services Division, EP2009-0162; 13 March 2009.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 January 2009.

Structures and Buildings - Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 January 2009.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Office; September 2007; as published 04 December 2008.

Extent of Bandelier Tuff Unit 4 – Los Alamos National Laboratory, Earth and Environmental Sciences Division, November 2010.



State Plane Coordinate System
New Mexico, Central Zone, US Survey Feet
NAD 1983, NGVD 1929

Revised 08 December 2010 CAncell
Revised 22 August 2011 by Adelante Consulting Inc.

Disclaimer: This map was created for work processes associated with the LANL Environmental Programs Directorate, Corrective Actions Projects (EP-CAPS). All other uses for this map should be confirmed with EP-CAP personnel.

0 0.5 1 2 3 4 Kilometers

0 0.375 0.75 1.5 2.25 3 Miles

N W E S

Figure 3.4-1 Qbt 4 background study borehole locations

Table 3.2-1
Surveyed Coordinates for Locations Sampled

Location ID	Easting (ft)	Northing (ft)
TA-06		
06-614310	1617172.092	1770660.515
TA-14		
14-614311	1617737.309	1766086.346
TA-16		
16-614312	1612151.88	1758531.761
TA-49		
49-614313	1625615.405	1751276.707
49-614314	1620587.537	1756432.891
49-614315	1623780.432	1755206.756
49-614395	1626688.869	1755523.264
TA-58		
58-614316	1614866.914	1772727.195
TA-67		
67-614317	1624226.818	1765676.829
TA-69		
69-614302	1611945.31	1771846.116

Table 3.3-1
Field-Screening Results

Location ID	Sample ID	Depth (ft bgs)	PID[a] (ppm)	Net Alpha (dpm)[b]	Net Beta/Gamma (dpm)
TA-06					
06-614310	RE06-11-9789	4–5.5	0	11	370
06-614310	RE06-11-9790	8.5–10	0	58	2400
06-614310	RE06-11-9791	13–14.5	0	0	544
TA-14					
14-614311	RE14-11-9792	6.5–7.5	0	7	885
14-614311	RE14-11-9793	12.5–13.5	0	37	885
14-614311	RE14-11-9794	18–20	0	43	1021
TA-16					
16-614312	RE16-11-9797	6–7	0	0	212
16-614312	RE16-11-9798	10.5–11.5	0	21	475
16-614312	RE16-11-9799	15–16	0	16	407
TA-49					
49-614313	RE49-11-9800	3.5–5	0	1	96
49-614313	RE49-11-9801	8–9.5	0	0	265
49-614313	RE49-11-9802	12.5–14	0	0	265
49-614314	RE49-11-9803	7–8.5	0	21	282
49-614314	RE49-11-9804	11.5–13	0	0	292
49-614314	RE49-11-9805	16–18	0	21	282
49-614315	RE49-11-9806	25–26	0	19	860
49-614315	RE49-11-9807	29.5–30.5	0	19	760
49-614315	RE49-11-9808	34–35	0	7	830
49-614395	RE49-11-9809	2.2–3.2	0	0	800
49-614395	RE49-11-9810	6.7–7.7	0	0	1200
49-614395	RE49-11-9811	11.2–12.2	0	0	470
TA-58					
58-614316	RE58-11-9814	7–8.5	0	31	192
58-614316	RE58-11-9815	11.5–13	0	26	471
58-614316	RE58-11-9816	16–17.5	0	35	619
TA-67					
67-614317	RE67-11-9817	6.5–7.5	0	19	1000
67-614317	RE67-11-9818	10–11	0	49	1000
67-614317	RE67-11-9819	15.5–16.5	0	25	1150
TA-69					
69-614302	RE69-11-9784	7–8.5	0	11	470
69-614302	RE69-11-9785	11.5–13	0	16	203
69-614302	RE69-11-9786	16–18	0	11	408

[a] PID = Photoionization detector.

[b] dpm = Disintegration per minute.

Table 3.4-1
Samples Collected and Analyses Requested

Sample ID	Location ID	Depth (ft)	Media	TAL Metals	Cyanide (Total)	Nitrate	Perchlorate	Isotopic Thorium	Isotopic Uranium
TA-06									
RE06-11-9789	06-614310	4–5.5	Qbt 4	11-2236*	11-2236	11-2236	11-2236	11-2236	11-2236
RE06-11-9790	06-614310	8.5–10	Qbt 4	11-2236	11-2236	11-2236	11-2236	11-2236	11-2236
RE06-11-9791	06-614310	13–14.5	Qbt 4	11-2236	11-2236	11-2236	11-2236	11-2236	11-2236
TA-14									
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	11-2288	11-2288	11-2288	11-2288	11-2288	11-2288
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	11-2288	11-2288	11-2288	11-2288	11-2288	11-2288
RE14-11-9794	14-614311	18–20	Qbt 4	11-2288	11-2288	11-2288	11-2288	11-2288	11-2288
TA-16									
RE16-11-9797	16-614312	6–7	Qbt 4	11-2232	11-2232	11-2232	11-2232	11-2232	11-2232
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	11-2232	11-2232	11-2232	11-2232	11-2232	11-2232
RE16-11-9799	16-614312	15–16	Qbt 4	11-2232	11-2232	11-2232	11-2232	11-2232	11-2232
TA-49									
RE49-11-9800	49-614313	3.5–5	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9801	49-614313	8–9.5	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9802	49-614313	12.5–14	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9803	49-614314	7–8.5	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9804	49-614314	11.5–13	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9805	49-614314	16–18	Qbt 4	11-2235	11-2235	11-2235	11-2235	11-2235	11-2235
RE49-11-9806	49-614315	25–26	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289
RE49-11-9808	49-614315	34–35	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289

Table 3.4-1 (continued)

Sample ID	Location ID	Depth (ft)	Media	TAL Metals	Total Cyanide	Nitrate	Perchlorate	Isotopic Thorium	Isotopic Uranium
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	11-2289	11-2289	11-2289	11-2289	11-2289	11-2289
TA-58									
RE58-11-9814	58-614316	7–8.5	Qbt 4	11-2234	11-2234	11-2234	11-2234	11-2234	11-2234
RE58-11-9815	58-614316	11.5–13	Qbt 4	11-2234	11-2234	11-2234	11-2234	11-2234	11-2234
RE58-11-9816	58-614316	16–17.5	Qbt 4	11-2234	11-2234	11-2234	11-2234	11-2234	11-2234
TA-67									
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	11-2290	11-2290	11-2290	11-2290	11-2290	11-2290
RE67-11-9818	67-614317	10–11	Qbt 4	11-2290	11-2290	11-2290	11-2290	11-2290	11-2290
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	11-2290	11-2290	11-2290	11-2290	11-2290	11-2290
TA-69									
RE69-11-9784	69-614302	7–8.5	Qbt 4	11-2233	11-2233	11-2233	11-2233	11-2233	11-2233
RE69-11-9785	69-614302	11.5–13	Qbt 4	11-2233	11-2233	11-2233	11-2233	11-2233	11-2233
RE69-11-9786	69-614302	16–18	Qbt 4	11-2233	11-2233	11-2233	11-2233	11-2233	11-2233

* Analytical request number.

Table 3.4-2
Summary of Borehole Depths

Location ID	Work Plan Borehole ID	Borehole TD (ft bgs)	Top of Unweathered Qbt 4 (ft bgs)
TA-06			
06-614310	3	15	4
TA-14			
14-614311	4	20	6.5
TA-16			
16-614312	6	19	6
TA-49			
49-614313	10	20	3.5
49-614314	7	20	7
49-614315	8	35	25
49-614395	9	15	2.2
TA-58			
58-614316	1	20	7
TA-67			
67-614317	5	20	6.5
TA-69			
69-614302	2	20	7

Table 4.1-1
Inorganic Chemical Results

Sample ID	Location ID	Depth (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Cyanide (Total)	Iron	Lead
Qbt 2, 3, 4 BVs[a]				**7340**	**0.5**	**2.79**	**46.0**	**1.21**	**1.63**	**2200**	**7.14**	**3.14**	**4.66**	**0.5**	**14,500**	**11.2**
TA-06																
RE06-11-9789	06-614310	4–5.5	Qbt 4	981 (J+)	1.01 (U)	1.07	15.8	0.319	0.507 (U)	712 (J+)	2.1	0.672	1.05	0.0999 (U)	5960	2.77
RE06-11-9790	06-614310	8.5–10	Qbt 4	556 (J+)	0.999 (U)	0.846 (J)	10.6	0.595	0.499 (U)	702 (J+)	1.63	0.615	0.645 (J)	0.217 (U)	5740	1.8
RE06-11-9791	06-614310	13–14.5	Qbt 4	827 (J+)	0.939 (U)	0.98	19.3	0.602	0.469 (U)	777 (J+)	2.16	0.687	1.2	0.082 (U)	6650	1.84
TA-14																
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	1350 (J+)	1.03 (U)	0.995 (J)	18.2	0.44	0.513 (U)	783 (J+)	2.27	0.845	1.94	0.242 (U)	9130	1.19
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	1500 (J+)	1.03 (U)	2.95	33.9	0.638	0.517 (U)	575 (J+)	5.62	1.02	1.77	0.0985 (U)	19500	4.63
RE14-11-9794	14-614311	18–20	Qbt 4	978 (J+)	1.01 (U)	0.632 (J)	19.8	0.628	0.506 (U)	705 (J+)	2.55	1.58	1.46	0.106 (U)	11700	5.51
TA-16																
RE16-11-9797	16-614312	6–7	Qbt 4	586 (J+)	0.927 (U)	0.973 (U)	18.5	0.205	0.463 (U)	567 (J+)	1.36	0.394 (J)	1.92	0.239 (U)	5750	1.23
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	296 (J+)	1.02 (U)	0.948 (U)	6.94	0.156	0.508 (U)	536 (J+)	2.12	0.268 (J)	1.47	0.249 (U)	4690	0.501 (J)
RE16-11-9799	16-614312	15–16	Qbt 4	214 (J+)	1.01 (U)	1.01 (U)	6.53	0.113	0.505 (U)	424 (J+)	0.65	0.189 (J)	0.985 (J)	0.249 (U)	4510	0.623 (J)
TA-49																
RE49-11-9800	49-614313	3.5–5	Qbt 4	2380	1.06 (U)	1.01 (J)	41.7	0.464	0.53 (U)	3850 (J-)	3.93	1.37	3.07	0.0856 (U)	9490	5.83
RE49-11-9801	49-614313	8–9.5	Qbt 4	2080	1.08 (U)	1.07	24.3	0.503	0.539 (U)	1060 (J-)	3.53	1.15	2.66	0.255 (U)	10100	2.66
RE49-11-9802	49-614313	12.5–14	Qbt 4	1670	1.05 (U)	1.07	26	0.493	0.523 (U)	948 (J-)	3.21	1.25	2.6	0.252 (U)	10200	3.37
RE49-11-9803	49-614314	7–8.5	Qbt 4	1360	0.944 (U)	3.08	11.5	0.231	0.472 (U)	928 (J-)	3.3	1.12	1.73	0.22 (U)	6120	3.07
RE49-11-9804	49-614314	11.5–13	Qbt 4	1330	1.01 (U)	3.2	15.3	0.333	0.505 (U)	983 (J-)	2.68	1.1	1.88	0.0917 (U)	10300	1.64
RE49-11-9805	49-614314	16–18	Qbt 4	1810	0.973 (U)	1.94	30.7	0.373	0.486 (U)	1080 (J-)	3.43	1.08	1.81	0.248 (U)	12700	3.31
RE49-11-9806	49-614315	25–26	Qbt 4	3350 (J+)	1.07 (U)	2.04	25	1.2	0.534 (U)	1310 (J+)	6.48	1.73	3.15	0.12 (U)	9700	102
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	1690 (J+)	0.985 (U)	0.338 (J)	28.2	0.443	0.493 (U)	1110 (J+)	5.13	1.14	2.24	0.119 (U)	10100	2.1
RE49-11-9808	49-614315	34–35	Qbt 4	1010 (J+)	0.901 (U)	0.328 (J)	15.5	0.404	0.451 (U)	843 (J+)	2.84	0.939	1.61	0.112 (U)	8570	1.23
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	1030 (J+)	0.966 (U)	0.262 (J)	15.4	0.236	0.483 (U)	901 (J+)	2.91	1.07	1.44	0.114 (U)	7160	0.888 (J)
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	854 (J+)	0.923 (U)	0.216 (J)	9.64	0.248	0.462 (U)	1010 (J+)	2.72	1.05	1.32	0.12 (U)	8120	0.981
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	1200 (J+)	0.912 (U)	0.994 (U)	16.3	0.229	0.456 (U)	951 (J+)	3.57	0.972	1.58	0.0892 (U)	8070	2.24
TA-58																
RE58-11-9814	58-614316	7–8.5	Qbt 4	947 (J+)	0.965 (U)	1.31	8.86	0.267	0.482 (U)	464 (J+)	2.01	0.684	1.04	0.248 (U)	7600	19.3
RE58-11-9815	58-614316	11.5–13	Qbt 4	2800 (J+)	0.996 (U)	1.46	38.4	0.548	0.498 (U)	923 (J+)	3.41	1.23	3.13	0.0964 (U)	9170	10.2
RE58-11-9816	58-614316	16–17.5	Qbt 4	836 (J+)	0.951 (U)	0.336 (J)	14	0.257	0.475 (U)	497 (J+)	3.22	0.863	2.14	0.252 (U)	8690	5.72

Table 4.1-1 (continued)

Sample ID	Location ID	Depth (ft)	Media	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Cyanide (Total)	Iron	Lead
Qbt 2, 3, 4 BVs[a]				**7340**	**0.5**	**2.79**	**46.0**	**1.21**	**1.63**	**2200**	**7.14**	**3.14**	**4.66**	**0.5**	**14,500**	**11.2**
TA-67																
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	1190 (J+)	0.93 (U)	0.674 (J)	38.2	0.338	0.465 (U)	964 (J+)	2.87	1.32	1.93	0.136 (U)	11800	21
RE67-11-9818	67-614317	10–11	Qbt 4	1740 (J+)	0.936 (U)	0.374 (J)	21.5	0.458	0.468 (U)	770 (J+)	2.78	0.92	2.04	0.105 (U)	9550	11
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	903 (J+)	0.88 (U)	0.676 (J)	15.8	0.368	0.44 (U)	339 (J+)	1.07	0.489	0.946	0.128 (U)	7080	3.28
TA-69																
RE69-11-9784	69-614302	7–8.5	Qbt 4	994 (J+)	0.99 (U)	0.415 (J)	18.1	0.637	0.495 (U)	983 (J+)	2.53	0.639	2.23	0.265 (U)	6730	1.79
RE69-11-9785	69-614302	11.5–13	Qbt 4	347 (J+)	1.01 (U)	0.993 (U)	10.2	0.279	0.506 (U)	385 (J+)	1.54	0.382 (J)	1.35	0.251 (U)	5900	0.443 (J)
RE69-11-9786	69-614302	16–18	Qbt 4	405 (J+)	1.02 (U)	0.248 (J)	12.2	0.398	0.508 (U)	429 (J+)	2.38	0.447 (J)	1.28	0.257 (U)	5740	0.553 (J)

Table 4.1-1 (continued)

Sample ID	Location ID	Depth (ft)	Media	Magnesium	Manganese	Mercury	Nickel	Nitrate	Perchlorate	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Qbt 2, 3, 4 BVs[a]				**1690**	**482**	**0.1**	**6.58**	**na[b]**	**na**	**3500**	**0.3**	**1**	**2770**	**1.1**	**17**	**63.5**
TA-06																
RE06-11-9789	06-614310	4–5.5	Qbt 4	306 (J+)	133 (J+)	0.0065 (J)	1.7	1.03 (U)	0.000739 (J)	218	1.03 (U)	0.507 (U)	97.9	0.411 (U)	3.21	16
RE06-11-9790	06-614310	8.5–10	Qbt 4	305 (J+)	165 (J+)	0.0175	1.48	1.01 (U)	0.0020 (U)	248	0.951 (U)	0.499 (U)	106	0.381 (U)	2.71	18.3
RE06-11-9791	06-614310	13–14.5	Qbt 4	410 (J+)	206 (J+)	0.0111 (U)	3.88	1.01 (U)	0.000692 (J)	281	0.975 (U)	0.469 (U)	102	0.39 (U)	3.64	15.8
TA-14																
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	574 (J+)	205	0.0122 (U)	1.86	1.24	0.00205 (U)	529 (J+)	1.02 (U)	0.513 (U)	269 (J+)	0.41 (U)	4.66	30.7
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	830 (J+)	297	0.0109 (U)	1.35	1.04 (U)	0.00231	1490 (J+)	1.02 (U)	0.517 (U)	355 (J+)	0.409 (U)	12.6	40.5
RE14-11-9794	14-614311	18–20	Qbt 4	374 (J+)	525	0.012 (U)	2.5	1.04 (U)	0.00455	428 (J+)	1.04 (U)	0.506 (U)	253 (J+)	0.0913 (J)	6.27	41.9
TA-16																
RE16-11-9797	16-614312	6–7	Qbt 4	178 (J+)	155 (J+)	0.0108 (U)	2.35	1.05 (U)	0.0021 (U)	263	0.973 (U)	0.463 (U)	97	0.389 (U)	1.98	17.5
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	54.1 (J+)	82.4 (J+)	0.0106 (U)	0.591	1.04 (U)	0.00207 (U)	151	0.948 (U)	0.508 (U)	81	0.379 (U)	1.48	13.3
RE16-11-9799	16-614312	15–16	Qbt 4	33.7 (J+)	84 (J+)	0.0118 (U)	0.324 (J)	1.04 (U)	0.00208 (U)	128	1.01 (U)	0.505 (U)	72.3	0.403 (U)	1.12	17
TA-49																
RE49-11-9800	49-614313	3.5–5	Qbt 4	1250	254	0.0106 (J)	3.06	1.09 (U)	0.00218 (U)	871	1.08 (U)	0.53 (U)	168	0.432 (U)	8.56	24.6
RE49-11-9801	49-614313	8–9.5	Qbt 4	1080	189	0.0119 (U)	2.96	1.08 (U)	0.00217 (U)	785	1.05 (U)	0.539 (U)	237	0.421 (U)	7.25	31.3
RE49-11-9802	49-614313	12.5–14	Qbt 4	1010	233	0.00627 (J)	2.66	1.07 (U)	0.00213 (U)	679	1.04 (U)	0.523 (U)	280	0.417 (U)	7.06	36.9
RE49-11-9803	49-614314	7–8.5	Qbt 4	702	44.1	0.00896 (J)	2.66	1.23	0.00205 (U)	519	1.01 (U)	0.472 (U)	129	0.404 (U)	6.78	12.1
RE49-11-9804	49-614314	11.5–13	Qbt 4	623	101	0.0119 (U)	3.67	1.02 (U)	0.00203 (U)	420	0.973 (U)	0.505 (U)	124	0.0737 (J)	6.55	16.7
RE49-11-9805	49-614314	16–18	Qbt 4	790	139	0.0122 (U)	3.56	1.03 (U)	0.000529 (J)	586	1.02 (U)	0.486 (U)	194	0.0911 (J)	7.15	22.5
RE49-11-9806	49-614315	25–26	Qbt 4	1280 (J+)	122	0.0052 (J)	2.8	1.47	0.00106 (J)	792 (J+)	1.05 (U)	0.534 (U)	206 (J+)	0.0928 (J)	9.82	37
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	897 (J+)	167	0.0124 (U)	1.72	1.25	0.000769 (J)	590 (J+)	0.958 (U)	0.493 (U)	249 (J+)	0.383 (U)	7.57	33
RE49-11-9808	49-614315	34–35	Qbt 4	632 (J+)	140	0.0112 (U)	1.65	1.24	0.000747 (J)	489 (J+)	1.03 (U)	0.451 (U)	224 (J+)	0.412 (U)	5.85	29
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	539 (J+)	177	0.0107 (U)	1.88	1.13	0.00202 (U)	396 (J+)	0.958 (U)	0.483 (U)	165 (J+)	0.383 (U)	4.43	28.2
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	581 (J+)	170	0.00786 (J)	1.79	1.01 (U)	0.00202 (U)	439 (J+)	0.92 (U)	0.462 (U)	186 (J+)	0.368 (U)	4.75	26.9
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	800 (J+)	207	0.0103 (U)	1.7	1.01 (U)	0.00203 (U)	531 (J+)	0.994 (U)	0.456 (U)	236 (J+)	0.398 (U)	6.93	22.9
TA-58																
RE58-11-9814	58-614316	7–8.5	Qbt 4	644 (J+)	125 (J+)	0.0111 (U)	1.66	1.13	0.00202 (U)	554	0.999 (U)	0.482 (U)	125	0.293 (J)	4.86	43.2
RE58-11-9815	58-614316	11.5–13	Qbt 4	539 (J+)	171 (J+)	0.00822 (J)	4.05	1.01 (U)	0.0016 (J)	512	0.966 (U)	0.498 (U)	104	0.161 (J)	7.31	55.1
RE58-11-9816	58-614316	16–17.5	Qbt 4	489 (J+)	213 (J+)	0.0106 (U)	1.7	1.16	0.00201 (U)	418	0.947 (U)	0.475 (U)	92.2	0.0614 (J)	6.6	44

Table 4.1-1 (continued)

Sample ID	Location ID	Depth (ft)	Media	Magnesium	Manganese	Mercury	Nickel	Nitrate	Perchlorate	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Qbt 2, 3, 4 BVs[a]				**1690**	**482**	**0.1**	**6.58**	**na[b]**	**na**	**3500**	**0.3**	**1**	**2770**	**1.1**	**17**	**63.5**
TA-67																
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	702 (J+)	334	0.018	2.56	1.01 (U)	0.00202 (U)	469 (J+)	0.967 (U)	0.465 (U)	134 (J+)	0.387 (U)	7.28	42.6
RE67-11-9818	67-614317	10–11	Qbt 4	793 (J+)	194	0.0123	2.13	1.01 (U)	0.00203 (U)	564 (J+)	0.97 (U)	0.468 (U)	142 (J+)	0.388 (U)	5.81	37.1
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	243 (J+)	208	0.00475 (J)	0.783	1.01 (U)	0.00201 (U)	253 (J+)	0.951 (U)	0.44 (U)	74.5 (J+)	0.38 (U)	2.75	36.1
TA-69																
RE69-11-9784	69-614302	7–8.5	Qbt 4	347 (J+)	221 (J+)	0.0074 (J)	2.24	1.33	0.00212 (U)	257	0.998 (U)	0.495 (U)	85.5	0.399 (U)	3.06	36
RE69-11-9785	69-614302	11.5–13	Qbt 4	151 (J+)	181 (J+)	0.0116 (U)	0.614	1.02 (U)	0.00205 (U)	179	0.993 (U)	0.506 (U)	88	0.397 (U)	1.98	30.5
RE69-11-9786	69-614302	16–18	Qbt 4	160 (J+)	216 (J+)	0.0113 (U)	0.949	1.03 (U)	0.00205 (U)	168	1 (U)	0.508 (U)	72.1	0.401 (U)	2.26	29.9

Note: Units are mg/kg. Data qualifiers are defined in Appendix A.

[a] BVs from LANL (1998, 059730).

[b] na = Not available.

Table 4.1-2
Inorganic Chemicals above BVs

Sample ID	Location ID	Depth (ft)	Media	Antimony	Arsenic	Calcium	Iron	Lead	Manganese	Nitrate	Perchlorate	Selenium
Qbt 2, 3, 4 BVs[a]				**0.5**	**2.79**	**2200**	**14,500**	**11.2**	**482**	**na**[b]	**na**	**0.3**
TA-06												
RE06-11-9789	06-614310	4–5.5	Qbt 4	1.01 (U)	—[c]	—	—	—	—	—	0.000739 (J)	1.03 (U)
RE06-11-9790	06-614310	8.5–10	Qbt 4	0.999 (U)	—	—	—	—	—	—	—	0.951 (U)
RE06-11-9791	06-614310	13–14.5	Qbt 4	0.939 (U)	—	—	—	—	—	—	0.000692 (J)	0.975 (U)
TA-14												
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	1.03 (U)	—	—	—	—	—	1.24	—	1.02 (U)
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	1.03 (U)	2.95	—	19500	—	—	—	0.00231	1.02 (U)
RE14-11-9794	14-614311	18–20	Qbt 4	1.01 (U)	—	—	—	—	525	—	0.00455	1.04 (U)
TA-16												
RE16-11-9797	16-614312	6–7	Qbt 4	0.927 (U)	—	—	—	—	—	—	—	0.973 (U)
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	1.02 (U)	—	—	—	—	—	—	—	0.948 (U)
RE16-11-9799	16-614312	15–16	Qbt 4	1.01 (U)	—	—	—	—	—	—	—	1.01 (U)
TA-49												
RE49-11-9800	49-614313	3.5–5	Qbt 4	1.06 (U)	—	3850 (J-)	—	—	—	—	—	1.08 (U)
RE49-11-9801	49-614313	8–9.5	Qbt 4	1.08 (U)	—	—	—	—	—	—	—	1.05 (U)
RE49-11-9802	49-614313	12.5–14	Qbt 4	1.05 (U)	—	—	—	—	—	—	—	1.04 (U)
RE49-11-9803	49-614314	7–8.5	Qbt 4	0.944 (U)	3.08	—	—	—	—	1.23	—	1.01 (U)
RE49-11-9804	49-614314	11.5–13	Qbt 4	1.01 (U)	3.2	—	—	—	—	—	—	0.973 (U)
RE49-11-9805	49-614314	16–18	Qbt 4	0.973 (U)	—	—	—	—	—	—	0.000529 (J)	1.02 (U)
RE49-11-9806	49-614315	25–26	Qbt 4	1.07 (U)	—	—	—	102	—	1.47	0.00106 (J)	1.05 (U)
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	0.985 (U)	—	—	—	—	—	1.25	0.000769 (J)	0.958 (U)

Table 4.1-2 (continued)

Sample ID	Location ID	Depth (ft)	Media	Antimony	Arsenic	Calcium	Iron	Lead	Manganese	Nitrate	Perchlorate	Selenium
Qbt 2, 3, 4 BVs[a]				**0.5**	**2.79**	**2200**	**14,500**	**11.2**	**482**	**na[b]**	**na**	**0.3**
RE49-11-9808	49-614315	34–35	Qbt 4	0.901 (U)	—	—	—	—	—	1.24	0.000747 (J)	1.03 (U)
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	0.966 (U)	—	—	—	—	—	1.13	—	0.958 (U)
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	0.923 (U)	—	—	—	—	—	—	—	0.92 (U)
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	0.912 (U)	—	—	—	—	—	—	—	0.994 (U)
TA-58												
RE58-11-9814	58-614316	7–8.5	Qbt 4	0.965 (U)	—	—	—	19.3	—	1.13	—	0.999 (U)
RE58-11-9815	58-614316	11.5–13	Qbt 4	0.996 (U)	—	—	—	—	—	—	0.0016 (J)	0.966 (U)
RE58-11-9816	58-614316	16–17.5	Qbt 4	0.951 (U)	—	—	—	—	—	1.16	—	0.947 (U)
TA-67												
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	0.93 (U)	—	—	—	21	—	—	—	0.967 (U)
RE67-11-9818	67-614317	10–11	Qbt 4	0.936 (U)	—	—	—	—	—	—	—	0.97 (U)
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	0.88 (U)	—	—	—	—	—	—	—	0.951 (U)
TA-69												
RE69-11-9784	69-614302	7–8.5	Qbt 4	0.99 (U)	—	—	—	—	—	1.33	—	0.998 (U)
RE69-11-9785	69-614302	11.5–13	Qbt 4	1.01 (U)	—	—	—	—	—	—	—	0.993 (U)
RE69-11-9786	69-614302	16–18	Qbt 4	1.02 (U)	—	—	—	—	—	—	—	1 (U)

Notes: Results are in mg/kg. Data qualifiers are in Appendix A.

[a] BVs are from LANL (1998, 059730).

[b] na = Not available.

[c] — = Not detected or not detected above BV.

Table 4.1-3
Results of Major Element Analysis by XRF

Sample ID	Location ID	Depth (ft)	Media	Aluminum (Al_2O_3)	Calcium CaO	Iron (Fe_2O_3)	Magnesium (MgO)	Manganese (MnO)	Phosphorus (P_2O_5)	Potassium K_2O)	Silica (SiO_2)	Sodium Na_2O)	Titanium (TiO_2)
TA-06													
RE06-11-9789	06-614310	4–5.5	Qbt 4	13.76	0.61	2.54	0.26	0.05	0.06	4.55	72.79	4.34	0.27
RE06-11-9790	06-614310	8.5–10	Qbt 4	13.43	0.72	2.32	0.24	0.06	0.07	4.62	73.34	4.59	0.26
RE06-11-9791	06-614310	13–14.5	Qbt 4	13.58	0.69	2.32	0.26	0.06	0.07	4.61	73.25	4.44	0.26
TA-14													
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	13.76	0.70	2.32	0.25	0.07	0.08	4.62	72.91	4.60	0.28
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	13.57	0.65	3.59	0.20	0.05	0.08	4.74	71.07	4.59	0.29
RE14-11-9794	14-614311	18–20	Qbt 4	13.86	0.71	2.35	0.22	0.11	0.08	4.66	72.64	4.70	0.28
TA-16													
RE16-11-9797	16-614312	6–7	Qbt 4	13.70	0.64	2.30	0.25	0.07	0.07	4.70	72.90	4.74	0.26
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	13.60	0.71	2.36	0.27	0.07	0.08	4.72	72.91	4.80	0.27
RE16-11-9799	16-614312	15–16	Qbt 4	13.64	0.68	2.28	0.26	0.07	0.07	4.74	73.03	4.77	0.26
TA-49													
RE49-11-9800	49-614313	3.5–5	Qbt 4	13.67	1.19	2.55	0.42	0.07	0.09	4.48	71.78	4.40	0.33
RE49-11-9801	49-614313	8–9.5	Qbt 4	13.56	0.82	2.38	0.33	0.06	0.08	4.62	72.83	4.38	0.29
RE49-11-9802	49-614313	12.5–14	Qbt 4	13.70	0.83	2.48	0.38	0.07	0.08	4.59	72.55	4.28	0.30
RE49-11-9803	49-614314	7–8.5	Qbt 4	13.88	0.73	1.77	0.27	0.03	0.07	4.50	73.18	4.49	0.30
RE49-11-9804	49-614314	11.5–13	Qbt 4	13.63	0.82	2.52	0.31	0.06	0.08	4.51	72.54	4.49	0.29
RE49-11-9805	49-614314	16–18	Qbt 4	13.60	0.81	2.78	0.31	0.05	0.08	4.56	72.46	4.44	0.30
RE49-11-9806	49-614315	25–26	Qbt 4	13.79	0.81	2.02	0.34	0.04	0.07	4.58	72.87	4.25	0.28
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	13.35	0.95	2.35	0.35	0.07	0.07	4.55	73.09	4.45	0.27

Table 4.1-3 (continued)

Sample ID	Location ID	Depth (ft)	Media	Aluminum (Al_2O_3)	Calcium CaO	Iron (Fe_2O_3)	Magnesium (MgO)	Manganese (MnO)	Phosphorus (P_2O_5)	Potassium K_2O)	Silica (SiO_2)	Sodium Na_2O)	Titanium (TiO_2)
RE49-11-9808	49-614315	34–35	Qbt 4	13.34	0.96	2.38	0.34	0.07	0.08	4.55	73.29	4.40	0.27
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	13.38	0.90	2.33	0.35	0.07	0.07	4.56	73.24	4.42	0.28
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	13.36	1.05	2.44	0.41	0.07	0.08	4.47	73.03	4.44	0.28
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	13.28	0.95	2.43	0.38	0.07	0.08	4.47	73.25	4.49	0.29
TA-58													
RE58-11-9814	58-614316	7–8.5	Qbt 4	13.35	0.56	2.19	0.27	0.06	0.07	4.58	73.64	4.50	0.25
RE58-11-9815	58-614316	11.5–13	Qbt 4	14.01	0.59	2.59	0.40	0.06	0.06	4.38	72.16	4.15	0.27
RE58-11-9816	58-614316	16–17.5	Qbt 4	13.49	0.66	2.33	0.29	0.07	0.07	4.61	73.40	4.55	0.26
TA-67													
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	13.24	0.62	2.26	0.26	0.07	0.07	4.68	73.64	4.47	0.26
RE67-11-9818	67-614317	10–11	Qbt 4	13.33	0.61	2.29	0.27	0.06	0.07	4.65	73.43	4.42	0.26
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	12.24	0.39	1.77	0.15	0.06	0.04	4.47	76.28	4.15	0.15
TA-69													
RE69-11-9784	69-614302	7–8.5	Qbt 4	13.64	0.59	2.45	0.28	0.08	0.07	4.60	72.81	4.40	0.25
RE69-11-9785	69-614302	11.5–13	Qbt 4	13.13	0.55	2.07	0.19	0.07	0.06	4.70	74.28	4.58	0.22
RE69-11-9786	69-614302	16–18	Qbt 4	13.33	0.60	2.21	0.24	0.07	0.06	4.72	73.78	4.53	0.24

Note: Results are in weight percentage.

Table 4.1-4
Results of Trace Element Analysis by XRF

Sample ID	Location ID	Depth (ft)	Media	Barium	Chromium	Copper	Lead	Nickel	Niobium	Rubidium	Strontium	Vanadium	Yttrium	Zinc	Zirconium
TA-06															
RE06-11-9789	06-614310	4–5.5	Qbt 4	449	13	2	18	11	40	86	78	15	36	57	342
RE06-11-9790	06-614310	8.5–10	Qbt 4	362	8	0	20	6	43	85	74	11	35	58	340
RE06-11-9791	06-614310	13–14.5	Qbt 4	329	8	0	21	7	44	89	74	14	39	52	339
TA-14															
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	393	4	0	15	6	43	81	88	11	39	65	363
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	416	6	0	21	5	40	81	93	14	40	49	357
RE14-11-9794	14-614311	18–20	Qbt 4	411	5	0	21	7	42	81	90	11	36	63	347
TA-16															
RE16-11-9797	16-614312	6–7	Qbt 4	342	3	0	15	3	44	81	68	9	40	63	389
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	346	4	0	15	6	44	82	70	10	35	71	363
RE16-11-9799	16-614312	15–16	Qbt 4	346	7	0	17	5	41	82	68	7	40	65	378
TA-49															
RE49-11-9800	49-614313	3.5–5	Qbt 4	466	9	4	30	9	38	81	116	18	34	69	363
RE49-11-9801	49-614313	8–9.5	Qbt 4	400	8	0	26	7	42	85	98	14	38	61	353
RE49-11-9802	49-614313	12.5–14	Qbt 4	374	8	1	26	8	43	89	93	18	38	69	357
RE49-11-9803	49-614314	7–8.5	Qbt 4	422	12	2	29	12	41	80	105	16	36	41	349
RE49-11-9804	49-614314	11.5–13	Qbt 4	423	8	0	23	10	42	84	103	15	37	55	352
RE49-11-9805	49-614314	16–18	Qbt 4	407	8	0	18	9	41	82	102	13	35	47	377
RE49-11-9806	49-614315	25–26	Qbt 4	362	11	0	114	8	43	90	88	17	35	56	341
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	371	11	0	20	9	43	86	85	13	36	68	341
RE49-11-9808	49-614315	34–35	Qbt 4	367	9	2	15	8	41	84	90	14	37	58	349
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	369	8	1	19	5	39	84	84	15	32	64	320
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	380	12	0	18	8	40	83	103	14	41	65	338
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	411	9	0	16	8	39	79	95	15	32	57	339
TA-58															
RE58-11-9814	58-614316	7–8.5	Qbt 4	344	3	0	82	6	40	83	75	13	30	113	334
RE58-11-9815	58-614316	11.5–13	Qbt 4	374	11	2	46	9	42	93	71	16	39	114	334
RE58-11-9816	58-614316	16–17.5	Qbt 4	358	7	0	40	7	38	81	79	12	33	98	342
TA-67															
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	338	8	0	41	9	44	93	79	14	36	76	348
RE67-11-9818	67-614317	10–11	Qbt 4	332	8	1	38	10	44	92	80	15	37	66	338
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	189	3	1	18	6	44	98	47	10	36	62	236

Table 4.1-4 (continued)

Sample ID	Location D	Depth (ft)	Media	Barium	Chromium	Copper	Lead	Nickel	Niobium	Rubidium	Strontium	Vanadium	Yttrium	Zinc	Zirconium
TA-69															
RE69-11-9784	69-614302	7–8.5	Qbt 4	309	6	0	20	9	43	89	65	12	46	76	339
RE69-11-9785	69-614302	11.5–13	Qbt 4	272	1	0	16	4	41	84	55	9	47	61	335
RE69-11-9786	69-614302	16–18	Qbt 4	275	8	2	16	6	46	88	58	9	47	67	349

Note: Units are mg/kg.

Table 4.1-5
Radionuclide Results

Sample_ID	Location_ID	Depth, ft	Media	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-235/236	Uranium-238
Qbt 2, 3, 4 BV*				**2.52**	**1.98**	**2.52**	**1.98**	**0.09**	**1.93**
TA-06									
RE06-11-9789	06-614310	4–5.5	Qbt 4	1.13	0.668	1.18	0.52	0.0153 (U)	0.512
RE06-11-9790	06-614310	8.5–10	Qbt 4	1.23	0.547	1.2	0.375	0.0455 (U)	0.405
RE06-11-9791	06-614310	13–14.5	Qbt 4	1.05	0.451	1.05	0.39	0.00723 (U)	0.342
TA-14									
RE14-11-9792	14-614311	6.5–7.5	Qbt 4	0.948	0.548	0.947	0.399	0.0146 (U)	0.326
RE14-11-9793	14-614311	12.5–13.5	Qbt 4	0.976	0.436	0.773	0.268	0.0212 (U)	0.268
RE14-11-9794	14-614311	18–20	Qbt 4	0.814	0.544	0.62	0.376	0.0314 (U)	0.36
TA-16									
RE16-11-9797	16-614312	6–7	Qbt 4	1.03	0.573	0.975	0.771	0.0518 (U)	0.764
RE16-11-9798	16-614312	10.5–11.5	Qbt 4	0.93	0.495	1.27	0.691	0.00879 (U)	0.636
RE16-11-9799	16-614312	15–16	Qbt 4	0.895	0.504	0.992	0.533	0.0565	0.541
TA-49									
RE49-11-9800	49-614313	3.5–5	Qbt 4	0.653	0.421	0.746	0.356	0.0134 (U)	0.351
RE49-11-9801	49-614313	8–9.5	Qbt 4	0.609	0.523	0.717	0.487	0.0262 (U)	0.39
RE49-11-9802	49-614313	12.5–14	Qbt 4	0.993	0.445	0.811	0.399	0.0245 (U)	0.283
RE49-11-9803	49-614314	7–8.5	Qbt 4	1.04	0.581	0.849	0.454	0.0273 (U)	0.361
RE49-11-9804	49-614314	11.5–13	Qbt 4	0.904	0.448	0.931	0.479	0.0415 (U)	0.454
RE49-11-9805	49-614314	16–18	Qbt 4	0.96	0.348	0.772	0.446	0.0249 (U)	0.419
RE49-11-9806	49-614315	25–26	Qbt 4	1.15	0.465	1.14	0.471	0.0457 (U)	0.369
RE49-11-9807	49-614315	29.5–30.5	Qbt 4	0.743	0.462	0.96	0.397	0.00452 (U)	0.329

Table 4.1-5 (continued)

Sample_ID	Location_ID	Depth, ft	Media	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-235/236	Uranium-238
Qbt 2, 3, 4 BV				**2.52**	**1.98**	**2.52**	**1.98**	**0.09**	**1.93**
RE49-11-9808	49-614315	34–35	Qbt 4	0.973	0.455	1.07	0.372	-0.00524 (U)	0.352
RE49-11-9809	49-614395	2.2–3.2	Qbt 4	1.09	0.44	0.944	0.452	0.0161 (U)	0.4
RE49-11-9810	49-614395	6.7–7.7	Qbt 4	0.933	0.482	1.09	0.42	0.027 (U)	0.364
RE49-11-9811	49-614395	11.2–12.2	Qbt 4	0.826	0.355	0.896	0.329	0.022 (U)	0.328
TA-58									
RE58-11-9814	58-614316	7–8.5	Qbt 4	1.04	0.665	0.999	0.668	0.0359 (U)	0.548
RE58-11-9815	58-614316	11.5–13	Qbt 4	1.03	0.411	1.06	0.431	0.00561 (U)	0.268
RE58-11-9816	58-614316	16–17.5	Qbt 4	0.943	0.408	0.814	0.324	0.00502 (U)	0.378
TA-67									
RE67-11-9817	67-614317	6.5–7.5	Qbt 4	1.13	0.581	0.769	0.419	0.0232 (U)	0.413
RE67-11-9818	67-614317	10–11	Qbt 4	1.02	0.551	1.05	0.31	0.0135 (U)	0.287
RE67-11-9819	67-614317	15.5–16.5	Qbt 3	1.38	0.814	1.43	0.774	0.0386(U)	0.788
TA-69									
RE69-11-9784	69-614302	7–8.5	Qbt 4	1.27	0.518	0.942	0.512	0.0482	0.518
RE69-11-9785	69-614302	11.5–13	Qbt 4	0.99	0.457	0.946	0.429	0.109	0.474
RE69-11-9786	69-614302	16–18	Qbt 4	1.09	0.561	1.1	0.397 (J-)	0.0479 (J-)	0.41 (J-)

Note: Units are pCi/g. Data qualifiers are defined in Appendix A.

* BVs from LANL (1998, 059730).

Table 4.1-6
Radionuclides Detected above BV

Sample_ID	Location_ID	Depth, ft	Media	Uranium-235/236
Qbt 2, 3, 4 BV*				**0.09**
TA-69				
RE69-11-9785	69-614302	11.5–13	Qbt 4	0.109

Note: Units are pCi/g. Data qualifiers are defined in Appendix A.
* BV from LANL (1998, 059730).

Appendix A

Acronyms and Abbreviations,
Metric Conversion Table, and Data Qualifier Definitions

A-1.0 ACRONYMS

AOC	area of concern
bgs	below ground surface
BV	background value
CME	Central Mine Equipment Company
COC	chain of custody
COPC	chemical of potential concern
DOE	Department of Energy (U.S.)
EDL	estimated detection limit
EES	Earth and Environmental Science (LANL division)
ENV-RCRA	Water Quality and RCRA (Laboratory group)
EPA	Environmental Protection Agency (U.S.)
FD	field duplicate
FR	field rinsate
GPS	global positioning system
ICS	interference check sample
IDL	instrument detection limit
IDW	investigation-derived waste
LAL	lower acceptance limit
LANL	Los Alamos National Laboratory
LCS	laboratory control sample
MDL	method detection limit
MS	matrix spike
NES	nuclear environmental site
NMED	New Mexico Environment Department
O.D.	outside diameter
PID	photoionization detector
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RPD	relative percent difference
RPF	Records Processing Facility
SCL	sample collection log

SMO	Sample Management Office
SOP	standard operating procedure
SOW	statement of work
SWMU	solid waste management unit
TA	technical area
TAL	target analyte list
TD	total depth
UAL	upper acceptance limit
UTL	upper tolerance limit
WCSF	waste characterization strategy form
XRF	X-ray fluorescence

A-2.0 METRIC CONVERSION TABLE

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

A-3.0 DATA QUALIFIER DEFINITIONS

Data Qualifier	Definition
U	The analyte was analyzed for but not detected.
J	The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.
J+	The analyte was positively identified, and the result is likely to be biased high.
J-	The analyte was positively identified, and the result is likely to be biased low.
UJ	The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit.
R	The data are rejected as a result of major problems with quality assurance/quality control (QA/QC) parameters.

Appendix B

Field Methods

B-1.0 INTRODUCTION

This appendix summarizes field methods used for the background study for unit 4 of the Bandelier Tuff (Qbt 4). Table B-1.0-1 summarizes the methods used, and the following sections provide more detailed description of the field methods. All activities were conducted in accordance with the applicable Environmental Programs Directorate standard operating procedures (SOPs) listed in Table B-1.0-2. These SOPs may be found at the following web address: http://www.lanl.gov/environment/all/qa.shtml.

B-2.0 SITE ACCESS AND PREMOBILIZATION ACTIVITIES

Fieldwork was conducted within Technical Areas (TAs) 06, 14, 16, 49, 58, 67, and 69. Locations 14-614311 and 67-614317 were within the secure area at TAs 14 and 67, respectively. These locations were also within Mexican spotted owl habitat and required completion of field activities in one day (May 2, 2011). The borehole locations within TAs 16, 58, and 69 were located either alongside paved roads (e.g., NM 4), or within a publically accessible area of TA-58 frequented by recreational hikers, mountain bikers, and runners. The remaining locations were located in remote areas accessible on paved and unpaved roads (TAs 06, 14, and 67), or within the secured area at TA-49.

Some areas of these TAs are currently used for both Laboratory operations and road and foot traffic. Public access is controlled through physical and administrative controls such as traffic cones and an access control office. All efforts were made to provide a secure and safe work area and to reduce impacts to Laboratory personnel, cultural resources, and the environment.

Site setup for field activities was initiated on April 26, 2011. Site setup activities included on-site housekeeping and inspections, obtaining all supporting documentation and equipment required for the project, briefing on the hazard control plan, and establishing a work zone at the first borehole. Before mobilization, the drill rig was given a safety inspection off-site.

B-3.0 GEODETIC SURVEYS

Geodetic surveys of borehole locations were conducted using a Trimble GeoXT handheld global positioning system (GPS). Surveys were conducted in accordance with the latest version of SOP 5028, Coordinating and Evaluating Geodetic Surveys.

B-4.0 FIELD SCREENING

Field screening for radionuclides and organic vapors was performed in accordance with the approved investigation work plan (LANL 2010, 111504; NMED 2011, 111680), to support on-site health and safety. All field-screening measurements are summarized in Table 3.3-1 of the Qbt 4 background study report.

Samples were screened for gross-alpha, -beta, and -gamma radiation. Screening was performed using an Eberline E600 with a 380AB probe in accordance with SOP-10.07, Field Monitoring for Surface and Volume Radioactivity Levels. The probe was held less than 1 in. away from the medium and measurements were made by conducting a 1-min reading to determine gross-alpha, -beta, and -gamma radiation levels. Field personnel collected and recorded daily background measurements for gross-alpha, -beta, and -gamma radiation, and the samples were screened for radioactivity by a radiological control technician before they were shipped to the Laboratory's Sample Management Office (SMO) to ensure compliance with U.S. Department of Transportation requirements. Field-screening results were recorded in field notebooks or on sample collection logs (SCLs) and chain of custody (COC) forms.

Field screening for organic vapors was conducted using an Ion Science PhoCheck Plus photoionization detector equipped with an 11.7-electronvolt lamp. Screening was performed in accordance with the manufacturer's specifications and SOP 6.33, Headspace Vapor Screening with a Photo Ionization Detector. Field screening was performed on each sample collected, and screening measurements were recorded in field logbooks or on the SCLs and COC forms.

B-5.0 BOREHOLE DRILLING AND SUBSURFACE SAMPLING

During the Qbt 4 background study, 30 subsurface tuff samples were collected from 10 locations in TAs 06, 14, 16, 49, 58, 67, and 69. A Central Mine Equipment Company (CME) 85-hollow-stem auger drill rig was employed for all drilling using 4.25-in.-inside-diameter and nominal 8.25-in.-outside-diameter (O.D.) augers. A hex-rod core retrieval system and 4-in.-O.D. core barrels were used for sampling. A nominal 9-in.-diameter drill bit was used for all borings. During drilling, continuous core was recovered using the core barrels through the center of the 4.25-in. drill string. Core was collected in 5-ft sample runs in accordance with SOP 6.26, Core Barrel Sampling for Subsurface Earth Materials. At the surface, cuttings and core were surveyed for gross-alpha, -beta, and –gamma radioactivity and organic vapors. The core was visually inspected and lithologically logged by a qualified geologist.

Standard quality assurance/quality control (QA/QC) samples (field duplicates [FDs], and field rinsates [FRs]) were collected in accordance with SOP 5059, Field Quality Control Samples, at a frequency of 10% of total samples collected.

Samples were preserved using coolers to maintain the required temperature in accordance with a Laboratory-approved subcontractor procedure technically equivalent to SOP 5056, Sample Containers and Preservation.

Samples were managed according to Laboratory-approved subcontractor procedures technically equivalent to SOP 5057, Handling, Packaging, and Transporting Field Samples, and WES-EDA-QP-219, Sample Control and Field Documentation. All sample collection activities were coordinated with the SMO. All samples were placed in appropriately labeled sample containers, sealed with custody seals, and documented, and remained in the controlled custody of the field team at all times until they were delivered to the SMO. Sample custody was then relinquished to the SMO for delivery to a preapproved off-site analytical laboratory. Project SCL and COC forms were completed for all samples to document proper sample collection and handling.

Field documentation included detailed borehole logs for each borehole drilled and sampled (Appendix C). The borehole logs documented the distribution and composition of the crystals, pumice and lithic fragments, and matrix material of the tuff. Fractures and surge beds, if present, and the degree of weathering were also described and recorded in the lithologic log. The borehole logs also included the depth to the top of tuff, the depth to the top of unweathered tuff, the results of all field screening, sampled interval depths, and sample numbers. Borehole material was stored and labeled in a core box for curating and archiving. All field documentation was completed in accordance with the current version of SOP 12.01, Field Logging, Handling, and Documentation of Borehole Materials.

B-6.0 BOREHOLE ABANDONMENT

All 10 hollow-stem auger boreholes from the Qbt 4 background study were abandoned in accordance with SOP 5034, Monitor Well and RFI Borehole Abandonment. All boreholes were immediately abandoned with 3/8-in. bentonite chips to within 1 ft of the surface. The remainder of each boring was filled with Portland Type I/II cement to surface grade.

B-7.0 EQUIPMENT DECONTAMINATION

All field equipment that had the potential to contact contaminated environmental media (e.g., spilt-spoon core barrel, sampling scoops, and bowls) was decontaminated between sample collection and between sampling locations to prevent cross-contamination of samples and sampling equipment. Decontamination was performed in accordance with SOP 5061, Field Decontamination of Equipment. Rinsate blanks were collected on sampling equipment to check the effectiveness of decontamination.

B-8.0 INVESTIGATION-DERIVED WASTE MANAGEMENT

Approximately 3.16 yd^3 of investigation-derived waste (IDW) was generated during the Qbt 4 background study and included (1) drill cuttings and (2) contaminated personal protective equipment (PPE). All wastes generated were managed in accordance with the IDW management plan in the approved work plan (LANL 2010, 111504; NMED 2011, 111608) and SOP 5238, Characterization and Management of Environmental Program Waste."SOP 5238 incorporates the requirements of applicable U.S. Environmental Protection Agency (EPA) and New Mexico Environment Department regulations.

Drill cuttings and PPE from all boreholes were collected and containerized in lined 55-gal. containers and stored at the borehole locations. Laboratory personnel removed the drums to a central location where the drill cuttings were directly sampled. Drill cuttings met the criteria for land application and were disposed of by land application.

Contact IDW included PPE (gloves), paper towels, and disposable sampling supplies. Such waste was containerized as “Green is Clean” at TA-54 and stored for disposal.

B-9.0 DEVIATIONS FROM APPROVED WORK PLAN

Deviations from the approved investigation work plan (LANL 2010, 111504; NMED 111680) are summarized below.

At location 14-614311 clay-rich, weathered tuff intervals were encountered at the proposed sampling depths of 11–12 ft and 15.5–16.5 ft below ground surface (bgs), based on the top of unweathered tuff at 6.5 ft bgs. Therefore, deeper sampling intervals were selected, after consultation with the on-site Laboratory geologist, to collect unweathered, competent Qbt 4 samples at 12.5–13.5 ft and 18–20 ft bgs, respectively.

At location 67-614317 a clay-rich weathered surge bed deposit was encountered at the proposed sampling depths of 11–12 ft bgs, based on the top of unweathered tuff at 6.5 ft bgs. Therefore, deeper sampling intervals were selected, after consultation with the on-site Laboratory geologist, to collect unweathered, competent Qbt 4 samples at 10–11 ft bgs.

The investigation work plan specified calculating upper tolerance limits (UTLs) for all constituents detected at a rate greater than or equal to 25%. These UTLs were to be used as background values (BVs) for Qbt 4. With very few exceptions, the results of analysis of inorganic chemicals and radionuclides in the Qbt 4 background study samples are below existing BVs for Bandelier tuff units 2, 3, and 4 (Qbt 2, 3, 4). Based on these results, the current Qbt 2, 3, 4 BVs are appropriate for use with unweathered Qbt 4 and there was no need to calculate UTLs from the Qbt 4 data.

B-10.0 REFERENCES

The following list includes all documents cited in this appendix. 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 New Mexico Environment Department 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.

LANL (Los Alamos National Laboratory), December 2010. "Work Plan for Determining Background Concentrations of Inorganic Chemicals in Unit 4 of the Bandelier Tuff," Los Alamos National Laboratory document LA-UR-10-8111, Los Alamos, New Mexico. (LANL 2010, 111504)

NMED (New Mexico Environment Department), January 12, 2011. "Notice of Approval, Work Plan to Determine Background Concentrations in Unit 4 of the Bandelier Tuff," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2011, 111680)

Table B-1.0-1
Brief Description of Field Investigation Methods

Method	Summary
Hollow-Stem Auger Drilling Methods	In this method, hollow-stem augers (sections of seamless pipe with auger flights welded to the pipe) act as a screw conveyor to bring cuttings of sediment, soil, and/or rock to the surface. Auger sections are typically 5 ft in length and have outside diameters of 4.25 to 14 in. Drill rods, split-spoon core barrels, Shelby tubes, and other samplers were passed through the center of the hollow-stem auger sections to collect discrete samples from desired depths.
Split-Spoon Core-Barrel Sampling	A stainless-steel core barrel was advanced using a hollow-stem auger drilling rig. The core barrel extracted a continuous length of soil and/or rock. The split-spoon core barrel is a cylindrical barrel split lengthwise so the two halves can be separated to expose the core sample. Once extracted, the section of core was screened for radioactivity and organic vapors and described in a geologic log. A portion of the core was then collected as a discrete sample from the desired depth.
Handling, Packaging, and Shipping of Samples	Field team members labeled samples before packing and ensured the sample containers and the transport containers were free of external contamination. Field team members packaged all samples to minimize the possibility of breakage during transportation. After all environmental samples were collected, packaged, and preserved, a field team member transported them to the SMO. The SMO arranged for shipping the samples to analytical laboratories.
Sample Control and Field Documentation	The collection, screening, and transport of samples was documented on standard forms generated by the SMO. These included SCLs, COC forms, and sample container labels. SCLs were completed at the same time as sample collection, and the logs were signed by the sampler and a reviewer who verified the logs for completeness and accuracy. Corresponding labels were applied to each sample container. COC forms were completed and assigned to verify that the samples were not left unattended.
Field Quality Control Samples	Field QC samples were collected as follows: Field Duplicate: At a frequency of 10%; collected at the same time as a regular sample and submitted for the same analyses. Field Rinsate: At a frequency of 10%; collected by rinsing sampling equipment with deionized water that is collected in a sample container and submitted for laboratory analysis.
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination was used to minimize the generation of liquid waste. Dry decontamination included the use of a wire brush or other tool for removal of soil or other material adhering to the sampling equipment, followed by use of Fantastik and paper wipes.
Containers and Preservation of Samples	Specific requirements/processes for sample containers, preservation techniques, and holding times are based on EPA guidance for environmental sampling, preservation, and QA. Specific requirements for each sample were printed on the SCLs provided by the SMO (size and type of container, i.e., glass, amber glass, polyethylene, preservative, etc.). Samples were preserved by placing in insulated containers with ice to maintain a temperature of 4˚C.

Table B-1.0-1 (continued)

Method	Summary
Coordination and Evaluation of Geodetic Surveys	Geodetic surveys focused on obtaining survey data of acceptable quality for use during project investigations. Geodetic surveys were conducted with a Trimble GeoTX GPS. All coordinates are expressed in New Mexico State Plain Coordinate System 1983, NM Central, U.S. ft coordinates. All elevation data were reported relative to the National Geodetic Vertical Datum of 1983.
Management, Characterization, and Storage of Investigation-Derived Waste	IDW was managed, characterized, and stored in accordance with an approved waste characterization strategy form that documents site history, field activities, and the characterization approach for each waste stream managed. Waste characterization was adequate to comply with on-site or off-site waste acceptance criteria. All stored IDW was marked with appropriate signage and labels. Each container of waste generated was individually labeled with waste classification, item identification number, and radioactivity (if applicable), immediately following containerization. Management of IDW is presented in Appendix D of this investigation report.

Table B-1.0-2
SOPs Used for Qbt 4 Background Study Activities

EP-DIR-SOP-5006, Control of Measuring and Test Equipment
EP-ERSS-SOP-5028, Coordinating and Evaluating Geodetic Surveys
EP-ERSS-SOP-5034, Monitor Well and RFI Borehole Abandonment
EP-ERSS-SOP-5055, General Instructions for Field Investigations
EP-ERSS-SOP-5056, Sample Containers and Preservation
EP-ERSS-SOP-5057, Handling, Packaging, and Transporting Field Samples
WES-EDA-QP-219, Sample Control and Field Documentation
EP-ERSS-SOP-5059, Field Quality Control Samples
EP-ERSS-SOP-5061, Field Decontamination of Equipment
EP-ERSS-SOP-5077, Field Sampling of Core and Cuttings for Geological Analysis
SOP-5181, Notebook and Logbook Documentation for Environmental Directorate Technical and Field Activities
SOP-5238, Characterization and Management of Environmental Program Waste
SOP-06.26, Core Barrel Sampling for Subsurface Earth Materials
SOP-06.33, Headspace Vapor Screening with a Photo Ionization Detector
SOP-10.07, Field Monitoring for Surface and Volume Radioactivity Levels
SOP-12.01, Field Logging, Handling, and Documentation of Borehole Materials

Note: These procedures are available at http://www.lanl.gov/environment/all/qa.shtml.

Appendix C

Borehole Logs

TA-49 Qbt 4 Background Study			
Borehole ID: 06-614310	**TA:** 06	**Drill Depth:** 15 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 4/28/2011	**End Date:** 4/28/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler			**Logged By:** S. Muggleton (TPMC) and S. Levy (LANL)
Background Values:	**PID=** 0.0 ppm	**α=** 47.7 dpm	**β/γ=** 2030 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 0.5' bgs organic-rich (plant and root fragments) with sand, silt and clay. Damp.	Soil	
2				0.5 – 1.5' bgs Large clay-filled fracture, fragmented weathered tuff and soil.		Contact of soil and Qbt 4 is at 1.5' bgs.
3				**Weathered Tuff:** 1.5' – 2.5' bgs AFT: Light gray/pale pink (7.5YR 7/1), partly to poorly	Weathered Qbt 4	
4				welded ash-flow tuff; with oxidized, clay-rich layers up to 10 mm thick. Oxidation decreases with depth.		Top of unweathered tuff is at 4' bgs.
5		PID= 0.0 α= 11	RE06-11-9789	**Unit 4 of the Tshirege Member of the Bandelier Tuff:**	Unweathered Qbt 4	Sample interval is 4' – 5.5' bgs.
6	5/5	β/γ= 370		AFT: White to light-gray/purple (5YR 8/1), poorly to partly well welded ash-flow tuff. Crystal-rich, with		
7				20% quartz, sanidine and oxide crystals; and oxidized and devitrified, brown to dark brown pumice		
8				fragments up to 10 mm in diameter, in an ash matrix.		
9		PID= 0.0	RE06-11-9790	SAA		Sample interval is 8.5' – 10' bgs.
10		α= 58 β/γ= 2400				
11	5/5					
12						
13						
14		PID= 0.0 α= 0	RE06-11-9791	SAA		Sample interval is 13' – 14.5' bgs.
15		β/γ= 544				TD at 15' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 14-614311	**TA:** 14	**Drill Depth:** 20 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 5/02/2011	**End Date:** 5/02/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler	**Logged By:** S. Muggleton (TPMC), G. WoldeGabriel and S. Levy (LANL)		
Background Values:	**PID=** 0.0 ppm	**α=** 40 dpm	**β/γ=** 1511 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 0.5' bgs medium brown, organic-rich (plant and root fragments), with silt and sand-sized	Soil	Contact of soil and Qbt 4 is at 0.5' bgs.
2				subrounded clasts, including pumice fragments. **Weathered Tuff:** 0.5' – 6.5' bgs, poorly to partly		
3				welded, medium brown to orange in color.		
4					Weathered Qbt 4	
5				**Surge bed:** 3.7' – 4.5' bgs orange in color, pumice- and clay-rich.		
6	5/5					
7		PID= 0.0	RE14-11-9792	**Unit 4 of the Tschirege Member of the**		Top of unweathered tuff is at 6.5' bgs. Sample interval is 6.5' – 7.5' bgs.
8		α= 7 β/γ= 885		**Bandelier Tuff:** AFT: Pale-purple to gray (5YR 7/2), poorly to		
9				partly welded ash-flow tuff. Crystal-rich, with 20% quatrz, sanidine and oxide crystals; 10% crystal clots;		
10				and 10% oxidized and devitrified, brown pumice fragments, up to 20 mm in diameter, in an ash matrix.		
11	5/5					
12				**Weathered Tuff:** 11' – 12' bgs.		
13		PID= 0.0	RE14-11-9793	SAA		Sample interval is 12.5' – 13.5' bgs.
14		α= 37 β/γ= 885			Unweathered Qbt 4	**Note:** Sample RE14-11-9793 was collected from 12.5' – 13.5' bgs instead
15						of 11' – 12' bgs because of the presence of a weathered tuff interval.
16	5/5					
17						**Note:** Sample RE14-11-9794 was collected from 18' – 20' bgs instead of
18				**Weathered Tuff:** 16.8' – 17.7' bgs.		17' – 18' bgs because of the presence of a weathered tuff interval.
19		PID= 0.0 α= 43	RE14-11-9794 RE14-11-9795	SAA		Sample interval is 18' – 20' bgs. FD of RE14-11-9794
20		β/γ= 1021	RE14-11-9796			FR of RE14-11-9794 TD at 20' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 16-614312	**TA: 16**	**Drill Depth:** 19 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 4/28/2011	**End Date:** 4/28/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and G. WoldeGabriel (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 47.7 dpm	**β/γ=** 2030 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	4.5/4.5			**Soil:** 0 – 1' bgs organic-rich (plant and root fragments) with sand, silt and minor clay. Dry.	Soil	
2				1 – 1.8' bgs fragmented weathered tuff and soil.	Soil	Contact of soil and Qbt 4 is at 1.8' bgs.
3				**Weathered Tuff:** 1.8' – 6' bgs AFT: Reddish-yellow (7.5YR 7/6), well to very well	Weathered Qbt 4	
4				welded ash-flow tuff. Crystal-rich with 50% quartz, sanidine and pyroxene crystals. Pumice-bearing, with	Weathered Qbt 4	
5	5/5			5% glassy, yellow-brown (i.e. oxidized) pumice fragments; glassy fiamme up to 10–20 mm in diameter;	Weathered Qbt 4	
6				and crystal clots up to 50 mm in diameter.	Weathered Qbt 4	Top of unweathered tuff is at 6' bgs.
7		PID= 0.0 α= 0 β/γ= 212	RE16-11-9797	**Unit 4 of the Tschirege Member of the Bandelier Tuff:**	Unweathered Qbt 4	Sample interval is 6' – 7' bgs.
8				AFT: Reddish-purple (2.5YR 7/4), very well welded ash-flow tuff. Crystal-rich with 20% quartz, sanidine and	Unweathered Qbt 4	
9				oxide crystals; 10% crystal clots up to 50 mm in diameter, and 20% red-brown glassy pumice fragments and	Unweathered Qbt 4	
10	5/5			fiamme in an ash matrix.	Unweathered Qbt 4	
11		PID= 0.0 α= 21 β/γ= 475	RE16-11-9798		Unweathered Qbt 4	Sample interval is 10.5' – 11.5' bgs.
12					Unweathered Qbt 4	
13					Unweathered Qbt 4	
14					Unweathered Qbt 4	
15	4.5/5				Unweathered Qbt 4	
16		PID= 0.0 α= 16 β/γ= 407	RE16-11-9799		Unweathered Qbt 4	Sample interval is 15' – 16' bgs.
17					Unweathered Qbt 4	
18					Unweathered Qbt 4	
19					Unweathered Qbt 4	TD at 19' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 49-614313	**TA:** 49	**Drill Depth:** 20 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 4/27/2011	**End Date:** 4/27/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and S. Levy (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 47.7 dpm	**β/γ=** 2030 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
	5/5			**Soil:** 0 – 1.5' bgs organic-rich (plant and		
1				root fragments) with sand, silt and minor clay.	Soil	
				Dry and brown.		Contact of soil and Qbt 4 is at 1.5' bgs.
2		PID= 0.0		**Weathered Tuff:** 1.5' – 3.5' bgs oxidized with		
		α= 1		clay-filled fracture (5 – 10 mm thick). Caliche +/- other	Weathered Qbt4	
3		β/γ= 96		salts present.		
						Top of unweathered tuff is at 3.5' bgs.
4			RE49-11-9800	**Unit 4 of the Tschirege Member of the**		Sample interval is 3.5' – 5' bgs.
				Bandelier Tuff:		
5				AFT: Pale pink (2.5YR 7/2), partly to moderately		
	5/5			well welded ash-flow tuff. Crystal-rich with 20% quartz,		
6				sanidine and oxide crystals. Pumice-poor, with 5%		
				pumice fragments, 5 – 20 mm in diameter, in an ash		
7				matrix.		
8				**Weathered Tuff:** Fractured, clay-altered tuff at 8' bgs.		
		PID= 0.0	RE49-11-9801			Sample interval is 8' – 9.5' bgs.
9		α= 0		**Weathered Tuff:** Fractured, clay-altered tuff at		
		β/γ= 265		9.5 – 9.8 ' bgs.		
10						
	5/5			**Weathered Tuff:** Oxidized tuff zone, yellow to orange		
11				with minor clay and manganese oxyhydroxide,		
				10 – 10.5 ' bgs.		
12						
13		PID= 0.0	RE49-11-9802		Unweathered Qbt 4	Sample interval is 12.5' – 14' bgs.
		α= 0				
14		β/γ= 265				
15						
	5/5					
16						
17						
18						
19						
20						TD at 20' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 49-614314	**TA:** 49	**Drill Depth:** 20 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 4/29/2011	**End Date:** 4/29/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and S. Levy (LANL)	
Background Values: **PID=** 0.0 ppm	**α=** 18 dpm	**β/γ=** 1958 dpm	

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 3' bgs dark brown, organic-rich (plant and root fragments), clay-rich with silt to pebble-sized clasts, including pumice fragments. Damp.	Soil	
2						
3						
4				**Soil:** 3 – 4' bgs clay-rich soil and weathered tuff fragments.		Contact of soil and Qbt 4 is at 4' bgs.
5				**Weathered Tuff:** 4.5' – 7' bgs. Yellow to pale-pink (7.5YR 7/2) poorly welded ash-flow tuff. Crystal-rich, with 20-30% quartz, sanidine and oxide crystals. Pumice-bearing with 5-10% oxidized and devitrified, brown to orange pumice fragments up to 5 mm in diameter, in an ash matrix. Clay-filled fractures with roots present. Minor local oxidation.	Weathered Qbt 4	
6	5/5					
7						Top of unweathered tuff is at 7' bgs.
8		PID= 0.0 α= 21 β/γ= 282	RE49-11-9803	**Unit 4 of the Tschirege Member of the Bandelier Tuff:** AFT: Pale-pink (2.5YR 7/2), partly to poorly welded devitrified ash-flow tuff. Crystal-rich ash-flow tuff. Crystal-rich with 20% quartz, sanidine and oxide crystals. Pumice-bearing with 10–15% oxidized and devitrified, brown pumice fragments up to 10 mm in diameter, in a shardy matrix.	Unweathered Qbt 4	Sample interval is 7' – 8.5' bgs.
9						
10						
11	5/5					
12		PID= 0.0 α= 0 β/γ= 292	RE49-11-9804	SAA		Sample interval is 11.5' – 13' bgs.
13						
14						
15						
16	5/5					
17		PID= 0.0 α= 21 β/γ= 282	RE49-11-9805 RE49-11-9812 RE49-11-9813	SAA		Sample interval is 16' – 17.5' bgs. FD of RE49-11-9805 FR of RE49-11-9805
18						
19						
20						TD at 20' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 49-614315	**TA:** 49	**Drill Depth:** 35 ft	**Total Pages:** 1 of 2
Drillers: M. Cain and K. Kayser		**Start Date:** 4/29/2011	**End Date:** 4/29/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and G. WoldeGabriel (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 40 dpm	**β/γ=** 1511 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 3.5' bgs Dark brown, organic-rich (plant and root fragments), clay-rich with silt to pebble-size clasts.	Soil	
2						
3						
4				**Soil:** 3.5 – 6.25' bgs Clay-rich soil and weathered tuff fragments.		
5						
6	5/5					Contact of soil and Qbt 4 is at 6.25' bgs.
7				**Weathered Tuff:** 6.25' – 7' bgs AFT: Pale-purple to gray ash-flow tuff. Crystal-rich, with 20–30% quartz, sanidine, oxide crystals and crystal-clots; 5–10% oxidized and devitrified, brown to red pumice fragments up to 10 mm in diameter, in an ash matrix. Clay-filled fractures are present.	Weathered Qbt 4	
8						
9						
10						
11	5/5					
12						
13						
14						
15						
16	5/5					
17						
18						
19						
20						

TA-49 Qbt 4 Background Study			
Borehole ID: 49-614315	**TA:** 49	**Drill Depth:** 35 ft	**Total Pages:** 2 of 2
Drillers: M. Cain and K. Kayser		**Start Date:** 4/29/2011	**End Date:** 4/29/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and G. WoldeGabriel (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 40 dpm	**β/γ=** 1511 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
	5/5				Weathered Qbt 4	
21						
22						
23						
34						
25						Top of unweathered tuff is at 25' bgs.
	5/5	PID= 0.0	RE49-11-9806	**Unit 4 of the Tshirege Member of the**	Unweathered Qbt 4	Sample interval is 25' – 26' bgs.
26		α= 19		**Bandelier Tuff:**		
		β/γ= 860		AFT: Pale-purple to gray (5YR 6/2) ash-flow tuff. Crystal-rich,		
27				with 20–30% quartz, sanidine, oxide crystals; 5% crystal-clots;		
				5–10% oxidized and devitrified, brown pumice		
28				fragments up to 10 mm in diameter, in an ash matrix.		
29						
30		PID= 0.0	RE49-11-9807	SAA		Sample interval is 29.5' – 30.5' bgs.
	5/5	α= 19				
31		β/γ= 760				
32						
33						
34						
		PID= 0.0	RE49-11-9808	SAA		Sample interval is 34' – 35' bgs.
35		α= 7				TD at 35' bgs.
		β/γ= 830				
36						
37						
38						
39						
40						

TA-49 Qbt 4 Background Study				
Borehole ID: 49-614395	**TA:** 49	**Drill Depth:** 15 ft		**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 5/02/2011		**End Date:** 5/02/2011
Drilling Equipment/Method: CME 85 Auger Rig				
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler			**Logged By:** S. Muggleton (TPMC) and G. WoldeGabriel (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 40 dpm	**β/γ=** 1511 dpm	

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 0.9' bgs dark brown, organic-rich (root fragments), pumice-rich (El Cajete) with some clay.	Soil	
2				0 .9 – 1.6' bgs medium brown, with silt, sand size subrounded clasts and pumice fragments.	Soil	Contact of soil and Qbt 4 is at 1.6' bgs. Top of unweathered tuff is at 2.2' bgs.
3		PID= 0.0 α= 0 β/γ= 800	RE49-11-9809	**Unit 4 of the Tshirege Member of the Bandelier Tuff:**	Unweathered Qbt 4	Sample interval is 2.2' – 3.2' bgs.
4				AFT: Pale purple to gray (5YR 6/2), partly to moderately welded ash-flow tuff. Crystal-rich, with 20% quartz, sanidine, oxide crystals and devitirfied		
5				crystal clots, in an ash matrix. Pumice-bearing with		
6	5/5			10–15% oxidized and devitrified, red-brown pumice fragments up to 20 mm in diameter.		
7		PID= 0.0 α= 0 β/γ= 1200	RE49-11-9810	SAA		Sample interval is 6.7' – 7.7' bgs.
8						
9						
10						
11	5/5					
12		PID= 0.0 α= 0 β/γ= 470	RE49-11-9811	SAA		Sample interval is 11.2' – 12.2' bgs.
13						
14						
15						TD at 15' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 58-614316	**TA:** 58	**Drill Depth:** 20 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 4/28/2011	**End Date:** 4/28/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC) and S. Levy (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 18 dpm	**β/γ=** 1958 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	5/5			**Soil:** 0 – 1' bgs: Organic-rich (plant and large root fragments)	Soil	
2				with sand and silt-size subrounded clasts. **Qc (colluvium):** 1 – 2' bgs:	Qc	
3				Clay-rich weathered vitric ash-flow tuff fragments. **Qoal (older alluvuim):** 2 – 3.4' bgs:	Qoal	
4				Tuffaceous sandstone, poorly indurated. Reworked, well-sorted, pumice-rich, sand-size,		
5				slope wash (possible channel-fill). **Weathered Tuff:** 3.4' – 7' bgs:	Weathered Qbt 4	Contact of soil and Qbt 4 is at 3.4' bgs.
6	5/5			Partly welded, very oxidized, clay-rich, poorly indurated ash-flow tuff.		
7						Top of unweathered tuff is at 7' bgs.
8		PID= 0.0 α= 31	RE58-11-981	**Unit 4 of the Tshirege Member of the Bandelier Tuff:**	Unweathered Qbt 4	Sample interval is 7' – 8.5' bgs.
9		β/γ= 192		AFT: Yellow-gray to pale-pink (7.5YR 7/2), partly welded, devitrified ash-flow tuff. Crystal-rich, with		
10				20% quartz, sanidine and oxides crystals, in a shardy matrix. Pumice-bearing, with 10-15%		
11	5/5			oxidized and devitrified, brown pumice fragments up to 10 mm in diameter.		
12		PID= 0.0	RE58-11-981	**SAA**		Sample interval is 11.5' – 13' bgs.
13		α= 26 β/γ= 471				
14						
15						
16	5/5					
17		PID= 0.0 α= 35	RE58-11-981	**SAA**		Sample interval is 16' – 17.5' bgs.
18		β/γ= 619				
19						
20						TD at 20' bgs.

TA-49 Qbt 4 Background Study			
Borehole ID: 67-614317	**TA:** 67	**Drill Depth:** 20 ft	**Total Pages:** 1 of 1
Drillers: M. Cain and K. Kayser		**Start Date:** 5/02/2011	**End Date:** 5/02/2011
Drilling Equipment/Method: CME 85 Auger Rig			
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler		**Logged By:** S. Muggleton (TPMC), G. WoldeGabriel and S. Levy (LANL)	
Background Values:	**PID=** 0.0 ppm	**α=** 40 dpm	**β/γ=** 1511 dpm

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
1	X				X	
2	4/5			**Soil:** 1 – 3.5' bgs medium brown, organic-rich (plant and root fragments), with silt and sand size	Soil	
3				subrounded clasts, including pumice fragments. 3.5– 4.7' bgs weathered tuff fragments with silt		
4				and sand size clasts of subrounded detritus. Minor clay, and powdery calcite coating present.		
5				**Weathered Tuff:** 4.7' – 6.5' bgs fractured with roots, minor powdery calcite, clay and brownish oxidation.		Contact of soil and Qbt 4 is at 4.7' bgs.
6	5/5				Weathered Qbt 4	
7		PID= 0.0 α= 19	RE67-11-9817	**Unit 4 of the Tschirege Member of the Bandelier Tuff:**	Unweathered Qbt 4	Top of unweathered tuff is at 6.5' bgs. Sample interval is 6.5' – 7.5' bgs.
8		β/γ= 1000		AFT: Pale-purple to gray (5YR 6/2), poorly to partly welded, devitrified ash-flow tuff. Crystal-rich, with 20%		
9				quartz, sanidine, oxide crystals and crystal clots, in an ash matrix. Pumice-bearing with 10% oxidized and devitrified,		
10				brown pumice fragments up to 10 mm in diameter.		
11	5/5	PID= 0.0 α= 49	RE67-11-9818	**SAA:** partly to moderately welded.		Sample interval is 10' – 11' bgs. **Note:** The above sample was collected
12		β/γ= 1000		**Weathered Tuff:** 11.5' – 13.3' bgs		at 10' – 11' bgs instead of 11' – 12' bgs because of the presence of a
13						weathered tuff and surge bed interval.
14				**Surge bed:** 13.3' – 15' bgs		
15						
16	5/5	PID= 0.0	RE67-11-9819	**SAA. P**oorly to partly welded.		Sample interval is 15.5' – 16.5' bgs.
17		α= 25 β/γ= 1150				
18						
19						
20						TD at 20' bgs.

TA-49 Qbt 4 Background Study						
Borehole ID: 69-614302	**TA:** 69		**Drill Depth:** 20 ft		**Total Pages:** 1 of 1	
Drillers: M. Cain and K. Kayser			**Start Date:** 4/28/2011		**End Date:** 4/28/2011	
Drilling Equipment/Method: CME 85 Auger Rig						
Sampling Equipment: 3" ID 5' Length Split Core-Barrel Sampler				**Logged By:** S. Muggleton (TPMC) and S. Levy (LANL)		
Background Values:	**PID=** 0.0 ppm		**α=** 18 dpm	**β/γ=** 1958 dpm		

DEPTH (ft bgs)	RECOVERY (ft/ft)	FIELD SCREENING RESULTS:	SAMPLE ID	LITHOLOGICAL DESCRIPTION	LITHOLOGICAL UNIT	NOTES
	5/5			**Soil:** 0 – 1.5' bgs organic-rich (plant and	Soil	
1				large root fragments) with sand, silt and clay.		
				1.5 – 2.5' bgs large clay- and root-filled fracture		
2						Contact of soil and Qbt 4 is at 2.5' bgs.
				Weathered Tuff: 2.5' – 6.1' bgs	Weathered Qbt 4	
3				AFT: Yellow/brown (5YR 7/2), partly to moderately		
				welded ash-flow tuff. Crystal-rich with 20–30% crystals		
4				of quartz, sanidine and oxides. Pumice-bearing		
				with 10–15% oxidized and devitrified, brown pumice		
5				fragments, in a devitrified and oxidized ash-matrix.		
	5/5			High-angle, clay and calcite filled fracture present.		
6						Top of unweathered tuff is at 6.1' bgs.
				Unit 4 of the Tschirege Member of the	Unweathered Qbt 4	
7				**Bandelier Tuff:**		
		PID= 0.0	RE69-11-9784	AFT: Pale-purple to gray (5YR 7/2), partly to moderately		Sample interval is 7' – 8.5' bgs.
8		α= 11		welded, devitrified ash-flow tuff. Crystal-rich, with 20–30%		
		β/γ= 470		quartz, sanidine and oxide crystals. Pumice-bearing		
9				with 10–15% oxidized and devitrified, brown pumice		
				fragments up to 10 mm in diameter, in a shardy matrix.		
10						
	5/5					
11						
12		PID= 0.0	RE69-11-9785	**SAA**		Sample interval is 11.5' – 13' bgs.
		α= 16				
13		β/γ= 203				
14						
15						
	5/5					
16						
		PID= 0.0	RE69-11-9786	**SAA.** Alteration zone from 17.0 – 17.4 bgs, with slightly		Sample interval is 16' – 18' bgs.
17		α= 11	RE69-11-9787	clay-altered pumice fragments.		FD of RE69-11-9786
		β/γ= 408	RE69-11-9788			FR of RE69-11-9786
18						
19						
20						TD at 20' bgs.

Appendix D

Investigation-Derived Waste Management

D-1.0 INTRODUCTION

This appendix describes the waste streams generated during the Qbt 4 background study. All waste generated by this project was managed in accordance with Standard Operating Procedure (SOP) 5238, Characterization and Management of Environmental Program Waste, which incorporates the requirements of all applicable U.S. Environmental Protection Agency and New Mexico Environment Department regulations, U.S. Department of Energy orders, and Los Alamos National Laboratory (the Laboratory) implementation requirements. In accordance with SOP-5238, a waste characterization strategy form (WCSF) was prepared for this investigation and is included in as Attachment D-1.

The waste streams generated during this project are summarized in Table D-1.0-1 and are described below.

D-2.0 DRILL CUTTINGS

This waste stream consists of approximately 0.5 yd^3 of soil and rock cuttings generated from the drilling of boreholes. The drill cuttings were stored in 55-gal. drums and characterized by direct sampling.

The drill cuttings met the criteria in ENV-RCRA Quality Procedure 011, Land Application of Drill Cuttings, and were land-applied in a manner pursuant to the procedure and approved by the Laboratory’s Water Quality and RCRA group (ENV-RCRA) and project management.

D-3.0 CONTACT WASTE

The contact waste stream consists of approximately 2.7 yd^3 of nitrile gloves, paper towels, empty polyethylene bags, glass and plastic sample jars, and disposable sampling supplies that were used during investigation activities.

Contact waste was characterized using acceptable knowledge based on the characterization of contaminants found in the media that the waste came in contact with. All contact waste met the Laboratory waste acceptance criteria for the “Green Is Clean Program” and was sent to Technical Area 54 (TA-54), where it was verified to be free of radioactive contamination.

Table D-1.0-1
Generation and Management of the Investigation-Derived Waste for Qbt 4 Background Study

Waste Stream	Waste Type	Volume or Weight	Storage Method	Final Disposition
Drill cuttings	Land application, nonhazardous waste	0.5 yd^3	Steel open-head drums	Land application
Contact waste	Green Is Clean, nonhazardous waste	2.7 yd^3	Steel open-head drums	Green Is Clean

Attachment D-1

Waste Characterization Strategy Form

Waste Characterization Strategy Form

Project Title	Background Concentration Study of Inorganic Chemicals and Naturally Occurring Radionuclides in Unit 4 of the Bandelier Tuff
Areas Investigated	Unit 4 of the Bandelier Tuff: TA-48, north of 2 Mile Canyon, south of NM 501; TA-69, north of Pajarito Canyon; TA-06, south of Two mile Canyon; TA-14, between Bulldog gulch and Canon de Valle; TA-67, north of the head of Three mile Canyon; TA-16, between Water Canyon and NM 4, east of NM 501; TA-49, western boundary, south of Water Canyon; TA-49, west of NES.
Activity Type	Sampling
TPMC Task Manager	Pattie C. Baucom
Waste Management Coordinator	Michael Le Scouarnec
Completed by	Jocelyn Buckley
Date	April 4, 2011

1.0 Description of Activity

The work will be performed in accordance with the New Mexico Environment Department (NMED)-approved Investigation Work Plan, *Work Plan for Determining Background Concentrations of Inorganic Chemicals in Unit 4 of the Bandelier Tuff* and EXHIBIT "D" Scope of Work under Subcontract No. 75676-001-09.

This waste characterization strategy form (WCSF) describes the management of investigation-derived waste (IDW) that is expected to be generated during site sampling activities throughout Unit 4 (Qbt 4) of the Bandelier Tuff. The IDW may include, but is not limited to, drill cuttings, contact waste, decontamination fluids (potential), municipal solid waste, and petroleum-contaminated soils (potential).

2.0 Relevant Site History and Description

Los Alamos National Laboratory (the Laboratory) uses background values (BVs) for inorganic chemicals and naturally occurring radionuclides to determine the extent of potential releases and to identify chemicals of potential concern when conducting environmental investigations. The BVs currently used by LANL were determined from statistical analysis of background data sets for soil, sediment, and rock units. Data from recent investigations of SWMUs and AOCs at TA-49 indicated the BVs used for cooling unit 4 of the Tshirege Member of the Bandelier Tuff (Qbt 4) may not be representative of background for this unit. The BVs used for Qbt 4 are composite values based on pooled background data from cooling units 2 and 3 (Qbt 2 and Qbt 3) and Qbt 4. The investigation results from TA-49, which had a high number of Qbt 4 samples, indicated that the composite BVs for Qbt 2, Qbt 3, and Qbt 4 (designated as Qbt 2,3,4) may be lower than the actual background concentrations for many inorganic chemicals in Qbt 4. In the response to the notice of disapproval for the investigation report for TA-49 sites outside the nuclear environmental site (NES), LANL indicated it would conduct a background study for Qbt 4. In the approval with modifications for this response, the NMED directed LANL to submit a work plan to determine background concentrations of inorganic chemicals in Qbt 4.

This WCSF implements the Investigation Derived Waste (IDW) waste management requirements as outlined in the NMED-approved Work Plan for determining background concentrations of inorganic chemicals and naturally occurring radionuclides in Qbt 4.

3.0 Characterization Strategy

This WCSF identifies the types of wastes expected, based on historical knowledge of the sites; however, other types of wastes may be encountered. An amendment to this strategy form will be prepared and submitted for review and approval if any of the waste streams change in description or characterization approach or a new waste stream is generated. All IDW will be managed in accordance with Los Alamos National Laboratory (LANL) Standard Operating Procedure (SOP) 5238, *Characterization and Management of Environmental Program Waste.*

Based upon historical knowledge of the areas being investigated in the background study, waste will initially be managed as non-hazardous. If analytical data indicates potentially listed constituents in the waste sample that is above LANL current background values, a due diligence evaluation will be conducted to determine the source of the contamination. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the type waste and its regulatory classification. Immediately following containerization, each waste container will be individually labeled with a unique identification number and with information such as waste classification, contents, radioactivity, and date generated, if applicable. A non-hazardous waste label, date of generation, the generator's name, container contents, and waste generating location (i.e., Qbt 4-BG-1, Qbt 4-BG-2, Qbt 4-BG-3, etc.) will be placed on non-hazardous waste containers as a best management practice.

IDW characterization will be completed by direct sampling of the IDW, with the exception of contact waste. The IDW will be sampled within 10 days of generation, and a 21 day turnaround time for analyses will be requested. Samples must be collected using the methods described in this WCSF by trained and qualified sampling personnel. Sampling personnel must record waste sampling information in accordance with LANL's procedure, EP-ERSS-SOP-5058, *Sample Control and Field Documentation* and EP-ERSS-SOP-5181, *Documentation of Waste and Environmental Technical Field Activities.*

A waste determination will be made within 45 days of the generation date of waste. For waste destined to TA-54, a Waste Acceptance Criteria (WAC) exception form (WEF) can be used if the generator does not meet the 45 day deadline. The generation of no path forward wastes must be approved by Department of Energy (DOE) prior to generation of the waste; however, no such wastes are anticipated for this project.

If documentation exist that the contaminant(s) originated from a listed source, which is not anticipated based upon historical knowledge, but the levels are below residential screening levels and the land disposal restriction treatment standards, a "contained-in" request may be submitted to the New Mexico Environment Department (NMED), who may approve removing the listings from the waste stream. A request to submit a "contained-in" determination to NMED must be submitted to Environmental Protection (ENV-RCRA) through the Subcontract Technical Representative (STR) within 70 days of generating the waste. A copy of any due diligence reviews, if applicable, or the NMED "contained-in" approval letter should accompany all waste profiles prepared for the waste(s) with potentially listed contaminants.

Sampling activities will be conducted in a manner that minimizes the generation of waste. Waste minimization will be accomplished by implementing the most recent version of the "Los Alamos National Laboratory Hazardous Waste Minimization Report." Waste streams will be recycled/reused, as appropriate.

3.1 Waste # 1: Contact Waste

This waste stream includes personnel protective equipment (PPE), contaminated sampling supplies, and dry decontamination waste that may have come in contact with contaminated environmental media and cannot be decontaminated. This includes, but is not limited to plastic sheeting (e.g., tarps and liners), gloves, coveralls (e.g. Tyvek), booties, paper towels, plastic and glass sample bottles, and disposable sampling supplies. Approximately 1 yd^3 of contact waste are expected to be generated.

Anticipated Regulatory Status: Industrial (Green is Clean (GIC))

Characterization Approach: Contact waste will be characterized using AK based on data from the media with which they came into contact, as follows:

- If generated during drilling, data from the associated drill cuttings will be used.
- If generated during hand augering, associated investigation sample data will be used.
- If generated during excavations, data from the associated excavated environmental media will be used.

All contact waste will be inspected before being placed in containers to determine if environmental media or staining is present, indicating contamination. If staining is present, an estimate of the portion or percentage of the item stained will be recorded. Results from the analytical data will be weighted by the extent of contamination for determining whether wastes are characteristic.

Storage and Disposal Method: The contact waste will be separately containerized in LANL-approved, clearly marked GIC containers and may be placed into the same container as the media with which it is contaminated. The contact waste will initially be managed as GIC and stored securely in designated areas. If analytical data changes the waste classification, the waste will be stored in an area appropriate for the type of waste. Contact waste will be disposed of via the LANL GIC Program.

3.2 Waste # 2: Drill Cuttings (IDW)

This waste stream consists of soil and rock cuttings generated from the drilling of boreholes. This may include small chips or unused core samples collected with a hollow-stem auger core barrel. Drill cuttings may include excess core samples not submitted for analysis and any returned drill cutting samples. Drill cuttings may be land applied if they meet the criteria in Quality Procedure QP-011, *Land Application of Drill Cuttings*. Approximately 1 yd^3 of drill cuttings are expected to be generated.

Anticipated Regulatory Status: Industrial (Land Application)

Characterization Approach: The drill cuttings will be characterized by direct sampling of the containerized cuttings. Cuttings will be sampled within 10 days of generation and submitted for analysis with a 21 day turnaround time. If a hand auger or thin-wall tube sampler is used to collect a representative sample, both will be used in accordance with LANL SOP-06.10, *Hand Auger and Thin-Wall Tube Sampler* to collect waste material from each container, augering from the surface to the bottom of the waste in a sufficient number of locations to obtain a representative sample. Samples will be analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total metals, total cyanide, nitrate, nitrite, perchlorate (if the area is potentially contaminated with high explosives), and toxicity characteristic (TCLP) metals, if needed (see Table 3.0). If process knowledge, odors, or staining indicate the cuttings may be contaminated with petroleum products, the materials will also be analyzed for total petroleum hydrocarbons (TPH [DRO/GRO]) and polychlorinated biphenyls (PCBs). Other constituents may be analyzed as necessary to meet the WAC for a receiving facility.

Storage and Disposal Method: Drill cuttings will be containerized at the point of generation in LANL approved containers appropriate for the quantity of waste generated and moved to a central location upon completion of project activities. Waste will initially be managed as non-hazardous and stored securely in designated areas. Drill cuttings from different sampling locations will not be combined before sampling. If container sizes are small, the representative sample may be collected from more than one container (e.g., one sample for every 20 cy^3 generated from a single sampling location). If analytical data changes the waste classification (e.g., PCB waste), the waste will be stored in an area appropriate for the type of waste. Cuttings may be land applied if they meet the criteria of the NMED-approved NOI decision tree for land application. Land application will be conducted in accordance with ENV-RCRA-QP-011, *Land Application of Drill Cuttings*. Drill cuttings that cannot be land applied, although none is expected, will be treated and/or disposed of at authorized off-site facilities appropriate for the waste classification.

3.3 Waste #3: Decontamination Fluids (potential)

The decontamination fluids waste stream will consist of liquid wastes generated from decontamination of excavation, sampling and drilling equipment. Consistent with waste minimization practices, the Laboratory employs dry decontamination methods to the extent possible. If dry decontamination cannot be performed, liquid decontamination wastes will be collected in appropriate containers at the point of generation. Less than 55 gal of decontamination fluids are expected to be generated.

Anticipated Regulatory Status: Industrial (Destined to RLWTF or SWWS)

Characterization Approach: All drilling equipment and tooling will be steam-cleaned by the drilling subcontractor prior to arriving onsite. If tooling appears unclean or odors are detected, the equipment must be steam-clean onsite in accordance with EP-ERSS-SOP-5061, *Field Decontamination of Equipment* or an approved equivalent procedure. The rinsate must be separately collected and sampled (do not mix with any other decontamination fluids).

Decontamination fluids will be characterized based upon the AK of the media with which it came into contact and/or using the analytical results obtained from direct sampling. Samples, if needed to meet a disposal facility WAC or due to poor AK, will be collected in accordance with LANL SOP-06.15, *COLIWASA Sampler for Liquids and Slurries* or subcontractor equivalent procedure. If the SOP is not used, the type of sampling equipment and methods used will be consistent with EPA 530-D-02-002 (http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/rwsdtg.pdf). A representative sample will be taken within 10 days of generation (i.e., date of initial placement into container) so that a waste determination can be made within 45 days of generation and wastes disposed within 90 days, if necessary. All samples will be submitted with a 21-day turnaround time for analyses. Multiple sampling events may be required to ensure WAC requirements are met. If the fluids cannot be treated on-site, they may be solidified for disposal off-site. The Material Safety Data Sheet (MSDS) for any absorbent used for solidification will be used as AK for waste characterization.

Samples will at a minimum be analyzed for TAL metals; radionuclides (by alpha and gamma spectroscopy); isotopic uranium, isotopic plutonium, americium-241, tritium, and strontium-90; VOCs; SVOCs; oil/grease; TSS; pH; explosive compounds; PCB; cyanide; nitrates/nitrites; perchlorates; fluoride; chlorine; sulfate; and pesticides/herbicides. Other constituents may be analyzed as necessary to meet the WAC of the disposal facility.

Sampling personnel must record sampling information in accordance with EP-ERSS-SOP-5058 and EP-ERSS-SOP-5181. The Field notebook or sample collection sheet must be used to document sample collection activities (e.g., equipment and sampling methods used, number and location of samples, etc.). Sampling personnel must also record filed conditions, problems encountered, local sources of contamination (e.g., operating generators or vehicles), the personnel involved, equipment and supplies used, waste generated, and field observations.

Storage and Disposal Method: Decontamination fluids will be collected in appropriate containers at the point of generation and stored securely in designated areas. Wastes will initially be managed as non-hazardous. If analytical data changes the waste classification (e.g., PCB wastes), the waste will be stored in an area appropriate for the type of waste. It is expected that the decontamination fluids will be treated on-site at TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF), or the Sanitary Waste Water System (SWWS). If the waste cannot be disposed of at either of these facilities, due to operational limitations or inability to meet the WAC, it will be sent to an authorized off-site facility for disposal. If solidification of decontamination fluids is required for disposal, it may be solidified using an approved absorbent. Solidification activities must be reviewed by the ENV-RCRA before being conducted.

3.4 Waste #4: Municipal Solid Waste (MSW)

This waste stream primarily consists of non- contact trash including, but not limited to paper, cardboard, wood, plastic, food and beverage containers, empty solution containers, but may also include commercial solid wastes which are derived from project activities. It is estimated that less than 1 yd^3 of MSW will be generated, but may change if vegetation removal is required.

Anticipated Regulatory Status: MSW

Characterization Approach: MSW will be characterized based on acceptable knowledge (AK) of the waste materials (including MSDS) and methods of generation.

Management and Disposal Method: MSW will be segregated from all other waste streams and managed in approved containers. It is anticipated that the waste will be stored in plastic trash bags or other appropriate containers and disposed of at the County of Los Alamos Transfer Station or other authorized solid waste landfill.

3.5 Waste #5: Petroleum Contaminated Soils (PCS) (potential)

PCS may be generated from releases of products such as hydraulic fluid, motor oil, unleaded gasoline, or diesel fuel (e.g. from the rupture of hydraulic or fuel hoses, or spills during maintenance or filling equipment) onto soil. PCS created by legacy contamination may also be encountered during investigations. Absorbent padding, paper towels, spill pillows or other absorbent material used to contain the released material may be added to the PCS waste for storage and disposal. It is estimated that less than 1 yd^3 of PCS will be generated.

Anticipated Regulatory Status: NMSW, Industrial, PCB

Characterization Approach: The contaminated soil may either be sampled in-place (by gridding the spill location and collecting and combining incremental samples into one sample) or after containerization in accordance with LANL SOP-06.10, *Hand Auger and Thin-Wall Tube Sampler*. If the spill is shallow (in-place sampling) or containers are small, Spade and Scoop Method for Collection of Soil Samples (LANL SOP-06.09) may also be appropriate. If the spill is new, it must be immediately reported to ENV-RCRA and the contaminated material must be containerized the same day it is spilled unless permission is received from ENV-RCRA to leave it longer (generally only granted for large spills). Representative samples of containerized waste will be collected within 10 days of generation and submitted for analysis with a 21 day turnaround time. Samples will be analyzed at a minimum for VOCs, SVOCs, TPH (DRO/GRO), and total metals (see Table 3.0). HE, perchlorates, nitrate, and total cyanide will be analyzed only if analysis of these constituents is required by the work plan for the contaminated area. If legacy petroleum contamination is present, the soils will also be analyzed for PCBs. Other constituents may be analyzed as necessary to meet the WAC for a receiving facility.

Storage and Disposal Method: PCS will be stored in clearly marked and appropriately constructed waste accumulation areas. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the most restrictive waste classification appropriate to the area where the spill occurred. If the PCS is suspect or known hazardous or MLLW, it will initially be managed in a registered hazardous waste accumulation area pending analysis. All PCS will be treated and/or disposed of, at an authorized off-site facility appropriate for the waste classification.

4.0 References

LANL (Los Alamos National Laboratory), December 2010. "Work Plan for Determining Background Concentraions of Inorganic Chemicals in Unit 4 of the Bandelier Tuff," Los Alamos, New Mexico. (LANL 2010, LA-UR-10-8111)

TABLE 3.0 - CHARACTERIZATION TABLE

NOTE: Multiple sampling may be required to ensure WAC requirements are met.

Waste Description	Waste # 1 Contact Waste	Waste #2 Drill cuttings	Waste #3 Decontamination Fluids	Waste #4 Municipal Solid Waste	Waste #5 Petroleum Contaminated Soils
Estimated Volume	1 CY	1 CY	<55 gal	<1 CY	<1 CY
Packaging	Approved Container	Approved Container	Approved Container	Approved Container	Approved Container
Regulatory Classification					
Radioactive Waste	—	—	—	—	—
Municipal Solid Waste (MSW)	—	—	—	X	—
Waste destined for LANL's SWWS or RLWTF[1]	—	—	X	—	—
Hazardous Waste	—	—	—	—	—
Mixed (hazardous and radioactive) Waste	—	—	—	—	—
Beryllium	—	—	—	—	—
Polychlorinated Biphenyls-Contaminated Waste	—	—	—	—	X
New Mexico Special Waste (NMSW)	—	—	—	—	X
Industrial	X	X	X	—	X
Characterization Method					
Acceptable knowledge (AK): Existing Data/Documentation	X	—	X	X	—
AK: Site Characterization	X	—	X	—	—
Direct Sampling of Waste	—	X	X	—	X
Analytical Testing					
Volatile Organic Compounds (EPA 8260-B)	—	X	X	—	X
Semi volatile Organic Compounds (EPA 8270-C)	—	X	X	—	X
Organic Pesticides (EPA 8081-A)	—	—	X	—	—
Organic Herbicides (EPA 8151-A)	—	—	X	—	—
PCBs (EPA 8082)	—	X[4]	X	—	X
Total Metals (EPA 6010-B/7471-A or EPA 6020)	—	X	X	—	X
Total Cyanide (EPA 9012-A)	—	X	X	—	X[4]
Nitrates/Nitrites (EPA 300.09-soil or 343.2-water)	—	X	X[1,4]	—	X[4]
Dioxins/Furans (EPA 1613 B)	—	—	—	—	—
Oil/Grease (EPA 1665)	—	—	X[1]	—	—
Fluoride, Chlorine, Sulfate (EPA 300)	—	—	X[1]	—	—
TTO (EPA 8260-B and EPA 8270-C)[2]	Request VOCs and SVOCs above				
Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) (EPA 160.1 and 160.2)	—	—	X[1]	—	—
Chemical Oxygen Demand (COD) (EPA 410.4)	—	—	X[1]	—	—
pH (EPA 904c)	—	—	X[1]	—	—
Microtox or Biological Oxygen Demand (BOD)[3]	—	—	X[1]	—	—
Perchlorates	—	X	X[4]	—	—
High Explosives Constituents (EPA 8330/8321-A)	—	—	X[4]	—	—
Asbestos	—	—	—	—	—
Tot. pet. hydrocarbon (TPH)-GRO (EPA 8015-M) TPH-DRO (EPA-8015-M)	—	X[4]	X[4]	—	X
Toxicity characteristic leaching procedure (TCLP) Metals (EPA 1311/6010-B)	—	X[4]	X[4]	—	X[4]
TCLP Organics (EPA 1311/8260-B & 1311/8270-C)	—	—	—	—	—
TCLP Pest. & Herb. (EPA 1311/8081-A/1311/8151-A)	—	—	—	—	—
Gross Alpha (alpha counting) (EPA 900)	—	—	X	—	X[4]
Gross Beta (beta counting) (EPA 900)	—	—	X	—	X[4]
Tritium (liquid scintillation) (EPA 906.0)	—	—	X	—	X[4]
Gamma spectroscopy (EPA 901.1)	—	—	X	—	X[4]
Isotopic plutonium (chem. separation/alpha spec.) (HASL-300)	—	—	X	—	X[4]
Isotopic uranium (chem. separation/alpha spec.) (HASL-300)	—	—	X	—	X[4]
Total uranium (6020 inductively coupled plasma mass spectroscopy [ICPMS])	—	—	X	—	X[4]
Strontium-90 (EPA 905)	—	—	X	—	X[4]
Americium-241 (Separation/alpha spec.) (HASL-300)	—	—	X	—	X[4]
Isotopic thorium	—	—	X	—	X[4]

[1]in addition to other analytes needed to characterize the waste (e.g., VOC, SVOC, total metals), analyze for TSS, TDS, Oil and Grease, gross alpha, gross beta, tritium, and pH for liquids destined for the LANL sanitary waste water system (SWWS). For wastes destined for the RLWTF additional constituents include TTO,TSS, COD, pH, total nitrates/nitrites, and gross alpha, gross beta (not including tritium), and gross gamma **or** the sum of individual alpha-, beta-, and gamma-emitting nuclides. Submit a sampling request to http://esp-esh-as01-f5.lanl.gov/~esh19/database/rfa_form.shtml .

[2]TTO is the total of volatile organic and semi-volatile organic compound contaminants. Request methods EPA 8260-B (VOCs) and EPA 8270-C (SVOCs).

[3] If Microtox analysis is not available, request BOD. Submit a sampling request to http://esp-esh-as01-f5.lanl.gov/~esh19/database/rfa_form.shtml .

[4] If needed.

Signatures	Date
Project Manager: Stephani Fuller	4/5/11
Waste Management Coordinator: Michael Le Scouarnec	4.5.11
ENV-RCRA Representative: Jocelyn Buckley	4-5-11
Waste Acceptance Representative: Andy Elicio	04/05/2011

Appendix E

Analytical Program

E-1.0 INTRODUCTION

This appendix presents (1) the analytical methods used and (2) a review of the data quality of the analytical results for the background study for unit 4 of the Bandelier Tuff (Qbt 4).

The analytical program for this investigation includes submission of samples to approved contract laboratories, with specific requirements for analytical methods, data quality, and reporting. Quality assurance (QA), quality control (QC), and data validation procedures were implemented in accordance with the requirements of the "Quality Assurance Project Plan Requirements for Sampling and Analysis" (LANL 1996, 054609) and the analytical services statement of work (SOW) for contract laboratories (LANL 2008, 109962). The results of the QA/QC activities were used to estimate the accuracy, bias, and precision of the analytical measurements. The QC samples included preparation blanks, spikes, matrix spikes (MSs), and laboratory control samples (LCSs) to assess accuracy and bias. Internal standards, surrogates, and tracers were also used to assess accuracy.

The type and frequency of QC analyses and the applicable analytical methods are described in the analytical service SOW (LANL 2008, 109962). Other QC factors, such as sample preservation and holding times, were also assessed in accordance with the requirements outlined in Standard Operating Procedure (SOP) 5056, Sample Containers and Preservation. Evaluating these QC indicators allows estimates to be made of the accuracy, bias, and precision of the analytical suites.

The following SOPs were used for data validation:

- SOP 5165, Routine Validation of Metals Analytical Data
- SOP 5166, Routine Validation of Gamma Spectroscopy, Chemical Separation Alpha Spectrometry, Gas Proportional Counting, and Liquid Scintillation Analytical Data
- SOP 5191, Routine Validation of LC/MS/MS Perchlorate Analytical Data (SW-846 EPA Method 6850)

Analytical data were reviewed and evaluated based on U.S. Environmental Protection Agency (EPA) National Functional Guidelines for inorganic and organic chemical data review where applicable (EPA 1994, 048639; EPA 1999, 066649). As a result of the data validation and assessment efforts, qualifiers may be assigned to the analytical records as appropriate. The data qualifiers used in the data validation procedures are defined in Appendix A.

E-2.0 ANALYTICAL DATA ORGANIZATION

The data sets evaluated for Qbt 4 background study included analytical results for samples collected in 2011. Only analytical data for which complete data packages and sample documentation are available are appropriate for decision-making purposes and are included in the data set(s).

E-3.0 INORGANIC CHEMICAL ANALYSES

All samples collected during the Qbt 4 background study were analyzed target analyte list (TAL) metals using EPA SW-846 Methods 6010B, 6020, and 7471A; nitrate using EPA Method 300.0; total cyanide using EPA SW-846 Method 9012A; and perchlorate using EPA SW-846 Method 6850. The analytical methods used for inorganic chemicals are listed in Table E-3.0-1.

Thirty samples (plus three field duplicates) were submitted for analysis of TAL metals, nitrate, total cyanide, and perchlorate.

All decision-level analytical data are included in Appendix F (on CD).

E-3.1 Inorganic Chemical Analyses

The use of QA/QC samples is designed to produce quantitative measures of the reliability of specific parts of an analytical procedure. The results of the QA/QC analyses performed on a sample provide confidence about whether the analyte is present and whether the concentration reported is accurate. To assess the accuracy and precision of inorganic chemical analyses, LCSs, preparation blanks, MS samples, laboratory duplicate samples, interference check samples (ICSs), and serial dilution samples were analyzed as part of the Qbt 4 background study. Each of these QA/QC sample types is defined in the analytical services SOW (LANL 2008, 109962) and is described briefly in the sections below.

The LCS serves as a monitor of the overall performance of each step during the analysis, including sample digestion. For inorganic chemicals in soil/tuff, LCS percent recoveries should fall within the lower acceptance limit (LAL) and upper acceptance limit (UAL).

The preparation blank is an analyte-free matrix to which all reagents are added in the same volumes or proportions as those used in the environmental sample processing and which is extracted and analyzed in the same manner as the corresponding environmental samples. Preparation blanks are used to measure bias and potential cross-contamination. All inorganic chemical results should be below the method detection limit (MDL).

MS samples assess the accuracy of inorganic chemical analyses. These samples are designed to provide information about the effect of the sample matrix on the sample preparation procedures and analytical technique. The MS acceptance criterion is between the LAL and UAL, inclusive for all spiked analytes.

Laboratory duplicate samples assess the precision of inorganic chemical analyses. All relative percent differences (RPDs) between the sample and laboratory duplicate should be ±35% for soil (LANL 2008, 109962).

The ICSs assess the accuracy of the analytical laboratory's interelement and background correction factors used for inductively coupled plasma emission spectroscopy. The ICS percent recovery should be between the LAL and UAL.

Serial dilution samples measure potential physical or chemical interferences and correspond to a sample dilution ratio of 1:5. The chemical concentration in the undiluted sample must be at least 50 times the MDL (100 times for inductively coupled plasma mass spectroscopy) for valid comparison. For sufficiently high concentrations, the RPD should be within 10%.

Details regarding the quality of the inorganic chemical analytical data included in the data set are summarized in the following sections.

E-3.2 Data Quality Results for Inorganic Chemicals

The majority of the analytical results are not qualified or are qualified as not detected (U) because the analytes were not detected by the respective analytical methods. These data do not have any quality issues associated with the values presented.

E-3.2.1 Chain of Custody

Chain-of-custody forms were maintained properly for all samples analyzed for inorganic chemicals (Appendix F).

E-3.2.2 Sample Documentation

All samples analyzed for inorganic chemicals were properly documented in the field in the sample collection logs (Appendix F).

E-3.2.3 Sample Dilutions

Some samples were diluted for inorganic chemical analyses. No qualifiers were applied to any inorganic chemical analytical results because of dilutions.

E-3.2.4 Sample Preservation

Preservation criteria were met for all samples analyzed for inorganic chemicals.

E-3.2.5 Holding Times

No qualifiers were applied to any inorganic chemical analytical results because holding times were exceeded.

E-3.2.6 Initial and Continuing Calibration Verifications

One total cyanide result was qualified as not detected (U) because the sample result was less than or equal to 5 times the concentration of total cyanide in the initial calibration blank/continuing calibration blank.

E-3.2.7 Interference Check Sample and/or Serial Dilutions

Interference check sample and serial dilution results were within acceptable limits for all samples analyzed for inorganic chemicals.

E-3.2.8 Method Blanks

Sixteen total cyanide results were qualified as not detected (U) because the sample results were less than or equal to 5 times the concentration of the total cyanide in the method blank.

E-3.2.9 Laboratory Duplicate Samples

No qualifiers were applied to any inorganic chemical analytical results because the RPD was greater than 35%.

E-3.2.10 Preparation Blanks

No qualifiers were applied to any inorganic chemical analytical results because sample results were less than or equal to 5 times the concentration of the related analyte in the preparation blank.

E-3.2.11 MS Samples

Seven calcium results were qualified as estimated and biased low (J-) because the MS recovery was less than the LAL but greater than 10%.

Twenty-six aluminum, calcium, and magnesium results and 13 manganese, potassium, and sodium results were qualified as estimated and biased high (J+) because the MS recovery was greater than the UAL.

E-3.2.12 LCS Recoveries

No qualifiers were applied to any inorganic chemical analytical results because LCS percent recoveries were less than the LAL but greater than 10% or greater than the UAL.

E-3.2.13 Detection Limit

A total of 49 TAL metal results were qualified as estimated (J) because the sample results were reported as detected between the instrument detection limit (IDL) and the estimated detection limit (EDL).

Seven results for perchlorate were qualified as estimated (J) because the sample results were reported as detected between the IDL and the EDL.

E-3.2.14 Rinsate Blanks

No inorganic chemical results were qualified as not detected (U) because the sample results were less than or equal to 5 times the concentration of the related analytes in the rinsate blank.

E-3.2.15 Rejected Results

No inorganic chemical results were rejected (R).

E-4.0 RADIONUCLIDE ANALYSES

Samples were analyzed for radionuclides by alpha spectroscopy (HASL-300 Methods) for isotopic thorium and isotopic uranium. All QC procedures were followed as required by the analytical laboratories SOW (LANL 2008, 109962). The methods used for analyzing radionuclides are listed in Table E-3.0-1.

A total of 30 samples (plus 3 field duplicates) were submitted for analyses of isotopic thorium and isotopic uranium.

All radionuclide results are included in Appendix F (provided on CD).

E-4.1 Radionuclide QA/QC Samples

All procedures were followed as required by the analytical services SOW (LANL 2008, 109962). To assess the accuracy and precision of radionuclide analyses, LCSs, method blanks, MS samples, laboratory duplicate samples, and tracers were analyzed. Each of these QA/QC sample types is defined in the analytical services SOW (LANL 2008, 109962) and is described briefly below.

The LCS serves as a monitor of the overall performance of each step during the analysis, including sample digestion. For radionuclides in soil/tuff, LCS percent recoveries should fall between the LAL and UAL.

Method blanks are an analyte-free matrix to which all reagents are added in the same volumes or proportions as those used in the environmental sample processing and which are analyzed in the same manner as the corresponding environmental samples. Method blanks are used to assess the potential for sample contamination during analysis. All radionuclide results should be below the minimum detectable concentration.

The MS samples assess the accuracy of radionuclide analyses. These samples are designed to provide information about the effect of the sample matrix on the sample preparation procedures and analytical technique. The MS acceptance criterion is between the LAL and UAL.

Tracers are radioisotopes added to a sample for the purposes of monitoring losses of the target analyte. The tracer is assumed to behave in the same manner as the target analytes. The tracer recoveries should fall between the LAL and UAL.

Laboratory duplicate samples assess the precision of radionuclide analyses. All RPDs between the sample and laboratory duplicate should be ±35% for soil (LANL 2008, 109962).

Details regarding the quality of the radionuclide analytical data included in the data set are summarized in the following sections.

E-4.2 Data Quality Results for Radionuclides

Some results were qualified as not detected (U) because the associated sample concentration was less than or equal to the minimum detectable concentration. This data qualification is related to detection status only, not to data quality issues.

E-4.2.1 Chain of Custody

Chain-of-custody forms were maintained properly for all samples (Appendix F).

E-4.2.2 Sample Documentation

All samples were properly documented on the sample collection logs in the field (Appendix F).

E-4.2.3 Sample Dilutions

No samples were diluted for radionuclide analyses. No qualifiers were applied to any radionuclide sample results because of dilutions.

E-4.2.4 Sample Preservation

Preservation criteria were met for all samples analyzed for radionuclides.

E-4.2.5 Holding Times

Holding-time criteria were met for all samples analyzed for radionuclides.

E-4.2.6 Method Blanks

No qualifiers were applied to any radionuclide sample results because of method blanks.

E-4.2.7 MS Samples

The MS criteria were met for all samples analyzed for radionuclides.

E-4.2.8 Tracer Recoveries

A total of three isotopic uranium results were qualified as estimated and biased low (J-) because the tracer was less than the LAL but greater than or equal to 10% recovery.

E-4.2.9 LCS Recoveries

No qualifiers were applied to any radionuclide sample results because of LCS recovery.

E-4.2.10 Laboratory Duplicate Samples Recoveries

No qualifiers were applied to any radionuclide sample results because of laboratory duplicate sample recovery.

E-4.2.11 Rejected Data

No radionuclide sample results were rejected (R).

E-5.0 REFERENCES

The following list includes all documents cited in this appendix. 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 New Mexico Environment Department 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.

EPA (U.S. Environmental Protection Agency), February 1994. "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review," EPA-540/R-94/013, Office of Emergency and Remedial Response, Washington, D.C. (EPA 1994, 048639)

EPA (U.S. Environmental Protection Agency), October 1999. "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review," EPA540/R-99/008, Office of Emergency and Remedial Response, Washington, D.C. (EPA 1999, 066649)

LANL (Los Alamos National Laboratory), March 1996. "Quality Assurance Project Plan Requirements for Sampling and Analysis," Los Alamos National Laboratory document LA-UR-96-441, Los Alamos, New Mexico. (LANL 1996, 054609)

LANL (Los Alamos National Laboratory), June 30, 2008. “Exhibit 'D' Scope of Work and Technical Specifications, Analytical Laboratory Services for General Inorganic, Organic, Radiochemical, Asbestos, Low-Level Tritium, Particle Analysis, Bioassay, Dissolved Organic Carbon Fractionation, and PCB Congeners,” Los Alamos National Laboratory document RFP No. 63639-RFP-08, Los Alamos, New Mexico. (LANL 2008, 109962)

Table E-3.0-1
Inorganic Chemical and Radionuclide Analytical Methods for Samples Collected for the Qbt 4 Background Study

Analytical Method	Analytical Description	Analytical Suite
EPA 300.0	Ion chromatography	Nitrate
EPA SW-846: 6010B	Inductively coupled plasma emission spectroscopy–atomic emission spectroscopy	Aluminum, antimony, barium, calcium, cadmium, cobalt, chromium, copper, iron, lead, magnesium, manganese, potassium, silver, sodium, vanadium, and zinc
EPA SW-846:6020	Inductively coupled plasma mass spectrometry	Arsenic, beryllium, nickel, selenium, and thallium
EPA SW-846: 9012A	Automated colorimetric/off-line distillation	Total cyanide
EPA SW-846:6850	Liquid chromatography–mass spectrometry/mass spectrometry	Perchlorate
EPA SW-846:7471A	Cold-vapor atomic absorption analysis	Mercury
HASL Method 300	Chemical separation alpha spectrometry	Isotopic thorium, isotopic uranium

Appendix F

Analytical Results and Analytical Reports
(on CD included with this document)