LA-UR-10-8111
December 2010
EP2010-0529

Work Plan for Determining Background Concentrations of Inorganic Chemicals in Unit 4 of the Bandelier Tuff

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

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EXECUTIVE SUMMARY

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 of solid waste management units and areas of concern. BVs have previously been established for various geologic units, or combinations of units, present at the Laboratory. A composite BV for the three uppermost units of the Bandelier Tuff (units 2, 3, and 4 or Qbt 2, Qbt 3, and Qbt 4) was developed for making background comparisons for samples from shallow boreholes (less than 50 ft). Recent investigations at sites having a high percentage of Qbt 4 samples indicate the composite BVs for Qbt 2, Qbt 3, and Qbt 4 are probably lower than the true background concentrations for many inorganic chemicals in Qbt 4. This condition could lead to false positives when making background comparisons.

This work plan describes activities to be performed to determine more representative BVs for inorganic chemicals and naturally occurring radionuclides in Qbt 4. Shallow subsurface samples of Qbt 4 will be collected from locations representative of areas where investigations are planned or are ongoing but are not impacted by Laboratory activities. The samples will be analyzed for inorganic chemicals, isotopic uranium, and isotopic thorium, and the data will be statistically analyzed to develop BVs specifically for Qbt 4, which augment the existing Bandelier Tuff BVs.

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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 the 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 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 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 2010, 110654.4), the Laboratory indicated 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 by December 17, 2010 (NMED 2010, 110859).

This work plan was developed in response to NMED's approval with modifications and describes the activities to be undertaken to determine background concentrations of inorganic chemicals and naturally occurring radionuclides in Qbt 4. Section 2 provides background information on the development of BVs and the need for unit-specific BVs for Qbt 4. Section 3 describes the technical approach that will be used to develop BVs for Qbt 4. Section 4 describes the specific methods to be used in implementing this technical approach, and section 5 presents a schedule for the background study. References cited in the work plan and data sources for maps are provided in section 6. Appendix A contains acronyms and abbreviations and metric conversion tables, and Appendix B is the management plan for investigation-derived waste (IDW).

2.0 BACKGROUND

2.1 Description of the Bandelier Tuff

The uppermost bedrock unit over most of the Laboratory is the Tshirege Member of the Bandelier Tuff. The Tshirege Member is a multiple-flow ignimbrite sheet that forms the prominent cliffs and mesas within the Pajarito Plateau. The Tshirege Member includes a number of cooling units and subunits that can be recognized based on differences in physical and weathering properties. In ascending order, the units of the Tshirege Member are as follows.

- The Tsankawi Pumice Bed (Qbtt) is the basal pumice fallout deposit of the Tshirege Member. It is composed of equant angular to subangular clast-supported pumice lapilli up to 2.5-in. in diameter.
- Unit 1g (Qbt 1g) is the lowermost unit in the thick ignimbrite sheet that makes up most of the Tshirege Member. Qbt 1g is a porous, nonwelded, poorly sorted vitric ignimbrite. It is poorly indurated but nonetheless forms steep cliffs because a resistant bench near the top of the unit forms a protective cap over the softer underlying tuffs.
- Unit 1v (Qbt 1v) is a series of cliff- and slope-forming outcrops composed of porous, nonwelded devitrified ignimbrite. The lower part of Qbt 1v is a resistant orange-brown colonnade tuff that forms a distinctive low cliff characterized by columnar jointing. The colonnade tuff is overlain by a distinctive white band of slope-forming tuffs.
- Qbt 2 is a distinctive, medium brown, vertical, cliff-forming unit that stands out in marked contrast to the slope-forming, lighter-colored tuffs above and below. This unit is devitrified and relatively highly welded.
- Qbt 3 is a partly to moderately welded devitrified ignimbrite. The basal part of Qbt 3 consists of a soft nonwelded tuff that forms a broad gently sloping bench on top of Qbt 2 in canyon wall exposures.
- Qbt 4 is a partly to densely welded ignimbrite characterized by small, sparse pumices and numerous intercalated surge deposits. Some of the most densely welded areas occur near the western margin of the Laboratory.

The Tshirege Member is underlain by tephra and volcaniclastic sediments of the Cerro Toledo interval (Qct), which is underlain by the Otowi Member of the Bandelier Tuff (Qbo). The Otowi Member is a nonwelded, poorly consolidated ignimbrite sheet composed of stacked ash-flow units composed of pumice lapilli supported by a matrix of ash and crystal fragments.

Bulk rock chemical compositions of Qbt 4 (based on data from borehole 49-2-700-1 at TA-49) are significantly different from other units of the Tshirege Member of the Bandelier Tuff (Stimac et al. 2002, 073391). Further, the major element abundances in Qbt 4 are more variable compared with other units of the Otowi and Tshirege Members of the Bandelier Tuff (Stimac et al. 2002, 073391). Unit Qbt 4 is less quartz-rich than other Bandelier Tuff units and shows a substantial decrease in the quartz-to-alkali feldspar ratios. Qbt 4 is also higher in aluminum, barium, calcium, chromium, iron, nickel, scandium, and titanium (Stimac et al. 2002, 073391).

2.2 Development of Current BVs for Tuff

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 then 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. Tuff sampling locations included the north wall of Los Alamos Canyon near TA-21 (two locations), the north and south walls of Mesita del Buey in

TA-54 (three locations), the north wall of Threemile Canyon in TA-15 and TA-67 (two locations), the north wall of Cañon de Valle in TA-16 (one location), and the north wall of Frijoles Canyon in Bandelier National Monument (two locations). Samples were typically collected in vertical stratigraphic sections 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. The methods used for sample preparation/extraction and analysis are summarized in Table 2.0-1.

The results of the sample analyses were divided into three groups: (1) the upper Bandelier Tuff, which consisted of units Qbt 2, Qbt 3, and Qbt 4; (2) the middle Bandelier Tuff, which consisted of unit Qbt 1v; and (3) 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.

2.3 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 BV. Specifically, 11 inorganic chemicals (aluminum, arsenic, barium, calcium, cobalt, copper, lead, manganese, nickel, selenium, and vanadium) typically exceeded the Qbt 2,3,4 BV 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 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 BV 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 BV and the maximum concentration from the background data set (LANL 2010, 110656, 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 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 TECHNICAL APPROACH

Based on the results of the 2010 investigations at TA-49, there is uncertainty in how representative the existing Qbt 2,3,4 BVs are for making background comparisons with results from analysis of the Qbt 4 samples collected at TA-49. As described in section 2.2, samples for the existing background data set were generally collected from sections along canyon walls, whereas most of the TA-49 samples were collected from shallow boreholes on the mesa top. The Qbt 4 background study proposes to collect, prepare, and analyze samples using methods that are consistent with current investigation practices, including investigations required by the Compliance Order on Consent (the Consent Order). This analysis will produce a data set that is more representative of current investigation samples.

Major elements of the technical approach are the number of samples to be collected, the locations where these samples will be collected, and statistical analysis to be performed on resulting sample data. These elements are discussed below, and specific methods for implementing this approach are discussed in section 4.0.

3.1 Number of Samples

In general, EPA guidance recommends collecting at least 8 to 10 samples to represent background concentrations (EPA 2009, 110368, p 17). This guidance also indicates that more samples are preferable. A larger data set helps to calculate statistics associated with analytes with varying detection frequencies. Based on these considerations, a sample size of 30 was selected for the Qbt 4 background study.

To test the appropriateness of this sample size, variability from the existing background data set was evaluated using the EPA's ProUCL software package, and minimum sample sizes were calculated for different statistical tests (single-sample t test, two-sample t test, single-sample Wilcoxon signed rank test, and two-sample Wilcoxon signed rank test). For the two-sided alternative hypothesis, the results of this evaluation showed approximate minimum sample sizes to range from 7 to 51, with most results less than 30. Thus, 30 samples appears to be a reasonable number to meet the objectives of the study.

3.2 Sampling Locations and Depths

The Qbt 4 background sampling locations should be representative of the entire area within the Laboratory boundary where Qbt 4 is present. Qbt 4 is present over the western half of the Laboratory; the areal distribution of Qbt 4 is shown in Figure 3.2-1. Aggregate areas investigated under the Consent Order that are partially or wholly within the area where Qbt 4 is present are identified in Table 3.2-1. As shown in Table 3.2-1, investigations are complete in only one of these aggregate areas, and this aggregate area is not on Laboratory property. Therefore, Qbt 4 background data should be of use for most or all of the planned and ongoing investigations.

Based on the target number of samples identified in section 3.1, the following sampling locations were identified (Figure 3.2-1):

1. TA-58, north of Twomile Canyon, south of NM 501
2. TA-69, north of Pajarito Canyon
3. TA-06, south of Twomile Canyon
4. TA-14, between Bulldog Gulch and Cañon de Valle
5. TA-67, north of the head of Threemile Canyon
6. TA-16, between Water Cayon and NM 4, east of NM 501
7. TA-49, western boundary, south of Water Canyon
8. TA-49, west of NES

9. TA-49, north of the head of North Ancho Canyon
10. TA-49, between Ancho Canyon and Frijoles Canyon, north of NM 4

These locations were selected to provide geographic coverage of the entire area where Qbt 4 is present at the Laboratory. Investigations of SWMUs and AOCs within aggregate areas generally involve collecting near-surface samples of soil and tuff from sites located on mesa tops. Therefore, background sampling locations were selected on mesa tops away from known sources of near-subsurface contamination. Selection of sampling locations also considered availability of access for sampling equipment. A higher concentration of sampling locations is planned near TA-49 because of the issues identified in the 2010 investigation of sites inside the NES.

To be representative of typical site investigations, samples will be collected from three depths at each location: 0 ft to 1 ft, 4.5 ft to 5.5 ft, and 9 ft to 10 ft below the top of Qbt 4, as determined by the field geologist. If the thickness of Qbt 4 at a location is less than 10 ft, sample intervals will be selected to represent the top, middle, and bottom of the unit. All samples will be submitted for laboratory analysis of TAL metals, total cyanide, nitrate, and perchlorate. Samples will also be submitted for analysis using x-ray fluorescence (XRF) to collect data to compare with historical XRF total metals analysis data for Qbt 4. Comparisons of XRF data will be made to confirm the samples were collected from Qbt 4. Additionally, samples will be analyzed for naturally occurring radionuclides (uranium and thorium isotopes) so Qbt 4–specific BVs may also be developed for these constituents. Sample preparation and analytical methods to be used are summarized in Table 3.2-2.

3.3 Statistical Evaluation of Data

As with the 1998 background study, UTLs will be calculated, when possible, for use as BVs. UTL values will be calculated for constituents that are detected at a rate greater than or equal to 25% using statistical methods described in the ProUCL technical guidance (EPA 2009, 110368). ProUCL Version 4.00.05 (EPA 2010, 109944) will be used to calculate the UTLs for all analytes and data groups.

ProUCL calculates UTLs for up to four different statistical distributions using robust methods to evaluate nondetected sample results. The following logic will be applied to select the UTL.

- If the data are normally distributed, then the normal UTL will be selected unless the analyte had any nondetects and the maximum likelihood estimate of the UTL will not be calculated. In this case, the nonparametric UTL will be selected.
- If the data are gamma-distributed, then the gamma UTL will be selected (Wilson Hilferty Approximate Gamma UTL). If there are any nondetects, then the gamma regression on order statistics substitution method will be used.
- If the data are lognormally distributed, then the lognormal UTL will be selected (95% UTL with 95% coverage). If the data contain nondetects, then the lognormal regression on order statistics substitution method will be used.
- If the data do not fit a discernable distribution, then the nonparametric UTL will be selected (95% UTL with 95% coverage). If there are any nondetects, then the Kaplan-Meier method will be used.

If the frequency of detection is less than 25%, the maximum detected value will be used as the BV.

4.0 INVESTIGATION METHODS

A summary of the investigation methods to be implemented is presented in Table 4.0-1. The standard operating procedures (SOPs) used to implement these methods are available at http://www.lanl.gov/environment/all/qa.shtml. Summaries of the field-investigation methods are provided below. Additional procedures may be added as necessary to describe and document quality-affecting activities.

4.1 Sampling Locations

Preliminary sampling locations necessary to meet the objectives of the background investigation have been identified and are shown in Figure 3.2-1. Following NMED concurrence with the proposed approach and approval of this work plan, final sampling locations will be established during a reconnaissance of actual field conditions and will be marked in the field using stakes and flagging.

4.2 Geodetic Surveys

Geodetic surveys of sampling locations will be conducted by a land surveyor in accordance with the latest version of SOP-5028, Coordinating and Evaluating Geodetic Surveys. The surveyors will use a Trimble GeoXT hand-held global positioning system (GPS) or equivalent instrument for the surveys. The coordinate values will be expressed in the New Mexico State Plane Coordinate System (transverse mercator), Central Zone, North American Datum 1983. Elevations will be reported per the National Geodetic Vertical Datum of 1929. All GPS equipment used will meet the accuracy requirements specified in SOP-5028.

4.3 Field Screening

Because sampling is being conducted in areas believed not to have been impacted by Laboratory activities, field screening will not be used to direct field-sampling activities. Instead, field screening will be conducted for health and safety purposes. The Laboratory’s proposed field-screening approach will be to (1) visually examine all samples for evidence of contamination, (2) screen for organic vapors, and (3) screen for radioactivity. If field screening indicates the site is potentially contaminated, an alternate sampling location will be selected after consulting with NMED.

4.3.1 Organic Vapors

Screening will be conducted using a photoionization detector (PID) capable of measuring quantities as low as 1 ppm. Vapor screening of subsurface core for organic vapors will be conducted using a PID equipped with an 11.7 electron volt lamp. All samples will be screened for organic vapors in headspace gas in accordance with SOP-06.33, Headspace Vapor Screening with a Photo Ionization Detector.

The PID will be calibrated daily to the manufacturer’s standard for instrument operation, and the daily calibration results will be documented in the field logbooks. All instrument background checks, background ranges, and calibration procedures will be documented daily in the field logbooks in accordance with SOP-5181, Notebook Documentation for Waste and Environmental Services Technical Field Activities.

4.3.2 Radioactivity

Radiological screening will target gross-alpha, -beta, and -gamma radiation. Field screening for alpha, beta, and gamma radiation will be conducted within 6 in. from the core material and will be performed using field instruments calibrated in accordance with the Laboratory's Health Physics Operations Group procedures. All instrument calibration activities will be documented daily in the field logbooks in accordance with SOP-5181, Notebook Documentation for Waste and Environmental Services Technical Field Activities.

4.4 Sample Collection

All samples will be collected using a split-spoon core barrel and hollow-stem auger drill rig. At each location, continuous sample core will be collected in accordance with SOP-06.26, Core Barrel Sampling for Subsurface Earth Materials to a depth sufficient to include the top 10 ft of Qbt 4. The on-site geologist will inspect the core to verify that the top 10-ft interval of Qbt 4 has been sampled or that the bottom of the Qbt 4 has been reached if the unit is less than 10 ft thick. Samples will then be collected from the core at three 1-ft-long depth intervals, as specified in section 3.2.

Field documentation will include detailed borehole logs for each borehole drilled. The borehole logs will document the matrix material in detail and will include the results of all field screening; fractures and matrix samples will be assigned unique identifiers. All field documentation will be completed in accordance with the current version of SOP-12.01, Field Logging, Handling, and Documentation of Borehole Materials.

Samples will be placed in appropriate containers in accordance with SOP-5056, Sample Containers and Preservation. Quality assurance/quality control (QA/QC) samples will be collected to monitor the validity of the sample collection procedures and will consist of field duplicate samples and equipment/rinsate blanks. These samples will be collected following the current version of SOP-5059, Field Quality Control Samples, and will comply with a frequency of 10% of total samples collected for field duplicates and rinsate blanks.

All hollow-stem auger boreholes will be abandoned in accordance with SOP-5034, Monitor Well and RFI Borehole Abandonment. Boreholes will be abandoned by filling the borehole with bentonite chips and then hydrating the chips in 1- to 2-ft lifts. The borehole will be visually inspected as the bentonite chips are added to ensure bridging does not occur. The use of backfill materials will be documented in a field logbook with respect to volumes (calculated and actual), intervals of placement, and additives used to enhance backfilling.

4.5 Chain of Custody for Samples

The collection, screening, and transport of samples will be documented on standard forms generated by the Laboratory's Sample Management Office (SMO). These include sample collection logs, chain-of-custody forms, and sample container labels. Sample collection logs will be completed at the time of sample collection and signed by the sampler and a reviewer who will verify the logs for completeness and accuracy. Corresponding labels will be initialed and applied to each sample container, and custody seals will be placed around container lids or openings. Chain-of-custody forms will be completed and signed to verify that the samples are not left unattended.

4.6 Laboratory Analytical Methods

The analytical suites for laboratory analyses are summarized in Table 3.2-2. All analytical methods are presented in the statement of work for analytical laboratories (LANL 2008, 109962). Sample collection and analysis will be coordinated with the SMO.

4.7 Health and Safety

The field investigations described in this investigation work plan will comply with all applicable requirements pertaining to worker health and safety. An integrated work document and a site-specific health and safety plan will be in place before fieldwork is performed.

4.8 Equipment Decontamination

Equipment for drilling and sampling will be decontaminated before and after drilling and sampling activities (as well as between drilling boreholes) to minimize the potential for cross-contamination. Dry decontamination methods are preferred and will be given priority because they do not generate liquid wastes. Residual material adhering to the equipment will be removed using dry decontamination methods, including wire-brushing and scraping, as described in SOP-5061, Field Decontamination of Equipment. Dry decontamination of sampling equipment may include use of a nonphosphate detergent such as Fantastik on a paper towel, and the equipment is wiped so no liquid waste is generated.

If dry decontamination methods are not effective, the equipment may be decontaminated by steam-cleaning or hot water pressure-washing, as described in SOP-5061. Wet decontamination methods will be conducted on a high-density polyethylene liner on a temporary decontamination pad. Cleaning solutions and wash water will be collected and contained for proper disposal. Decontamination solutions will be sampled and analyzed to determine the final disposition of the wastewater and the effectiveness of the decontamination procedures.

4.9 Investigation-Derived Waste

The IDW generated during field-investigation activities may include drill cuttings; contaminated personal protective equipment (PPE), sampling supplies, and plastic; fluids from the decontamination of PPE and sampling equipment; and all other waste that has potentially come into contact with contaminants.

All IDW generated during field-investigation activities will be managed in accordance with applicable SOPs that incorporate the requirements of all applicable EPA and NMED regulations, DOE orders, and Laboratory implementation requirements. Appendix B presents the IDW management plan.

5.0 SCHEDULE

Allowing for potential constraints because of winter weather, it is expected that field activities can begin in April 2011. This schedule is also expected to allow coordination with the Phase II investigation for TA-49 sites outside the NES so multiple field mobilizations are not needed. Approximately 5 mo is expected to be needed to collect field samples, perform laboratory analysis of samples, verify and validate the analytical data, perform statistical analysis of the data, and prepare a final report. The Laboratory proposes to submit the Qbt 4 background study report by September 1, 2011. As shown in Table 3.2-1, completion of the study by this date will provide Qbt 4 BVs for all planned and ongoing aggregate area investigations in areas where Qbt 4 is present, except in the Potrillo/Fence Canyons Aggregate Area.

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.

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6.2 Map Data Sources

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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.

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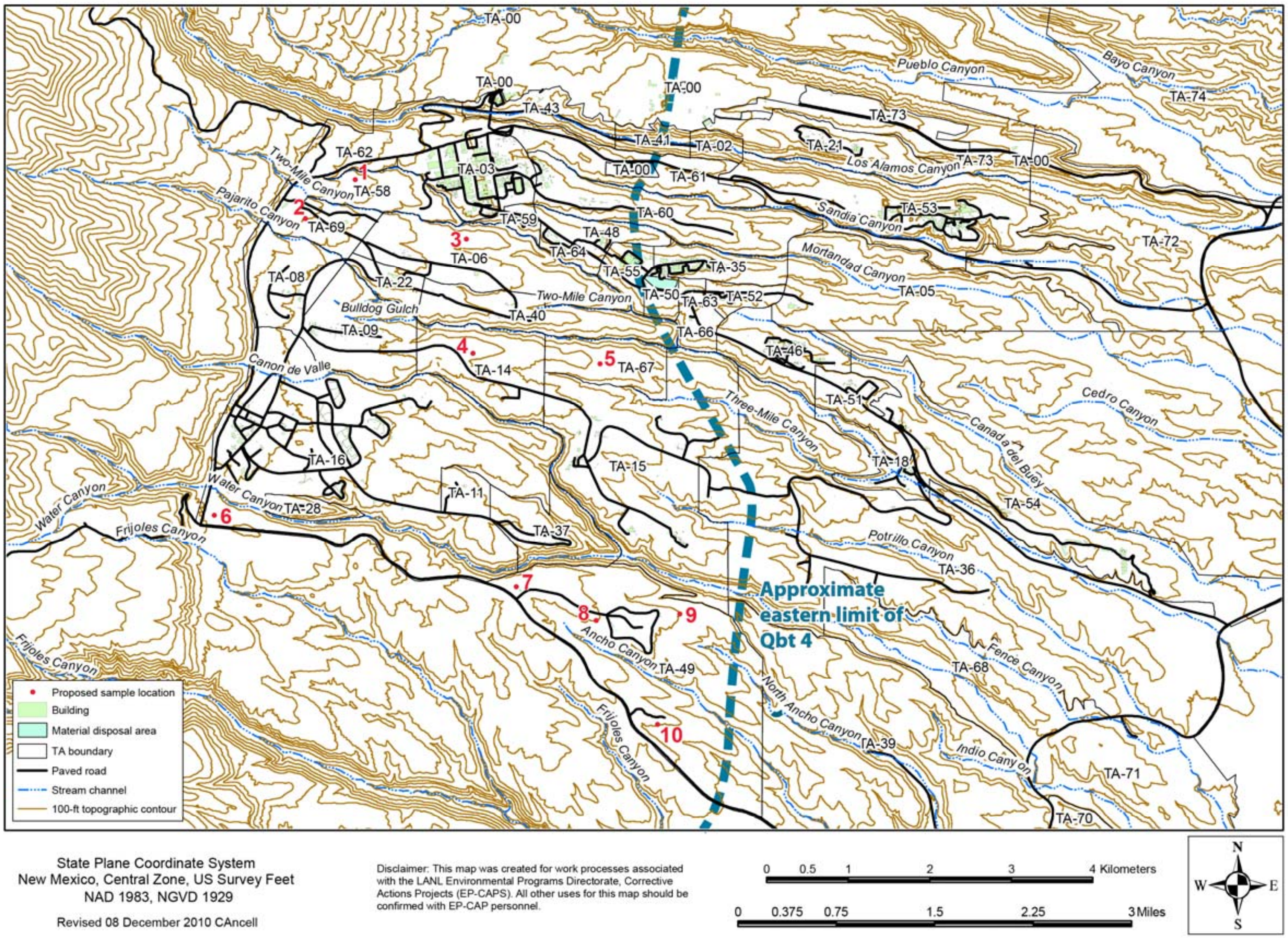

Figure 3.2-1 Extent of Qbt 4 and proposed background sampling locations

Table 2.0-1
Summary of Sample Preparation and Analysis Methods from 1998 Background Study

Analyte	Sample Preparation Method	Analytical Method
Aluminum	Acid Digestion, SW-846 3050A	ICPES[a], SW-846 6010B
Antimony	Acid Digestion, SW-846 3050A	ICPMS[b], SW-846 6020
Arsenic	Acid Digestion, SW-846 3050A	GFAA[c], SW-846 7010
Barium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Beryllium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Cadmium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Calcium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Chromium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Cobalt	Grinding	INAA[d]
Copper	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Iron	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Lead	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Magnesium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Manganese	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Mercury	Acid Digestion, SW-846 7471	CVAA[e], SW-846 7471
Nickel	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Potassium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Selenium	Acid Digestion, SW-846 3050A	GFAA, SW-846 7010
Silver	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Sodium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Tantalum	Acid Digestion, SW-846 3050A	ICPMS, SW-846 6020
Thallium	Acid Digestion, SW-846 3050A	ICPMS, SW-846 6020
Thorium	Acid Digestion, SW-846 3050A	ICPMS, SW-846 6020
Uranium	Acid Digestion, SW-846 3050A	ICPMS, SW-846 6020
Vanadium	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B
Zinc	Acid Digestion, SW-846 3050A	ICPES, SW-846 6010B

[a] ICPES = Inductively coupled plasma emission spectroscopy.
[b] ICPMS = Inductively coupled plasma mass spectrometry.
[c] GFAA = Graphite furnace atomic absorption spectroscopy.
[d] INAA = Instrumental neutron activation analysis.
[e] CVAA = Cold vapor atomic absorption spectroscopy.

Table 3.2-1
TAs and Aggregate Areas Where Qbt 4 Is Present

Aggregate Area	TAs with SWMUs and AOCs	Investigation Status
Cañon de Valle	14, 15, 16	Phase I investigation ongoing (first report due January 15, 2012)
Gauje/Barrancas/Rendija Canyons	00	Complete
Lower Water/Indio Canyons	15	Work plan not prepared (due September 30, 2012)
Potrillo/Fence Canyons	15, 36	Phase I investigation ongoing (report due May 15, 2011)
S-Site	11, 16	Phase I investigation completed (report submitted August 31, 2010), Phase II required
Starmer/Upper Pajarito Canyon	08, 09, 22, 40	Work plan submitted (September 30, 2010)
TA-49 Inside NES	49	Phase I investigation completed, Phase II required (work plan due July 1, 2011)
TA-49 Outside NES	49	Phase I investigation completed, Phase II required (work plan due February 28, 2011)
Threemile Canyon	12, 14, 15, 36	Phase I investigation completed (report submitted November 3, 2010), Phase II required
Twomile Canyon	06, 22, 40	Work plan approved, Phase I investigation pending (report due August 15, 2012)
Upper Cañada del Buey	04, 46, 52	Phase I investigation completed (report submitted November 19, 2010), Phase II required
Upper Los Alamos Canyon	00, 01, 03, 41, 43, 61	Phase I investigation completed, Phase II required (work plan submitted October 21, 2010)
Upper Mortandad Canyon	03, 48, 50, 55	Phase I investigation completed, Phase II required (work plan submitted December 6, 2010)
Upper Sandia Canyon	03, 60, 61	Phase I investigation completed, Phase II required (work plan due May 9, 2011)
Upper Water Canyon	11, 16	Work plan submitted (August 31, 2010)

Table 3.2-2
Summary of Analytical Methods

Analyte	Analytical Method
TAL metals	SW846-3050B* SW-846:6020 (all but mercury) SW-846:7471A (mercury)
Total cyanide	SW-846:9012A
Nitrate	EPA:300.0
Perchlorate	SW-846:6850
Isotopic thorium	HASL-300 alpha spectroscopy
Isotopic uranium	HASL-300 alpha spectroscopy

* Sample preparation method.

Table 4.0-1
Summary of Investigation Methods

Method	Summary
Handling, Packaging, and Shipping of Samples	Field team members seal and label samples before packing and ensure the sample containers and the containers used for transport are free of external contamination. Field team members package all samples to minimize the possibility of breakage during transport. After all environmental samples are collected, packaged, and preserved, a field team member transports the samples either to the SMO or to an SMO-approved radiation screening laboratory under chain of custody. The SMO arranges to ship samples to the analytical laboratories. The field team member must inform the SMO and/or the radiation screening laboratory coordinator when levels of radioactivity are in the action-level or limited-quantity ranges.
Sample Control and Field Documentation	The collection, screening, and transport of samples are documented on standard forms generated by the SMO. These forms include sample collection logs, chain-of-custody forms, and sample container labels. Collection logs are completed at the time of sample collection and are signed by the sampler and a reviewer who verifies the logs for completeness and accuracy. Corresponding labels are initialed and applied to each sample container, and custody seals are placed around container lids or openings. Chain-of-custody forms are completed and assigned to verify that the samples are not left unattended. Site attributes (e.g., former and proposed soil sampling locations, sediment sampling locations) are located by using a GPS. Horizontal locations will be measured to the nearest 0.5 ft. The survey results for this field event will be presented as part of the investigation report. Sample coordinates will be uploaded into the Sample Management Database.
Field Quality-Control Samples	Field quality-control samples are 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. *Equipment rinsate blank*: At a frequency of 10%; collected by rinsing sampling equipment with deionized water, which is collected in a sample container and submitted for laboratory analysis.
Field Decontamination of Drilling and Sampling Equipment	Dry decontamination is the preferred method to minimize generating liquid waste. Dry decontamination may include using a wire brush or other tool to remove soil or other material adhering to the sampling equipment, followed by using a commercial cleaning agent (nonacid, waxless cleaners) and paper wipes. Dry decontamination may be followed by wet decontamination, if necessary. Wet decontamination may include washing with a nonphosphate detergent and water, followed by a water rinse and a second rinse with deionized water. Alternatively, steam-cleaning may be used.
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 are printed on the sample collection logs provided by the SMO (size and type of container [glass, amber glass, polyethylene, preservative, etc.]). All samples are preserved by placing them in insulated containers with ice to maintain a temperature of 4°C. Other requirements such as nitric acid or other preservatives may apply to different media or analytical requests.

Table 3.0-1 (continued)

Method	Summary
Management, Characterization, and Storage of IDW	IDW is 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 complies with on- or off-site waste acceptance criteria. All stored IDW will be marked with appropriate signage and labels, as appropriate. Drummed IDW will be stored on pallets to prevent the containers from deteriorating. Generators are required to reduce the volume of waste generated as much as technically and economically feasible. Means to store, control, and transport each potential waste type and classification will be determined before field operations that generate waste begin. A waste storage area will be established before waste is generated. Waste storage areas located in controlled areas of the Laboratory will be controlled as needed to prevent inadvertent addition or management of wastes by unauthorized personnel. Each container of waste generated will be individually labeled as to waste classification, item identification number, and radioactivity (if applicable), immediately following containerization. All waste shall be segregated by classification and compatibility to prevent cross-contamination. See Appendix B for additional information.
Geodetic Surveys	This method describes the methodology for coordinating and evaluating geodetic surveys and establishing QA and QC for geodetic survey data. The procedure covers evaluating geodetic survey requirements, preparing to perform a geodetic survey, performing geodetic survey field activities, preparing geodetic survey data for QA review, performing QA review of geodetic survey data, and submitting geodetic survey data.
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 can pass through the center of the hollow-stem auger sections for collection of discrete samples from desired depths.

Appendix A

Acronyms and Abbreviations and
Metric Conversion Table

A-1.0 ACRONYMS AND ABBREVIATIONS

AK	acceptable knowledge
AOC	area of concern
bgs	below ground surface
BV	background value
COPC	chemicals of potential contamination
CVAA	cold vapor atomic absorption spectroscopy
DOE	Department of Energy (U.S.)
EPA	Environmental Protection Agency (U.S.)
GFAA	graphite furnace atomic absorption spectroscopy
GPS	global positioning system
ICPES	inductively coupled plasma emission spectroscopy
ICPMS	inductively coupled plasma mass spectrometry
IDW	investigation-derived waste
INAA	instrumental neutron activation analysis
LANL	Los Alamos National Laboratory
NES	nuclear environmental site
NMED	New Mexico Environment Department
PID	photoionization detector
PPE	personal protective equipment
QA	quality assurance
QC	quality control
RPF	Records Processing Facility
SMO	Sample Management Office
SOP	standard operating procedure
SWMU	solid waste management unit
TA	technical area
TAL	target analyte list
UTL	upper tolerance limit
XRF	x-ray fluorescence
WCSF	waste characterization strategy form

A-2.0 METRIC CONVERSION TABLE

Multiply SI (Metric) Unit	by	To Obtain U.S. 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)

Appendix B

Management Plan for Investigation-Derived Waste

B-1.0 INTRODUCTION

This appendix describes how investigation-derived waste (IDW) generated while collecting samples to determine the background concentrations of inorganic chemicals in unit 4 of the Bandelier Tuff (Qbt 4) will be managed by Los Alamos National Laboratory (the Laboratory). IDW may include, but is not limited to, drill cuttings, contact waste, decontamination fluids, and all other waste that has potentially come into contact with contamination.

B-2.0 IDW

All IDW generated during investigation activities will be managed in accordance with the current version of Standard Operating Procedure (SOP) 5238, Characterization and Management of Environmental Program Waste. This SOP incorporates the requirements of applicable U.S. Environmental Protection Agency (EPA) and New Mexico Environment Department (NMED) regulations, U.S. Department of Energy (DOE) orders, and Laboratory requirements.

The most recent version of the Laboratory’s Hazardous Waste Minimization Report will be implemented during the investigation to minimize waste generation. The Hazardous Waste Minimization Report is updated annually as a requirement of Module VIII of the Laboratory’s Hazardous Waste Facility Permit.

A waste characterization strategy form (WCSF) will be prepared and approved per requirements of SOP-5238, Characterization and Management of Environmental Program Waste. The WCSF will provide detailed information on IDW characterization methods, management, containerization, and potential volumes. IDW characterization is completed through review of investigation data and/or documentation or by direct sampling. Waste characterization may include a review of historical information and process knowledge to identify whether listed hazardous waste may be present (i.e., due diligence reviews). If low levels of listed hazardous waste are identified, a “contained in” determination may be submitted for approval to NMED.

The initial management of the waste will rely on the data from previous investigations and/or process knowledge. If new analytical data changes the expected waste category, the waste will be managed in accumulation areas appropriate to the final waste determination. Waste accumulation area postings, regulated storage duration, and inspection requirements will be based on the type of IDW and its classification. Container and storage requirements will be detailed in the WCSF and approved before the waste is generated. Table B-2.0-1 summarizes how waste is expected to be managed. The waste streams anticipated to be generated during work plan implementation are described below.

B-2.1 Drill Cuttings

This waste stream consists of soil and rock chips generated by the drilling of boreholes with the intent to sample. Drill cuttings include excess core sample not submitted for analysis and any returned samples sent for analysis. Drill cuttings will be containerized in 55-gal. drums at the point of generation.

Cuttings will be land applied if they meet the criteria in the NMED-approved Notice of Intent Decision Tree for Land Application of Investigation Derived Waste Solids from Construction of Wells and Boreholes. This waste stream will be characterized based on direct sampling of the waste and the results from core samples collected during drilling. Core samples will be analyzed for target analyte list metals, total cyanide, nitrate, perchlorate, isotopic uranium, and isotopic thorium. These data will be augmented by analyzing waste samples for volatile organic compounds and semivolatile organic compounds. Because boreholes are only being drilled at locations believed not to have been impacted by Laboratory activities, the Laboratory expects all cuttings will be land applied.

B-2.2 Contact Waste

The contact waste stream consists of potentially contaminated materials that "contacted" waste during sampling and excavation. This waste stream consists primarily of, but is not limited, to personal protective equipment such as gloves; decontamination wastes such as paper wipes; and disposable sampling supplies. Characterization of this waste stream will use acceptable knowledge (AK) of the waste materials; the methods of generation; and an analysis of the material contacted (e.g., drill cuttings). The waste will be containerized at the point of generation. Because sampling is being conducted only at locations believed not to have been impacted by Laboratory activities, the Laboratory expects all contact waste will be nonhazardous industrial waste.

B-2.3 Decontamination Fluids

This waste stream will consist of liquid wastes from decontamination activities if dry decontamination cannot be performed. Consistent with waste minimization practices, the Laboratory uses dry equipment decontamination methods to the extent possible. If dry decontamination cannot be performed, liquid decontamination wastes will be collected in containers at the point of generation. The fluids from decontaminating drilling or sampling equipment will be characterized through AK of the waste materials and the levels of contamination measured in the environmental media (e.g., the results of the associated drill cuttings). Because sampling is being conducted only at locations believed not to have been impacted by Laboratory activities, the Laboratory expects any decontamination liquid waste to be nonhazardous liquid waste that will be sent to one of the Laboratory's wastewater treatment facilities.

Table B-2.0-1
Summary of Estimated IDW Generation and Management

Waste Stream	Expected Waste Type	Expected Disposition
Drill Cuttings	Nonhazardous	Land application
Contact Waste	Industrial	Disposal at an approved off-site facility
Decontamination Fluids	Industrial	Treatment at an on-site wastewater treatment facility