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RFI Report for Field Unit 1

SWMU 3-010(a)

Environmental Restoration Project

Los Alamos National Laboratory

April 28, 1995

A Department of Energy

Environmental Cleanup Project

APR 3 0 1997

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EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act (RCRA) Facility Investigation Report describes the Phase I, voluntary corrective action (VCA), and Phase II investigations performed on the west side of building TA-3-30 within technical area (TA)-3, the main technical area at Los Alamos National Laboratory (LANL).

TA-3 contains the core of operational facilities at LANL. Included in TA-3 are the principal administration buildings, library, cafeteria, shops, warehouses, several large laboratory buildings housing diverse groups and programs, and numerous smaller buildings serving specialized functions. TA-3 is almost completely developed. Roads and large paved parking lots surround the buildings. Unpaved areas are landscaped. Approximately one-third of the area, including the Administration Building and the Chemistry and Metallurgy Research (CMR) Building , is enclosed within a security fence for controlled access. TA-3 is bounded on the north by 300-ft-deep Los Alamos Canyon and on the south by 80-ft-deep Twomile Canyon.

The investigations targeted activities associated with SWMU 3-010(a), deposition of waste vacuum pump oil, originating from a vacuum pump repair shop located in the southwest corner of building TA-3-30, the Laboratory's general warehouse.

The purpose of the RFI Phase I Investigation was to define the nature and extent of contamination suspected to be present at the site based on historical site knowledge. The purpose of the VCA was to remediate soil contamination known to be present at the site as a result of the Phase I Investigation. Finally, the purpose of the Phase II Investigation was to characterize the nature and extent of VOC contamination identified during the VCA, and to determine if further remediation was necessary to protect human health and the environment.

The results of the human health risk assessment indicate that potential noncarcinogenic health risks are below levels of concern for occupational and recreational (trail user) scenarios. In summary, the VCA was successful in removing the source term for the volatile constituents, and reducing concentrations of lead and mercury in the soil to concentrations below levels of concern, therefore SWMU 3-010(a) is recommended for no further action (NFA).

1.0 INTRODUCTION

This report presents the results of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for potential release site (PRS) 3-010(a), a former vacuum pump repair shop at technical area (TA) -3, the main technical area at Los Alamos National Laboratory (LANL). Included in this report are summaries of Phase I, voluntary corrective action (VCA), and Phase II activities at building TA-3-30; analysis approach; data assessment; risk assessment; and site-specific results, conclusions, and recommendations for PRS 3-010(a). More precisely, PRS 3-010(a) is solid waste management unit (SWMU) 3-010(a).

1.1 Background

SWMU 3-010(a) was used from 1950 to 1957 to dispose of used vacuum pump oil from the pump repair area in building TA-3-30 (Fig. 1-1). Contaminants in the oil included radionuclides and metals, particularly mercury. The disposal site is approximately 40 ft long by 15 ft wide and is located on a moderately steep hillside on the western margin of TA-3. As shown in Fig. 1.2, the site is bounded on the east by building TA-3-30, on the west by a primitive road (currently used as a recreational footpath), and on the north and south by small thickets of ponderosa pine, piñon pine, juniper, and scrub brush. A surface water drainage transects the lower quarter of the site and flows down to the eastern edge of Twomile Canyon, which drains west-southwest to the Rio Grande.

1.2 RFI Phase I Activities

Five preliminary soil and sediment samples were collected in 1992 to identify the potential contaminants of concern (PCOCs) for SWMU 3-010(a). Laboratory analysis revealed total mercury levels from 0.002 mg/kg to less than 2 mg/kg in all five samples; however, all five samples were less than 0.025 mg/L for mercury TCLP analysis. One sample also revealed total petroleum hydrocarbons (TPH) at 37 100 mg/kg. The analyte list for the 1993 Phase I sampling campaign was based on these results, which indicated that mercury was the principal contaminant of concern and that TPH was a PCOC. Detected concentrations of organic constituents, including polychlorinated biphenyls (PCBs), were below Environmental Restoration (ER) Project screening action levels (SALs), and were therefore omitted from the 1993 sampling campaign analyte list. Following the 1992 sampling, LANL and the New Mexico Environment Department (NMED) Surface Water Quality Bureau of the Water Quality Control Commission entered into an agreement to remove all mercury-contaminated soils to a concentration of 20 ppm and TPH-contaminated soils to a concentration of 100 ppm.

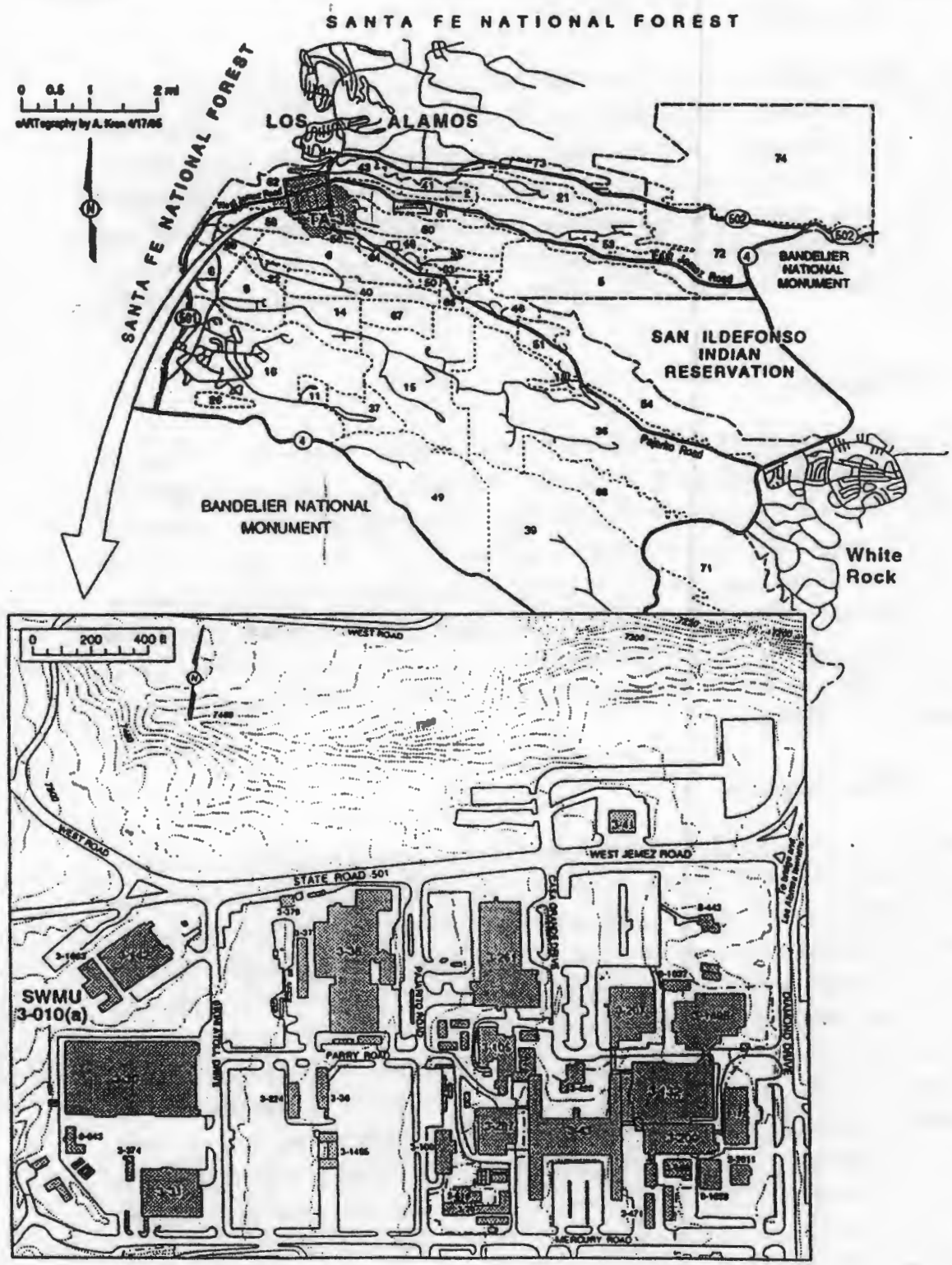

Fig. 1-1. Site location map.

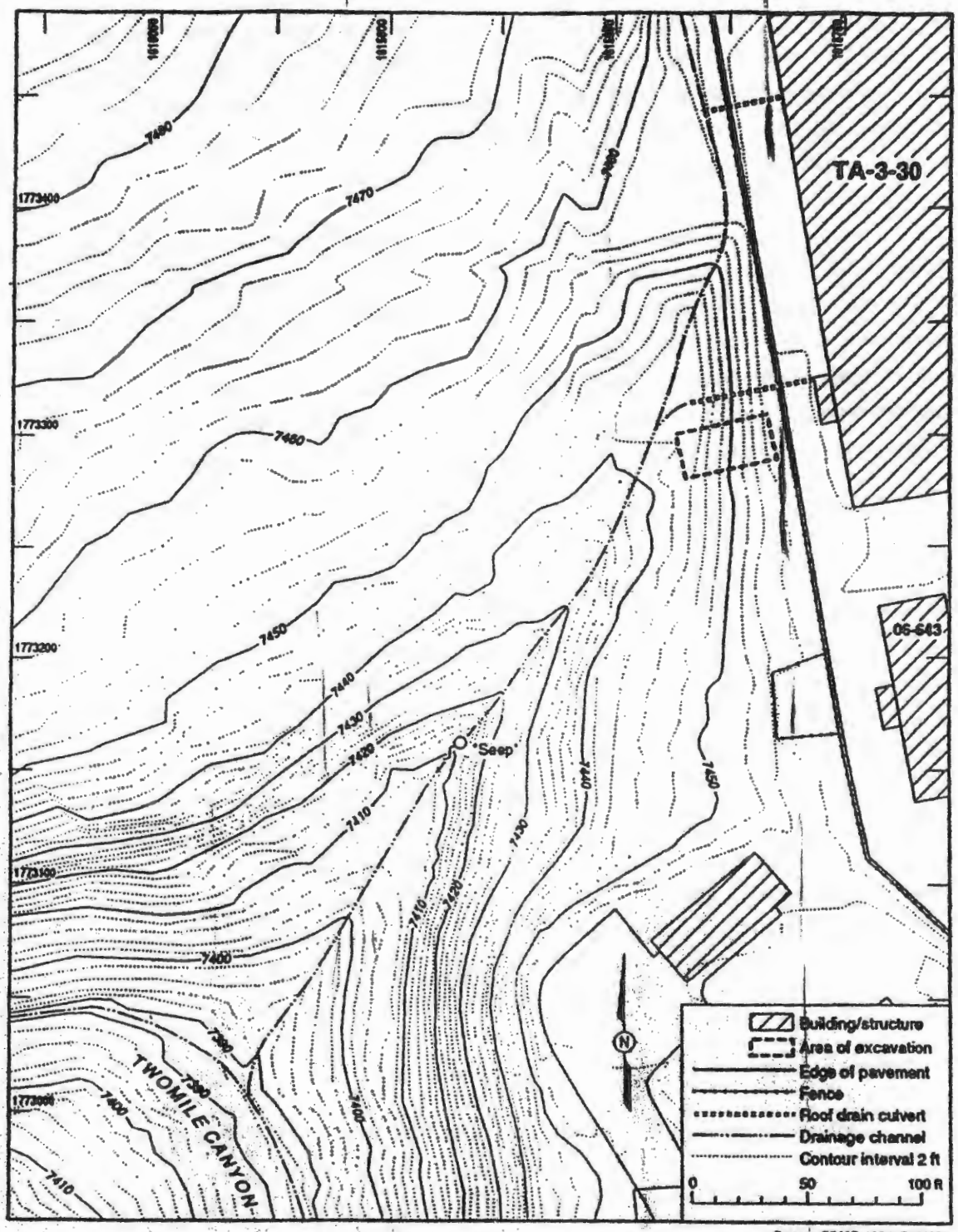

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Fig. 1-2. Detailed site map.

The Phase I sampling plan conducted in 1993 was designed to determine the horizontal and vertical extent of mercury contamination in the soil, to define TPH concentrations around the site, and to determine if water quality standards were being exceeded from runoff at the site. A sampling grid was established over and around the visible erosion channel, including the area of greatest contamination (determined by 1992 sampling results). Composite samples were collected from each of the ten rows and columns of the grid and analyzed for total metals, TPH, and radiological constituents (plutonium-238, plutonium-239, tritium, and cesium-137). Discrete samples were collected from 42 grid points and analyzed for total mercury. Six more samples were collected from the downgradient elevated metals area [determined by x-ray fluorescence (XRF)] and submitted for toxicity characteristic leaching procedure (TCLP) metals analysis. Surface water samples were collected from the stream channel below the site during three separate storm events and analyzed for; total and dissolved metals, TPH, tritium, isotopic plutonium, cesium-137, and gross alpha, beta and gamma radioactivity.

1.3 VCA Activities

The VCA at the SWMU 3-010(a) site consisted of removing the soils (engineered fill placed during the construction of building TA-3-30) within the grid area described in the Phase I sampling campaign. Removal of the soils occurred in three separate lifts and was intended to segregate specific contaminants (mercury; low-level radiological constituents cesium, plutonium-238 and -239; higher levels of tritium; and TPH), thereby minimizing the quantities of waste soils having special disposal needs. Following removal of the third lift, confirmatory samples for mercury and benzene, toluene, ethylbenzene, and xylene (BTEX) were collected from the soil and/or tuff remaining at the bottom of the excavation. Mercury concentrations in the soils after lift two were below SALs. However, the volatile organic compound (VOC) analysis that was done in lieu of BTEX analysis revealed the unexpected presence of VOCs other than BTEX. Because the extent of VOC contamination was not known and the presence of VOCs created mixed waste problems, the VCA could not be completed as a final remedy for the site. A Phase II site investigation work plan was written and executed in 1994.

1.4 RFI Phase II Activities

The Phase II site investigation was conducted during September and October 1994 in the area surrounding the open excavation created by VCA activities. The primary objective of the field investigation was to determine the subsurface concentrations of VOCs, TPH, and tritium and the area significantly affected by these constituents. Field activities consisted of preparing the site for heavy equipment use, which included backfilling the excavation with clean fill. A

bentonite layer was applied to the excavation before the excavation was backfilled to inhibit water from percolating through the site. A soil vapor probe survey was implemented, followed by a drilling and sampling program that was based, in part, on the soil vapor data. Seven boreholes were drilled, one used as a monitoring well and one used to obtain geological characterization data.

2.0 ENVIRONMENTAL SETTING

2.1 Climate

The Pajarito Plateau climate is characterized by a semiarid, temperate mountain climate with summer temperatures typically ranging from a low of 50 degrees to a high of 80 degrees Fahrenheit during a 24-hour period (Bowen 1990, 0033) . Winter temperatures generally range from the teens to about 50 degrees during a 24-hour period. The annual precipitation on the higher-elevation, western portion of the Laboratory in the vicinity of TA-3-30 is about 18 in., with much of the precipitation occurring during summer rain showers in July and August. Runoff events occur during these brief, intense summer thundershowers and also during the spring snowmelt, causing intermittent streamflow in the nearby canyons.

2.2 Geology

The bedrock at the site is Bandelier Tuff, a 1.2 million-year-old ash-flow tuff formed by gas-charged ash eruptions in the Jemez Mountains. Although the tuff was formed by eruption of numerous individual flow units, groups of flow units that erupted near the same time tended to cool as single cooling units. Hence, the tuff consists of a smaller number of cooling units than eruptive units. The temperature of the cooling units and the rate of cooling controlled the degree of welding (fusing the individual hot, glassy ash particles under the weight of the deposit), porosity, permeability, and mineralogy of the cooling units. Thus, the cooling units rather than primary flow units dominate the physical and hydrologic properties of Bandelier Tuff.

SWMU 3-010(a) is probably located on cooling unit four, a densely welded unit of the upper Bandelier Tuff, although detailed mapping of flow units within Bandelier Tuff has not extended to this site. Some lateral and vertical variability in grain size and other mineralogical and physical properties is present within unit four due to inhomogeneities in flow and/or cooling properties and secondary alteration. Unit four is an estimated 25 to 30 m thick at TA-3-30 based on extrapolation of existing mapping and on a core hole located about 320 m east of SWMU 3-010(a) (Gardner et al. 1993, 0848).

2.3 Hydrology

2.3.1 Setting

The main groundwater aquifer beneath the Pajarito Plateau is located about 300 m below the mesa top at TA-3 and is not relevant to SWMU 3-010(a). The local hydrology is controlled by the geomorphology and local construction history affecting buildings adjacent to SWMU 3-010(a). The site is located on the east side of a small drainage, a tributary of Twomile Canyon, which cuts across the mesa. Prior to the construction of TA-3-30, part of the mesa surface was excavated and regraded to provide a level building site. The site was enlarged by filling part of an arroyo, presumably with rubble (mainly crushed Bandelier Tuff) derived from the excavation and regrading. Thus, a portion of TA-3-30 is located on fill in the former drainage (Fig. 2-1).

2.3.2 Surface Drainage

SWMU 3-010(a) is located in the upper part of a small tributary drainage to Twomile Canyon. The drainage divide between Twomile Canyon and Los Alamos Canyon to the east is located on the top of the mesa approximately 70 m east of SWMU 3-010(a). The natural drainage (i.e., prior to construction of TA-3-30 and other buildings on this site) is shown in Fig. 2-1. Because the source term for SWMU 3-010(a) was removed during the VCA, surface drainage at the site is not expected to carry PCOCs to areas downgradient of the SWMU.

Leveling and regrading the site and construction of the TA-3-30 and other buildings, have had three major effects on drainage at SWMU 3-010(a). First, much of the drainage from the paved parking areas and all drainage from the roof of TA-3-30, now drains into the small tributary canyon, and much of it directly onto the area of SWMU 3-010(a). Thus, the drainage divide has been moved east of its natural (pre-construction) location (Fig. 2-2). The major effect on drainage is from the roof of TA-3-30, which has an area of approximately 9 900 square meters. Approximately three-quarters of the building lie east of the natural divide, but all roof drainage flows to the west. Thus, TA-3-30 increased drainage into the SWMU by about 7 425 square meters. In addition, all the parking area north of the building and some parking area south of TA-3-30 much of which previously lay east of the drainage divide, now drains to the west and into the tributary canyon.

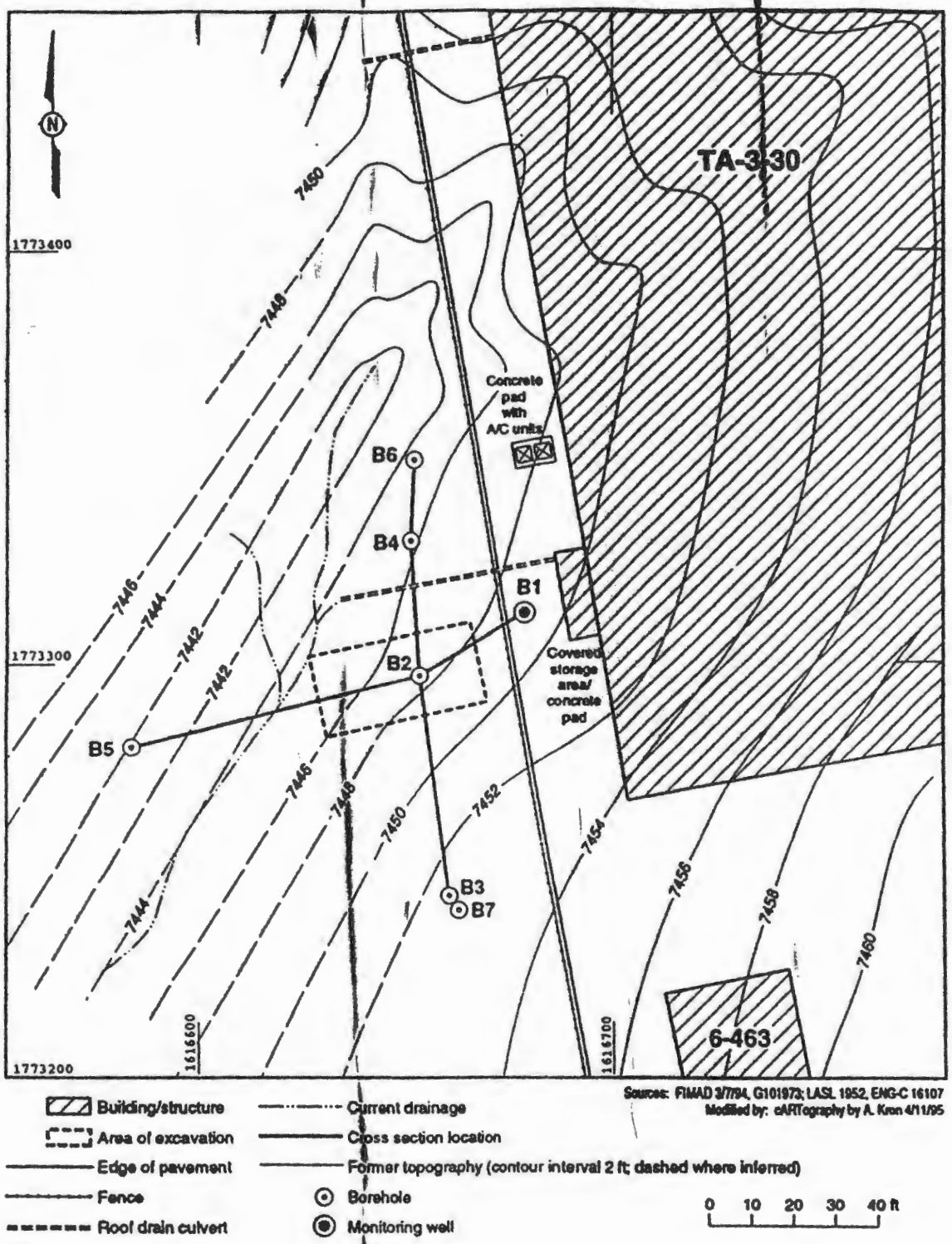


Fig. 2-1. Topography before construction of TA-3-30 and cross section locations.

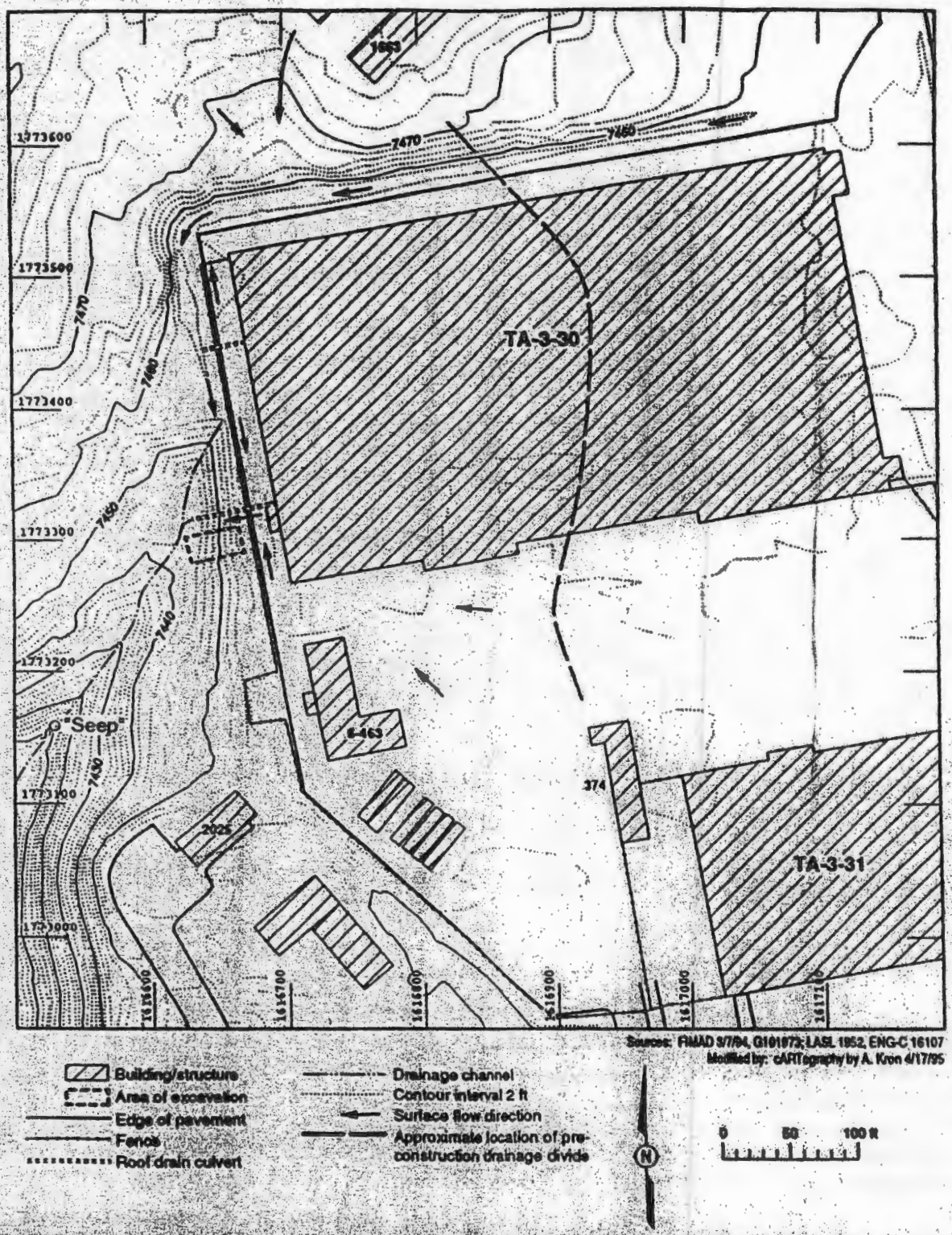


Fig. 2-2. Existing topography and surface drainage patterns in the vicinity of SWMU 3-010(a).

The second effect relates to the rate at which precipitation infiltrates the ground. Before the site was developed much of the precipitation would have infiltrated the soil and bedrock, and relatively little precipitation would have run off (except during heavy rainfalls). Because there are now roofs and pavement, most water runs west of the new drainage divide and into the canyon.

Third, it has been observed in other areas of the Laboratory that water tends to collect beneath pavement, i.e., that soil beneath pavement tends to be saturated. Although the source of the water is not completely understood, it is likely that precipitation infiltrates cracks in the pavement and the pavement inhibits evaporation of the moisture. Thus, the extensive pavement around TA-3-30 may lead to shallow saturated conditions, promoting downward percolation of water through the soil and fill of the paleochannel and through SWMU 3-010(a).

2.3.3 Water Encountered in Phase II Boreholes

As part of the Phase II work, seven boreholes were drilled at SWMU 3-010(a) (Fig. 2-1); all boreholes penetrated into Bandelier Tuff. Water was encountered in boreholes B1, B4, and B6. Observations of these boreholes in September 1994 and January 1995 indicate standing water at a depth of about 3 to 4 m below the bedrock/fill interface. Evidence of a fracture was observed in core obtained from the depth at which saturated conditions were first encountered in this hole. Additional fractures were observed in the upper part of the tuff during excavation of SWMU 3-010(a).

Saturated conditions were encountered in borehole B4, and wet but unsaturated conditions in borehole B6. In both boreholes, water was observed at or slightly above bedrock in rubble filling the natural drainage channel (Figs. 2-3 and 2-4).

2.3.4 Existence and Significance of Seep

In the RFI Work Plan for Operable Unit 1114, a seep was identified in the bottom of the drainage downgradient from SWMU 3-010(a) (Fig. 2-2) (LANL 1993, 1090). Observations at the site, considered with the above discussion regarding surface drainage, lead to the conclusion that the seep probably does not represent the exposed edge of a perched water aquifer. Rather, the seep probably represents water moving through the thin and discontinuous alluvium within this ephemeral drainage. The location and volume of wet alluvium in the stream channel has been observed to change, depending on the amount of available runoff. The source of this water is assumed to be surface drainage from the roof of TA-3-30 and parking areas adjacent to TA-3-30, and from moisture draining through the bank above SWMU 3-010(a).

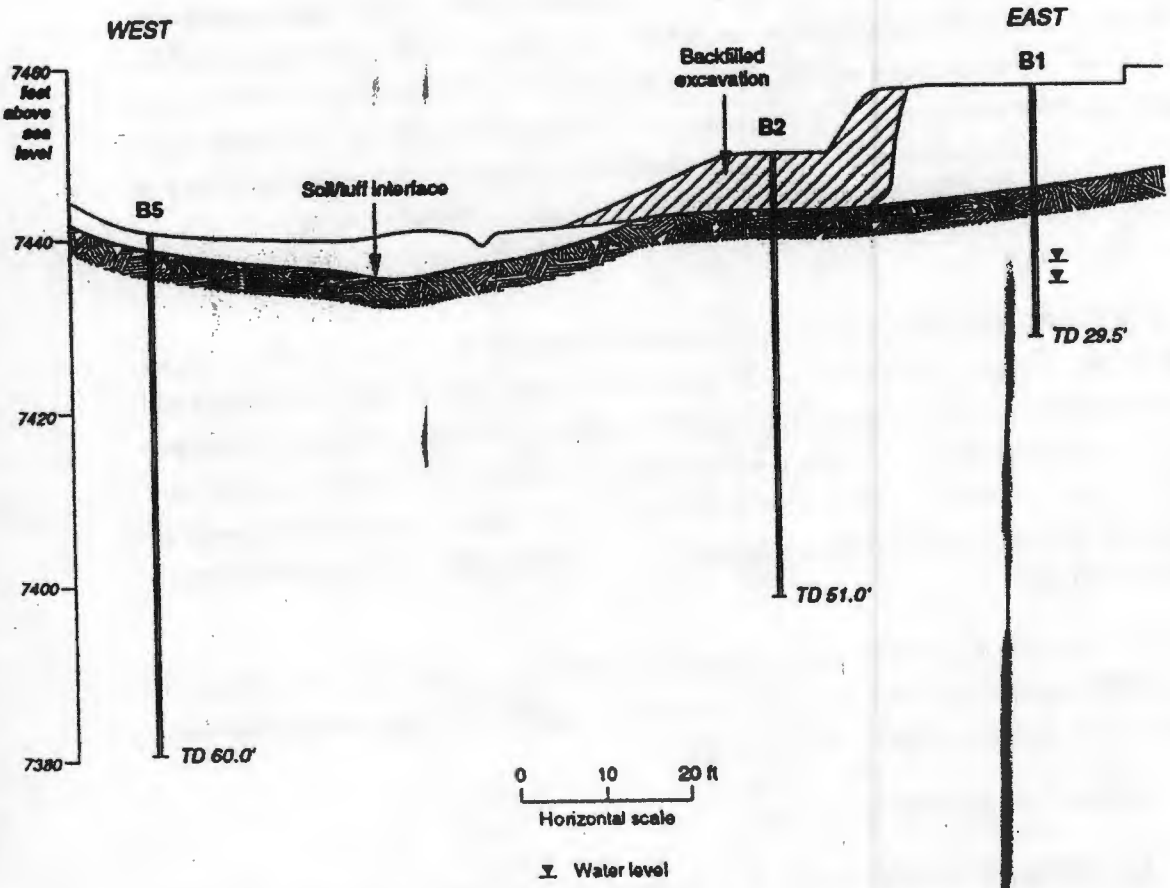


Fig. 2-3. West-east cross section.

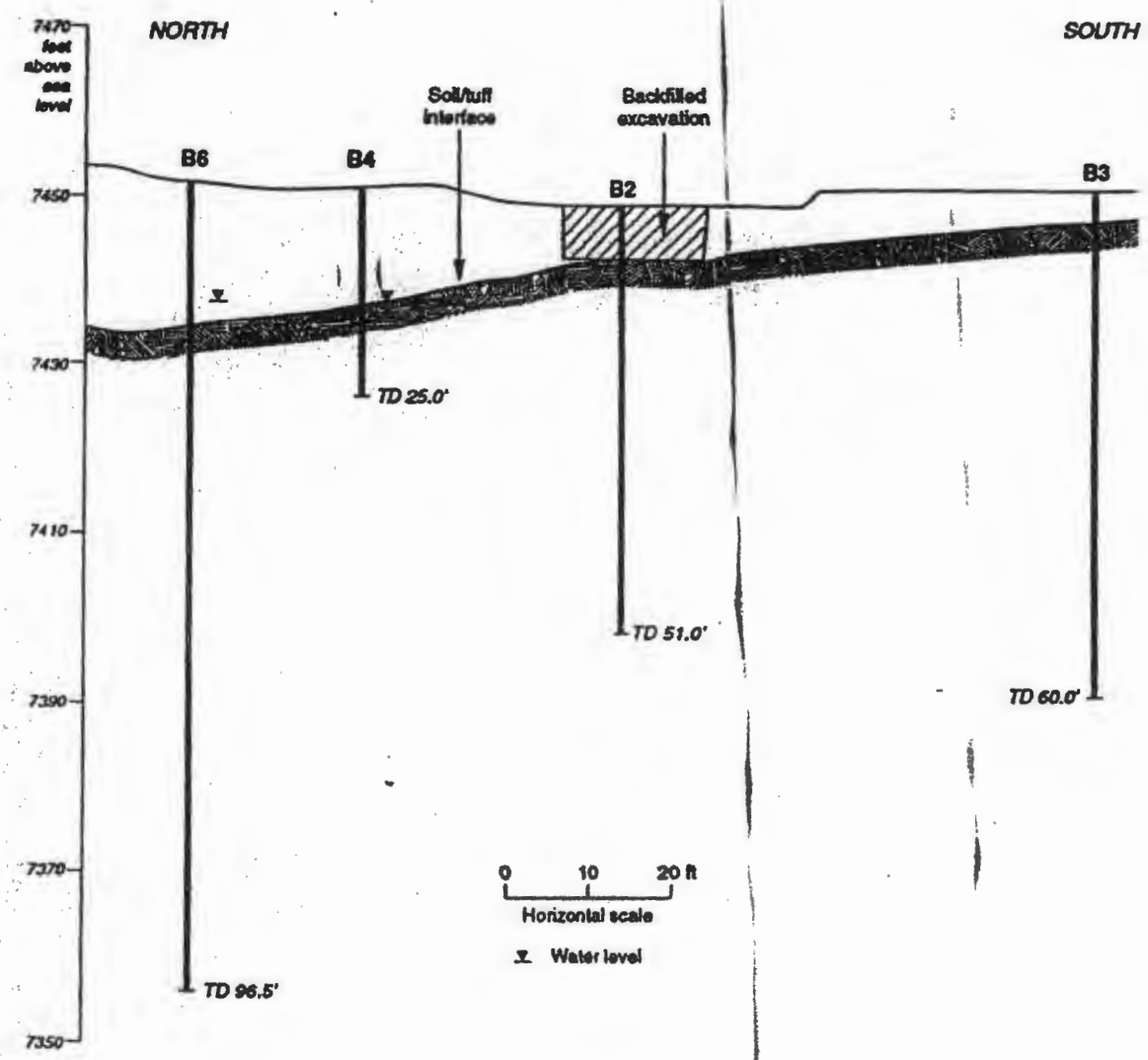


Fig. 2-4. North-south cross section.

2.3.5 Hydrologic Model for SWMU 3-010(a)

Although a perched aquifer within the tuff is possible, the presence of a major perched zone is unlikely. Some evidence supporting this conclusion is provided by borehole SHB-2, located about 320 m east of SWMU 3-010(a). The borehole's wellhead elevation is at 7 436 ft and the hole was drilled to a depth of 61 m but no water was encountered. If a perched zone of significant lateral extent 6 to 8 m below the mesa top was present, the borehole should have encountered water (Gardner et al. in press 1993, 0848).

Alternatively, it is more likely that water observed in the boreholes and at the seep results from surface runoff that infiltrated the alluvium of the filled channel and the shallow bedrock. As described above, large quantities of water run off rapidly from TA-3-30 and the surrounding area during precipitation events. The water is directed into fill material of the paleochannel, where it probably percolates downward until it encounters the upper surface of the bedrock. Precipitation that infiltrates directly into the bank and through the paved areas above SWMU 3-010(a) is stored in, and eventually drains through, the fill material of the paleochannel, coming to the surface as a seep. Also, the water infiltrates fractures in the surface of the bedrock. Water in boreholes B4 and B6 was encountered in the fill at or above the bedrock interface. Borehole B1 is located very near a low point in the pavement that is above fill and adjacent to TA-3-30 (Fig. 2-2). Water in borehole B1 is most likely from surface runoff that percolates into the tuff through fractures that were observed during excavation and coring. Water observed in the boreholes is significantly above (approximately 5 m) the elevation of the seep.

Site development has dramatically increased surface drainage into the small tributary (and into the paleocanyon) where SWMU 3-010(a) is situated. Thus, water observed in the boreholes and in the alluvium of the drainage most likely derives from this increased surface runoff and from bank storage, and has no hydrologic connection to any perched aquifer (if present). Moreover, the water is ephemeral and depends on local precipitation. The drainage is not of sufficient volume to constitute a usable resource, and is therefore judged not to be a significant exposure pathway.

2.4 Plant and Animal Communities

Southwest of TA-3-30 three major plant communities are evident and each has a number of habitats supporting characteristic fauna.

Mesa tops at this elevation support a ponderosa pine forest typified by ponderosa pine, Gambel's oak and Rocky Mountain juniper overstory. Bearberry, barberry and wild rose typify the shrubs, along with the mountain muhly and pine dropseed grasses. This community supports characteristic fauna such as mule deer, Abert's squirrel, Steller's jay, montane vole, deer mouse, and pipistrelle bat. Threatened and endangered animals that regionally nest or forage in the ponderosa pine forest habitats include the meadow jumping mouse, peregrine falcon, northern goshawk, and spotted bat.

The north facing slopes at this elevation support a mixed conifer forest community. Douglas fir, ponderosa pine, white fir, and limber pine are the predominant trees. Bearberry and Gambel's oak are the major shrubs, with junegrass and pine dropseed the major grasses. Characteristic fauna include the elk, mule deer, red squirrel, and mountain cottontail. Threatened and endangered species that regionally inhabit, nest, or forage in the mixed conifer forest include meadow jumping mouse, Jemez Mountains salamander, northern goshawk, and Mexican spotted owl.

The canyon bottom in Twomile Canyon south of TA-3-30 has a narrow, dense, shrubby riparian plant community. Since the availability of water is a limiting factor for plant and animal distribution in the southwest, the presence of an intermittent stream creates a complex and diverse habitat which combines plant and animal species from the ponderosa and mixed conifer communities along with the distinct deciduous plants and water-loving animals found along streams. Riparian areas in the higher-elevation, western portion of the Laboratory are characterized by dense stands of Gambel's oak, dogwood, currant, barberry, cliffbush, and raspberry shrubs along narrow corridors at the bottom of steep, narrow canyons. The Jemez Mountain salamander (an endangered species) is attracted to deep, cool canyon areas at this elevation. The black bear can frequently be found foraging in the riparian areas because of the excellent cover and food availability. A mountain lion den has been observed in mid Pajarito Canyon to the east of Twomile Canyon. Because human access to these deep and undisturbed canyons is restricted, sensitive habitats remain capable of supporting these large predators.

3.0 DATA ASSESSMENT AND ANALYSIS APPROACH

3.1 Summary of Quality Assurance/Quality Control Activities

All samples collected during Phase I, II and VCA activities were submitted with chain-of-custody documentation to the sample coordination facility (SCF) or to the mobile chemistry van

TABLE 3-1

SUMMARY OF QA/QC ACTIVITIES

LOCATION ID	SAMPLE ID	SAMPLE TYPE	LOCATION	ANALYSIS	REQUEST #	QUALITY CONTROL COMMENTS
03-1261	AAB2015	Soil-Surface (start=0)	East Wall, SM-30	Hg[1]	17397	QC Results within allowable limits; all data valid
03-1261	AAB2015	Soil-Surface (start=0)	East Wall, SM-30	VOA[2]	17398	Sample dilution (for high TCA[3]) caused 'J' flags[4] for 4 analytes
03-1262	AAB2016	Soil-Surface (start=0)	East Wall, SM-30	Hg	17397	QC Results within allowable limits; all data valid
03-1262	AAB2016	Soil-Surface (start=0)	East Wall, SM-30	VOA	17398	Sample dilution (for high TCA) caused 'J' flags for 4 analytes
03-1263	AAB2017	Soil-Surface (start=0)	East Wall, SM-30	Hg	17397	QC Results within allowable limits; all data valid
03-1263	AAB2017	Soil-Surface (start=0)	East Wall, SM-30	VOA	17398	Sample dilution (for high TCA) caused 'J' flags for 4 analytes
03-2664	AAC0357	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH[5]	20143	QC Results within allowable limits; all data valid
03-2664	AAC0357	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	Tritium	20250	QC Results within allowable limits; all data valid
03-2664	AAC0358	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	Tritium	20250	QC Results within allowable limits; all data valid
03-2664	AAC0359	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH	19925	QC Results within allowable limits; all data valid
03-2664	AAC0359	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	Tritium	20250	QC Results within allowable limits; all data valid
03-2664	AAC0459	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH	20143	TCA above linear calibration range of instrument, flagged 'J'
03-2664	AAC0460	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH	20143	QC Results within allowable limits; all data valid
03-2664	AAC0461	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA	19965	Internal standard areas low, all data qualified 'UJ'
03-2664	AAC0467	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH	20143	TCA above linear calibration range of instrument, flagged 'J'
03-2664	AAC0468	Soil	West of TA-3-30 in alley through asphalt, Borehole 1	VOA/TPH	19925	Internal standard areas low; all data qualified 'J' or 'UJ'
03-2664	AAC0469	Water	West of TA-3-30 in alley through asphalt, Borehole 1	VOA	19925	QC Results within allowable limits; all data valid
03-2664	AAC1081	Water Liquid	West of TA-3-30 in alley through asphalt, Borehole 1	Tritium (aq/nonaq[6])	20013	One blind QC sample 12% low, aqueous values flagged 'J'
03-2665	AAC0481	Soil	Borehole 2	VOA/TPH	19959	Internal standard areas low, all data qualified 'J' or 'UJ'. TCA above linear calibration range of instrument
03-2665	AAC0482	Soil	Borehole 2	VOA/TPH	19959	TCA above linear calibration range of instrument, flagged 'J'
03-2665	AAC0483	Soil	Borehole 2	VOA/TPH	20069	TCA above linear calibration range of instrument, flagged 'J'
03-2665	AAC0484	Soil	Borehole 2	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2665	AAC0485	Soil	Borehole 2	VOA/TPH	20069	TCA above linear calibration range of instrument, flagged 'J'
03-2665	AAC0486	Soil	Borehole 2	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2665	AAC0487	Soil	Borehole 2	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2665	AAC0488	Soil	Borehole 2	VOA/TPH	20062	QC Results within allowable limits; all data valid
03-2665	AAC0489	Soil	West of SM-30, Borehole 2	VOA/TPH	20062	Surrogate recovery above upper control limits, all detects flagged 'J'. TCA above linear calibration range of instrument
03-2665	AAC0490	Soil	West of SM-30, Borehole 2	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2665	AAC0491	Soil	West of SM-30, Borehole 2	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2665	AAC0492	Soil	West of SM-30, Borehole 2	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2666	AAC0493	Soil	West of TA-30, Borehole 3	VOA/TPH	20062	QC Results within allowable limits; all data valid
03-2666	AAC0494	Soil	West of TA-30, Borehole 3	VOA/TPH	20062	QC Results within allowable limits; all data valid
03-2666	AAC0495	Soil	West of TA-30, Borehole 3	VOA/TPH	20062	QC Results within allowable limits; all data valid
03-2666	AAC0496	Soil	West of TA-30, Borehole 3	VOA/TPH	20050	QC Results within allowable limits; all data valid
03-2666	AAC0497	Soil	West of TA-30, Borehole 3	VOA/TPH	20050	QC Results within allowable limits; all data valid
03-2666	AAC0499	Soil	West of TA-30, Borehole 3	VOA/TPH	20050	QC Results within allowable limits; all data valid
03-2666	AAC0500	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0501	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0502	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0503	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0504	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0505	Soil	West of TA-30, Borehole 3	VOA/TPH	20069	QC Results within allowable limits; all data valid
03-2666	AAC0506	Soil	West of TA-30, Borehole 3	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2666	AAC0507	Soil	West of TA-30, Borehole 3	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2666	AAC0508	Soil	West of TA-30, Borehole 3	Tritium (aq/nonaq)	20016	One blind QC sample 12% low, aqueous values flagged 'J'
03-2667	AAC0509	Soil	West of TA-30, Borehole 4	VOA/TPH	20081	High surrogate recoveries, no detects, no qualifications
03-2667	AAC0510	Soil	West of TA-30, Borehole 4	VOA/TPH	20081	QC Results within allowable limits; all data valid

TABLE 3-1 (CONTINUED)

SUMMARY OF QA/QC ACTIVITIES

LOCATION ID	SAMPLE ID	SAMPLE TYPE	LOCATION	ANALYSIS	REQUEST #	QUALITY CONTROL COMMENTS
03-2667	AAC0511	Soil	West of TA-30, Borehole 4	VOA/TPH	20081	QC Results within allowable limits; all data valid
03-2667	AAC0512	Soil	West of TA-30, Borehole 4	VOA/TPH	20081	QC Results within allowable limits; all data valid
03-2667	AAC0849	Soil	West of TA-30, Borehole 4	VOA	20081	QC Results within allowable limits; all data valid
03-2667	AAC0850	Soil	West of TA-30, Borehole 4	VOA/TPH	20081	QC Results within allowable limits; all data valid
03-2667	AAC0852	Soil	West of TA-30, Borehole 4	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2667	AAC0856	Water, Liquid	West of TA-30, Borehole 4	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2667	AAC0856	Water	West of TA-30, Borehole 4	VOA/TPH	20078	High surrogate recoveries, all detects flagged 'J'. TCA and TCFA above linear calibration range.
03-2667	AAC0857	Soil	West of TA-30, Borehole 4	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2667	AAC0858	Soil	West of TA-30, Borehole 4	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2668	AAC0851	Soil	West of TA-30, Borehole 5	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2668	AAC0853	Soil	West of TA-30, Borehole 5	VOA/TPH	20078	High surrogate recovery, no detects, no qualification
03-2668	AAC0855	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0859	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0860	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0861	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0862	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0863	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0864	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0865	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	QC Results within allowable limits; all data valid
03-2668	AAC0866	Soil	West of TA-30, Borehole 5	VOA/TPH	20076	Internal standard area high, no analytes detected, no data qualification
03-2668	AAC0867	Soil	West of TA-30, Borehole 5	VOA/TPH	20075	
03-2668	AAC0869	Soil	West of TA-30, Borehole 5	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2668	AAC0870	Soil	West of TA-30, Borehole 5	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2668	AAC0871	Soil	West of TA-30, Borehole 5	Tritium (aq/nonaq)	20018	One blind QC sample 12% low, aqueous values flagged 'J'
03-2669	AAC0470	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2670	AAC0471	Soil	West side of fence, second flag from south	Hg	20531	QC Results within allowable limits; all data valid
03-2671	AAC0472	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2672	AAC0473	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2673	AAC0474	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2674	AAC0475	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2675	AAC0476	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2676	AAC0477	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2677	AAC0478	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2678	AAC0479	Soil	Surface sample west side of fence	Hg	20531	QC Results within allowable limits; all data valid
03-2679	AAC0872	Soil	West of TA-30, Borehole 6	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2679	AAC0873	Soil	West of TA-30, Borehole 6	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2679	AAC0874	Soil	West of TA-30, Borehole 6	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2679	AAC0875	Soil	West of TA-30, Borehole 6	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2679	AAC0876	Soil	West of TA-30, Borehole 6	VOA/TPH	20078	QC Results within allowable limits; all data valid
03-2679	AAC0877	Soil	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), not found in sample
03-2679	AAC0878	Soil	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), found in sample 120ug/kg. EQL raised
03-2679	AAC0879	Soil	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), not found in sample
03-2679	AAC0880	Water	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), not found in sample
03-2679	AAC0881	Soil	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), not found in sample
03-2679	AAC0882	Soil	West of TA-30, Borehole 6	VOA/TPH	20074	Acetone in blank (180ug/kg), not found in sample
03-2679	AAC0883	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0884	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0885	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0886	Soil	West of TA-30, Borehole 6	Tritium (aq/nonaq)	20017	One blind QC sample 12% low, aqueous values flagged 'J'
03-2679	AAC0887	Soil	West of TA-30, Borehole 6	Tritium (aq/nonaq)	20017	One blind QC sample 12% low, aqueous values flagged 'J'

TABLE 3-1 (CONTINUED)

SUMMARY OF QA/QC ACTIVITIES

LOCATION ID	SAMPLE ID	SAMPLE TYPE	LOCATION	ANALYSIS	REQUEST #	QUALITY CONTROL COMMENTS
03-2679	AAC0888	Soil	West of TA-30, Borehole 6	Tritium (aq/nonaq)	20017	One blind QC sample 12% low, aqueous values flagged 'J'.
03-2679	AAC0895	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0896	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0897	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0898	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	QC Results within allowable limits; all data valid
03-2679	AAC0899	Soil	West of TA-30, Borehole 6	VOA/TPH	20071	Internal standard areas low, all data qualified 'J' or 'UJ'
03-2681	AAB7760	Water	Seep sampling	Tritium	19655	QC Results within allowable limits; all data valid
03-2681	AAB7760	Water	Seep sampling	TPH	19968	
03-2681	AAB7760	Water	Seep sampling	VOA	19968	QC Results within allowable limits; all data valid
03-2681	AAB7760	Water	Seep sampling	VOA	19968	QC Results within allowable limits; all data valid
03-2681	AAB7761	QA Water (trip blanks)	Field Blank	Tritium	19655	QC Results within allowable limits; all data valid
03-2681	AAB7764	QA Water (Duplicate)	Seep sampling	TPH	19968	
03-2681	AAB7764	QA Water (Duplicate)	Seep sampling	TPH	19968	
03-2681	AAB7764	QA Water (Duplicate)	Seep sampling	TPH	19968	
03-2681	AAB7764	QA Water (rinsates, trip blanks, etc.)	Seep sampling	VOA	19968	QC Results within allowable limits; all data valid
03-2681	AAB7764	QA Water (Duplicate)	Seep Sampling	VOA	21193	QC Results within allowable limits; all data valid
03-2681	AAC3129	Water	Seep sampling	VOA	21193	QC Results within allowable limits; all data valid
03-N/A	AAC3132	Field Blank	QA Water Blank			

[a] Hg = Mercury
[b] VOA = Volatile organic analysis
[c] TCA = Trichloroethane
[d] 'J' Flags =
[e] TPH = Total petroleum hydrocarbons
[f] Aq/nonaq = Aqueous/nonaqueous

for analysis. This section addresses data from the Phase II and VCA activities only, since the Phase I data relates to soils that have been excavated from the site and have been removed as waste. Selected samples were analyzed for target analyte list (TAL) metals by flame atomic absorption (EPA SW-846 Method 7420), electrothermal vaporization atomic absorption (EPA SW-846 Method 7060 or 7760), cold vaporization atomic absorption (EPA SW-846 Method 7471), inductively coupled plasma emission spectroscopy (EPA SW-846 Method 6010) and inductively coupled plasma/mass spectrometry (EPA SW-846 Method 6020). The TAL metals include aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. Volatile analyses were conducted using gas chromatography/mass spectrometry (GC/MS), EPA SW-846 Method 8240 (purge and trap method) or Method 8260 (capillary column method). For the radiological constituents, tritium analyses were done using liquid scintillation counting, plutonium isotopes were analyzed using alpha spectroscopy, and cesium-137 was analyzed using gamma spectroscopy.

A summary of all the quality assurance/quality control (QA/QC) results for each sample can be found in Table 3-1.

Eighteen samples were submitted for metals analysis. Two of the 18 samples were analyzed for TAL metals, 13 for mercury only, and three for lead only. The mercury and lead only analyses were performed under request numbers 17397, 20531, and 20019. Request number 20020 was submitted for TAL metals. All quality control parameters for these requests were within allowable limits and all of the data are usable without qualification.

Thirty-five samples were submitted for radiological analyses. Nineteen of the 35 samples were analyzed for tritium only and 16 samples were analyzed for tritium, plutonium-238, plutonium-239, and cesium-137. The tritium was analyzed under requests 19655, 20013, 20016, 20017, 20018 and 20250. (In requests 20013, 20016, 20017, 20018, and 20250 both aqueous and nonaqueous tritium analyses were performed). Requests 17221 and 20022 were for tritium, plutonium-238, plutonium-239, and cesium-137. For request 20021, samples were analyzed for tritium and cesium-137 as well gross alpha and beta activity. The only requests with QC difficulties were 17221, 20013, 20016, 20017 and 20018.

In request 17221, the cesium-137 value for the blind QC sample was 30% high and therefore outside allowable limits. Because of this, the cesium-137 values are qualified as "J," estimated values. The data may be biased high, as indicated by the value for the QC sample. Because cesium-137 values are quite low, the qualification should not affect usability of the data.

Requests 20013, 20016, 20017, and 20018 were batched together at the laboratory and the same two blind QC samples for tritium were used for all four requests. The problem was that tritium was detected below allowable limits in one of the blind QC samples. The lower of the two QC values was detected correctly (550 ± 80 pCi/l found, 560 ± 15 pCi/l, QC value). The higher QC sample (7 400 ± 135 pCi/L found, 8 420 ± 220 pCi/L, QC value) was approximately 12% low. The low value found for the QC sample was possibly caused by improper preservation of the QC sample (lack of refrigeration/freezing). Because of the QC values, the data are qualified as "J," estimated values. The sample data are all lower than the smaller of the two QC values and, therefore, the usability of the data should not be affected by the data qualification.

Seventy-four samples were submitted for volatile analyses under 16 separate requests. Five requests, 19968, 20059, 20075, 20089, and 21193, had no QC problems and the data are usable without qualification.

For request 17398, the first time sample AAB2015 was analyzed, 1,1,1 trichloroethane was outside the linear range of the instrument. The sample was diluted to get the 1,1,1-trichloroethane within linear range. In doing so, several target compounds found in the original analysis were diluted out. For this reason, acetone, benzene, 1,2-dichloroethane, 1,1-dichloroethene are qualified "J" for this sample. Ethyl benzene was detected below the estimated quantitation limit (EQL) and therefore is also qualified "J."

For request 19925, the internal standard areas for sample AAC0468 were all low (causing a high bias). Because of this, all of the non-detected analytes are qualified "UJ," estimated non-detected quantities. Only 1,1,1-trichloroethane was detected in the sample and is qualified "J."

For request 19959, the internal standard areas for sample AAC0481were all low (causing a high bias). Because of this high bias, all of the non-detected analytes are qualified "UJ," and all detected analytes are qualified "J." Also for samples AAC0481 and 0482, 1,1,1-trichloroethane was detected above the linear range of the instrument. This may cause a low bias for the value. The samples were not diluted and reanalyzed.

For request 19965, sample AAC0461, the internal standard areas were all low (causing a high bias). Because of this problem, all detected analytes are qualified "J" and all undetected analytes are qualified "UJ."

In request 20062, sample AAC4089 had several QC problems. The first was that one of the surrogates was detected above the upper confidence limit (UCL). Because high recoveries

only affect detected values, all of the detected values are qualified "J." The other problem was that the value for 1,1,1-trichloroethane was above the linear range of the instrument. This may cause a low bias for the value. The sample was not diluted and reanalyzed.

For request 20064, samples AAC1072 and AAC1075 had low internal standard areas (causing a high bias) and low surrogate recoveries (for toluene-d8). Because of these problems, all data for these samples are qualified "J" for detected analytes and "UJ" for non-detected analytes. Also, for sample AAC1072, the value for 1,1,1-trichloroethane was above the linear range of the instrument. This may cause a low bias for the value. The sample was not diluted and reanalyzed.

For request 20069, samples AAC0483 and AAC0485, the values for 1,1,1-trichloroethane were above the linear range of the instrument. The samples were not diluted and reanalyzed; therefore, the 1,1,1-trichloroethane values are qualified "J." The values may have a low bias as a result of being above the linear range of the instrument.

For request 20071, acetone was found in the method blank at a concentration of 350 µg/kg. Because of this contamination, the EQL was raised for the samples in which acetone was detected (all were less than ten times the blank amount). Also, for sample AAC0899, the internal standard areas were low (causing a high bias) which results in the undetected analytes being qualified "UJ." Only 1,1,1-trichloroethane was detected in the sample and is qualified "J."

For request 20074, acetone was found in the method blank at a concentration of 180 µg/kg. Due to this contamination, the EQL was raised for sample AAC0878 in which acetone was detected at a concentration of 120 µg/kg.

In request 20076, the internal standard area was high for sample AAC0866. Because high standard areas only affect detected compounds and no compounds were detected in the sample, no data qualifications are necessary.

For request 20078, samples AAC0853 and AAC0856 had surrogate recoveries above the upper control limits. Only detected compounds are affected by the high surrogate recoveries. Because only AAC0856 had detected compounds (1,1,1-trichloroethane and 1,1,2-trichloro-1,2,2-fluorethane), these analytes are qualified "J." The values for 1,1,1-trichloroethane and 1,1,2-trichloro-1,2,2-fluorethane were also above the linear range of the instrument. This may cause a low bias for the values. The samples were not diluted and reanalyzed.

For request 20081, sample AAC-0509 had two surrogate recoveries above the UCLs. High surrogate recoveries only affect detected analytes and because no analytes were detected in the sample, the data are not qualified.

For request 20143, samples AAC0459 and AAC0467, 1,1,1-trichloroethane was detected above the linear range of the instrument. This may cause a low bias for the values. The samples were not diluted and reanalyzed, therefore the 1,1,1-trichloroethane values are qualified "J" for these samples.

3.2 Screening Assessment Approach

The screening assessment, based on simple comparisons of SWMU 3-010(a) to background and SALs, identifies PCOCs for the human health risk assessment. This screening assessment follows the same general approach taken at other LANL PRSs. However, the SWMU 3-010(a) investigation has been driven by a unique sequence of events, and a formal screening assessment was not implemented following any of the previous investigations. The site was investigated in three main phases: RFI Phase I (pre-VCA implementation), VCA implementation and verification, and RFI Phase II. Table 3-2 summarizes the analytical data collected for soil and water during each phase of investigation. The screening assessment is based on a subset of this data that best represents the current condition of the site. The VCA removed most of the contaminated soil sampled in the RFI Phase I sampling, but certain analyte suite data (radionuclides and metals) collected during RFI Phase I sampling are used to help focus the list of constituents for the risk analysis. Table 3-2 indicates which data are used to support the screening assessment, and which data will support the risk assessment.

3.2.1 Human Health

The human health portion of the screening assessment will follow the procedures outlined in Chapter 4 and Appendix J of the LANL Installation Work Plan (IWP) (LANL 1993, 1017). There are four basic data analysis steps required to complete a screening assessment. These steps are presented in Fig. 3-1, and include: (1) a determination of positive bias in samples from either laboratory or field bias; (2) comparison to natural and anthropogenic background concentrations; (3) comparison to LANL SALs; and, (4) the multiple constituent evaluation step. The determination of positive bias is not formally part of the screening assessment. This step is used to exclude data impacted by contamination occurring in the analytical laboratory from consideration in the screening assessment.

Table 3-2

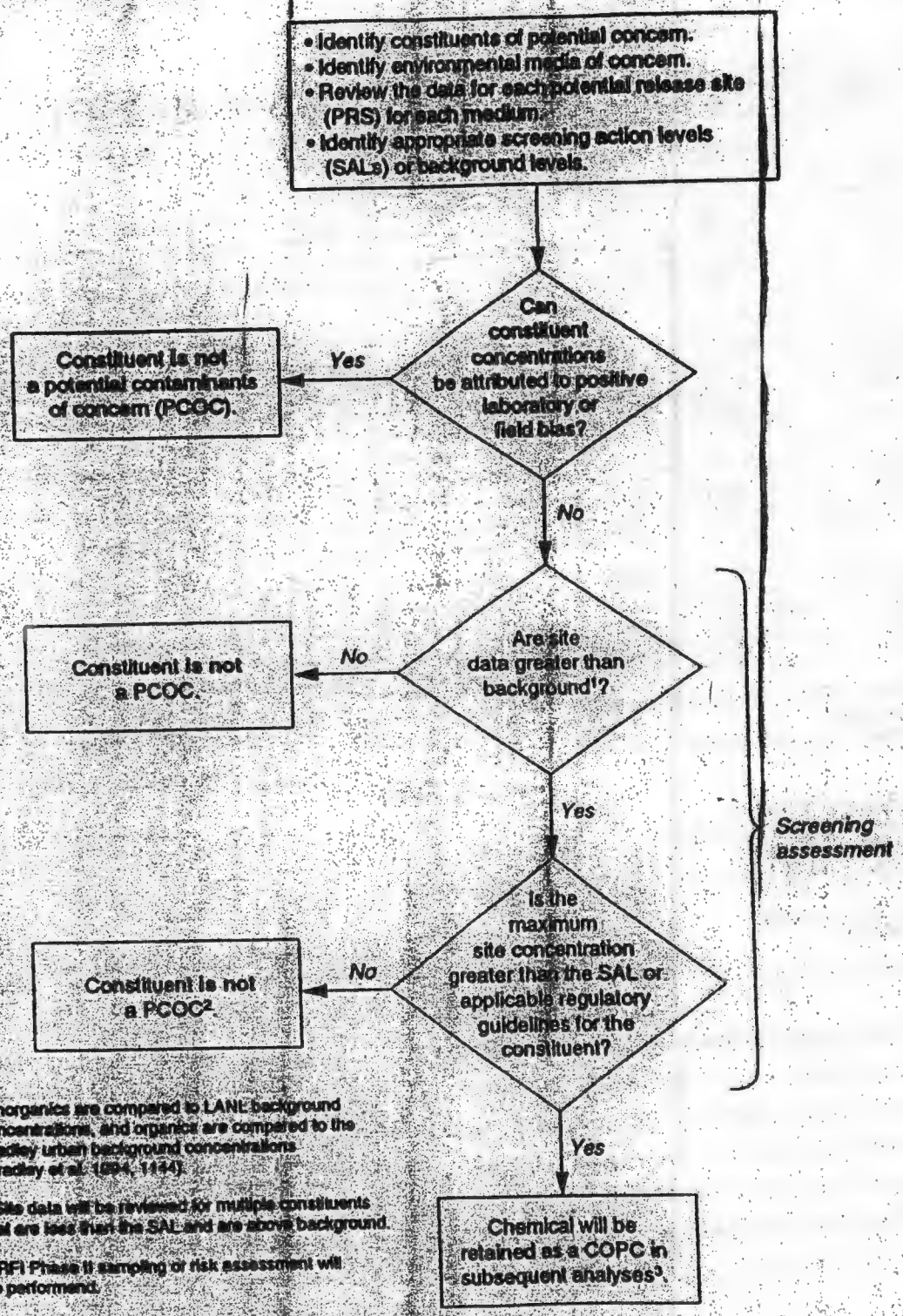
Summary of Characterization Activities

CHARACTERIZATION ACTIVITY	DATA USE	MATRIX	RAD	RAD SCREENING	TPH	VOC	INORGANICS
Phase I							
ESH samples	None[1]	Soil	x		x	x	x
ESH samples	None	Sediment	x		x	x	x
Surface soils	None	Soil	x[2]		x		x[3,4]
Surface soils	SA[5]	Soil	x[6]				
Surface soils	SA	Soil					x[7]
Surface water	SA	Water	x		x		x
VCA							
Implementation:							
Biased locations	None	Soil	x[2]		#[8]		
Excavation soil	None	Soil	x[2]		#		
Oil samples	None	Sil/soil	x[9]		#		
Verification:							
Backfill	SA	Soil	x	x			x
Surface soils	SA	Soil		x			x[3]
Biased samples	SA	Soil			#	x	x[3]
Biased samples	SA	Soil	x[10]	x			x[4]
Phase II							
Boreholes	RA[11]	Soil	x[9]	x	#	x	
Boreholes	RA	Sater			#	x	
Monitor well	RA	Sater	x[9]	x			
Seep samples	RA	Sater	x[9]	x	#	x	

[1] None = These data are not used in this report. They were used to guide voluntary corrective action (VCA) implementation
[2] Cesium, plutonium, and tritium only
[3] Mercury only
[4] Lead only
[5] SA = Screening assessment
[6] Excluded plutonium, cesium, and tritium
[7] Excluded mercury and lead
[8] # = Analysis was done by field test kits or by Infra-red (IR) instrument
[9] Tritium only
[10] Plutonium and cesium only
[11] RA = Risk assessment

3.2.1.1 Blanks Comparison

The first decision point in the data analysis flow chart (Fig. 3-1) is to determine whether the constituent is detected at a greater concentration in the analytical sample data than in the laboratory blanks. This comparison helps distinguish between site-related contamination and laboratory- or field-induced contamination. As noted in Subsection 3.1, acetone was detected in laboratory method blanks for requests 20071 and 20074. The EQLs for these samples were adjusted, and no other adjustments for laboratory contaminants were needed for any data analyzed for SWMU 3-010(a).



[1] Inorganics are compared to LANL background concentrations, and organics are compared to the Bradley urban background concentrations (Bradley et al. 1094, 1144).

[2] Site data will be reviewed for multiple constituents that are less than the SAL and are above background.

[3] RFI Phase II sampling or risk assessment will be performed.

Fig. 3-1. Data analysis flow chart for SWMU 3-010(a) RFI Phase II report.

3.2.1.2 Statistical Comparison to Background

The second data analysis point (Fig. 3-1), and the start of the screening assessment, is a background comparison. Analytes that occur naturally in soils, including most metals and some radionuclides, are compared statistically to concentrations in comparable uncontaminated soils.

An appropriate set of background data must be chosen for the statistical comparisons. For this analysis, the LANL-wide surface soil samples were used because most results presented in this report are for surface soil or sediment samples. The LANL-wide background data include soil samples from the A, B, and C soil horizons from a variety of locations across Los Alamos County (Longmire et al. in preparation, 1142). The LANL-wide background soil database also includes measurements of total concentrations (in mg/kg) of uranium, thorium, and potassium. These data were converted to activity units (pCi/g) by assuming natural abundance of the radioisotopes for these metals. Background concentrations of radionuclides associated with global fallout from atmospheric nuclear testing (for example, plutonium and tritium) should be compared to regional soil concentrations. The LANL Environmental Surveillance reports (Purtymun et al. 1987, 0211; ESG 1988, 0408; ESG 1989, 0308; Environmental Protection Group 1990, 0497; Environmental Protection Group 1992, 0740) report regional concentrations of five fallout-related radionuclides (cesium-137, plutonium-238, plutonium-239/240, strontium-90, and tritium). There are no background data currently available for surface water, so background comparisons will be made for soil and sediment data only.

The statistical comparisons to background follow the general guidance provided in the LANL ER Project policy paper on background comparisons (LANL 1995, 17-1231). This policy paper uses methods that are described in the Environmental Protection Agency (EPA) guidance document, "Statistical Analysis of Ground-Water Monitoring Data" (EPA 1989, 1141). For this analysis, the hot measurement test described in the EPA guidance document was used as the statistically based screening tool for background comparisons. The hot measurement test is based on the upper tolerance limit (UTL), and the UTL has been calculated for naturally occurring metal and radionuclide constituents (Table 3-3). The hot measurement test is used to identify which PRS data exceed the largest background values. The UTL is defined as the 95% upper confidence level of the 99th percentile. The 99th percentile is a value, estimated from the data distribution, such that 1% (100 to 99) of the data will exceed this value. Where the existing background does not permit calculation of the UTL, the maximum reported value for that constituent is used. UTLs were not calculated for analytes that were rarely detected. UTLs were not calculated for the environmental surveillance data, because the statistical sample size for these data was small (six regional locations).

Table 3-3

Upper Tolerance Limits (UTLs) for LANL Soil Background Data

ANALYTE	SAL (mg/kg)	MEAN[1] (mg/kg)	STANDARD DEVIATION (mg/kg)	UTL[2] 99%,0.95 (mg/kg)	N[3]	N > DL[4]
Aluminum	NA[5]	19 000	13 800	123 000	47	47
Antimony	32	2.45	0.36	2.5[6]	46	2
Arsenic	NA	4.4	2.5	11.6	46	46
Barium	5 600	161	129	1 140	47	47
Beryllium	NA	1.15	0.75	3.31	47	47
Cadmium	80	0.39	0.54	2.7[6]	47	5
Calcium	NA	5 790	12 500	54 400	47	47
Cesium-137[7]	4	0.42	0.31	1.4[6]	79	79
Chromium (total)[8]	NA	11.7	7.6	34.2	47	47
Cobalt	NA	15.2	7.6	51.1	47	47
Copper	3 000	5.3	3.6	15.7	47	45
Iron	NA	14 500	7 320	35 600	47	47
Lead	400	15.0	8.3	39.0	47	44
Magnesium	NA	2 920	2 150	16 100	47	47
Manganese	11 000	343	238	1 030	47	47
Mercury	24	0.05	0.01	0.1[6]	48	4
Nickel	1 600	9.7	5.9	26.7	47	45
Plutonium-238[7]	20	0.0013	0.0024	0.014[6]	76	62
Plutonium -239/240[7]	18	0.0083	0.0079	0.052[6]	88	85
Potassium	NA	2 420	1304	6 180	47	47
Potassium-40[9]	NA	21.6	5.07	36.1	50	50
Selenium	400	0.43	0.41	1.7 [6]	46	23
Silver	400	NA	NA	1.61[10]	NA	NA
Sodium	NA	577	453	1 880	47	47
Strontium-90[7]	5.9	0.34	0.27	1[6]	29	29
Thallium	6.4	0.27	0.24	0.9[6]	45	21
Thorium-232[9]	5	1.71	0.34	2.68	50	50
Tritium[11]	810 pCi/g	0.88 pCi/g	0.82 pCi/g	4.08[6] pCi/g	50 pCi/g	50 pCi/g
Uranium[12]	160	3.41	0.80	5.71	50	50
Uranium-234[9]	86	1.21	0.29	2.03	50	50
Uranium-235[9]	18	0.052	0.012	0.088	50	50
Uranium-238[9]	59	1.14	0.27	1.90	50	50
Vanadium	560	25	14	66	47	47
Zinc	24 000	41	21	101	47	47

1 Concentration values <DL (detection limit) were replaced by 1/2 of the DL.
2 UTL = Upper tolerance limit.
3 N = Number of samples.
4 DL = Detection limit.
5 NA = Not available.
6 Maximum value is reported, rather than the UTL.
7 Data are from the Environmental Surveillance Reports (1974–1990), units are pCi/g.
8 SAL for chromiumIII is 80,000 mg/kg and for Chromium-VI is 400 mg/kg.
9 Data are converted from elemental concentrations reported in the LANL background report, units are

3.2.1.3 Comparison to Screening Action Levels

The third data analysis point (Fig. 3-1) in the screening assessment is the comparison to SALs. SALs are conservative, risk-based concentration levels based on RCRA Subpart S that are used as a preliminary screening tool. Appendix J of the Installation Work Plan (LANL 1993, 1017) provides an in-depth explanation of how SALs are derived. All PCOCs that were detected at concentrations greater than background are compared to their respective SALs. If the maximum concentration of a PCOC exceeds its SAL, it is included in the risk assessment.

3.2.1.4 Multiple Constituent Evaluation

LANL also considers whether PCOCs should be included in the risk assessment because of multiple constituent effects. A combination of constituents found in concentrations that are near, but do not exceed SALs may warrant further analysis. The multiple constituent evaluation assumes additive effects of PCOCs, and uses SALs to normalize the contribution of each PCOC that was detected above background and less than the SAL, to the multiple constituent total. If the multiple constituent total is less than one, the PCOCs included in the multiple constituent analysis will not be considered in the risk assessment. If the multiple constituent total is greater than one, then all PCOCs in the multiple constituent analysis that contribute more than 10% to the total will be included in the risk assessment. The formula used to calculate the multiple constituent total is provided in Appendix J of the Installation Work Plan (LANL 1993, 1017).

3.2.2 Ecotoxicological Screening Assessment Approach

A discussion of the requirements and generic approach for ecological risk assessment is presented in Appendix L of the LANL IWP (LANL 1993, 1017). A detailed method for determining ecotoxicological screening action levels (ESALs) was developed to determine if further action at hazardous waste sites is warranted based on toxicological effects to birds, mammals, and reptiles inhabiting the site (Ebinger et al.1994, 17-1219; Ferenbaugh 1995, 17-1220).

For radionuclides the ecotoxicological pathways are screened against the human health SAL values because ESALs were not derived for radionuclides. Radiation-induced carcinogenity has not been measured for these organisms (Ebinger et al. 1994, 17-1219).

If the screening assessment finds potential ecotoxicological impacts, then a number of decisions are possible depending on the size of the contaminated area (as compared to the ranges of the animals inhabiting the area), whether threatened or endangered plants and

animals inhabit or use the site, and whether the site is a sensitive habitat (Cross 1994, 17-1221). Further investigation would then be necessary beyond initial biological surveys and screening to determine the current impact of the contaminant and also the impacts from possible remediation alternatives.

3.3 Risk Assessment Approach

3.3.1 Human Health Risk Assessment

The human health portion of the risk assessment follows the procedures outlined in Chapter 4 and Appendix K of the LANL Installation Work Plan (LANL 1993, 1017). The human health risk assessment process consists of the following four steps: 1) identify the potential contaminants of concern; 2) perform an exposure assessment; 3) perform a toxicity assessment; and, 4) develop risk characterization. Each step is described briefly below.

3.3.1.1 Identification of Potential Contaminants of Concern

As stated in Subsection 3.2, the primary purpose of the screening assessment is to identify PCOCs for the risk assessment. If data collected for the screening assessment are sufficient for completing the human health risk assessment, no further PCOCs identification is required. However, SWMU 3-010(a) required a second phase of investigation to collect additional data to support the risk assessment. As a result, data from all phases of investigation need to be evaluated and an appropriate data set developed for inclusion in the risk assessment. This data assessment will include, but not be limited to, an evaluation of data qualifiers, nondetect results, and frequency of detection. The data assessment results will include a final list of PCOCs and corresponding representative chemical concentrations for inclusion in the human health risk assessment.

3.3.1.2 Exposure Assessment

Exposure assessment is the process of quantifying exposure to a chemical by measuring or estimating the intensity, frequency, and duration of exposure. The exposure assessment is performed within the framework of a conceptual model that identifies potential contaminant sources and transport routes, potential current and future receptors, and exposure scenarios and routes linking sources and receptors. A conceptual model for SWMU 3-010(a) was developed based on results of the Phase I investigation and was presented in the Phase II sampling plan (LANL 1994, 17-1222). As new information becomes available, a conceptual model is reevaluated to verify that potential complete human exposure pathways have been identified. A complete exposure pathway must include the source of a contaminant that could

cause an adverse effect, a potential for human contact with the exposure medium, and a route of human exposure to that medium. Using representative concentrations developed during the data assessment described above, estimates of potential chemical uptake (or dose) are calculated for the exposure scenarios and routes identified in the conceptual model.

3.3.1.3 Toxicity Assessment

Toxicity assessment is a two-step process. First, it evaluates available information regarding the potential for a contaminant to cause adverse health effects to exposed individuals (hazard identification). Second, it estimates the relationship between the extent of exposure and the increased likelihood (probability or chance) and/or severity of adverse effects (dose-response assessment).

Hazard identification entails determining if a contaminant can cause an increase in a particular adverse effect (e.g., cancer) and the likelihood that the adverse effect will occur in humans. The result of the hazard identification is a toxicity profile that summarizes available toxicological information and its relevance to human exposure under current site conditions. Dose-response assessment entails quantifying the relationship between the dose of a contaminant and the incidence of adverse effects in the exposed population. The dose-response assessment results in a toxicity criterion used in the risk characterization to estimate the likelihood of adverse effects occurring in humans at different exposure levels. The toxicity criteria used to evaluate noncarcinogenic and carcinogenic health risks are commonly referred to as reference doses (RfDs) and slope factors (SFs), respectively.

Toxicity assessments have been completed by federal and/or state regulatory agencies for most chemicals commonly found at hazardous waste sites. If a toxicity assessment has already been completed for a PCOC, then the toxicity criteria included in that assessment are used in the human health risk assessment. Otherwise, a toxicity profile is written based on information in the scientific literature, and if possible, toxicity criteria are developed according to guidance provided by EPA (EPA 1989, 0305).

3.3.1.4 Risk Characterization

Risk characterization, the final step in the risk assessment process, integrates results of the exposure and toxicity assessments into quantitative or qualitative estimates of potential carcinogenic or noncarcinogenic health risks. In addition, risk characterization interprets and qualifies the results with respect to the considerable uncertainty inherent in the risk assessment process and various regulatory guidelines for acceptable levels of risk.

4.0 SITE-SPECIFIC RESULTS

4.1 Phase I RFI Field Investigation and Sampling Activities

Initial characterization of PCOCs at SWMU 3-010(a) included collecting five soil samples from the erosion channel that marked the center of the SWMU. The sample analysis information was also used to set protective levels for worker health and safety. The five soil samples collected in 1992 were analyzed for total mercury; total beryllium; TCLP metals; total alpha, beta, and gamma radioactivity; total uranium; isotopic plutonium; and tritium. One soil sample was collected where mercury was visible at the soil surface and was analyzed for VOCs, TPH, and PCBs in addition to the analytes listed above. The 1992 samples revealed one detection of 1,1,1-trichloroethane (160 ppb concentration) from the 63 constituents in the volatile organic analyses (VOA) suite. The 1992 samples also indicated the presence in surface and subsurface soil of metals, including elemental mercury and lead; radionuclides including plutonium, cesium, and tritium; and, TPH.

In 1993 Phase I sampling activities, a 50-point grid (5 columns, 10 rows) was established over and around the highly contaminated soil determined by an XRF survey and the visible erosion channel. Composite soil samples were taken from each row and column of the grid. Composite samples from rows one through five were analyzed for TAL metals, radionuclides, and TPH; composite samples from rows six through ten were analyzed for TAL metals and radionuclides. Because the resulting analysis showed high levels of mercury, discrete soil samples were collected from each of 42 grid points for mercury analysis. TCLP analysis was performed on a subset of discrete samples collected from row 6, columns 2 to 4 and row 8, columns 2 to 4.

Because radioactive constituents were detected above background, all the materials to be excavated and removed from the site in a VCA were handled as low-level radioactive waste. However, because metals were below TCLP limits at the site, waste generated was not considered mixed waste. All radioactive constituents were at concentrations less than ER Project SALs. Water samples taken during three separate storm events on May 24, July 20, and August 1, 1993, revealed no measurable mercury migrating into the waste stream.

4.2 Voluntary Corrective Action

The VCA at SWMU 3-010(a) consisted of removing three lifts of contaminated soil and/or construction fill. Excavation of the three lifts created a trench approximately 40 ft long by 15 ft wide in the hillside west of building TA-3-30. The total amount of material removed from all three lifts during the VCA was approximately 130 to 140 cubic yards. The first 19 drums of soil

were taken to the mixed waste dome at TA-54, Area L for treatment to extract the mercury. All other soils were taken to the TA-54, Area G low-level radioactive landfill in bulk.

Soil samples were collected from the trench after the removal of the second lift to confirm that all soils containing radioactivity above background had been removed. Of the ten samples collected, two had levels slightly over background. Removal of the third lift eliminated any residual elevated plutonium levels in the soils. Additional samples were collected for TPH on-site infrared analysis during the removal of Lift 3. Because TPH concentrations varied with depth, distribution of TPH in the subsurface was thought to be associated with features such as fractures in the tuff. Field analysis of samples taken in the sidewalls of the excavation indicated that lateral migration was limited.

After the third lift was excavated, several soil [tuff] samples were collected from the bottom of the excavation to confirm that mercury was below 20 ppm and that the remaining mineral oil did not contain BTEX constituents. Results of the confirmatory sampling showed the mercury concentration at the bottom of the excavation was below the mercury SAL (20 ppm). A total VOC analyses was performed instead of the BTEX analysis. The volatile samples revealed no BTEX; however, the full analytical suite showed the unexpected presence of 1,1-dichloroethene, 1,2-dichloroethane, and trichloroethene. Twelve other VOCs were also detected in the upper biased sample and three VOCs were detected in the east vertical wall sample, all at concentrations below their respective SALs. The introduction of VOCs indicated that the VCA could not be completed as a final remedy for the site and further investigations were initiated.

4.3 Screening Assessment

The purpose of the screening assessment is to identify the constituents remaining at the site after implementation of the VCA and to determine what constituents will be considered in the risk assessment. The VCA was implemented to remove a volume of soil that was known to be contaminated with mercury, lead, and TPH. The soil removed during the VCA also had concentrations of radionuclides above background (tritium, plutonium-238, plutonium-239/240).

The screening assessment for SWMU 3-010(a) will consider surface soil and surface water data collected during the RFI Phase I Investigation (by either LANL Environment, Safety, and Health personnel or ER personnel) and the verification data collected at the conclusion of the VCA. These data provide information on all potential contaminants for this site. Table 4-1 summarizes the analyses requested for screening assessment sampling locations.

and the analyses requested for locations within the excavation and upgradient (offsite) of SWMU 3-010(a). Data used in the screening assessment were from samples collected at the bottom, adjacent to, and downgradient of the excavation. The backfill soil data document that the excavation was filled with clean soil. The sample locations within the excavation are presented for information purposes only and are not used in the screening assessment.

Data for two sample locations (AAA2375, AAA2376) represent composite sediment samples collected in the stream channel downgradient of SWMU 3-010(a). Figure 4-1 shows the locations of sediment samples downgradient from the excavation, an upgradient sediment sample location, and surface water samples from the drainage channel. The analytical data from composite sampling locations should be interpreted carefully, because there could be one elevated reading that is averaged out by low values in the other aliquots of the composite sample. Because these composite locations overlap with other grab sample locations, they are presented for comparison. No adjustments, based on the number of aliquots in the composite sample, will be made for either background or SAL comparisons.

The following subsections describe the results of the screening assessment process for the sample locations summarized in Table 4-1. The data analysis steps needed to support the screening assessment include comparisons to natural background and comparisons to SALs. Table A-1 in Appendix A summarizes the range of concentrations measured for soil analytes at the locations considered in the screening assessment and the locations within the excavation. Table A-2 in Appendix A lists all detected soil analytes by sample identification number. Table A-3 summarizes the range of concentrations measured for analytes in the storm water runoff samples. Table A-4 in Appendix A lists all analytes detected in storm water runoff samples.

4.3.1 Ecotoxicological Screening Assessment

The initial screening of the Phase I and Phase II data against the limits of detection (LOD), blanks, and background data to determine analytes for further ecotoxicological screening is the same procedure as for the human health screening assessment. Once the analytes are considered hits, or PCOCs, then they are screened against a different set of action levels, called ESALs. The analytes are then considered contaminants of potential ecological concern (COPECs) and are carried through the remaining screening assessment shown in Figure 4-2.

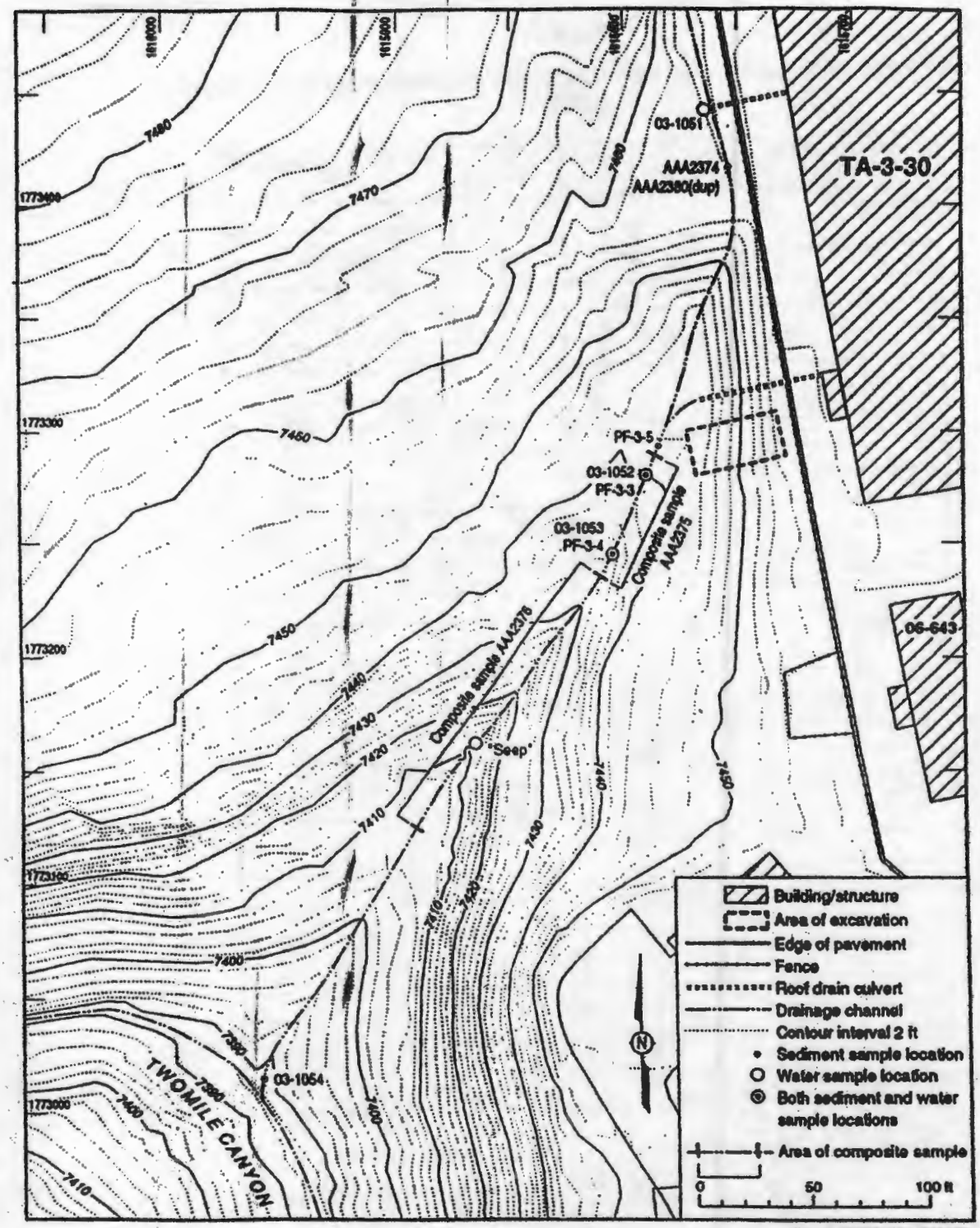
Since the SWMU area was excavated during the VCA and is considered an industrial site, an ecotoxicological screening assessment indicates that no further assessment is proposed for SWMU 3-010(a). However, the SWMU lies in a small side canyon and is part of a large

TABLE 4-1

SUMMARY OF THE ANALYSES REQUESTED FOR THE SCREENING ASSESSMENT LOCATIONS

CHARACTERIZATION ACTIVITY	SAMPLE LOCATION	RAD	RAD SCREENING	TPH	VOC	INORGANICS
ESH samples						
	03-1003	x[1]		x	x	x[2]
	03-1038	x[1]				x[2]
	03-1051A	x[1]				x[2]
	03-1052A	x[1]				x[2]
	03-1053A	x[1]				x[2]
Surface soils	03-1013	x[3]		x		x[4]
	03-1018	x[3]		x		x[4]
	03-1023	x[3]		x		x[4]
	03-1051	x[3]		x		x[4]
	03-1052	x[3]		x		x[4]
	03-1053	x[3]		x		x[4]
	03-1054	x[3]		x		x[4]
Surface waters	03-N/A	x[3]		x		x[5]
Verification						
Biased samples	03-1261			#[6]	x	x[7]
	03-1262			#	x	x[7]
	03-1263			#	x	x[7]
	03-2605	x[8]	x			x[9]
	03-2606	x[8]	x			x[9]
Backfill	03-SM30	x[10]	x			x[11]
Surface soils	03-2669		x			x[7]
	03-2670		x			x[7]
	03-2671		x			x[7]
	03-2672		x			x[7]
	03-2673		x			x[7]
	03-2674		x			x[7]
	03-2675		x			x[7]
	03-2676		x			x[7]
	03-2677		x			x[7]
	03-2678		x			x[7]

[1] Plutonium and tritium only
[2] Mercury, barium and uranium only (Barium, chromium, cadmium, and lead were soil, extracted samples)
[3] Plutonium, cesium, and tritium only
[4] Antimony, arsenic, barium, beriliun, cadmium, chromium, copper, manganese,nickel, lead, mercury, selenium, silver, thallium, vanilium, and zinc only
[5] Antimony, arsenic, barium, beriliun, cadmium, chromium, lead, manganese, mercury, nickel, selenium, silver, thallium, vanilium, and zinc only
[6] # = Analysis was done by field test kits or by Infrared (IR) instrument
[7] Mercury only
[8] Plutonium, cesium only
[9] Lead only
[10] Tritium, alpha, beta, lead-212, lead-214, potassium-40, radium-224, radium-226, thallium-208 only
[11] Aluminum , antimony, arsenic, barium, beriliun, cadmium, calcium, chromium, cobalt, copper, iron, Lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanilium, and zinc only



Source: FIMAD 1994, G101973
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Fig. 4-1. Locations of sediment and storm water runoff samples.

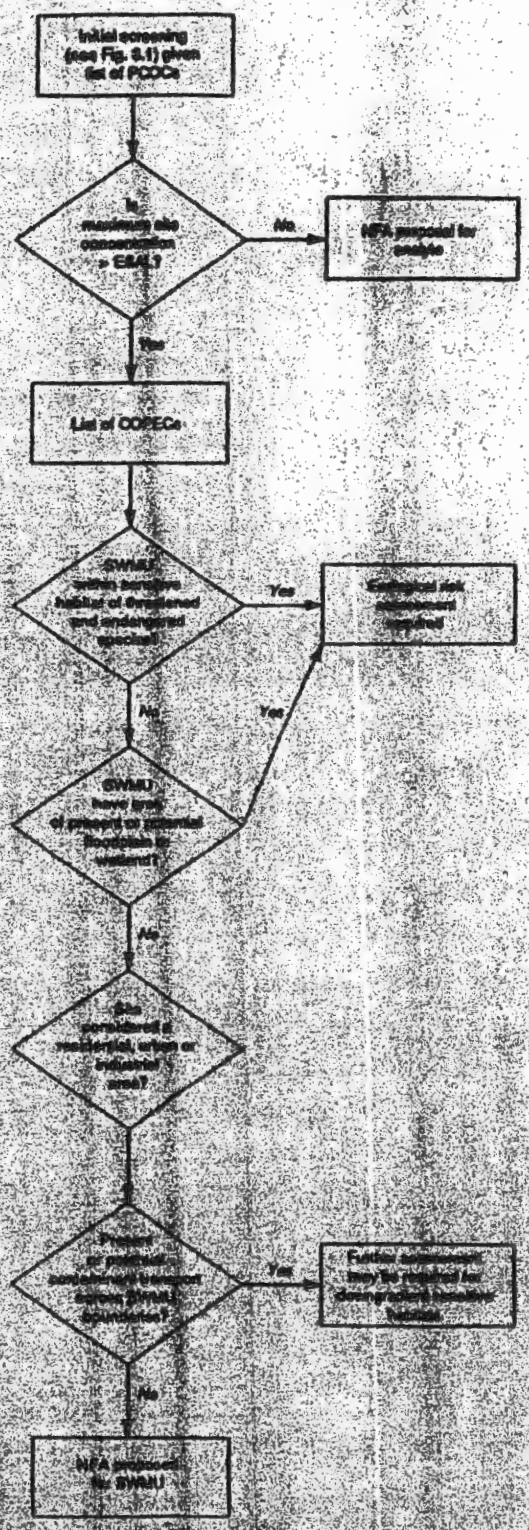


Fig. 4-2. Data analysis and screening assessment decision logic flow chart.

watershed, which could impact sensitive habitats in the lower canyon ecosystems. Therefore, possible transport of contaminants from the site downgradient was screened to determined if an ecological risk assessment is needed at this time. The ecotoxicological screening assessment is presented in Subsection 4.4.

4.3.2 Background Comparison

The background comparison is performed on metal and radionuclide analytes that occur naturally and have a background concentration range. As discussed in Subsection 3.2, the UTL (95% upper confidence value of the 99th percentile) is being used as the background screening value. Analytes present at concentrations less than the UTL are considered to fall within the ordinary background range and will not be considered in subsequent screening assessment data analysis steps.

Metal concentration data from SWMU 3-010(a) sampling locations were compared to LANL-wide background concentration data. Seventeen metals (aluminum, antimony, barium, beryllium, calcium, cobalt, iron, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, uranium, and vanadium) were measured at concentrations within the LANL-wide background concentration range and were then eliminated from consideration (Appendix A-1 presents a data summary for these and all other measured analytes). Seven metals (arsenic, cadmium, chromium, copper, lead, mercury and zinc) were measured at concentrations exceeding the UTL value in either the excavated soil or the screening assessment data. The concentration values for these metals are presented by location in Tables 4-2 and 4-3, and the sampling locations are on Fig. 4-1 and Fig. 4-3. Only lead and mercury were detected at concentrations exceeding the UTLs in the screening assessment data. Mercury concentrations were greater than background at 12 of 20 locations, which included the majority of the sample locations at the bottom of the excavation and adjacent to the excavation (Fig. 4-3). As shown in Fig. 4-3, mercury was not measured above background at a sampling location (PF-3-3) downgradient of the excavation. It is significant to note the dramatic decrease in concentrations of lead and mercury from the excavation locations to either the bottom of the excavation or adjacent to the excavation. These data indicate that the VCA was effective in removing most elevated metal concentrations from the site. Downgradient sample locations of cadmium, copper, and zinc clearly indicate that the greater-than-background concentrations of these constituents were limited to the excavation. Arsenic was the only additional metal analyte detected at above-background concentrations, and it was detected in an upgradient sample location (AAA2374).

TABLE 4-2

ANALYTICAL RESULTS FOR SAMPLING LOCATIONS OFFSITE (AND UPGRADIENT) AND WITHIN THE EXCAVATION

ANALYTE		OFFSITE	WITHIN EXCAVATION (SOIL WAS REMOVED DURING THE PCA)					SAL
		03-1051	PF-3-1	03-1013	03-1018	03-1023	PF-3-2	
Arsenic	Maximum	14.0		6.12	6.03	0.35		NA[1]
	Count	3		5	4	4		NA
Cadmium	Maximum	0.6		17	4.1	39		80
	Count	2		6	4	4		NA
Chromium	Maximum	17		34	81	30		NA
	Count	2		6	4	4		NA
Copper	Maximum	84		80	38	87		8000
	Count	2		6	4	4		NA
Lead	Maximum	250		609	780	1 039		400
	Count	2		5	4	4		NA
Mercury	Maximum	1.6	≥2	720	480	498	1.709	81
	Count	6	1	15	12	12	1	NA
Zinc	Maximum	170		169	130	220	NA	24 000
	Count	2		6	4	4	NA	NA
Cesium-137[2]	Maximum	1.84		1.13	1.08	0.77		4
	Count	2		1 6	4	4		NA
Plutonium-238[2]	Maximum	0.011	0.005	0.013	0.011	0.013	0.008	80
	Count	2	1	5	4	5	1	NA
Plutonium-239[2]	Maximum	0.048	0.139	1.405	1.046	0.894	1.86	16
	Count	2	1	5	4	5	1	NA
Tritium[2]	Maximum	2.1	41.19	402.3	551.85	480.84	47.27	840
	Count	2	1	5	4	4	1	NA
1,1,1-Trichloroethane	Maximum		0.16					1 000
	Count		1					NA
1,1-Dichloroethane	Maximum		<0.005					410
	Count		1					NA
1,2-Dichloroethane	Maximum		<0.005					0.2
	Count		1					NA
1,1-Dichloroethene	Maximum		<0.005					0.4
	Count		1					NA
Acetone	Maximum		0.008					6 000
	Count		1					NA
Benzene	Maximum		<0.005					0.67
	Count		1					NA
Chloroform	Maximum		<0.005					0.21
	Count		1					NA
Chloromethane	Maximum		<0.01					6.4
	Count		1					NA
cis-1,3-Dichloropropene	Maximum		<0.005					0.17
	Count		1					NA
Ethylbenzene	Maximum		<0.005					3 900
	Count		1					NA
Toluene	Maximum		<0.005					910
	Count		1					NA
Total petroleum hydrocarbons	Maximum	1 220	37 100	27 400	23 300	37 600		100
	Count	2	1	5	4	4		NA
Mixed xylenes	Maximum		<0.005					160 000
	Count		1					NA

[1] NA = Not available.

[2] Results are in pCi/g. All other results are in mg/kg.

This shading indicates no analysis was requested for the analyte.

Bold, left-justified numbers indicate results above the background range.

Indicates the result is above SAL.

TABLE 4-3

ANALYTICAL RESULTS FOR SAMPLING LOCATIONS AT SWMU 3-010(a)

ANALYTE		BOTTOM OF EXCAVATION					ADJACENT TO EXCAVATION											DOWNGRADIENT					BACKFILL	SAL
		03-1261	03-1262	03-1263	03-2665	03-2666	PF-3-5	03-2668	03-2670	03-2671	03-2672	03-2673	03-2674	03-2675	03-2676	03-2677	03-2678	PF-3-3	PF-3-4	AJA 2275	AJA 2276	03-1664	03-2620	
Arsenic	Maximum																			3.61	3.22	2.57	<1.9	N/A[d]
	Count																			1	1	1	2	
Cadmium	Maximum																			<0.4	<0.4	<0.4	<0.83	80
	Count																			1	1	2	2	
Chromium	Maximum																			6.1	4.8	4.7	<0.78	N/A[d]
	Count																			1	1	2	2	
Copper	Maximum																			14	2.9	3.3	<1.9	3 000
	Count																			1	1	2	2	
Lead	Maximum				9.5	7.4														51	21	25	3.4	400
	Count				2	1														1	1	2	2	
Mercury	Maximum	0.9	1.2	<0.11			1.94	0.3	0.5	1.4	0.3	0.7	10	0.1	0.07	0.2	0.2	0.0495	0.0019	0.7	<.2	<.2	<0.08	24
	Count	1	1	1			1	3	3	3	3	3	3	3	3	3	3	1	1	3	3	3	2	
Zinc	Maximum																			79	42	43	33.9	24 000
	Count																			1	1	2	2	
Cesium-137[a]	Maximum				<.1842	<.1739														1.04	0.54	<0.66		4
	Count				2	1														1	1	1		
Plutonium-238[b]	Maximum				-0.0007	0.0027	0.04											0.001	0.001	0.01	0.002	0.003		20
	Count				2	1	1											1	1	1	1	1		
Plutonium-239[b]	Maximum				0.0078	0.0027	0.24											0.008	0.002	0.036	0.003	0.001		16
	Count				2	1	1											1	1	1	1	1		
Tritium[c]	Maximum						16.5											2.32	0.071	2.22	0.361	0.022	0.0069	810
	Count						1											1	1	1	1	1	2	
Tritium[b]	Maximum				0.82	0		0	0	0	0	0	0	0	0	0	0						0	810
	Count				2	1		1	1	1	1	1	1	1	1	1	1						2	
1,1,1-Trichloroethane	Maximum	100	1.1	0.03																				1 000
	Count	1	1	1																				
1,1-Dichloroethane	Maximum	0.2	<0.006	<0.006																				410
	Count	1	1	1																				
1,2-Dichloroethane	Maximum	0.91	<0.006	<0.006																				0.2
	Count	1	1	1																				
1,1-Dichloroethene	Maximum	29	0.044	<0.006																				0.4
	Count	1	1	1																				
Acetone	Maximum	0.25	<0.024	<0.024																				8 000
	Count	1	1	1																				
Benzene	Maximum	0.38	<0.006	<0.006																				0.67
	Count	1	1	1																				
Chloroform	Maximum	0.069	<0.006	<0.006																				0.21
	Count	1	1	1																				
Chloromethane	Maximum	0.13	<0.012	<0.012																				6.4
	Count	1	1	1																				
cis-1,3-Dichloropropene	Maximum	0.054	<0.006	<0.006																				0.17
	Count	1	1	1																				
Ethylbenzene	Maximum	0.023	<0.006	<0.006																				3 100
	Count	1	1	1																				
Toluene	Maximum	0.26	<0.006	<0.006																				910
	Count	1	1	1																				
Total petroleum hydrocarbons	Maximum	15 000[e]	2 000[e]	10[e]																211	425	126		100
	Count	1	1	1																1	1	1		
Mixed-xylenes	Maximum	0.029	<0.006	<0.006																				160 000
	Count	1	1	1																				

[a] Results are in pCi/g. All other results are in mg/kg.
[b] Tritium data is screening data from the Radvan.
[c] Infra-red field analysis values.
[d] N/A = Not available.

This shading indicates no analysis was requested for the analyte.
Bold, left-justified numbers indicate results above the background range.
Indicates the result is above SAL.

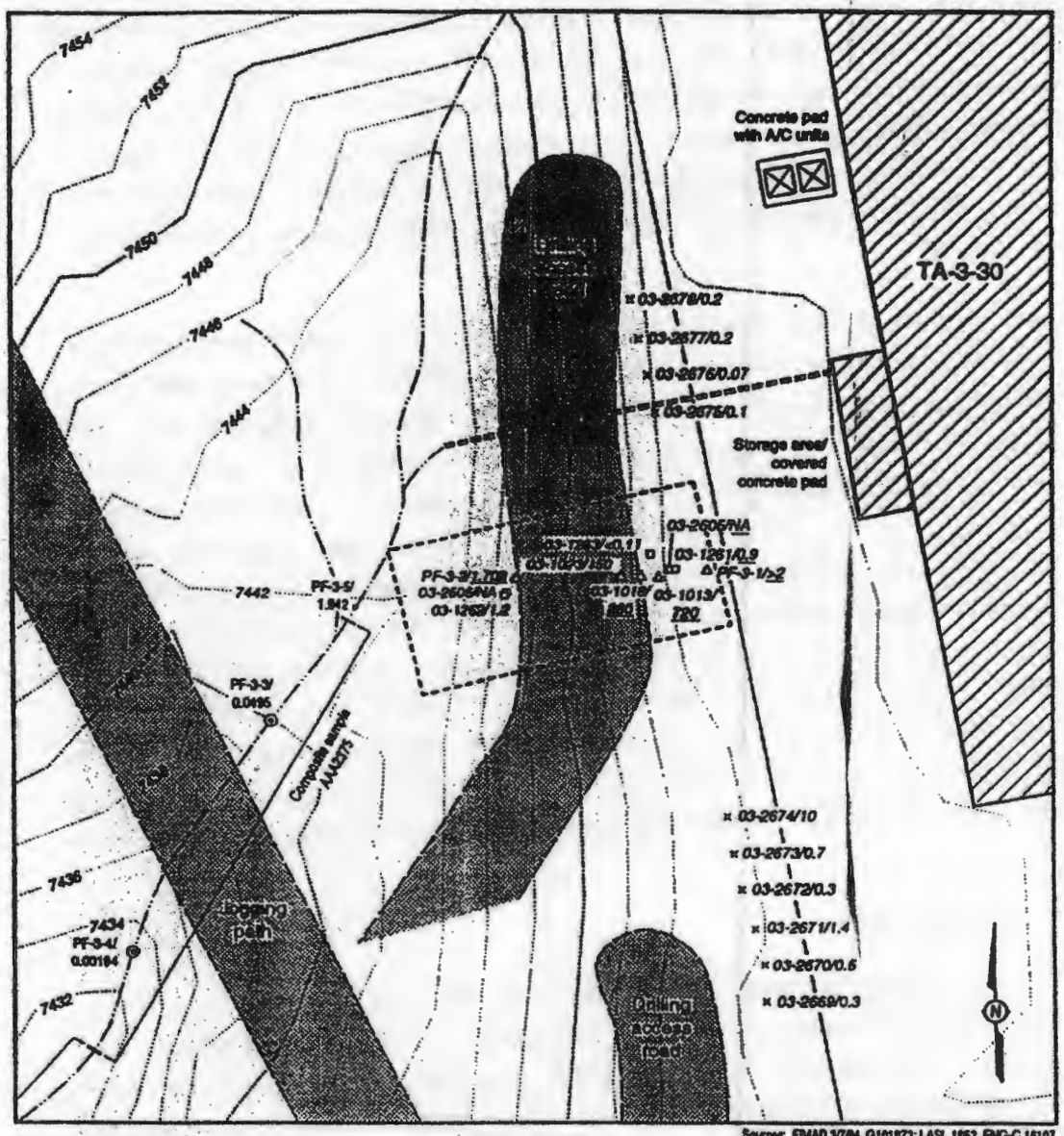
Three radionuclides were measured above regional background concentrations. Tritium[1] was detected above regional background soil concentrations at two sampling locations: one adjacent to the excavation (PF-3-5), and the other at the bottom of the excavation (03-2605) (Fig. 4-3). Plutonium-238 and plutonium-239 and -240 were above regional background concentrations at one location adjacent to the excavation (PF-3-5). Cesium-137 was detected above regional background concentrations at the upgradient location (AAA2374). Concentrations of radionuclides are significantly lower in samples collected below or downgradient of the excavation. This indicates that the VCA effectively removed the majority of these elevated concentrations.

In summary, of the metals and radionuclides measured at the screening assessment sample locations, only mercury, lead, tritium, plutonium-238, and plutonium-239 and -240 are observed at concentrations above background. Mercury, lead, tritium, plutonium-238 and plutonium-239 and -240 will be carried to the next data analysis step (SAL comparison). Arsenic, cadmium, copper, lead, zinc and cesium-137 will not be considered in subsequent screening assessment steps. The upgradient location is outside the SWMU boundary as determined by the extent of the most ubiquitous contaminant (1,1,1-TCA). The sample was initially collected to compare downgradient sediment samples from the SWMU site to a local background, therefore an upgradient sample location was selected. The data point gives us information about what can be expected in sediments in storm drainages around this area of TA-3, but does not relate specifically to what is contributed by the SWMU site and consequently will not be included in the risk assessment. A summary of all soil analytes for the screening assessment sample locations is given in Table A-1 of Appendix A and Table A-2 presents all data for the detected analytes.

4.3.3 SAL Comparison

For the soil sampling locations, all detected organic chemicals, mercury, lead, tritium, plutonium-238 and plutonium-239 and -240 were compared to the appropriate SALs. Only three analytes were detected at concentrations above the SAL. At location 03-1261, 1,2-dichloroethane (1,2-DCA) and 1,1-dichloroethene (1,1-DCE), and TPH exceeded the SALs (Table 4-3). TPH also exceeded the SAL at four other sampling locations (03-1262, AAA2375, AAA2376, 03-1054), which were either at the bottom of, or downgradient of the excavation (Fig. 4-3). However, the SAL for TPH is based on the migration potential of BTEX and assumes that the site is within 50 ft of useable groundwater. TPH must be evaluated based on the toxicity of its components. Any VOCs associated with the mineral oil TPH at this site have been

[1] To convert tritium in soil moisture to a soil concentration requires a measurement of soil moisture. Soil moisture data was not measured for either the regional background concentrations or three sample locations (03-1051A, 03-1052A, and 03-1053A). The largest soil moisture value measured at the remaining locations (26.3% water content) was used since this represents the most conservative conversion factor.



Source: FMAD 3/7/94, G101973; LASL 1652, ENG-C 16197
Modified by: eARTography by A. Kron 4/17/95

03-2674/10 Location ID/ Mercury Concentration (mg/kg)

03-2674/10 Underlined values represent soil removed

Building/structure

Unimproved road

Roof drain culvert

Fence

Drainage channel

Area of excavation

Contour interval 2 ft

Within excavation soil sample location

Bottom of excavation (after lift 3) soil sample location

Mercury sample location

Sediment sample location

Sediment and water sample location

Area of composite sample

NA = Not analyzed

0 10 20 ft

Fig. 4-3. Soil sampling locations with mercury concentration data.

evaluated on a compound-by-compound basis in the screening assessment. In addition, it is unlikely that any hazardous SVOCs will be present because there is strong evidence that the source of the TPH at SWMU 3-010(a) is mineral oil. Therefore, TPH will not be included as a PCOC in the risk assessment.

There were no analytes measured above the SAL in the surface water runoff samples collected from the site. Table 4-4 lists the maximum value for the analytes detected in the three storm water sampling events. Table A-3 in Appendix A summarizes the complete list of analytes measured in these surface water samples, and Table A-4 presents all data for the detected analytes.

TABLE 4-4

MAXIMUM VALUE FOR ANALYTES DETECTED IN STORM WATER SAMPLING EVENTS

ANALYTE		03-1051[b]	03-1052	03-1053	03-1054	OVERALL MAXIMUM[c]	SAL
Arsenic	Maximum	7.18	6.13	5.8	6.71	6.71	50
	Count	1	1	1	1	3	
Barium	Maximum	11	20	25	21	25	2 000
	Count	1	1	1	1	3	
Lead	Maximum	32	13	8	8	13	50
	Count	1	1	1	1	3	
Manganese	Maximum	16	30	23	23	30	180
	Count	1	1	1	1	3	
Nickel	Maximum	<10	20	<10	<10	20	100
	Count	1	1	1	1	3	
Total petroleum hydrocarbons	Maximum	8 410	<2 000	<2 000	2 450	2 450	NA[d]
	Count	3	3	3	3	9	
Zinc	Maximum	90	82	71	34	82	10 000
	Count	1	1	1	1	3	
Cesium-137[e]	Maximum	34.9	41.4	50.6	89	89	110
	Count	2	2	2	2	6	
Plutonium-238[e]	Maximum	0.005	0.005	-0.01	0.005	0.005	15
	Count	2	2	2	2	6	
Plutonium-239[e]	Maximum	0.072	0.128	0.093	0.068	0.128	15
	Count	2	2	2	2	6	
Tritium[e]	Maximum	200	200	300	300	300	20 000
	Count	2	2	2	2	6	

- Results are in µg/L.
- This is an upgradient water sample.
- Maximum excludes the upgradient water sample.
- NA = Not available.
- Radionuclide results are in pCi/L.

4.3.4 Multiple Constituent Analysis

The multiple constituent analysis determines if analytes present at concentrations less than the SAL warrant further consideration in the risk assessment because of potential additive health effects. Mercury, lead, tritium, plutonium-238 and plutonium-239 and -240 are the only metals and radionuclides considered in the multiple constituent analysis for SWMU 3-010(a). All detected organic analytes that did not exceed the SAL are also considered in this multiple constituent analysis.

Appendix J of the IWP (LANL 1993, 1017) suggests that the multiple constituent analysis should be applied to the maximum concentration measured at each location. This location-by-location application of the multiple constituent analysis will yield meaningful results only if the same analytes are measured at each location. Given that the analyte suite at each location or group of locations (e.g., the bottom of the excavation) was not identical, the multiple constituent analysis was not performed on a location-by-location basis. The multiple constituent analysis was calculated using the maximum value for each analyte across all screening assessment soil sampling locations. Thus, the multiple constituent analysis for SWMU 3-010(a) is more conservative than the approach outlined in Appendix J of the IWP (LANL 1993, 1017). The maximum value for each analyte in the chemical carcinogen, chemical noncarcinogen, and radionuclide groups was used to calculate the multiple constituent total for each group. The multiple constituent totals of the chemical noncarcinogen and radionuclide analyte groups were less than one (Table 4-5), which means that no additional analytes from these groups need be considered in the risk assessment. The multiple constituent total for the chemical carcinogens exceeded one, and benzene, chloroform, cis-1,3-dichloropropene all contributed more than 10% to the total (Table 4-5).

The multiple constituent analysis was also conducted on the storm water runoff samples. None of the multiple constituent analyses exceeded one (Table 4-6). The upgradient storm water sample does not differ significantly from the downgradient storm water samples. To better address potential impacts of SWMU 3-010(a) on surface water quality, the Phase II data include surface water samples from the seep downgradient of the site. Any additional PCOCs identified by these Phase II water data will be considered in the risk assessment.

TABLE 4-5

MULTIPLE CONSTITUENT ANALYSIS FOR SCREENING ASSESSMENT SOIL SAMPLES

ANALYTE	MAXIMUM	SAL	MULTIPLE CONSTITUENT ANALYSIS
Chemical Carcinogens	mg/kg	mg/kg	mg/kg
Benzene [a]	0.38	0.67	0.567
Chloroform [a]	0.069	0.21	0.329
cis-1,3-Dichloropropene [a]	0.054	0.17	0.318
			Chemical Carcinogens Total
			1.213
Non-Carcinogens	mg/kg	mg/kg	mg/kg
Copper	14	3 000	0.005
Lead	51	400	0.128
Mercury	10	24	0.417
Zinc	79	24 000	0.003
1,1,1-Trichloroethane	100	1 000	0.100
1,1-Dichloroethane	0.2	410	0.000
Acetone	0.25	8 000	0.000
Chloromethane	0.13	6.4	0.020
Ethylbenzene	0.023	3 100	0.000
Toluene	0.28	910	0.000
Mixed-xylenes	0.029	160 000	0.000
			Non-Carcinogens Total
			0.673
Radionuclides	pCi/g	pCi/g	pCi/g
Cesium-137[b]	1.04	4	0.260
Plutonium-238[b]	0.036	20	0.002
Plutonium-239[b]	0.24	18	0.013
Tritium[b]	16.45	810	0.020
Tritium[b,c]	8.82	810	0.011
			Radionuclides[d] Total
			0.295

- If the multiple constituent analysis total was greater than one, the indicated analyte contributed at least 10% of the total.
- Results are in pCi/g. All other results are in mg/kg.
- Tritium data is screening data from the rad van.
- Total includes only the higher of the two tritium values.

TABLE 4-6

MULTIPLE CONSTITUENT ANALYSIS FOR SCREENING ASSESSMENT SURFACE WATER SAMPLES

ANALYTE	MAXIMUM	SAL	MULTIPLE CONSTITUENT ANALYSIS
Chemical Carcinogens	µg/L	µg/L	µg/L
Arsenic	7.18	50	0.144
			Chemical Carcinogens Total
			0.144
Non-Carcinogens	µg/L	µg/L	µg/L
Barium	25	2 000	0.013
Lead	13	50	0.260
Manganese	30	180	0.167
Nickel	20	100	0.200
Zinc	82	10 000	0.008
			Non-Carcinogens Total
			0.648
Radionuclides	pCi/L	pCi/L	pCi/L
Cesium-137	89	110	0.809
Plutonium-238	0.005	15	0.000
Plutonium-239	0.128	15	0.009
Tritium	300	20 000	0.015
			Radionuclides Total
			0.833

4.3.5 Screening Assessment Conclusions

The screening assessment provides a rationale for selecting PCOCs to consider in the risk assessment. The storm water runoff data does not seem to indicate that SWMU 3-010(a) is impacting surface water quality. However, the Phase II downgradient water concentration data will confirm whether SWMU 3-010(a) is impacting surface water quality. In summary, the screening assessment of the soil sample locations identified the following PCOCs: benzene, chloroform, 1,2-DCA, 1,1-DCE, and cis-1,3-dichloropropene.

4.4. Ecotoxicological Screening Assessment for Phase I and Phase II

4.4.1 Ecotoxicological Screening Assessment for Phase I

The soil sampling data was screened in two separate exercises, Phase I and Phase II as presented previously. The Phase I data described in Subsection 4-3-2 and presented in Tables 4-2 and 4-3 are compared to ESALs by location in Table 4-7.

TABLE 4-7

MAXIMUM PHASE I SOIL SAMPLE VALUES COMPARED TO THE SOIL ESAL (VALUES IN mg/kg OR pCi/g)

ANALYTE	UPGRADIENT (NO. ABOVE LOD[a])	RESIDUAL (NO. ABOVE LOD)	ADJACENT (NO. ABOVE LOD)	DOWNGRADIENT (NO. ABOVE LOD)	ESAL[b]	COPEC[c]
Lead	250(2)			51(4)	0.004	Yes
Mercury	1.5(6)	1.2(3)	10(11)	0.7(11)	0.003	yes
1,2-dichloroethane		0.91(3)			0.15	yes
1,1-dichloroethene		29(3)			0.002	yes
1,1,1-tricholoethane		100(3)			NA[d]	yes
Total petroleum hydrocarbons	1 220(2)	15 000(3)		425(3)	NA[e]	yes
Tritium		8.8(3)	16.5(1)		810 (SAL[f])	No
Plutonium-238			0.036(1)		20 (SAL)	no
Plutonium-239			0.24(1)		18 (SAL)	no

[a] LOD = Limits of detection.
[b] ESAL = Ecotoxilogical screening action levels.
[c] COPEC = Contaminant of potential concern.
[d] NA = ESAL not available.
[e] NA = TPH toxicity needs to be based on constituents. No ESAL is available.
[f] SAL = Screening action level.

The ESALs represent the lowest soil exposure pathway value for the mammals, birds, and reptiles addressed during the ESAL development (Ebinger 1994, 17-1219). The most sensitive organism in all cases was a small omnivorous or granivorous bird which occupied the site continuously and ingested the contaminant with food or incidental soil. The radionuclides were compared to SAL values instead of ESAL values because radiation induced carcinogenicity is not available for this range of organisms and no ESALs for radionuclides are available (Ebinger 1994, 17-1219). The radionuclides dropped out as COPECs in this table. The remaining six COPECs were carried forward during the screening of the Phase II data.

4.4.2 Ecotoxicological Screening Assessment for Phase II

Initial Phase II data screening against LODs and background are presented in Subsection 4.5. The analytes which were above LODs and background for the borehole soil vapor, borehole

soil, borehole water, and seep water (downgradient) after the VCA are compared to the corresponding ESAL in Table 4-8. Benzene, chloroform, 4-isopropyltoluene, and tetrachlorylethylene were detected very infrequently and are eliminated from further consideration.

TABLE 4-8

MAXIMUM PHASE II SAMPLE RESULTS

ANALYTE	BOREHOLE VAPOR (µg/L)	BOREHOLE SOIL (mg/kg)	BOREHOLE WATER (µg/L)	SEEP WATER (µg/L)	ESAL	COPEC
1,1-dichloro-ethane	6-660(38/64)[1]	.012-.029(5/62)[1]	18(1/3)[1]		na	yes
1,2-dichloro-ethane[2]	5.8-200(16/64)	.012-0.15(11/62)	12(1/3)	0.7(11)	0.015s(c)[5,7] 1.3w(c)[4,7] 0.015a(c)[3,7]	yes
1,1-dichloro-ethene[2]	11-1800(52/64)	.013-.049(3/62)	34(1/3)		0.022s(c)[5,7] 0.2w(c)[4,7] 0.022a(c)[3,7]	yes
1,1,2-tricholoro-1,2,2-fluoro-ethane	6-450(48/64)	.013-.049(2/62)	26-230(3/3)		119s[6]	no
1,1,1-trichloro-ethane[2]	11-3600(62/64)	.011-1.8(37/62)	130-180(3/3)	7.9-13(3/3)	na	yes
trichloroethene	7-280(30/64)	.019-.052)(2/62)			0.308a(c)[3,7] 0.31s(c)[5,7] 18.2w(c)[4,7]	yes
TPH[2]		2200(1/56)		5000(1/2)	na	yes
tritium(pCi/mL)		0.39-162(20/20)	0.05-2.71(4/4)	.413-458(2/2)	20(SAL)	yes

[1] Number above LOD or background over the total number of samples in parentheses
[2] Analyte was also found to be a COPEC in Phase I
[3] ESALa = lowest ESAL for air exposure pathway
[4] ESALw = lowest ESAL for water ingestion pathway
[5] ESALs = lowest ESAL for soil ingestion pathway
[6] (s) = systemic toxicity
[7] (c) = carcinogenic

When more than one ESAL was available for air, soil, or water pathways for the same organism, the lowest ESAL matching the sample type, is presented in the table. In the ESAL column, 1,1-DCA, 1,1,1-TCA, and TPH do not have ESALs available to compare to the analyte values; but they are still considered COPECs. For 1,1-DCA, the ESAL values for 1,2-DCA were used to conservatively screen the potential impact because the toxicity for 1,2-DCA is much greater than the toxicity for 1,1-DCA. As discussed previously the toxicity of the TPH mixture present at the site is probably low because of the lack of volatile constituents (the low BTEX values described earlier).

Of particular interest is the noticeable decrease in water concentrations between the boreholes and the seep, indicating some dilution. Another observation is the reasonable correlation between the borehole vapor and soil analyte data indicating that the major contaminants were also detected in the soil samples. Even minor detections of TPH at the seep (5 ppm) indicates that TPH may be moving down the channel. Evaluation of the tritium distribution in the area is complex due to the large, nearby source terms at TA-3-16 which influence the entire TA-3 region. TA-3-16 stacks (off gasses from accelerator operations) emit tritium in the mCi/m^3 range which condenses to give above-background levels of tritium in the soil water in the canyons (Environmental Protection Group 1993, 0829).

The six COPECs in Table 4-7 plus the three COPECs in Table 4-8 make a total of nine COPECs which have been taken forward in the ecotoxicological screening assessment. The next step in this analysis is to take these COPECs through the decision tree shown in Fig. 4-2. The SWMU is not within sensitive habitat of a threatened or endangered species, floodplain or wetland and the site has already been remediated (ie: any prior habitat on the site has been removed). The site is also adjacent to a building and so was not a natural habitat anyway; but a highly disturbed industrial area receiving unnaturally high amounts of runoff from the TA-3-30 roof drain and parking lots.

The last screening decision is a determination of whether the site has present or potential contaminant transport across SWMU boundaries needs to be addressed based on the sample locations given in Tables 4-7 and 4-8 above. It is clear that the VCA removed most of the TPH, tritium, mercury and other contaminants found in the excavated wastes discussed earlier. Some contaminants were also found offsite (upgradient) which indicates there may be other source terms or SWMUs upgradient of SWMU 3-010(a). The data from the seeps indicate that some contaminants such as TPH, 1,1,1-TCA, and tritium have migrated down the stream channel a few hundred feet below the site. All data from this PRS will be made available for use in the investigation of possible contamination down the stream channel and in the Canyons. This investigation will be conducted by the canyons field unit.

4.4.3 Ecotoxicological Screening Assessment Conclusions

No further actions (such as an ecological risk assessment) are recommended at SWMU 3-010(a) based on impact to nonhuman receptors. Current transport of the COPECs down the channel appears to be minimal and probably will not impact the biota further down in Twomile and Pajarito Canyons, because the source term was remediated during the VCA. However, there may be another source term upgradient to this SWMU and the impact to the canyons below this site will be addressed during characterization of other SWMUs in the area and when the canyons field unit investigates these canyons.

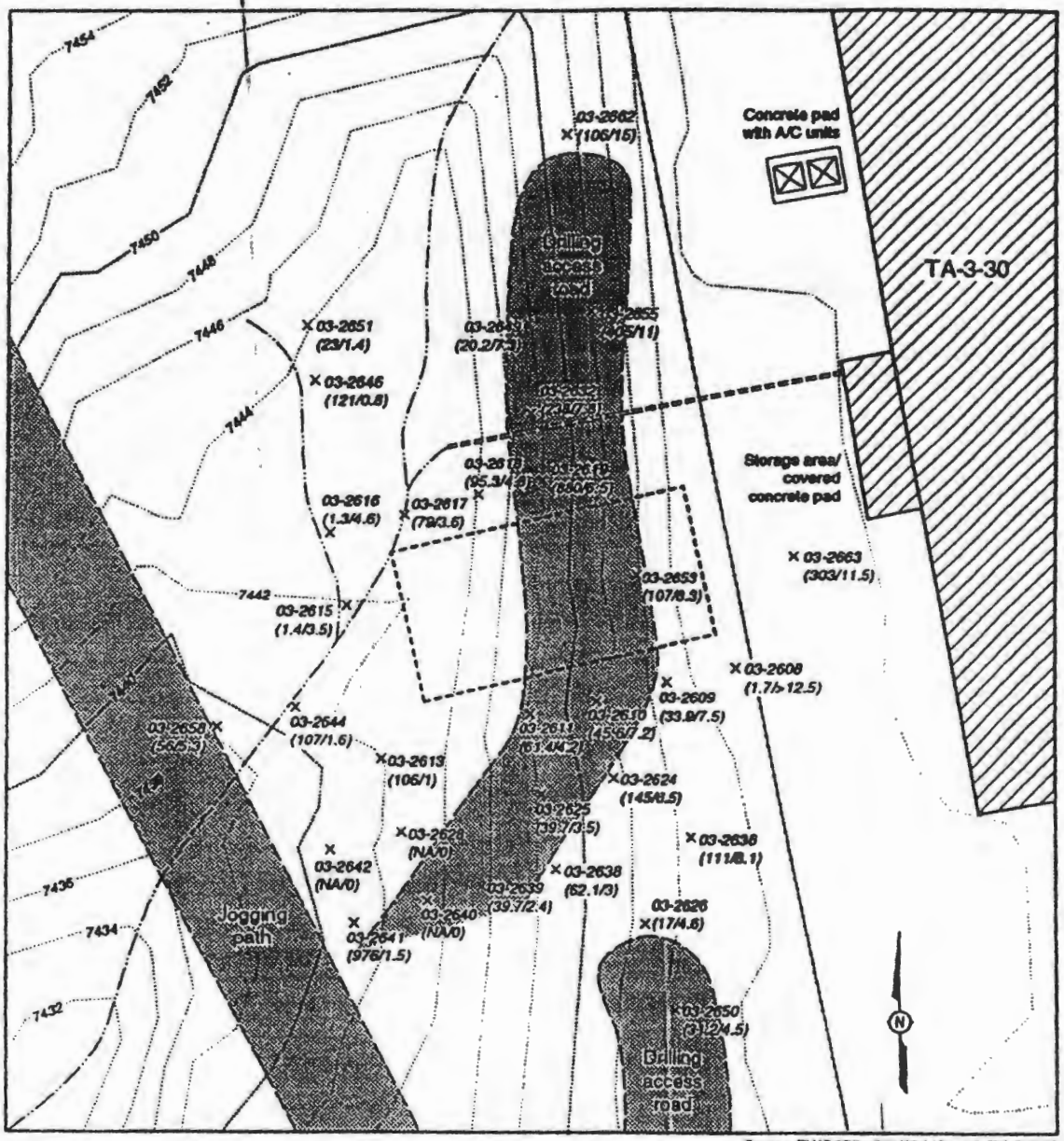
4.5 Phase II RFI Field Investigation and Sampling Activities

Mobilization for the Phase II investigation involved completing a number of necessary activities before the primary investigation could begin. When the VCA was completed the site had been maintained with an open trench covered by a wooden frame lined with polyethylene sheeting. On September 12, 1994, the frame was disassembled. The bottom of the boards and plastic were screened for radioactivity and swiped for tritium before disposal. Two tuff samples were then collected from the base of the excavation (upper and lower biased samples) and analyzed for radionuclides and lead. These samples were collected at locations roughly correlating with the upper and lower biased locations that were sampled following removal of the third lift during the VCA. An 18 to 24 in.-thick engineered hydraulic barrier of bentonite powder and crushed tuff was then placed in the bottom of the trench to reduce the potential for infiltration of surface water into the area of suspected subsurface contamination. The bentonite layer was compacted to within 92 to 93 % of maximum density before the trench was backfilled with clean, crushed tuff then compacted with a backhoe and remote tamper. A composite sample was collected from the backfill material to confirm that it contained no Appendix VIII metals or radionuclides above levels of concern. Following completion of the soil vapor probe survey (used as a tool to direct borehole locations), a road was constructed across the upper third of the backfilled excavation to provide access for the drill rig and a platform for the drilling operations. The road extended approximately 45 ft to the north of the excavation.

The LANL mobile chemical analytical laboratory provided soil and soil-vapor data on a real-time basis. This information was used to evaluate the need to continue drilling in each borehole and whether to drill additional boreholes. The mobile chemical analytical laboratory was configured with a gas chromatograph/mass spectroscopy instrument for VOC analysis and with an infrared spectroscopy instrument for TPH analysis. An off-site mobile radiological analytical laboratory provided field analytical services for gross radiological analyses.

4.5.1 Soil-Vapor Probe Survey

The initial Phase II characterization activity conducted at the site was a soil-vapor probe survey, conducted to obtain data that would guide the selection of borehole locations. A 10-ft grid was first established over the 5 000 ft^2 area surrounding the excavation to provide guidance in locating sampling points. At each sampling location, the probe was driven to the fill/tuff interface or to a depth where refusal occurred. A photoionization detector (PID) was then attached to Teflon™ tubing and used to draw soil-pore vapor to the surface and analyze the air stream for VOCs. The internal pump of the PID was designed to draw approximately one liter of air per minute. Calculations showed that it took the pump approximately 30 to



Sources: FIMAD 3/7/94, G101972, LASL 1952, ENG-C 16107
Modified by: cARTography by A. Kron 4/17/95

×	Soil vapor sample location	▬▬▬	Roof drain culvert
03-2639	Location ID	———	Fence
(39.7/2.4)	PID reading at 30 seconds (ppm)/depth to refusal (tuff)	—·—·—	Drainage channel
▨	Building/structure	▬▬▬	Area of excavation
▒▒▒	Unimproved road	·····	Contour interval 2 ft

0 10 20 ft

Fig. 4-4. Soil vapor survey locations with 30-second photoionization detector (PID) results.

35 seconds to purge five volumes of air from the teflon tubing. Therefore, the first PID reading was recorded after purging for 30 seconds, with subsequent readings being recorded after 1 minute and 1.5 minutes of purging. Figure 4-4 shows the soil-vapor probe sampling locations with the 30-second PID results and depth to refusal (tuff). All PID data are summarized in Table 4-9.

TABLE 4-9

SOIL VAPOR SURVEY DATA FOR PHASE II INVESTIGATION

LOCATION ID	PROBE REFUSAL DEPTH (ft) [1]	PID VALUE (ppm) AFTER SPECIFIED PURGE TIME [2]		
		0.5 Min.	1 Min.	1.5 Min.
03-2608	>12.5	1.7	1.8	1.5
03-2609	7.5	33.9	32.5	39.5
03-2610	7.2	NA [3]	NA	45.6
03-2611 [4]	4.2	61.4	49.5	NA
03-2613 [4]	1	106	86.5	82.4
03-2615 [5]	3.5	1.4	0.5	0
03-2616 [5]	4.6	1.3	1.1	1.4
03-2617 [5]	3.6	79	30.8	15.5
03-2618 [4]	4.8	95.3	114	113
03-2619	6.5	880	477	294
03-2624	6.5	145	78.9	66.3
03-2625	3.5	39.7	39.4	36.8
03-2626 [4]	4.6	17	11.2	9.4
03-2628	0	-	-	-
03-2632	7.8	238	219	210
03-2636	8.1	111	56.2	63.4
03-2638	3	62.1	43.1	35.6
03-2639 [5]	2.4	39.7	40	37.4
03-2640	0	-	-	-
03-2641 [4]	1.5	976	737	578
03-2642	0	-	-	-
03-2644 [5]	1.6	107	36.7	17.2
03-2646	0.8	121	108	102
03-2649	7.3	20.2	27.9	31.6
03-2650	4.5	31.2	28.4	26.5
03-2651 [6]	1.4	23	21.7	19.8
03-2652 [6]	1.5	14.1	14.1	14.1
03-2653	8.3	107	107	114
03-2655 [7]	11	405	488	578
03-2658	5.3	56	41.6	32.7
03-2662	15	106	48.3	41.3
03-2663	11.5	303	250	230

[1] Depth to probe refusal considered to equal depth to soil/tuff interface.
[2] Five tubing volumes purged every 30-35 seconds.
[3] NA = Data not available
[4] Saturated conditions existed at depth from which soil vapor sample collected.
[5] Soil vapor sample collected for NMED.
[6] Background
[7] Tedlar™ bag sample collected for analysis by the on-site mobile chemistry laboratory.

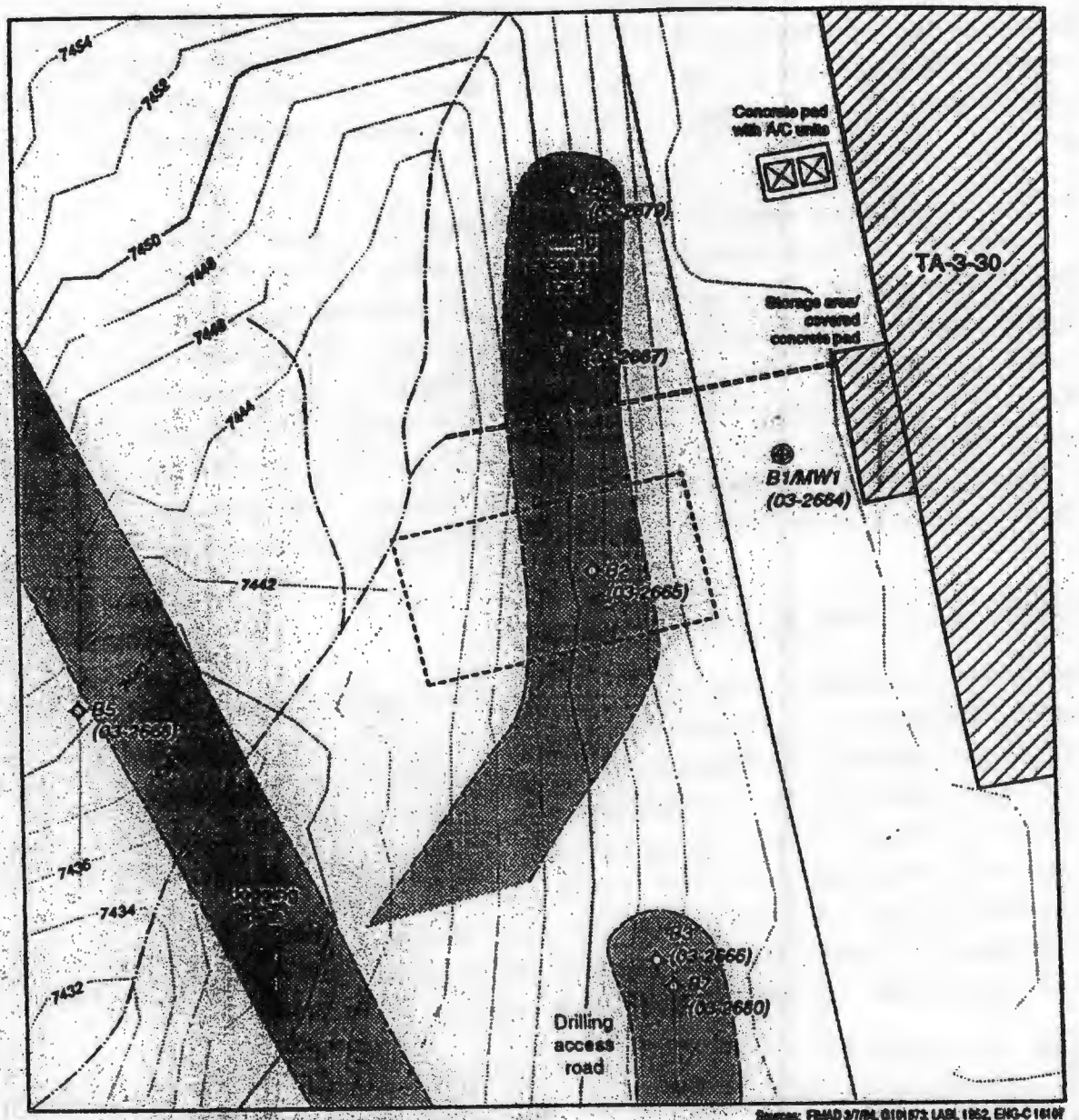
Following collection of the PID values, a tritium monitor was attached to the Teflon™ tubing and the air stream was analyzed for tritium. However, the reliability and accuracy of the tritium data are questionable because the VOC content of the soil vapor probably interfered with the performance of the tritium monitor. For this reason, the tritium data are not presented in this report.

It was initially assumed that background values for PID-detectable VOCs in soil vapor were zero. When efforts to define the lateral extent of detectable VOCs at the fill/tuff interface failed, this assumption was reevaluated. To determine if there was a naturally occurring background VOC concentration in the area of the investigation, soil-vapor probe readings were taken in two locations on a hillslope across the drainage from SWMU 3-010(a), where it is unlikely that VOCs from the site would have migrated. PID readings from these locations indicated that the site has naturally occurring background VOC concentrations of 15 to 25 ppm. One possible source of these background concentrations could be the numerous evergreen trees in the area, as demonstrated by the positive PID reading detected on freshly scratched ponderosa pine bark.

4.5.2 Drilling and Subsurface Sampling

Seven boreholes were drilled during the field investigation. Six boreholes were drilled for the purpose of characterizing subsurface chemical contamination (boreholes B1 to B6). The seventh borehole was drilled to obtain additional geologic information (borehole B7). Borehole B1 and the majority of borehole B2 were drilled with a CME-45, buggy mounted, hollow-stem auger drilling rig using 8.25-in. outside diameter (OD) and 4-in. inside diameter hollow-stem augers. Continuous core samples were collected using 3.125-in. OD, 2.5-ft long stainless-steel split-barrel samplers lined with six-inch-brass or stainless-steel sleeves. The bottom five feet of borehole B2 and all remaining boreholes (B3 to B7) were drilled with the same configuration as above, but using a CME-750, buggy mounted, hollow-stem auger drilling rig.

Plastic sheeting was placed beneath and around the drill rig prior to setting up on each borehole to help prevent surface-soil contamination from leaks or spills. Drill cuttings were captured on an additional sheet of plastic placed around the borehole.



Sources: FMAD 9/7/94, 0101973; LABL 1952, ENG-C 16107
Modified by: cARTography by A. Kron 4/17/95

Borehole location
B-3 Borehole number
03-2666 Location ID
Monitor well
Building/structure
Unimproved road
Roof drain culvert
Fence
Drainage channel
Area of excavation
Contour interval 2 ft
N
0 10 20 ft

Fig. 4-5. Site map with borehole locations.

4.5.2.1 Borehole Locations

Results of the soil-vapor probe survey guided placement of the boreholes (Fig. 4-5), to determine lateral extent of the subsurface area significantly affected by contaminants. If these borehole locations did not successfully define the lateral extent of contaminants at depth, then additional boreholes were to be drilled at locations farther away from the area thought to be the source of contamination.

While drilling the chemical characterization boreholes, the sample barrels were lined with six-inch brass or stainless-steel sleeves. Because the soil and tuff samples were not extruded from many of these sleeves, continuous, detailed geologic information was not available. To obtain higher-resolution geologic information for the site, geologic characterization borehole B-7 was drilled. The core was described and archived in the event geotechnical information becomes necessary to evaluate remedial site alternatives.

4.5.2.2 Monitor Well Construction and Sampling

The sampling plan stated that if water was encountered within 10 ft below the deepest detectable contamination, the borehole would be completed as a monitoring well. Borehole B1 encountered water at approximately 23 ft below ground surface. Drilling proceeded an additional six feet in an attempt to define the bottom of the saturated zone. Drilling was terminated at 29 ft after the borehole began producing sufficient water to refill to the approximate depth at which saturated conditions were first encountered. Borehole B1 was then completed as a two-inch diameter, stainless steel monitoring well (MW1), the construction details of which are illustrated in Fig. 4-6.

The water in borehole B1 was sampled on three occasions; September 22, 1994, prior to installing the well, October 27, 1994, and February 2, 1995, as part of a larger surface and ground water sampling event attended by the NMED. The initial sample was analyzed for VOCs, the second sample was analyzed for tritium and gross alpha/beta/gamma, and the third sample was analyzed for cation/anion balance and gross alpha/beta/gamma. The NMED also measured pH (7.43 SU), specific conductance (80 mmhos), and temperature (11.9 °C). The well was never properly developed or purged prior to sampling, and it is uncertain how this may have affected the analytical results, summarized in Table 4-10.

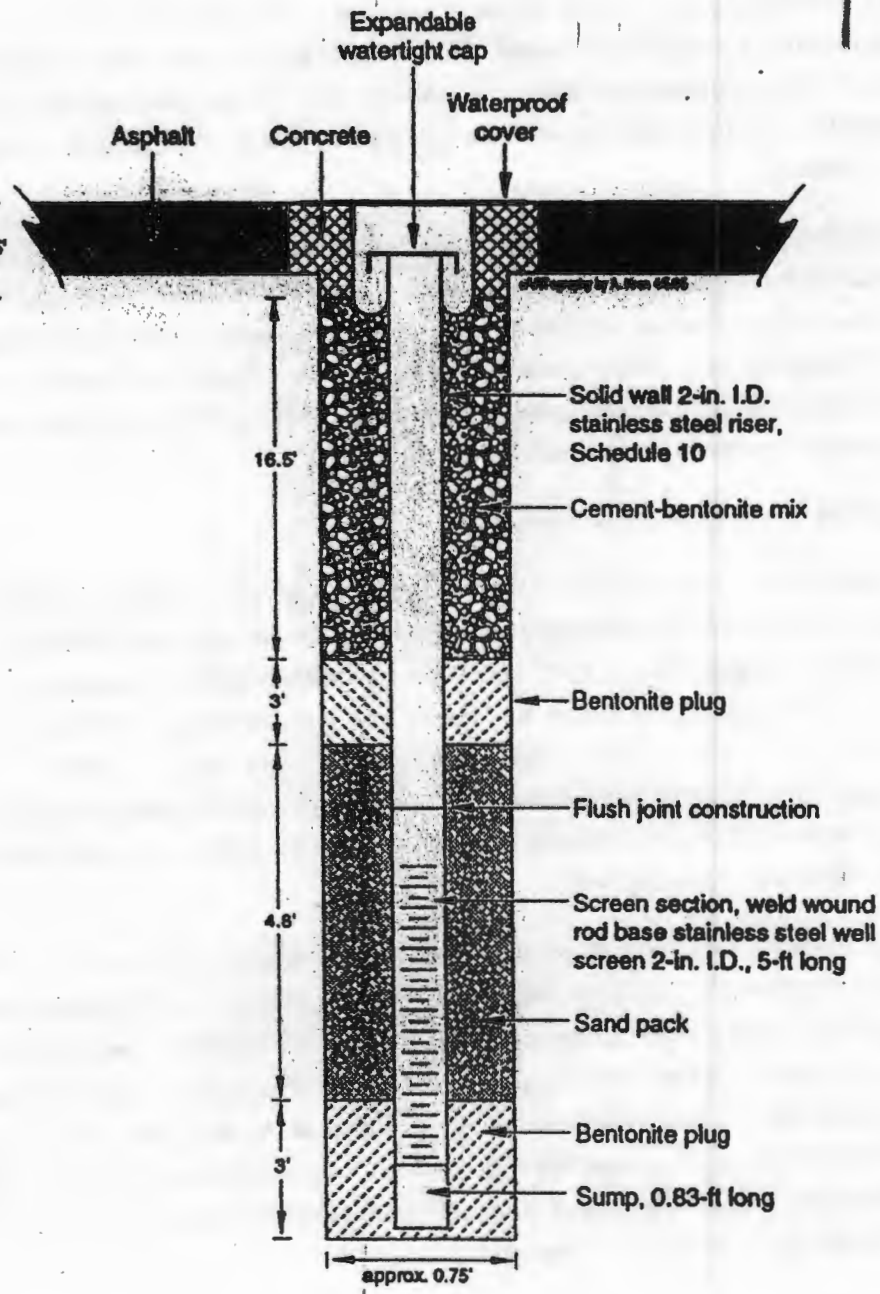


Fig. 4-6. General well construction details for Monitor Well MW1.

TABLE 4-10

MONITOR WELL MW-1 ANALYTICAL RESULTS

LOCATION ID	SAMPLE ID	ANALYTE	RESULT	UNCERTAINTY	UNITS	SAL
03-2664	AAC0469	Dichloroethane [1,1-]	18	5	µg/L	3 500
03-2664	AAC0469	Dichloroethane [1,2-]	12	4	µg/L	5
03-2664	AAC0469	Dichloroethene [1,1-]	34	10	µg/L	7
03-2664	AAC0469	Trichloro-1,2,2-trifluoroethane [1,1,2-]	26	8	µg/L	NA[a]
03-2664	AAC0469	Trichloroethane [1,1,1-]	800	240	µg/L	200
03-2664	AAC1081	Tritium	2 710	95	pCi/L	20 000

[a]NA = Not available

The water level in MW1 has been measured on several occasions, as summarized in Table 4-11.

TABLE 4-11

MONITOR WELL MW-1 WATER LEVELS

DATE	TIME	DEPTH TO WATER (ft BGS[a])
9/22/94	1700	22.10
9/27/94	1315	23.13
10/5/94	NA	22.79
10/20/94	1145	21.25
10/27/94	1340	22.50
1/19/95	NA[b]	20.90
2/2/95	0845	20.30

[a]ft BGS = Feet below ground surface.
[b]NA = Not available.

4.5.2.3 Subsurface Sampling Approach

The objective of the subsurface sampling strategy was to collect fill, tuff, and soil vapor samples for analysis of VOCs, TPH, and tritium. The VOC and TPH analyses were conducted on site in the mobile chemical analytical laboratory. Tritium samples were sent off site for analysis.

The sampling and analysis plan specified that all boreholes would be advanced a minimum of 10 ft into the tuff (LANL 1993, 1090). It also specified that drilling would be terminated only after no VOCs were detected, no visual staining was observed, and field screening revealed no TPH within two successive five-foot intervals. However, during the drilling of boreholes B1 and B2, these criteria were modified in response to field and drilling conditions. The revised criteria to stop advancing a borehole were TPH concentrations in soil below the detection level in two consecutive intervals, and either non-detection of VOCs in soil or low and/or decreasing trends of VOC contamination in soil vapor. Mobile chemical analytical laboratory results for soil and soil vapor samples were used to make these decisions. Of the six chemical characterization boreholes, three (B2, B3 and B5) were terminated using the revised criteria, two (B1 and B4) were terminated when they encountered ground water, and one (B6) was terminated because of drill rig problems, although the analytical data for B6 were such that the borehole could have been terminated anyway.

According to the sampling and analysis plan, two to three soil samples were to be collected for analysis from each borehole, depending upon field screening results and total depth. Additional samples were to be collected for analysis from boreholes greater than 25 ft deep. The number of additional samples was to be based on the coefficient of variation of the downhole soil vapor measurements taken at each five foot depth interval in the borehole. However, the mobile chemical analytical laboratory had the capability to analyze many more samples than this procedure would have generated. Therefore, following the completion of borehole B1, it was decided that soil or tuff would be collected and analyzed from every five-foot interval for the entire depth of the remaining boreholes. As a result, in boreholes B2 through B6 samples were collected for VOC and TPH analysis from the bottom six-inch sleeve in each five-foot core run. Based on these results, additional samples were analyzed for tritium and gross alpha, beta, and gamma radiation. Table 4-12 summarizes the borehole Facility for Information Management and Display (FIMAD) identification numbers, sample numbers and depths, requested analyses, and pertinent comments.

TABLE 4-12

BOREHOLES WITH CORRESPONDING SAMPLE NUMBERS

LOCATION AND MEDIA	AAC No.	Depth (ft)	Analyses	Comments
Borehole No. B1, 03-2664				
Soil Vapor Samples	0457	5	VOCs[1]	-
	0458	10	VOCs	-
	0459	15	VOCs	-
	0460	19	VOCs	-
Soil Samples	0460	18.5-19	VOCs/TPH[2]	Base of 5 ft interval
	0467	11.5-12	VOCs/TPH	Top soil/tuff interface (a)
	0357	23-23.5	VOCs/TPH	At water level
	0357	23.5-24	Tritium/Rad[3]	Below water level
	0459	14.5-15	VOCs/TPH	Base of 5 ft interval
	0468	29-29.5	VOCs/TPH	Bottom of borehole
	0359	27.5-28	VOCs/TPH/Trit./Rad	-
	0358	12-12.5	Tritium/Rad	Bottom soil/tuff interface (b)
	0461	Soil Cuttings Composite	VOCs	-
Water Sample	0469	-	VOCs	Sample collected prior to installing well
Borehole No. B2, 03-2665				
Soil Vapor Samples	0480	5.5	VOCs	-
	0481	10.5	VOCs	-
	0482	15.5	VOCs	-
	0483	20.5	VOCs	-
	0484	25.5	VOCs	-
	0485	30.5	VOCs	-
	0486	35.5	VOCs	-
	0487	40.5	VOCs	-
	0488	45	VOCs	-
	0489	51 not analyzed	-	-
Soil Samples	0481	10-10.5	VOCs/TPH	Base of 5 ft interval
	0482	15-15.5	VOCs/TPH	"
	0483	20-20.5	VOCs/TPH	"
	0484	25-25.5	VOCs/TPH	"
	0485	30-30.5	VOCs/TPH	"
	0486	35-35.5	VOCs/TPH	"
	0487	40-40.5	VOCs/TPH	"
	0488	44.5-45	VOCs/TPH	"
	0490	14-14.5	Tritium/Rad	Adjacent to highest TPH concentration
	0491	24-24.5	Tritium/Rad	10 ft below highest TPH concentration
	0492	50-50.5	Tritium/Rad	Bottom of boring
	0889	5.5-15.5 Soil Cuttings Composite	VOCs/TPH	-
Borehole No. B3, 03-2666				
Soil Vapor Samples	0493	5	VOCs	-
	0494	10	VOCs	-
	0495	15	VOCs	-
	0496	20	VOCs	-
	0497	25	VOCs	-
	0498	Blank	VOCs	-
	0499	30	VOCs	-
	0500	35	VOCs	-
	0501	40	VOCs	-
	0502	45	VOCs	-
	0503	50	VOCs	-
	0504	55	VOCs	-
	0505	60	VOCs	-

TABLE 4-12 (CONTINUED)

BOREHOLES WITH CORRESPONDING SAMPLE NUMBERS

Soil Samples	0493	4.5-5	VOCs/TPH	Base of 5' interval
	0494	9.5-10	VOCs/TPH	"
	0495	14.5-15	VOCs/TPH	"
	0496	19.5-20	VOCs/TPH	"
	0497	24.5-25	VOCs/TPH	"
	0499	29.5-30	VOCs/TPH	"
	0500	34.5-35	VOCs/TPH	"
	0501	39.5-40	VOCs/TPH	"
	0502	44.5-45	VOCs/TPH	"
	0503	49.5-50	VOCs/TPH	"
	0504	54.5-55	VOCs/TPH	"
	0505	59.5-60	VOCs/TPH	"
	0506	29-29.5	Tritium/Rad	Adjacent to highest TPH concentration
	0507	39-39.5	Tritium/Rad	10 ft below highest TPH concentration
	0508	59-59.5	Tritium/Rad	Bottom of boring
Borehole No. B4, 03-2667				
Soil Vapor Samples	0509	5	VOCs	–
	0510	10	VOCs	–
	0511	15	VOCs	–
	0512	20	VOCs	–
	0850	25	VOCs	–
Soil Samples	0509	4.5-5	VOCs/TPH	Base of 5 ft interval
	0510	9.5-10	VOCs/TPH	"
	0511	14.5-15	VOCs/TPH	"
	0512	19.5-20	VOCs/TPH	"
	0850	24.5-25	VOCs/TPH	"
	0849	21-21.5	VOCs	Mud from suspected fracture
	0852	20.0-21.0	Tritium/Rad	Cuttings sample
	0857	4-4.5	Tritium	Adjacent to highest TPH concentration
	0858	14-14.5	Tritium	10 ft below highest TPH concentration
Water Sample	0856	–	VOCs/TPH/Rad/ Tritium	–
Borehole No. B5, 03-2668				
Soil Vapor Samples	0854	10	VOCs	–
	0855	15	VOCs	–
	0859	20	VOCs	–
	0860	25	VOCs	–
	0861	30	VOCs	–
	0862	35	VOCs	–
	0863	40	VOCs	–
	0864	45	VOCs	–
	0865	50 (10/5/94)	VOCs	–
	0868	50 (10/6/94)	VOCs	–
	0866	55	VOCs	–
	0867	60	VOCs	–
Soil Samples	0851	4.5-5	VOCs/TPH	Base of 5 ft interval
	0853	9.5-10	VOCs/TPH	"
	0855	14.5-15	VOCs/TPH	"
	0859	19.5-20	VOCs/TPH	"
	0860	24.5-25	VOCs/TPH	"
	0861	29.5-30	VOCs/TPH	"
	0862	34.5-35	VOCs/TPH	"
	0863	39.5-40	VOCs/TPH	"
	0864	44.5-45	VOCs/TPH	"
	0865	49.5-50	VOCs/TPH	"
	0866	54.5-55	VOCs/TPH	"
	0867	59.5-60	VOCs/TPH	"
	0869	19-19.5	Tritium/Rad	Adjacent to highest TPH concentration
	0870	29-29.5	Tritium/Rad	10 ft below highest TPH concentration
	0871	59-59.5	Tritium/Rad	Bottom of boring

TABLE 4-12 (CONTINUED)

BOREHOLES WITH CORRESPONDING SAMPLE NUMBERS

Borehole No. B6, 03-2679				
Soil Vapor Samples	AAC0872	5	VOCs	-
	AAC0873	10	VOCs	-
	AAC0874	15	VOCs	-
	AAC0875	20	VOCs	-
	AAC0876	25	VOCs	-
	AAC0877	30	VOCs	-
	AAC0878	35	VOCs	-
	AAC0879	40	VOCs	-
	AAC0881	45	VOCs	-
	AAC0882	50	VOCs	-
	AAC0883	55	VOCs	-
	AAC0884	60	VOCs	-
	AAC0885	65	VOCs	-
	AAC0895	70	VOCs	-
	AAC0896	75	VOCs	-
	AAC0897	80	VOCs	-
	AAC0898	85	VOCs	-
	AAC0899	90	VOCs	-
	AAC0900	95	VOCs	-
	AAC0902	Blank	VOCs	-
Soil Samples	AAC0872	4.5-5	VOCs/TPH	Base of 5 ft interval
	AAC0873	9.5-10	VOCs/TPH	"
	AAC0874	14.5-15	VOCs/TPH	"
	AAC0875	19.5-20	VOCs/TPH	"
	AAC0876	24.5-25	VOCs/TPH	"
	AAC0877	29.5-30	VOCs/TPH	"
	AAC0878	34.5-35	VOCs/TPH	"
	AAC0879	39.5-40	VOCs/TPH	"
	AAC0881	44.5-45	VOCs/TPH	"
	AAC0882	49-49.5	VOCs/TPH	"
	AAC0883	54.5-55	VOCs/TPH	"
	AAC0884	59.5-60	VOCs/TPH	"
	AAC0885	64.5-65	VOCs/TPH	"
	AAC0895	69.5-70	VOCs/TPH	"
	AAC0896	74.5-75	VOCs/TPH	"
	AAC0897	79.5-80	VOCs/TPH	"
	AAC0898	84.5-85	VOCs/TPH	"
	AAC0899	89.5-90	VOCs/TPH	"
	AAC0886	24-24.5	Tritium/RAD	Adjacent to highest TPH concentration
	AAC0887	34-34.5	Tritium/RAD	10 ft below highest TPH concentration
	AAC0888	89-89.5	Tritium/RAD	Bottom of boring
Water Sample	AAC0880	-	VOCs/TPH	-
Borehole No. B7, 03-2680				
Soil Samples	AAC0889	4.6-4.7	Rad/tritium/moisture	
	AAC0890	9.4-9.6	"	
	AAC0891	13.3-13.5	"	
	AAC0892	19.4-19.6	"	
	AAC0893	24.2-24.4	"	
	AAC0894	28.8-29	"	
	AAC1053	33.9-34.1	"	
	AAC1054	39.1-39.3	"	
	AAC1055	44.1-44.3	"	
	AAC1056	49.5-49.7	"	
	AAC1057	54.1-54.3	"	
	AAC1058	59.6-59.8	"	
	AAC1059	64.4-64.6	"	
	AAC1060	69.6-69.8	"	
	AAC1065	74.7-74.8	"	
	AAC1066	78.5-78.7	"	
	AAC1067	84.3-84.5	"	
	AAC1068	89.3-89.5	"	
	AAC1069	93.8-94	"	

TABLE 4-12 (CONTINUED)

BOREHOLES WITH CORRESPONDING SAMPLE NUMBERS

Miscellaneous Samples				
Soil, Soil Vapor and Water Samples	AAB7698		Rad/lead	Upper biased sample
	AAB7699		Rad/lead	Upper biased sample duplicate
	AAB7700		Rad/lead	Lower biased sample
	AAB7712		Rad/App. VIII metals	Composite backfill sample
	AAB7713		Rad/App. VIII metals	Backfill sample duplicate
	AAB7759		VOCs	Soil vapor from 03-2639
	AAC0470		Rad/mercury	Soil from 03-2669
	AAC0471		Rad/mercury	Soil from 03-2670
	AAC0472		Rad/mercury	Soil from 03-2671
	AAC0473		Rad/mercury	Soil from 03-2672
	AAC0474		Rad/mercury	Soil from 03-2673
	AAC0475		Rad/mercury	Soil from 03-2674
	AAC0476		Rad/mercury	Soil from 03-2675
	AAC0477		Rad/mercury	Soil from 03-2676
	AACO478		Rad/mercury	Soil from 03-2677
	AAC0479		Rad/mercury	Soil from 03-2678
	AAC0903		TPH/VOCs	Drum L6
	AAC0904		TPH/VOCs	Drum L2
	AAC0905		TPH/VOCs	Drum L4
	AAC0906		TPH/VOCs	Drum L1
	AAC0907		TPH/VOCs	Drum L16
	AAC0908		TPH/VOCs	Drum L12
	AAC0909		TPH/VOCs	Drum L10
	AAC0910		TPH/VOCs	Drum L13
	AAC0911		TPH/VOCs	Drum L17
	AAC0912		TPH/VOCs	Drum L8
	AAC1061		TPH/VOCs	Drum L11
	AAC1062		TPH/VOCs	Drum L14
	AAC1063		TPH/VOCs	Drum L15
	AAC1064		TPH/VOCs	Drum L9
	AAC1073		TPH/VOCs	Drum L18
	AAB7760		TPH/VOCs/tritium	Seep sample
	AAB7761		VOCs	Field blank
	AAB7764		TPH/VOCs/tritium	Seep sample duplicate
	AAC1071		VOCs (2-Butanone)	DI water & Fantastic™
	AAC1072		TPH/VOCs	Klean Guard (Drum S3)
	AAC1074		TPH/VOCs	Paper Towel (Drum S3)
	AAC1075		TPH/VOCs	Unused Klean Guard
	AAC1076		TPH/VOCs	Unused Paper Towel
	AAC1077		VOCs (2-Butanone)	Drum L2
	AAC1078		VOCs (2-Butanone)	Drum L6
	AAC1079		VOCs (2-Butanone)	Drum L9
	AAC1080		VOCs (2-Butanone)	Drum L12
	AAC1081		Rad/tritium	Monitor well MW1
	AAC1082		Ignitability	Drum L10 (DI & Meth.)
	AAC3129		VOCs/cations/anions	Seep sample

[1] VOC = Volatile organic compounds
[2] TPH = Total petroleum hydrocarbons
[3] RAD = Radiological constituents

Soil vapor samples were collected with a downhole packer assembly at the bottom of each five-foot core run. The procedure used to obtain the soil vapor samples consisted of first lowering an inflatable packer to the bottom of the hole and inflating it with compressed nitrogen to seal the interior of the hollow-stem auger, thus isolating the bottom of the hole from the external atmosphere. The internal pump of a flame ionization detector was then used to purge five volumes of air from the 100-ft long Teflon™ tubing attached to the inflatable packer. Calculations showed that it took approximately 2.75 minutes to purge five tubing volumes, after which a PID was attached to the tubing. The soil vapor VOC concentrations were then observed for one minute to document their rate of change or relative stability. A Tedlar™ bag was then attached to the tubing, and with the use of a lung box, a soil vapor sample was collected for VOC analysis. A more detailed discussion of the method used for collection of the soil vapor samples is provided in the sampling and analysis plan (LANL 1994, 17-1222).

4.5.2.4 Field Screening

The only field screening that was conducted relative to field decisions, other than the soil vapor probe survey, was organic vapor monitoring using a PID of the ends of each six-inch sleeve as it was removed from the core barrel. The purpose of this screening strategy was to determine if additional samples needed to be collected and analyzed.

4.5.2.5 Borehole Logging and Curation Procedures

Basic geologic information was obtained from the chemical characterization boreholes (B1 - B6) by observations of the ends of the six-inch sleeves and from drill cuttings. This information was recorded on forms tailored specifically for this purpose. The completed borehole log forms are included as Appendix B.

Borehole B-7 was drilled specifically for geologic characterization purposes; therefore, the core barrel was not lined with six-inch sleeves. This allowed for more complete core recovery and a more detailed geologic description. The field log is included in Appendix B. The information was recorded on the log form included in LANL-ER-SOP-12.01, R1, Field Logging, Handling and Documentation of Borehole Materials. The core from B-7 was placed in core boxes with the following information: top and bottom of core run, core-loss locations, and depth intervals. Each box was then labeled with the borehole identification number, depth interval,

and box number. The core boxes were submitted to the sample management facility to be archived.

4.5.3 Seep Sampling

Surface water samples were collected October 18, 1994, and February 2, 1995, from a location downstream from SWMU 3-010(a) in the drainage channel seep. The objective of sampling the seep was to evaluate the possible impact of contaminants at the SWMU on water found emerging from the alluvium. During the first sampling event, sufficient water flow permitted collecting the sample at a location where water flowed over a ledge in the channel. A much-reduced flow during the second sampling event required the use of a syringe to collect water from a shallow depression in the channel. The water was then slowly injected into sample bottles. Care was taken during the entire procedure not to subject the sample to excessive negative pressures or undue agitation.

During the second sampling event, the NMED collected a duplicate sample to be analyzed for VOCs and possibly total metals. They also measured water temperature (3.6°C) and pH (8.58 SU). Sample collection information is provided in Table 4-12.

4.5.4 Geodetic Survey

A geodetic survey was performed for the soil-vapor probe survey locations, borehole locations, miscellaneous sample locations, and key structures such as the less-than 90-day storage area adjacent to TA-3-30. All points were recorded in the New Mexico State Planar Coordinate System and were submitted to FIMAD for incorporation into its database. A tabulation of the coordinates is also provided in Appendix C.

4.6 Human Health Risk Assessment

As discussed in Subsection 3.3.1, the human health risk assessment is composed of four steps that include data assessment, exposure assessment, toxicity assessment, and risk characterization. The SWMU 3-010(a) results from each of these steps is provided in the following Subsections.

4.6.1 Data Assessment

Data assessment consists of a data review of the compounds detected in each media (soil, soil vapor, and water) during the RFI Phase II activities. This data review determines if the PCOC list determined by the screening assessment is correct. Frequency of detection and a

comparison to SALs are included in the data review process. The following Subsections will present the results of the data review for the Phase II water, soil vapor, and soil samples.

4.6.1.1 Phase II Water Samples

There were two kinds of water samples collected in Phase II. Three water samples were collected and analyzed from the seep. Table A-5 of Appendix A summarizes the list of 63 compounds that were analyzed in the surface water samples. TPH, 1,1,1-TCA, and tritium were detected in the seep samples. All detected analytes for the seep samples are provided in Table 4-13. Tritium was detected in two seep samples at concentrations much less than the SAL, which is also the drinking water maximum concentration level (MCL) value (20 000 pCi/L). In all three samples, 1,1,1-TCA was detected at values between 7.9 and 13 µg/L; the water SAL is 200 µg/L. TPH was detected in one sample at 5 000 µg/L, which is consistent with the Phase I RFI data that also detected TPH in sediments downstream of SWMU 3-010(a). Any potential adverse effects of TPH are based on gasoline-related TPH components, which have not been identified as a problem in the seep water. In summary, the seep water data suggest that there is no potential for a negative human health impact from surface water at the site.

TABLE 4-13

SEEP WATER SAMPLES

SAMPLE ID	ANALYTE	RESULT	UNCERTAINTY	UNITS	SAL
AAB7760	Petroleum hydrocarbons, total recoverable	5	1 500	mg/L	NA
AAB7760	Trichloroethane [1,1,1-]	12	3.6	µg/L	200
AAB7764	Trichloroethane [1,1,1-]	13	3.9	µg/L	200
AAC3129	Trichloroethane [1,1,1-]	7.9	2.37	µg/L	200
AAB7760	Tritium	413	94	pCi/L	20 000
AAB7764	Tritium	458	95.5	pCi/L	20 000

Water was also detected in three boreholes. As discussed in Subsection 2.3, this water does not represents a true perched water body that could be developed into a drinking water resource. In addition, the water samples collected from these boreholes do not meet the usual requirements for a monitoring well (i.e., the boreholes were not converted into monitoring wells and developed before samples were collected). However, these data do help determine if there is a substantial quantity of any PCOCs in the water phase. Table A-6 in Appendix A summarizes the 63 compounds that were analyzed in the borehole water samples. Six compounds, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), 1,1,2-trichloro-1,1,2-trifiouroethane (Freon-113), 1,1,1-trichloroethane (1,1,1-TCA), and tritium, were detected in the borehole water samples (Table 4-14). With the exception of Freon-113, all of the volatile organics detected in the borehole water samples were also detected in

confirmatory samples collected after the VCA action. Freon-113 was detected at low concentrations (26 to 230 µg/L) in three samples. A SAL has not been established for this compound, but freons are of very low toxicity. Therefore, Freon-113 was not added as a PCOC for the risk assessment. Tritium was detected in two borehole water samples at values between 540 and 2 710 pCi/L, which is roughly a factor of ten or more below the drinking water MCL. These borehole water results are generally consistent with previous soil sampling results, and do not suggest that any additional PCOCs should be included in the risk assessment.

TABLE 4-14

BOREHOLE WATER SAMPLE RESULTS

LOCATION ID	SAMPLE ID	ANALYTE	RESULT	UNCERTAINTY	UNITS	SAL
03-2664	AAC0469	Dichloroethane [1,1-]	18	5	µg/L	3 500
03-2664	AAC0469	Dichloroethane [1,2-]	12	4	µg/L	5
03-2664	AAC0469	Dichloroethene [1,1-]	34	10	µg/L	7
03-2664	AAC0469	Trichloro-1,2,2-trifluoroethane [1,1,2-]	26	8	µg/L	NA
03-2667	AAC0856	Trichloro-1,2,2-trifluoroethane [1,1,2-]	230	69	µg/L	NA
03-2679	AAC0880	Trichloro-1,2,2-trifluoroethane [1,1,2-]	40	12	µg/L	NA
03-2664	AAC0469	Trichloroethane [1,1,1-]	800	240	µg/L	200
03-2667	AAC0856	Trichloroethane [1,1,1-]	300	90	µg/L	200
03-2679	AAC0880	Trichloroethane [1,1,1-]	130	39	µg/L	200
03-2664	AAC1081	Tritium	2 710	95	pCi/L	20
03-2667	AAC0856	Tritium	540	80	pCi/L	20

It is important to note that 1,1,1-TCA concentrations in the borehole water samples (130 to 800 µg/L) are roughly ten times greater than the 1,1,1-TCA concentrations detected in the seep water samples (7.9 to 13 µg/L). Assuming that there is a hydrological connection between the borehole water and the seep, the water plume extends from the boreholes 1, 4, and 6 to the seep, yet concentrations of 1,1,1-TCA and tritium in the seep water are well below any risk-based concentrations of concern.

4.6.1.2 Phase II Downhole Soil Vapor Data

Soil vapor data were collected at six boreholes drilled to determine the extent of volatile organic contamination. These data were used in the field to determine the depth to which boreholes were drilled. These data are also used in this data assessment to confirm that the PCOC list based on the RFI Phase I data is correct. Table A-7 in Appendix A summarizes the results for 61 compounds analyzed in the soil vapor samples. Four volatile organic compounds (benzene, chloroform, 4-isopropyltoluene, and tetracholoroethylene) were detected three or fewer times out of 64 sample measurements (Table A-7, Appendix A). EPA risk assessment guidance (EPA 1989, 0305) recommends that compounds detected in 5% or fewer of the samples should not be included in the risk assessment; therefore, these four VOCs are not included as PCOCs. Another six VOCs [1,1-DCA, 1,2-DCA, 1,1-DCE, Freon-113, 1,1,1-TCA, and trichloroethene (TCE)] were detected more frequently in the soil vapor. The concentration values by borehole and depth for all detected soil vapor compounds are presented in Table 4-15. There are no

TABLE 4-15

PHASE II DOWNHOLE SOIL VAPOR DATA

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS
03-2664	AAC0458	9.5-10 ft	Dichloroethane [1,1-]	64	µg/L
			Dichloroethene [1,1-]	400	µg/L
			Tetrachloroethylene	17	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	10	µg/L
			Trichloroethane [1,1,1-]	1 200	µg/L
			Trichloroethene	30	µg/L
	AAC0459A	14.5-15 ft	Dichloroethane [1,1-]	31	µg/L
			Dichloroethene [1,1-]	230	µg/L
			Trichloroethane [1,1,1-]	1 100	µg/L
			Trichloroethene	12	µg/L
	AAC0460A	18.5-19 ft	Dichloroethane [1,1-]	29	µg/L
			Dichloroethane [1,2-]	7	µg/L
			Trichloroethane [1,1,1-]	670	µg/L
03-2665	AAC0480	5-5.5 ft	Dichloroethane [1,2-]	8	µg/L
			Dichloroethene [1,1-]	11	µg/L
			Tetrachloroethylene	9	µg/L
			Trichloroethane [1,1,1-]	2 100	µg/L
			Trichloroethene	11	µg/L
	AAC0481A	10-10.5 ft	Benzene	30	µg/L
			Dichloroethane [1,1-]	660	µg/L
			Dichloroethane [1,2-]	200	µg/L
			Dichloroethene [1,1-]	1 800	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	130	µg/L
			Trichloroethane [1,1,1-]	3 600	µg/L
			Trichloroethene	280	µg/L
	AAC0482A	15-15.5 ft	Benzene	12	µg/L
			Dichloroethane [1,1-]	230	µg/L
			Dichloroethane [1,2-]	90	µg/L
			Dichloroethene [1,1-]	1 200	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	17	µg/L
			Trichloroethane [1,1,1-]	1 300	µg/L
			Trichloroethene	170	µg/L
	AAC0483A	20-20.5 ft	Benzene	10	µg/L
			Chloroform	18	µg/L
			Dichloroethane [1,1-]	650	µg/L
			Dichloroethane [1,2-]	33	µg/L
			Dichloroethene [1,1-]	1 200	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	320	µg/L
			Trichloroethane [1,1,1-]	3 200	µg/L
			Trichloroethene	150	µg/L
	AAC0484A	25-25.5 ft	Dichloroethane [1,1-]	130	µg/L
			Dichloroethane [1,2-]	13	µg/L
			Dichloroethene [1,1-]	750	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	32	µg/L
			Trichloroethane [1,1,1-]	1 800	µg/L
			Trichloroethene	69	µg/L
	AAC0485A	30-30.5 ft	Dichloroethane [1,1-]	90	µg/L
			Dichloroethane [1,2-]	11	µg/L
			Dichloroethene [1,1-]	420	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	350	µg/L
			Trichloroethane [1,1,1-]	1 500	µg/L
			Trichloroethene	35	µg/L
	AAC0486A	35-35.5 ft	Dichloroethane [1,1-]	56	µg/L
			Dichloroethane [1,2-]	5.8	µg/L
			Dichloroethene [1,1-]	300	µg/L
			Trichloroethane [1,1,1-]	1 200	µg/L
			Trichloroethene	28	µg/L
	AAC0487A	40-40.5 ft	Dichloroethane [1,1-]	98	µg/L
			Dichloroethane [1,2-]	9	µg/L
			Dichloroethene [1,1-]	190	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	130	µg/L
			Trichloroethane [1,1,1-]	910	µg/L
			Trichloroethene	16	µg/L
	AAC0488A	44.5-45 ft	Dichloroethane [1,1-]	22	µg/L
			Dichloroethene [1,1-]	16	µg/L
			Trichloroethane [1,1,1-]	420	µg/L

TABLE 4-15 (CONTINUED)

PHASE II DOWNHOLE SOIL VAPOR DATA

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS
03-2666	AAC0493A	4.5-5 ft	Isopropyltoluene [4-]	16	µg/L
			Trichloroethane [1,1,1-]	120	µg/L
	AAC0494A	9.5-10 ft	Trichloroethane [1,1,1-]	190	µg/L
	AAC0495A	14.5-15 ft	Dichloroethene [1,1-]	33	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	31	µg/L
			Trichloroethane [1,1,1-]	340	µg/L
	AAC0496A	19.5-20 ft	Dichloroethene [1,1-]	48	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	47	µg/L
			Trichloroethane [1,1,1-]	260	µg/L
	AAC0497A	24.5-25 ft	Dichloroethene [1,1-]	54	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	42	µg/L
			Trichloroethane [1,1,1-]	300	µg/L
	AAC0499A	29.5-30 ft	Trichloroethane [1,1,1-]	400	µg/L
	AAC0500A	34.5-35 ft	Dichloroethane [1,1-]	9	µg/L
			Dichloroethane [1,2-]	6	µg/L
			Dichloroethene [1,1-]	200	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	140	µg/L
			Trichloroethane [1,1,1-]	590	µg/L
			Trichloroethene	7	µg/L
	AAC0501A	39.5-40 ft	Dichloroethane [1,1-]	10	µg/L
			Dichloroethane [1,2-]	10	µg/L
			Dichloroethene [1,1-]	170	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	140	µg/L
			Trichloroethane [1,1,1-]	540	µg/L
			Trichloroethene	7	µg/L
	AAC0502A	44.5-45 ft	Dichloroethane [1,1-]	13	µg/L
			Dichloroethane [1,2-]	15	µg/L
			Dichloroethene [1,1-]	180	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	130	µg/L
			Trichloroethane [1,1,1-]	520	µg/L
			Trichloroethene	9	µg/L
	AAC0503A	49.5-50 ft	Dichloroethane [1,1-]	14	µg/L
			Dichloroethane [1,2-]	19	µg/L
			Dichloroethene [1,1-]	180	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	120	µg/L
			Trichloroethane [1,1,1-]	490	µg/L
			Trichloroethene	10	µg/L
	AAC0504A	54.5-55 ft	Dichloroethane [1,1-]	12	µg/L
			Dichloroethane [1,2-]	16	µg/L
			Dichloroethene [1,1-]	150	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	91	µg/L
			Trichloroethane [1,1,1-]	390	µg/L
			Trichloroethene	8	µg/L
	AAC0505A	59.5-60 ft	Dichloroethane [1,1-]	10	µg/L
			Dichloroethane [1,2-]	12	µg/L
			Dichloroethene [1,1-]	100	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	74	µg/L
			Trichloroethane [1,1,1-]	360	µg/L
			Trichloroethene	7	µg/L
03-2667	AAC0509A	5 ft	Trichloroethane [1,1,1-]	50	µg/L
	AAC0510A	9.5-10 ft	Dichloroethene [1,1-]	44	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	160	µg/L
			Trichloroethane [1,1,1-]	480	µg/L
	AAC0511A	15 ft	Dichloroethene [1,1-]	45	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	310	µg/L
			Trichloroethane [1,1,1-]	480	µg/L
	AAC0512A	20 ft	Dichloroethene [1,1-]	19	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	450	µg/L
			Trichloroethane [1,1,1-]	250	µg/L
	AAC0850A	25 ft	Dichloroethene [1,1-]	28	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	290	µg/L
			Trichloroethane [1,1,1-]	210	µg/L

TABLE 4-15 (CONTINUED)

PHASE II DOWNHOLE SOIL VAPOR DATA

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS
03-2668	AAC0854	9.5-10 ft	Trichloroethane [1,1,1-]	17	µg/L
	AAC0855A	14.5-15 ft	Dichloroethene [1,1-]	18	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	29	µg/L
			Trichloroethane [1,1,1-]	84	µg/L
	AAC0859A	19-20 ft	Dichloroethane [1,1-]	8	µg/L
			Dichloroethene [1,1-]	62	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	160	µg/L
			Trichloroethane [1,1,1-]	170	µg/L
	AAC0860A	24.5-25 ft	Dichloroethane [1,1-]	9	µg/L
			Dichloroethene [1,1-]	67	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	180	µg/L
			Trichloroethane [1,1,1-]	180	µg/L
	AAC0861A	30-30 ft	Dichloroethane [1,1-]	9	µg/L
			Dichloroethene [1,1-]	71	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	160	µg/L
			Trichloroethane [1,1,1-]	190	µg/L
	AAC0862A	35-35 ft	Dichloroethane [1,1-]	9	µg/L
			Dichloroethene [1,1-]	74	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	100	µg/L
			Trichloroethane [1,1,1-]	210	µg/L
	AAC0863A	40-40 ft	Dichloroethane [1,1-]	10	µg/L
			Dichloroethene [1,1-]	65	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	92	µg/L
			Trichloroethane [1,1,1-]	220	µg/L
	AAC0864A	45-45 ft	Dichloroethene [1,1-]	39	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	45	µg/L
			Trichloroethane [1,1,1-]	110	µg/L
	AAC0865A	50-50 ft	Dichloroethene [1,1-]	33	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	42	µg/L
			Trichloroethane [1,1,1-]	110	µg/L
	AAC0866A	54.5-55 ft	Dichloroethene [1,1-]	33	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	35	µg/L
			Trichloroethane [1,1,1-]	110	µg/L
	AAC0867A	60-60 ft	Dichloroethene [1,1-]	27	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	26	µg/L
			Trichloroethane [1,1,1-]	86	µg/L
03-2679	AAC0872A	4.5-5 ft	Trichloroethane [1,1,1-]	42	µg/L
	AAC0873A	9.5-10 ft	Trichloro-1,2,2-trifluoroethane [1,1,2-]	6	µg/L
			Trichloroethane [1,1,1-]	74	µg/L
	AAC0874A	15-15 ft	Dichloroethene [1,1-]	19	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	69	µg/L
			Trichloroethane [1,1,1-]	200	µg/L
	AAC0875A	19.5-20 ft	Dichloroethane [1,1-]	17	µg/L
			Dichloroethene [1,1-]	20	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	72	µg/L
			Trichloroethane [1,1,1-]	120	µg/L
	AAC0876A	30-30.5 ft	Dichloroethane [1,1-]	7	µg/L
			Dichloroethene [1,1-]	13	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	53	µg/L
			Trichloroethane [1,1,1-]	78	µg/L
	AAC0877A	29.5-30 ft	Dichloroethane [1,1-]	6	µg/L
			Dichloroethene [1,1-]	32	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	45	µg/L
			Trichloroethane [1,1,1-]	99	µg/L
	AAC0878A	34.5-35 ft	Trichloroethane [1,1,1-]	11	µg/L
	AAC0879A	39-40 ft	Dichloroethane [1,1-]	6	µg/L
			Dichloroethene [1,1-]	51	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	110	µg/L
			Trichloroethane [1,1,1-]	270	µg/L
			Trichloroethene	8	µg/L

TABLE 4-15 (CONTINUED)

PHASE II DOWNHOLE SOIL VAPOR DATA

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS
	AAC0881A	44.5-45 ft	Dichloroethane [1,1-]	6	µg/L
			Dichloroethene [1,1-]	57	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	99	µg/L
			Trichloroethane [1,1,1-]	270	µg/L
			Trichloroethene	11	µg/L
	AAC0882A	49-49.5 ft	Dichloroethane [1,1-]	61	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	60	µg/L
			Trichloroethane [1,1,1-]	210	µg/L
			Trichloroethene	6	µg/L
	AAC0883A	54.5-55 ft	Dichloroethane [1,1-]	7	µg/L
			Dichloroethene [1,1-]	61	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	71	µg/L
			Trichloroethane [1,1,1-]	180	µg/L
			Trichloroethene	13	µg/L
	AAC0884A	50.5-60 ft	Dichloroethane [1,1-]	10	µg/L
			Dichloroethene [1,1-]	110	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	90	µg/L
			Trichloroethane [1,1,1-]	250	µg/L
			Trichloroethene	24	µg/L
	AAC0885A	64.5-65 ft	Dichloroethane [1,1-]	11	µg/L
			Dichloroethene [1,1-]	130	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	93	µg/L
			Trichloroethane [1,1,1-]	270	µg/L
			Trichloroethene	29	µg/L
	AAC0895A	69.5-70 ft	Dichloroethane [1,1-]	12	µg/L
			Dichloroethene [1,1-]	130	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	89	µg/L
			Trichloroethane [1,1,1-]	280	µg/L
			Trichloroethene	33	µg/L
	AAC0896A	74.5-75 ft	Dichloroethane [1,1-]	11	µg/L
			Dichloroethene [1,1-]	140	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	82	µg/L
			Trichloroethane [1,1,1-]	290	µg/L
			Trichloroethene	35	µg/L
	AAC0897A	79.5-80 ft	Dichloroethane [1,1-]	8	µg/L
			Dichloroethene [1,1-]	140	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	80	µg/L
			Trichloroethane [1,1,1-]	310	µg/L
			Trichloroethene	38	µg/L
	AAC0898A	84.5-85 ft	Dichloroethene [1,1-]	130	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	58	µg/L
			Trichloroethane [1,1,1-]	250	µg/L
			Trichloroethene	25	µg/L
	AAC0899A	89.5-90 ft	Dichloroethane [1,1-]	7	µg/L
			Dichloroethene [1,1-]	130	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	80	µg/L
			Trichloroethane [1,1,1-]	310	µg/L
			Trichloroethene	37	µg/L
	AAC0900A	94.5-95 ft	Dichloroethane [1,1-]	13	µg/L
			Dichloroethene [1,1-]	150	µg/L
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	82	µg/L
			Trichloroethane [1,1,1-]	310	µg/L
			Trichloroethene	33	µg/L

SALs for soil vapor, and the soil vapor data will not be used directly in the risk assessment. Instead, the soil concentrations of these compounds, as discussed in the next section, are compared to SALs to determine if any additional PCOCs are identified by the Phase II data.

4.6.1.3 Phase II Borehole Soil Data

Soil data were also collected at six boreholes for VOC, TPH and tritium analysis. Table A-8 of Appendix A summarizes the results for 63 compounds analyzed at soil borehole sampling locations. Eight compounds [1,1-DCA, 1,2-DCA, 1,1-DCE, Freon-113, 1,1,1-TCA, TCE, TPH, and tritium] were detected in the soil samples. Although TPH is not considered a PCOC, the toxicity of any detected TPH components is considered. The concentration values by borehole and depth for all detected compounds are presented in Table 4-16. The data from these 62 Phase II samples will be evaluated together with the 3 samples collected at the bottom of the excavation.

For these 65 sample values, five compounds (benzene, chloroform, cis-1,3-dichloropropene, Freon-113, and TCE) were detected in zero to two samples. These compounds are not considered PCOCs, because EPA risk assessment guidance recommends that compounds detected in 5% or fewer of the samples should not be included in the risk assessment (EPA 1989, 0305). Thus, benzene and chloroform are dropped from the PCOC list developed during the screening assessment.

Tritium was detected in 20 samples at concentrations between 0.13 and 11 pCi/g. Two of the measurements are greater than background (sample IDs AAC0490 and AAC0508), but none are greater than the SAL. Thus, tritium is not included as a PCOC in the risk assessment.

TCA [1,1,1-] was detected in 37 soil samples collected during Phase II sampling, and the highest concentration measured in these samples was 1.8 mg/kg. Because the SAL for 1,1,1-TCA is 1 000 mg/kg, 1,1,1-TCA should not be considered a PCOC in the risk assessment. Two volatile organics (1,2-DCA and 1,1-DCE) were measured at a concentration greater than the SAL at the upper biased Phase I sampling location (03-1261). These compounds were also detected in the Phase II soil data and will be retained as PCOCs in the risk assessment.

4.6.1.4 Estimates of the Concentration Term

Analysis of the Phase II data narrowed the original list of five PCOCs to two PCOCs (1,2-DCA and 1,1-DCE). The concentration of these two volatile organics in the subsurface must be estimated for the risk calculations. The EPA risk assessment guidance suggests that the average concentration and 95% UCL of the average should be used as estimates of the concentration term in the risk calculations. This estimate of the concentration term is important because risk scales linearly with the estimate of the concentration. Thus, a concentration of 100 mg/kg is associated with a risk 100 times larger than a concentration of 1 mg/kg.

TABLE 4-16

CONCENTRATION VALUES FOR ALL DETECTED COMPOUNDS

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS	SAL
03-2664	AAC0467	11.5-12 ft	Dichloroethane [1,1-]	0.029	mg/kg	410
			Dichloroethane [1,2-]	0.014	mg/kg	0.2
			Dichloroethene [1,1-]	0.049	mg/kg	0.4
			Trichloroethane [1,1,1-]	1.8	mg/kg	1 000
			Trichloroethene	0.052	mg/kg	3.2
	AAC0358	12-12.5 ft	Tritium	1.96	pCi/g	810
	AAC0459	14.5-15 ft	Dichloroethane [1,1-]	0.011	mg/kg	410
			Dichloroethane [1,2-]	0.012	mg/kg	0.2
			Trichloroethane [1,1,1-]	0.41	mg/kg	1 000
	AAC0460	18.5-19 ft	Dichloroethane [1,2-]	0.014	mg/kg	0.2
			Trichloroethane [1,1,1-]	0.11	mg/kg	1 000
	AAC0357	23-23.5 ft	Trichloroethane [1,1,1-]	0.036	mg/kg	1 000
			Tritium	0.737	pCi/g	810
	AAC0359	27.5-28 ft	Petroleum hydrocarbons, total recoverable	3	mg/kg	100
			Trichloroethane [1,1,1-]	0.15	mg/kg	1 000
			Tritium	0.829	pCi/g	810
			Tritium	0.87	pCi/g	810
	AAC0468	29-29.5 ft	Trichloroethane [1,1,1-]	0.13	mg/kg	1 000
03-2665	AAC0481	10-10.5 ft	Dichloroethane [1,1-]	0.013	mg/kg	410
			Dichloroethane [1,2-]	0.15	mg/kg	0.2
			Petroleum hydrocarbons, total recoverable	3	mg/kg	100
			Trichloroethane [1,1,1-]	0.88	mg/kg	1 000
	AAC0490	14-14.5 ft	Tritium	9.213	pCi/g	810
	AAC0482	15-15.5 ft	Dichloroethane [1,1-]	0.014	mg/kg	410
			Dichloroethane [1,2-]	0.1	mg/kg	0.2
			Dichloroethene [1,1-]	0.034	mg/kg	0.4
			Petroleum hydrocarbons, total recoverable	2200	mg/kg	100
			Trichloroethane [1,1,1-]	0.99	mg/kg	1 000
			Trichloroethene	0.019	mg/kg	3.2
	AAC0483	20-20.5 ft	Dichloroethane [1,1-]	0.011	mg/kg	410
			Dichloroethane [1,2-]	0.012	mg/kg	0.2
			Trichloroethane [1,1,1-]	0.62	mg/kg	1 000
	AAC0491	24-24.5 ft	Tritium	1.203	pCi/g	810
			Tritium	1.3	pCi/g	810
	AAC0484	25-25.5 ft	Petroleum h ydrocarbons, total recoverable	2	mg/kg	100
			Trichloroethane [1,1,1-]	0.059	mg/kg	1 000
	AAC0485	30-30.5 ft	Dichloroethane [1,2-]	0.015	mg/kg	0.2
			Petroleum hydrocarbons, total recoverable	1	mg/kg	100
			Trichloroethane [1,1,1-]	0.37	mg/kg	1 000
	AAC0486	35-35.5 ft	Trichloroethane [1,1,1-]	0.02	mg/kg	1 000
	AAC0487	40-45.5 ft	Trichloroethane [1,1,1-]	0.018	mg/kg	1 000
	AAC0488	44.5-45 ft	Petroleum hydrocarbons, total recoverable	25	mg/kg	100
	AAC0492	50-50.5 ft	Tritium	0.685	pCi/g	810
03-2666	AAC0496	19.5-20 ft	Petroleum hydrocarbons, total recoverable	1	mg/kg	100
	AAC0497	24.5-25 ft	Trichloroethane [1,1,1-]	0.011	mg/kg	1 000
	AAC0506	29-29.5 ft	Tritium	1.184	pCi/g	810
	AAC0499	29.5-30 ft	Petroleum hydrocarbons, total recoverable	6	mg/kg	100
			Trichloroethane [1,1,1-]	0.012	mg/kg	1 000
	AAC0500	34.5-35 ft	Petroleum hydrocarbons, total recoverable	2	mg/kg	100
			Trichloroethane [1,1,1-]	0.013	mg/kg	1 000
	AAC0507	39-39.5 ft	Tritium	1.452	pCi/g	810
	AAC0501	39.5-40 ft	Dichloroethane [1,2-]	0.017	mg/kg	0.2
			Petroleum hydrocarbons, total recoverable	3	mg/kg	100
			Trichloroethane [1,1,1-]	0.042	mg/kg	1 000
	AAC0502	44.5-45 ft	Dichloroethane [1,2-]	0.034	mg/kg	0.2
			Petroleum hydrocarbons, total recoverable	2	mg/kg	100
			Trichloroethane [1,1,1-]	0.073	mg/kg	1 000
	AAC0503	49.5-50 ft	Dichloroethane [1,2-]	0.014	mg/kg	0.2
			Petroleum hydrocarbons, total recoverable	2	mg/kg	100
			Trichloroethane [1,1,1-]	0.013	mg/kg	1 000
	AAC0504	54.5-55 ft	Trichloroethane [1,1,1-]	0.017	mg/kg	1 000
	AAC0505	59.5-60 ft	Dichloroethane [1,2-]	0.013	mg/kg	0.2
			Trichloroethane [1,1,1-]	0.035	mg/kg	1 000
	AAC0508	59-59.5 ft	Tritium	10 989	pCi/g	810

TABLE 4-16 (CONTINUED)

CONCENTRATION VALUES FOR ALL DETECTED COMPOUNDS

LOCATION ID	SAMPLE ID	DEPTH	ANALYTE	RESULT	UNITS	SAL
03-2667	AAC0509	4.5-5 ft	Petroleum hydrocarbons, total recoverable	11	mg/kg	100
	AAC0857	4-4.5 ft	Tritium	0.352	pCi/g	810
	AAC0511	14.5-15 ft	Petroleum hydrocarbons, total recoverable	5	mg/kg	100
			Trichloroethane [1,1,1-]	0.085	mg/kg	1 000
	AAC0858	14-14.5 ft	Tritium	0.687	pCi/g	810
	AAC0512	19.5-20 ft	Petroleum hydrocarbons, total recoverable	1	mg/kg	100
	AAC0852	20-21 ft	Tritium	0.29	pCi/g	810
	AAC0849	21-21.5 ft	Trichloro-1,2,2-trifluoroethane [1,1,2-]	0.049	mg/kg	NA[1]
			Trichloroethane [1,1,1-]	0.044	mg/kg	1 000
	AAC0850	24.5-25 ft	Petroleum hydrocarbons, total recoverable	3	mg/kg	100
			Trichloro-1,2,2-trifluoroethane [1,1,2-]	0.013	mg/kg	NA
			Trichloroethane [1,1,1-]	0.012	mg/kg	1 000
03-2668	AAC0853	9.5-10 ft	Petroleum hydrocarbons, total recoverable	3	mg/kg	100
	AAC0859	19-20 ft	Petroleum hydrocarbons, total recoverable	2	mg/kg	100
	AAC0869	19-19.5 ft	Tritium	0.165	pCi/g	810
	AAC0870	29-29.5 ft	Tritium	0.24	pCi/g	810
	AAC0862	34.5-35 ft	Petroleum hydrocarbons, total recoverable	1	mg/kg	100
			Trichloroethane [1,1,1-]	0.028	mg/kg	1 000
	AAC0863	39.5-40 ft	Petroleum hydrocarbons, total recoverable	2	mg/kg	100
			Trichloroethane [1,1,1-]	0.014	mg/kg	1 000
	AAC0871	59-59.5 ft	Tritium	0.128	pCi/g	810
03-2679	AAC0873	9.5-10 ft	Trichloroethane [1,1,1-]	0.027	mg/kg	1 000
	AAC0874	14.5-15 ft	Petroleum hydrocarbons, total recoverable	8	mg/kg	100
			Trichloroethane [1,1,1-]	0.067	mg/kg	1 000
	AAC0875	19.5-20 ft	Trichloroethane [1,1,1-]	0.029	mg/kg	1 000
	AAC0886	24-24.5 ft	Tritium	0.228	pCi/g	810
	AAC0887	34-34.5 ft	Tritium	0.287	pCi/g	810
	AAC0879	39-40 ft	Trichloroethane [1,1,1-]	0.02	mg/kg	1 000
	AAC0881	44.5-45 ft	Trichloroethane [1,1,1-]	0.053	mg/kg	1 000
	AAC0882	49-49.5 ft	Dichloroethene [1,1-]	0.013	mg/kg	0.4
	AAC0882	49-49.5 ft	Trichloroethane [1,1,1-]	0.062	mg/kg	1 000
	AAC0888	89-89.5 ft	Tritium	0.316	pCi/g	810
	AAC0896	74.5-75 ft	Trichloroethane [1,1,1-]	0.02	mg/kg	1 000
	AAC0897	79.5-80 ft	Trichloroethane [1,1,1-]	0.016	mg/kg	1 000
	AAC0898	84.5-85 ft	Trichloroethane [1,1,1-]	0.012	mg/kg	1 000
	AAC0899	89.5-90 ft	Trichloroethane [1,1,1-]	0.031	mg/kg	1 000

The area or volume over which the concentration term is averaged is a critical part of the data assessment. The Phase II data have bounded the extent of the subsurface vapor plume. This assertion is substantiated by the concentration data for the three most widely detected volatile organics in the soil (1,2-DCA, 1,1-DCE, and 1,1,1-TCA). Figures 4-7 and 4-8 depict two cross-section views of SWMU 3-010(a) borehole sample locations. These figures show the concentration values measured for 1,2-DCA, 1,1-DCE, and 1,1,1-TCA. These data show that the highest concentrations are measured in boreholes B1 and B2, which are the boreholes nearest to the upper biased location.

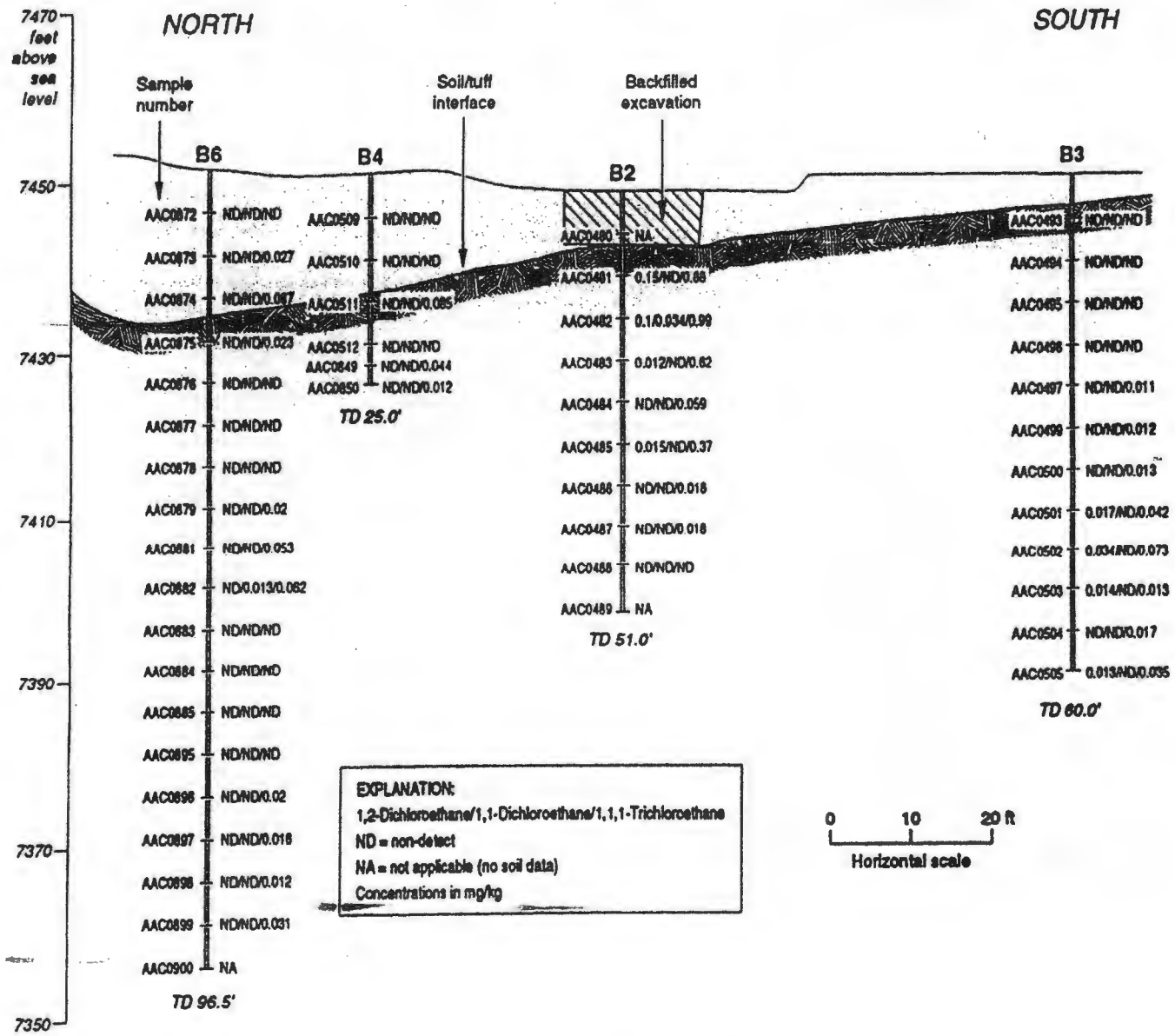


Fig. 4-7. North-south cross section with 1,2-Dichloroethane/1,1-Dichloroethane/1,1,1-Trichloroethane concentrations.

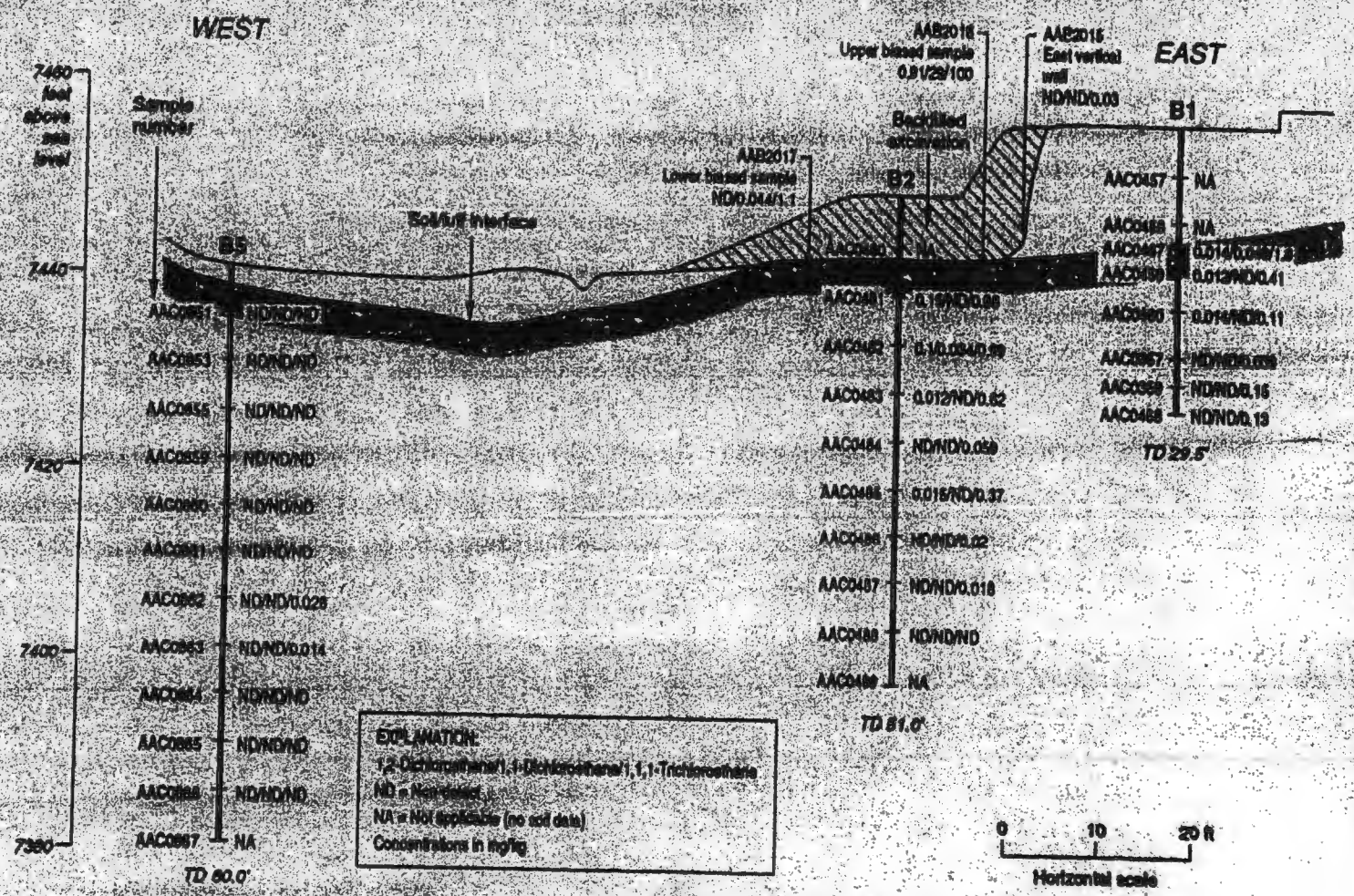


Fig. 4-8. West-east cross section with 1,2-Dichloroethane/1,1-Dichloroethane/1,1,1-Trichloroethane concentrations.

The Phase II data suggest that the upper biased location is in the highest concentration zone of the volatile organic plume. Samples close to the upper biased location tend to have higher VOC concentrations than samples taken from further away. This relationship is clearly shown in Figure 4-9(a), which shows that sample locations within 40 ft of the upper biased location have elevated concentrations of 1,1,1-TCA. The east wall sample location (03-1263) is an exception to this general trend, because it is the closest location to the upper biased sample location, but has only one detected volatile organic (1,1,1-TCA at 0.03 mg/kg). These results suggest that the east wall sample location is upgradient of the vapor plume. The dramatic decrease in 1,1,1-TCA concentration within 40 ft of the upper biased location is more clearly shown if sample locations within ten ft of the upper biased location are excluded, as shown in [Fig. 4-9(b)].

The previous discussion implies that there are logical groups of sample locations that differ significantly in VOC concentrations. Figure 4-10 shows a simplified conceptual model of the subsurface contamination, including how borehole data are grouped. These groups are intended to represent relatively uniform concentration volumes in the volatile plume. Because exposure will occur based on an average subsurface concentration, the observed subsurface concentration data should be weighted by the volume of each respective portion of the plume.

The Phase II data are grouped based on the distance of the volatile organic sampling location from the upper biased location. Table 4-17 presents the grouping strategy. The purpose of creating these groups is to properly weight the concentration data within each group by the volume contaminated in that portion of the vapor plume. The 1,1,1-TCA data clearly show that the volume of the plume encompasses a soil volume (or surface area) covered by boreholes B1 through B4 and B6, but is also clearly limited by borehole B5. Because B5 is roughly 80 ft from the upper biased location, 80 ft was used as the maximal extent of the subsurface plume. For group one data, 10 ft was used as a conservative estimate of the lateral extent of the source area of the plume, because the 1,1,1-TCA soil concentration is two orders of magnitude lower at locations (lower biased location and boreholes B1 and B2) that are roughly 20 ft from the upper biased location. The vertical extent of group one data was estimated to be 10 ft, based on the decrease in 1,1,1-TCA concentration with depth observed in boreholes B1 and B2. For group two data, the average distance of samples collected in boreholes B1 and B2 was used as the radius of lateral extent (Table 4-17), while the vertical extent of this group was based on the observed depth of elevated 1,1,1-TCA concentrations in boreholes B1 and B2. A similar rationale was applied to estimate the subsurface volume within data group three.

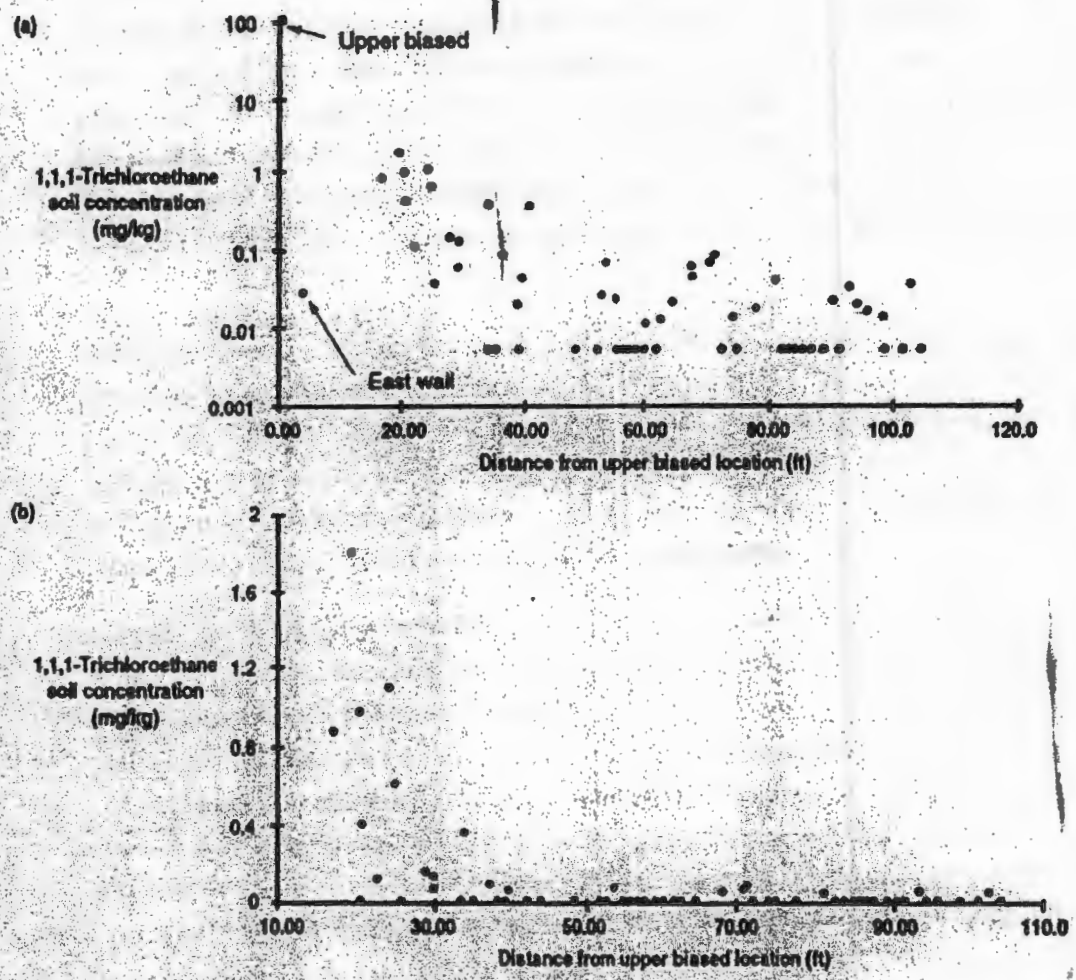


Fig. 4-9. 1,1,1-Trichloroethane soil concentrations in boreholes and three RFI Phase 1 sample locations (upper biased, 03-1261; lower biased, 03-1262; east wall, 03-1263) plotted versus the distance from the upper biased location. (a) All sample data are plotted, where the 1,1,1-TCA concentration data are represented on a log-scale. (b) Sample locations further than 10 ft from the upper biased location are plotted. These data clearly show that the subsurface volatile plume is limited to within 40 ft of the upper biased location.

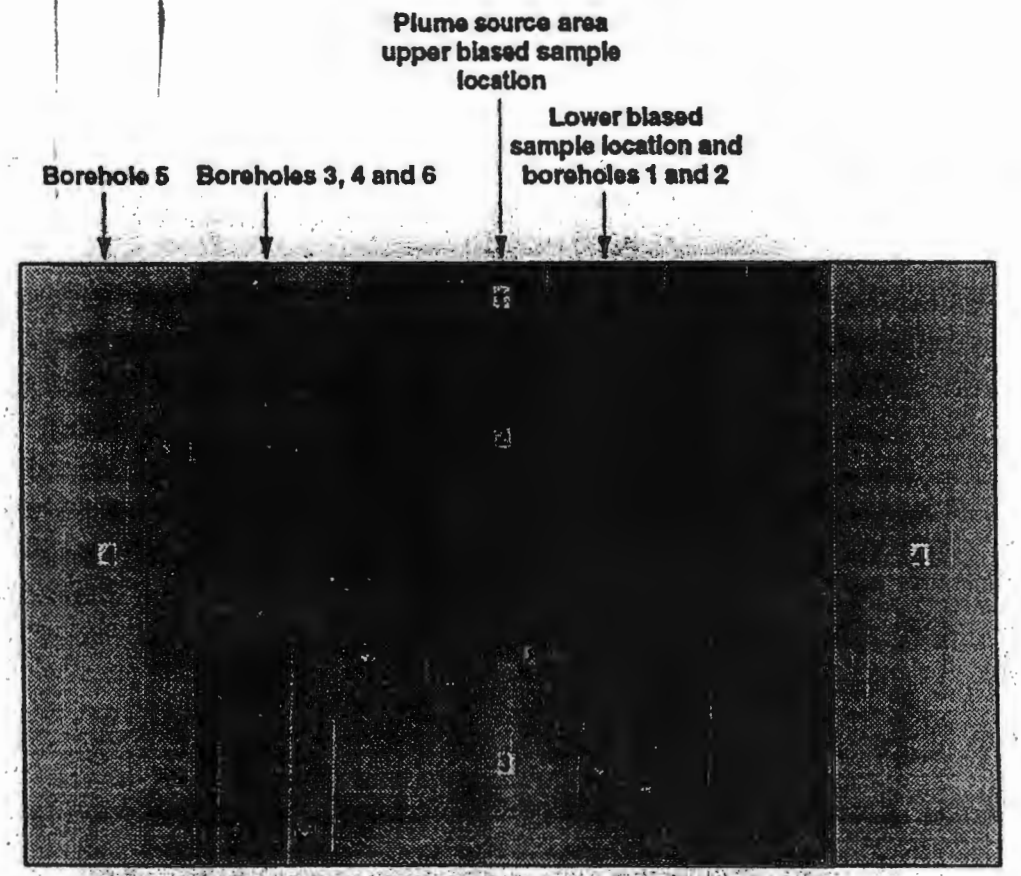


Fig. 4-10. Simplified cross-sectional view of the subsurface vapor plume, which shows the four data groups used to estimate the concentration term for the risk assessment.

TABLE 4-17

GROUPING OF THE PHASE I AND PHASE II SUBSURFACE VOLATILE ORGANIC DATA

DATA GROUP	AVERAGE DISTANCE FROM UB[1] LOCATION	NUMBER OF VOC ANALYSES	RADIUS (ft)	SURFACE AREA (ft)	DEPTH (ft)	VOLUME (ft^3)	INCREMENTAL VOLUME (ft^3)	WEIGHTING FACTOR FOR THIS GROUP[2]
UB location	0	1	10	310	10	3100	3100	0.17%
LB[3] location, Boreholes 1,2	28	16	30	2 800	40	110 000	110 000	6.1%
Boreholes 3,4,6	63	36	60	11 000	90	1 000 000	900 000	50%
EW[4] location, Borehole 5	87	12	80	20 000	90	1 800 000	790 000	44%

[1] UB = Upper biased location (03-1261).
[2] Weights are rounded. Do not add to 100%.
[3] LB = Lower biased location (03-1262).
[4] EW = East wall location (03-1263).

The statistics for the subsurface data groups are presented in Table 4-18, which summarizes the data for three volatile organics, 1,2-DCA, 1,1-DCE, and 1,1,1-TCA. The 1,1,1-TCA data are presented for comparison purposes only and will not be included in the risk assessment. A simple calculation of the average and UCL for the 65 samples differs from the weighted average and UCL calculation. The weighted average and UCL will be used in the risk assessment, because these data better represent the subsurface plume. A key assumption needed to calculate the weighted UCL is an estimate of the variance for group one data. It is assumed that the coefficient of variation for group one data (CV, which is the standard deviation divided by the average) is one-half of the CV for group two data. There is a general trend for data variability to decrease as concentration increases, which is the rationale for making the conservative assumption that the CV is reduced by one-half if the concentration values are two orders of magnitude higher.

4.6.3 Exposure Assessment

Exposure assessment, discussed in Section 3.3.1.2, is the process of quantifying the exposure to a chemical by measuring or estimating the intensity, frequency, and duration of exposure. The principal elements of exposure assessment include the steps described in the following subsections.

4.6.3.1 Potential Exposure Pathways

Exposure pathways are the mechanisms through which an individual may come into contact with a chemical in the environment. Exposure pathways are influenced by environmental conditions (e.g., depth of groundwater, extent of vegetative or other cover, prevailing wind direction), by the potential for the chemical to move from one medium (e.g., soil, water, or air) to another, and by the general lifestyles and/or work activities of the potentially exposed population (e.g., gardening, construction work, office work).

Table 4-18

SUMMARY OF THE SUBSURFACE CONCENTRATIONS OF SELECTED VOLATILE ORGANICS. THE WEIGHTED STATISTICS ARE CALCULATED BASED ON THE VOLUME CALCULATIONS PRESENTED IN TABLE 4-17

DATA GROUP	STATISTIC	ANALYTE		
		1,2-DCA[1]	1,1-DCE[2]	1,1,1-TCA[3]
One	Count[4]	1	1	1
	Average	0.91	29	100
	St. dev.	NC[5]	NC	NC
	Variance[6]	0.696	342	3920
	Weight	0.17%	0.17%	0.17%
Two	Count	16	16	16
	Average	0.023	0.012	0.42
	St. dev.	0.041	0.015	0.53
	CV[7]	1.83	1.28	1.25
	Variance	0.0017	0.00023	0.28
	Weight	6.1%	6.1%	6.1%
Three	Count	36	36	36
	Average	0.0066	0.0052	0.021
	St. dev.	0.0054	0.0013	0.022
	Variance	0.00003	0.0000018	0.00049
	Weight	50%	50%	50%
Four	Count	12	12	12
	Average	0.0048	0.0048	0.0098
	St. dev.	0.00058	0.00058	0.0094
	Variance	0.00000033	0.00000033	0.000088
	Weight	44%	44%	44%
All	Count	65	65	65
	Average	0.024	0.45	1.6
	St. dev.	0.11	3.6	12
	95% UCL[9]	0.052	1.3	4.7
Weighted	Average	0.0084	0.056	0.21
	Variance	0.0013	0.59	6.8
	Count	24	24	24
	95% UCL	0.024	0.38	1.3

[1] DCA = Dichloroethane.
[2] DCE = Dichloroethene.
[3] TCA = Trichloroethane.
[4] Count = Number of analyses.
[5] NC = Standard deviation cannot be calculated with one analysis.
[6] The variance of this group is estimated from the coefficient of variation (CV) for group two. We assumed that the CV for group one would be one-half of the CV measured in group two.
[7] CV = Coefficient of variation.
[8] St. dev. = Standard deviation.
[9] UCL = 95% upper confidence limit of the average.

Although many potential pathways are possible, only a few may be complete. For a pathway to be complete, each of the following elements must exist:

- a source and mechanism for chemical release into the environment (e.g., air, water, or soil);
- a point of potential contact with the environment; and
- an exposure route at the contact point (e.g., inhalation, ingestion, dermal contact).

A conceptual exposure model for SWMU 3-010(a) was presented in the Phase II sampling plan (LANL 1994, 17-1222) based on the results of the Phase I investigation. The following potential human exposure pathways were identified:

- Soil/sediment
  - incidental ingestion
  - dermal contact
  - external radiation
- Home-grown produce
  - ingestion
- Air
  - inhalation of volatiles
- Surface Water
  - incidental ingestion
  - dermal contact

Results of the Phase II investigation, however, suggest that the majority of these pathways are not complete. For example, based on the results of both phases of investigation, the PCOCs are present in only a limited area of subsurface soil. Direct exposure to soil would not be expected, regardless of future land use. In addition, none of the PCOCs are radionuclides; therefore, the external radiation pathway is not applicable to this SWMU. Exposure via ingestion of homegrown produce also would not be expected to occur, because the PCOCs are located several feet below the surface, and both PCOCs are volatile organic compounds, which have limited ability to concentrate in plants. Finally, none of the PCOCs was detected in surface water collected from a nearby drainage. Therefore, based on the additional information collected during Phase II, the only potentially complete exposure pathway for the PCOCs is inhalation of vapors from subsurface soil.

4.6.3.2 Environmental Fate and Transport of Potential Chemicals of Concern

The environmental fate of the PCOCs is controlled by the cumulative interaction of transport and transformation processes. Once released into the environment, a chemical may partition between various media (e.g., soil, water, air). The transport processes that define the movement of chemicals between media are a function of the physicochemical properties of both the chemicals and the environmental media.

Both PCOCs, 1,2-DCA and 1,1-DCE, are considered VOCs. The physical constants for the PCOCs are summarized in Table 4-19. They have high vapor pressures and high Henry's Law constants, which suggest that the PCOCs have a high propensity to volatilize from environmental media such as air, soil, and surface water. In addition, the PCOCs have relatively low octanol-water partitioning coefficients (K_{ow}s) and low organic carbon partitioning coefficients (K_{oc}s). Compounds with low K_{ow}s tend to be water soluble, and chemicals with low K_{oc}s bind weakly to organic matter in soil and are relatively mobile in soil. Therefore, the PCOCs present in subsurface soil at SWMU 3-010(a) will tend to volatilize and migrate through the soil column in the vapor phase or dissolve into water moving through the subsurface soil. However, if impacted water reached the surface, the PCOCs would be expected to volatilize into the atmosphere.

TABLE 4-19

PHYSICAL CONSTANTS FOR POTENTIAL CHEMICALS OF CONCERN AT SWMU 3-010(a)

CHEMICAL	HENRY'S LAW CONSTANT[a] (H) (atm.-m^3/mole)	DIFFUSIVITY IN AIR[b] (Di) (cm^2/sec)	OCTANOL-CARBON PARTITION COEFFICIENT[a] (Koc) (cm^3/g or L/kg)	WATER SOLUBILITY[a] (S) (mg/L)
1,2-Dichloroethane	1.10×10^{-3}	9.1×10^{-2}	14	8 690
1,1-Dichloroethylene	1.54×10^{-1}	7.9×10^{-2}	65	400

[a] EPA 1990a, 17-001229.
[b] EPA 1995, 17-001229.

to water table, precipitation, and wind speed). According to EPA's Risk Assessment Guidance for Superfund (RAGS), Part B, Development of Risk-based Remediation Goals (EPA 1991, 0302), a "volatilization factor" can be used to define the relationship between the concentration of chemicals in soil and the volatilized chemicals in a theoretically enclosed box above the impacted area. EPA presented an equation to calculate the volatilization factor in RAGS Part B, but this equation was later revised (EPA 1992, 17-1223). In this assessment, the volatilization factors were calculated using the following revised equation:

$$VF(m^3/kg) = \frac{LS \times V \times DH}{A} \times \frac{\sqrt{3.14 \times \alpha \times T}}{2 \times D_{ei} \times P_a \times K_{as} \times 10^{-3} kg/g}$$

Where:

VF = Volatilization factor (m^3/kg);

LS = Length of side of contaminated area (43 m; square root of impacted area);

V = Wind speed in mixing zone (2.25 m/sec; EPA 1991, 0302);

DH = diffusion height (2 m; EPA 1991, 0302);

A = Area of contamination (1.9×10^{-7} cm^2; impacted area);

α = $(D_{ei} \times P_a)/(P_a + [(r_s)(1-P_a)/K_{as}])$;

D_{ei} = Effective diffusivity [cm^2/sec; $D_i(P_a^{3.33}/P_t^2)$];

P_a = Air-filled soil porosity (unitless; $P_t - \Theta_m b$);

P_t = Total soil porosity [unitless; $1-(b/r_s)$];

θ_m = Gravimetric water content (0.088 cm^3-water/g-soil; see Subsection 4.4);

β = Soil bulk density (1.25 g/cm^3; Longmire et al. in preparation, 1142);

K_{as} = Soil/air partition coefficient [g-soil/cm^3-air; $(H/K_d) \times 41$, where 41 is a conversion factor];

ρ_s = True soil density (2.65 g/cm^3; EPA 1991, 0302);

T = Time interval [1.89×10^8 sec (6 years-child resident); 2.84×10^8 sec (9 years-adult trail user); 7.57×10^8 sec; (24 years-adult resident); 7.88×10^8 sec; (25 years-adult worker)];

D_i = Molecular diffusivity (cm^2/sec; see Table 4-19);

H = Henry's Law constant (atm-m^3/mol; see Table 4-19);

K_d = Soil-water partition coefficient (cm^3/g; $K_{oc} \times OC$);

K_{oc} = Organic carbon partition coefficient (cm^3/g; see Table 4-19);

OC = Organic carbon content of soil (0.0046; Longmire et al., in preparation, 1142).

The volatilization factors estimated for the PCOCs are presented in Table 4-20; the actual calculations are summarized in Appendix D. It should be noted that this model assumes that the area of contamination is at the surface. At SWMU 3-010(a), the impacted area is covered by as much as 10 ft or more of unimpacted soil; therefore, the volatilization factors used in this evaluation most likely represent conservative estimates of exposure to the potentially exposed populations. It should also be noted that EPA is in the process of revising the volatilization factor equation (EPA 1994, 17-1224); however, this revision is not expected to have a significant effect on the predicted volatilization factors.

TABLE 4-20

ESTIMATED VOLATILIZATION FACTORS FOR THE POTENTIAL CHEMICALS OF CONCERN

EXPOSURE SCENARIO	1,2-DICHLOROETHANE	1,1-DICHLOROETHYLENE
Long-term worker	2 597	211
Trail user (adult)	1 559	127

The volatilization factor model is not considered applicable if the soil concentration of the VOC is above soil saturation (EPA 1991, 0302). The saturation concentration is the concentration above which free-phase contaminants may be present. EPA presented an equation to calculate the saturation concentration in RAGS Part B, but this equation was revised in 1992 (EPA 1992, 17-1223) and again in 1994 (EPA 1994, 17-1224). The current equation is shown below. It should be noted that the units for some of the parameters common to both the volatilization factor and soil saturation models are different, although interchangeable, depending on the requirements of the individual equations.

$$C_{sat} = \frac{S}{B} \times (K_d \times \beta + P_w + H \times P_a)$$

Where:

C_{sat} = Soil saturation concentration (mg/kg);

K_d = Soil-water partition coefficient (mg/kg-soil per mg/L-water; K_{oc} ¥ OC);

K_{oc} = Organic carbon partition coefficient (mg/kg-OC per mg/L-water; see Table 4-19);

OC = Organic carbon content of soil (0.0046 kg-OC/kg-soil; Longmire et al. in preparation, 1142);

S = Solubility in water (mg/L-water; see Table 4-19);

β = Soil dry bulk density (1.25 kg-soil/L-soil; Longmire et al. in preparation, 1142);

P_w = Water-filled soil porosity (unitless; P_t-P_a);

H' = Henry's Law constant (unitless; H ¥ 41, where 41 is a conversion factor);

H = Henry's Law constant (atm-m^3/mol; see Table 4-19);

P_a = Air-filled soil porosity (unitless; P_t-Θ);

Θ = Volumetric water content (L-water/L-soil; $\Theta\beta/\rho_w$);

Θ_m = Gravimetric water content (0.088 kg-water/kg-soil; see Subsection 4.4);

ρ_w = Density of water (1 kg/L);

P_t = Total soil porosity (unitless; $1-\beta/\rho_s$);

ρ_s = True soil density (2.65 kg/L; EPA 1991, 0302).

The saturation concentrations estimated for 1,2-DCA and 1,1-DCE are 1461 mg/kg and 999 mg/kg, respectively; the actual calculations are summarized in Appendix D. The representative concentrations calculated for these chemicals in Subsection 4.5.1 are well below the saturation concentrations; therefore, the volatilization factor model is applicable to the this assessment of risks posed by inhalation of vapors emitted from subsurface soil.

4.6.3.5 Exposure Equations and Input Parameters

The health hazards associated with exposure to a chemical are proportional to the amount taken up by the body (i.e., dose). The equation used to calculate the average daily dose (ADD) and lifetime average daily dose (LADD) for inhalation of vapors emitted from subsurface soil is presented in this section. The ADD and LADD both provide quantitative estimates of an individual's daily exposure to a chemical. The difference between the two estimates is the time over which the exposure is averaged. Noncarcinogenic health effects are assumed to occur only after a threshold dose is reached (see Subsection 4.5.3.1); therefore, the ADD during the period of exposure must be determined (i.e., if an individual is exposed for six years, is the threshold reached at any time during those years?). Conversely, carcinogenic health risks are not considered to be threshold phenomena (see Subsection 4.5.3.2). In this case, the LADD (i.e., the daily dose averaged over an entire lifetime) must be estimated (i.e., if an individual

is exposed for only six years, what is the probability he will develop cancer sometime in the future?).

The components of this exposure equation are presented below; values used for each input parameter, including the source and rationale, are summarized in Table 4-21.

TABLE 4-21

EXPOSURE PARAMETERS FOR THE INHALATION EXPOSURE PATHWAY

EXPOSURE PARAMETERS	UNITS	LONG-TERM WORKER	TRAIL USER (ADULT)
Inhalation rate (IR_a)	m^3/hr	Value: 1.7 Rationale: LANL, 1994	Value: 2.1 Rationale: LANL, 1994
Total exposure time (ET)	hrs/day	Value: 8 Rationale: LANL, 1994	Value: 2 Rationale: LANL, 1994
Exposure frequency (EF)	days/yr	Value: 250 Rationale: LANL, 1994	Value: 170 Rationale: LANL, 1994
Exposure duration (ED)	yrs	Value: 25 Rationale: LANL, 1994	Value: 9 Rationale: LANL, 1994
Body weight (BW)	kg	Value: 70 Rationale: LANL, 1994	Value: 70 Rationale: LANL, 1994

Inhalation of Vapors Emitted from Subsurface Soil

$$Dose_{IV} = \frac{[Soil] \times IR_a \times ET \times EF \times ED}{VF \times BW \times AT}$$

Where:

$Dose_{IV}$ = Dose received through inhalation of vapors (mg/kg-day);

[Soil] = Chemical concentration in soil (mg/kg);

IR_a = Inhalation rate (m^3/hour);

ET = Exposure time (hours/day);

EF = Exposure frequency (days/year);

ED = Exposure duration (years);

VF = Volatilization factor (m^3/kg; calculated as described above);

BW = Body weight (kg);

AT = Averaging time (days).

Doses estimated for the PCOCs are presented in Table 4-22; actual calculations are summarized in Appendix D.

TABLE 4-22

DOSE ESTIMATES FOR THE EXPOSURE SCENARIOS

EXPOSURE SCENARIO	AVERAGE DAILY DOSE (ADD)[a]		LIFETIME AVERAGE DAILY DOSE (LADD)	
	95% UCL OF WEIGHTED AVERAGE	WEIGHTED AVERAGE	95% UCL OF THE WEIGHTED AVERAGE	WEIGHTED AVERAGE
1,2-Dichloroethane:				
Long-term worker	1.23×10^{-6}	4.31×10^{-7}	4.39×10^{-7}	1.54×10^{-7}
Trail user (adult)	4.30×10^{-7}	1.51×10^{-7}	5.53×10^{-8}	1.94×10^{-8}
1,1-Dichloroethylene:				
Long-term worker	2.40×10^{-4}	3.53×10^{-5}	8.56×10^{-5}	1.26×10^{-5}
Trail user (adult)	8.39×10^{-5}	1.24×10^{-5}	1.08×10^{-5}	1.59×10^{-6}

[a] Units are in milligrams per kilogram per day (mg/kg-day)

4.6.4 Toxicity Assessment

As discussed in Subsection 3.3.1.3, toxicity assessment is a two-fold process composed of a hazard identification and dose-response assessment. The outcome of the toxicity assessment includes toxicity criteria (i.e., RfDs for noncarcinogenic health risks and SFs for carcinogenic health risks) used in the risk characterization to estimate the likelihood of adverse effects occurring in the identified populations. The basis for these criteria is described briefly in the following Subsections.

4.6.4.1 Toxicity Criteria for Noncarcinogenic Health Risks

Biological effects of noncarcinogenic chemical substances occur only after a threshold dose is reached. For the purposes of establishing health criteria, this threshold dose is usually estimated from the no-observed adverse effect level (NOAEL) or the lowest-observed adverse effect level (LOAEL) determined in chronic animal exposure studies. The NOAEL is defined as the highest dose at which no adverse effects were observed, while the LOAEL is defined as the lowest dose at which adverse effects were observed. NOAELs and LOAELs determined in animal studies are used by EPA and other regulatory agencies to derive RfDs. RfDs, which are usually expressed in terms of mg/kg per day, are criteria intended to represent the highest dose of a chemical that is not expected to cause adverse health effects over a lifetime of daily exposure, even in sensitive individuals (EPA 1994, 17-1225).

Uncertainty factors are used to set RfDs in an attempt to account for limitations in the quality or quantity of available data. Most RfDs include at least a 100-fold safety factor: a factor of 10 to account for uncertainties in extrapolating animal data to human health effects, and another ten-fold safety factor to account for differences in sensitivity within the human population. Further, if the available database is incomplete or if the chemical is persistent or bioaccumulative, then an additional tenfold safety factor may be applied.

4.6.4.2 Toxicity Criteria for Carcinogenic Risks

Regulatory guidance assumes that carcinogenic chemicals should be treated as if they do not have thresholds (EPA 1989, 0305). This approach assumes that the dose-response curve for carcinogens only predicts zero risk at zero dose, i.e., for all doses greater than zero, some risk is assumed to be present. To extrapolate theoretical responses at dose levels much less than those examined experimentally, various mathematical models are used. The accuracy of the projected risk depends on how well the model predicts the true relationship between dose and risk at dose levels where the relationship cannot be actually measured.

Health risks for exposure to carcinogens are defined in terms of probabilities, which identify the likelihood of a carcinogenic response in an individual who receives a given dose of a particular compound. The SF, which is expressed in units of $(mg/kg\ per\ day)^{-1}$, is defined by the 95 percent upper confidence limit (95% UCL) of the slope of the dose-response relationship in terms of the average daily intake of a chemical over 70 years. By using the 95% UCL, the estimate of carcinogenic response is purposely conservative and is expected to overestimate the actual risk posed by the chemical.

4.6.4.3 Toxicity Criteria Used in Health Risk Assessment

The EPA has completed toxicity assessments for both PCOCs (EPA 1995, 17-1226). The associated toxicity criteria used in this human health risk assessment are presented in Table 4-23.

TABLE 4-23

TOXICITY CRITERIA FOR POTENTIAL CHEMICALS OF CONCERN

CHEMICAL	RfDi[a] (mg/kg-day)	SFI[b] $(mg/kg\text{-}day)^{-1}$
1,2-Dichloroethane	Not determined	9.1×10^{-2}
1,1-Dichloroethylene	9×10^{-3}	1.8×10^{-1}

[a] Inhalation reference dose (EPA 1995, 17-001226).
[b] Inhalation cancer potency slope factor (EPA 1995, 17-001226).

4.6.5 Risk Characterization

As discussed in Subsection 3.3.1.4, risk characterization represents the final step in the risk assessment process. Noncarcinogenic and carcinogenic health risks are characterized separately, described in the following Subsections. The risk characterization is concluded with a discussion regarding the potential significance of these results with respect to carcinogenic risks that typically warrant regulatory concern and the uncertainly inherent in their calculations.

4.6.5.1 Noncarcinogenic Health Effects

Potential noncarcinogenic adverse health effects are evaluated by comparing the ADD to the appropriate RfD. This comparison is expressed in terms of a hazard quotient, and is calculated as follows:

$$Hazard\ Quotient = \frac{ADD}{RfD}$$

Where:

ADD = Average daily dose (mg/kg/day, see Table 4-22)

RfD = Reference dose (mg/kg/day, see Table 4-23).

A hazard quotient less than or equal to one indicates that the predicted exposure should not pose a noncarcinogenic health risk (EPA 1989, 0305). In cases where individual chemicals potentially act on the same organs or result in the same health endpoint (e.g., respiratory irritants), additive effects are addressed by summing the hazard quotients for the individual chemicals. This sum is referred to as the hazard index. A hazard index of less than or equal to one is indicative of acceptable exposure levels for chemicals having an additive effect.

The hazard indices estimated for the identified exposure scenarios are presented in Table 4-24, and range from 1×10^{-3} (current or future trail user assuming the weighted average concentration) to 3×10^{-2} (current

or future long-term worker assuming the 95% UCL weighted average concentration). These hazard indices are below one, indicating that inhalation of vapors emitted from subsurface soil should not result in any noncarcinogenic adverse effects to current or future workers and current or future trail users.

TABLE 4-24

HEALTH RISK ESTIMATES FOR THE EXPOSURE SCENARIOS

EXPOSURE SCENARIO	HAZARD INDICES[1]		ESTIMATED EXCESS CANCER RISK[1]	
	USING THE 95% UCL OF WEIGHTED AVERAGE	USING THE WEIGHTED AVERAGE	USING THE 95% UCL OF THE WEIGHTED AVERAGE	USING THE WEIGHTED AVERAGE
Long-term worker	3×10^{-2}	4×10^{-3}	2×10^{-5}	2×10^{-6}
Trail user (adult)	9×10^{-3}	1×10^{-3}	2×10^{-6}	3×10^{-7}

[1] Health risk estimates for the exposure scenarios are based on the sum of the hazard indices and cancer risk estimates for 1,2-dichloroethane and 1,1-dichloroethylene.

4.6.5.2 Carcinogenic Health Risks

Carcinogenic health risks are defined in terms of the probability of an individual developing cancer as the result of exposure to a given chemical at a given concentration. In this assessment, lifetime excess cancer risks are estimated as follows:

$$Estimated\ Cancer\ Risk = LADD \times SF$$

Where:

LADD = Lifetime average daily dose (mg/kg per day; see Table 4-22);

SF = Carcinogenic potency slope factor [(mg/kg per day)$^{-1}$; see Table 4-23].

As with hazard indices, the estimated cancer risks for each PCOC are summed to estimate the total excess cancer risk (aggregate risk) for the exposed individual.

The total excess cancer risks for the identified scenarios are presented in Table 4-24, and range from 3×10^{-7} (current or future trail user assuming the weighted average concentration) to 2×10^{-5} (current or future long-term worker assuming the 95% UCL weighted average concentration). These cancer risks were conservatively estimated and most likely overstate the actual risks, if any, to current and future exposed populations. For example, a current or future long-term worker would probably not spend his or her entire work day outdoors. In addition, it is unlikely that a current or future trail user would spend two hours per day within the impacted area on a regular basis. Instead, it would be much more likely for a trail user to walk through the impacted area within a matter of minutes. Lastly, the estimated air concentrations are based on current site conditions, because the volatilization factor model does not take into account natural degradation and dispersion over time. Therefore, future long-term workers or trail users would be exposed to air concentrations that could be substantially less than those estimated in this evaluation.

The EPA has stated that the upper end of acceptable risk can range from 10^{-4} to 10^{-6} (one-in-ten thousand to one-in-one million excess cancer risks in a population), depending on site-specific considerations (e.g., size of the potentially exposed population, likelihood of residential land use (EPA 1990, 0432; EPA 1990, 17-1227). Based on current site conditions, the estimated cancer risks are within the range of acceptable risk levels. Given the conservative nature of this evaluation and the small size of the potentially exposed population, these results suggest that inhalation of vapors emitted from subsurface soil should not pose an unacceptable cancer risk to current and future workers, current and future trail users.

4.6.5.3 Uncertainty Analysis

Uncertainty is inherent in many aspects of the risk assessment process and generally arises from a lack of knowledge of: 1) site conditions, 2) toxicology of the potential chemicals of concern, and 3) the degree to which an individual will be exposed to those chemicals. Various assumptions are then made based on information presented in the scientific literature or on professional judgment. While some assumptions have significant scientific basis, others have much less. Assumptions that introduce the greatest amount of uncertainty and their effects on the noncarcinogenic and carcinogenic risk estimates are discussed below. This discussion is qualitative in nature because the uncertainties associated with risk assessment results are often difficult to quantify. Where possible, order of magnitude estimates of uncertainty are provided.

Representative Concentrations

As discussed in Subsection 4.5.1, the representative concentrations for each PCOC represent a weighted average or a 95% UCL of the weighted average of data collected during both phases of investigation. Several assumptions were required to estimate these weighted averages, including the average concentration of the PCOCs at varying distances from the source (identified as groups one through four) and the volume of soil containing the PCOCs at those estimated concentrations. There is additional uncertainty in the 95% UCL weighted averages, because one of the four groups of data is represented by a single point. Therefore, a level of variance had to be assumed for this group to calculate the 95% UCL. These assumptions likely overestimate the average concentrations of PCOCs remaining at SWMU 3-010(a), but probably by less than an order of magnitude.

Toxicity Criteria

There is considerable uncertainty in extrapolating the results from animal bioassays to humans. Depending on the type of extrapolation model used, estimates of carcinogenic potency can span several orders of magnitude. The SFs used in this assessment were developed by EPA. The linear multi-stage model used by EPA is purposely designed to overestimate rather than underestimate carcinogenic

potency in humans. In addition, there is considerably less evidence that 1,1-DCE is a carcinogen, even in animals, than there is for 1,2-DCA, a fact that is not taken into account when estimating the SF. As such, the cancer risks presented in this assessment may have been overestimated by one or more orders of magnitude, especially for 1,1-DCE.

Environmental Transport Modeling

Use of the volatilization factor model to estimate ambient air concentrations in the absence of air monitoring data may have introduced considerable uncertainty into this human health risk assessment. This model represents an oversimplification of the process it attempts to predict, and contains conservative assumptions designed to bias the result so that air concentrations are not underestimated. Therefore, the predicted air concentrations used in this risk assessment are likely overestimated, potentially by one or more orders of magnitude.

5.0 CONCLUSIONS AND RECOMMENDATIONS

An RFI Phase I investigation, VCA, and RFI Phase II investigation have been conducted at SWMU 3-010(a). The purpose of the RFI Phase I investigation was to define the nature and extent of contamination suspected to be present at the site based on historical site knowledge. The purpose of the VCA was to remediate soil contamination known to be present at the site as a result of the Phase I investigation. Finally, the purpose of the Phase II investigation was to characterize the nature and extent of VOC contamination identified during the VCA, and to determine if further remediation was necessary to protect human health and the environment.

Results of the Phase I investigation indicated that lead, mercury, and TPH were present in surface and subsurface soils at concentrations that could potentially pose a risk to human health or the environment. The VCA involved excavation of successive layers of soil at the site, and successfully removed the majority of soil contaminated with lead, mercury, and TPH. For example, the concentration of lead was reduced by approximately a factor of 30, and the concentration of mercury and TPH were reduced by approximately a factor of 90. Therefore, the potential risks posed by these chemicals at the site also were reduced by approximately the same factors.

Residual concentrations of lead and mercury are well below SALs. Residual concentrations of TPH are greater than the 100 mg/kg concentration level previously agreed upon. However, the value of 100 mg/kg represents a cleanup level established by the NMED for cleanup of underground storage tanks where gasoline or diesel is the petroleum product of concern. These products have relatively high concentrations of BTEX, and the 100 mg/kg cleanup level

was set to protect groundwater from these constituents. The petroleum product at the site is vacuum pump oil, as evidenced by detecting benzene in only two of the numerous volatile organic analysis at very low levels, thereby eliminating it from the risk assessment. If the oil were from gasoline or diesel, more of the BTEX components would have been reported, and at higher concentrations; therefore, the residual TPH contamination is not considered to represent a risk to human health or the environment. No further remedial action is recommended for the residual TPH contamination.

Confirmation samples taken after the VCA identified the presence of VOCs (1,2-DCA and 1,1-DCE) in soil that had not been identified in the Phase I investigation. The Phase II investigation successfully characterized the nature and extent of these VOCs, and collected data to assess the potential health risks to human health and the environment.

The human health risk assessment evaluated two potential site-specific exposure scenarios: occupational and recreational (trail user). The only exposure pathway of potential concern identified for both scenarios was inhalation of vapors due to volatilization of 1,2-DCA and 1,1-DCE present in subsurface soil. Results of the human health risk assessment indicate that potential noncarcinogenic health risks are below levels of concern for both exposure scenarios. With regard to potential carcinogenic health risks, the estimated lifetime excess cancer risks were 2E-05 and 2E-06 for the occupational and recreational exposure scenarios, respectively; 1,1-DCE accounted for greater than 99% of the total risk estimates. These risk values were calculated using conservative exposure assumptions and are believed to represent upper bound estimates of potential carcinogenic health risks posed by the site, especially given the fact that there is only limited evidence that 1,1-DCE is carcinogenic in animals and is very unlikely to be a human carcinogen. These risk values also are within the 1E-04 to 1E-06 risk range cited in the NCP.

A screening assessment for potential ecological impacts was also conducted for the site. The results of this assessment indicate that residual chemical concentrations of contamination at the site are below levels of concern to nonhuman receptors.

During the Phase II investigation, subsurface water was found to be present at three borehole locations. This water is believed to be present primarily because of increased runoff and infiltration resulting from altered drainage patterns created during the construction of TA-3-30. The water was found to contain low concentrations of VOCs. The quantity of water in the subsurface makes it unlikely that it represents a usable water source. The seep downgradient of the site was also found to contain VOCs at even lower concentrations, indicating a potential connection between the subsurface water and the seep. However, the seep does not represent

a viable exposure pathway for humans and concentrations were below a level of concern for non-human receptors.

In summary, the VCA was successful in accomplishing its intent and SWMU 3-010(a) is recommended for NFA based on the following:

- The VCA was successful in reducing concentrations of lead and mercury in site soil to concentrations below levels of concern. Although residual TPH concentrations in soil still exceed the 100 mg/kg standard, this standard was established to be protective of groundwater based on the presence of a BTEX component in the TPH. BTEX was not found at this site at any value that would equate the TPH to gasoline or diesel. Overall risk reduction as a result of the VCA was significant.

- Residual concentrations of 1,2-DCA and 1,1-DCE in subsurface soil were found to be below levels of concern based on the results of a site-specific human health risk assessment and a screening assessment of potential ecological impacts.

- The source term for the volatile constituents was removed during the VCA; therefore, residual concentrations of 1,2-DCA and 1,1-DCE in subsurface soil and water has been dramatically decreased and will continue to decrease with time due to chemical and biological degradation.

- Water found in the three borehole locations is most likely due to increased runoff and infiltration caused by altered drainage patterns, and does not represent a usable water source.

- Concentrations of volatile contaminants in the seep are significantly lower than those present in the monitoring well and should continue to decrease with time.

REFERENCES

ACGIH (American Conference of Governmental Industrial Hygienists), 1994. "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices," Cincinnati, Ohio.

Bowen, B.M., May 1990, "Los Alamos Climatology", Los Alamos National Laboratory Report LA-11735-MS, Los Alamos, New Mexico (Bowen 1990,0033)

Brady, N.C., 1974, "The Nature and Properties of Soils ", MacMillan Publishing, New York (Brady 1974, 17-1230)

Cross, S., 1994, "Biological Evaluation for Environmental Restoration Program Operable Unit 1114, TAs 3,30,59,60,61,64 ", BRET, Environmental Protection Group ESH-20 Draft Report (Cross 1994, 17-1221)

Ebinger, M.H., R.W. Ferenbaugh, A.F. Gallegos, W.R. Hansen, O.B. Myers, W.J. Wenzel, October 1994 ,"Preliminary Ecological Screening Assessment for Operable Unit 1106" , Los Alamos National Laboratory Report LA-UR-94-3885, Los Alamos, New Mexico (Ebinger 1994, 17-1219)

Environmental Protection Group, December 1990. "Environmental Surveillance at Los Alamos during 1989," Los Alamos National Laboratory Report LA-12764-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1990, 0497)

Environmental Protection Group, March 1992. "Environmental Surveillance at Los Alamos during 1990," Los Alamos National Laboratory Report LA-12271-MS, Los Alamos, New Mexico. (Environmental Protection Group 1992, 0740)

Environmental Protection Group, August 1993, "Environmental Surveillance at Los Alamos during 1991" Los Alamos National Laboratory Report LA-12572-MS, Los Alamos, New Mexico (Environmental Protection Group 1993, 0829)

EPA (US Environmental Protection Agency), April 1989. "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance," Office of Solid Waste, Waste Management Division, Washington, D.C. (EPA 1989, 1141)

EPA (US Environmental Protection Agency), December 1989. "Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)," Interim Final, EPA 540/1-89/002, Office of Emergency and Remedial Response, Washington, DC. (EPA 1989, 0305)

EPA (US Environmental Protection Agency), March 8, 1990. "National Oil and Hazardous Substances Pollution Contingency Plan, *Federal Register*, Vol. 55(46), pp. 8666-8865 (EPA 1990, 17-1227)

EPA (US Environmental Protection Agency), July 27, 1990. "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," Proposed Rule, Title 40 Parts 264, 265, 270, and 271, *Federal Register*, Vol. 55 (145), pp. 30798-30889 (EPA 1990, 0432)

EPA (US Environmental Protection Agency), October 1990. "Subsurface Contamination Reference Guide," EPA/540-2-90/011, Office of Emergency and Remedial Response, Washington, D.C. (EPA 1990, 17-1229)

EPA (US Environmental Protection Agency), March 25, 1991. "Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Factors," Interim Final, OSWER Directive 9285.603, Office of Emergency and Remedial Response, Toxics Integration Branch, Washington, D.C. (EPA 1991, 0746)

EPA (US Environmental Protection Agency), December 1991. "Risk Assessment Guidance for Superfund, Volume 1-Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)," Interim, EPA/540/R-92/003, Publication 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C. (EPA 1991, 0302)

EPA (US Environmental Protection Agency), November 9, 1992. Memorandum to Regional Toxic Integration Coordinators: Updates to the Soil-to-Air Volatilization and Radiation Equations presented in the Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)," Interim, EPA/540/R-92/003 from Janine Dinan (EPA 1992, 17-1223)

EPA (US Environmental Protection Agency), March, 1994. "Health Effects Assessment Summary Tables, Annual FY 1994," Office of Research and Development, Washington, D.C. (EPA 1994, 17-1225)

EPA (US Environmental Protection Agency), December 1994. "Draft Soil Screening Level Guidance," EPA/540/R-94/101, Publication 9355.4-14, Office of Solid Waste and Emergency Response, Hazardous Site Control Division, Washington, D.C. (EPA 1994, 17-1224)

EPA (US Environmental Protection Agency), February 1, 1995. "Region IX Preliminary Remediation Goals (PRGs) First Half 1995," Technical Support Section, San Francisco, California (EPA 1995, 17-1226)

APPENDIX A: DATA TABLES

ESG, May 1988. *Environmental Surveillance at Los Alamos during 1987*, Los Alamos National Laboratory Report LA-11306-ENV, Los Alamos, New Mexico. (ESG 1988, 0408)

ESG, June 1989. *Environmental Surveillance at Los Alamos during 1988*, Los Alamos National Laboratory Report LA-11628-ENV, Los Alamos, New Mexico. (ESG 1988, 0308)

Ferenbaugh, R. 1995. "ESAL Decision Tree Report", EES-15 draft report EES15-95-110 March 30, 1995 (Ferenbaugh 1995, 17-1220)

Foxx, T. et al. 1993, "Characterization of a Palustrine Wetland and Wildlife Use - Pajarito Canyon- A Monitoring Study 1990-1992," Los Alamos National Laboratory Biological Resource Evaluation Team, ESH-20 draft report, Los Alamos, New Mexico (Foxx et al. 1993, 17-1228)

Gardner, J. N., Kolbe, T., and Chang, S., in press 1993, Geology, drilling, and some hydrologic aspects of Seismic Hazards Program core holes, Los Alamos National Laboratory Report LA-12460-MS, 19 p., Los Alamos, New Mexico (Gardner et al. in press, 0848)

LANL (Los Alamos National Laboratory), November 1993. "Installation Work Plan for Environmental Restoration," Revision 3, Los Alamos National Laboratory Report LA-UR-93-3987, Los Alamos, New Mexico. (LANL 1993, 1017)

LANL (Los Alamos National Laboratory), July 1993. "RFI Work Plan for Operable Unit 1114," Los Alamos National Laboratory Report LA-UR-93-1000, Los Alamos, New Mexico.(LANL 1990, 1090)

LANL (Los Alamos National Laboratory), March 28, 1995. "Statistical Comparisons to Background, Part I," Los Alamos National Laboratory Report LA-UR-95-1217, Environmental Restoration Project, Assessments Council, Los Alamos, New Mexico (LANL 1995, 17-1231)

Longmire, P. S. Reneau, P. Watt, J. Gardner, and C. Duffy, in preparation. "Pedogenesis and Geochemistry of Background Bandelier Tuff and Selected Soil Profiles, Los Alamos, New Mexico," Los Alamos National Laboratory Report_____, Los Alamos, New Mexico. (Longmire et al. in preparation, 1142)

Purtymun, W.D., R.J. Peters, T.E. Buhl, M.N. Maes, and F.H. Brown, November 1987. "Background Concentrations of Radionuclides in Soils and River Sediments in Northern New Mexico, 1974-1986," Los Alamos National Laboratory Report LA-11134-MS, Los Alamos, New Mexico. (Purtymun et al. 1987, 0211)

TABLE A-1

SUMMARY OF THE RANGE OF CONCENTRATIONS MEASURED FOR SOIL ANALYTES

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NON-DETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		UTL[a]	SAL[b]
			MIN	MAX		MIN	MAX		
Acetone	4	2	0.024	0.024	2	0.030	0.25	n/a[c]	8000
Alpha[d]	2	0	N/A	N/A	2	19.5	23	n/a	n/a
Aluminum	2	0	N/A	N/A	2	657	747	123000	n/a
Antimony	20	12	0.02	0.53	8	0.03	0.36	2.8	32
Aroclor 1242	1	1	0.06	0.06	0	N/A	N/A	n/a	n/a
Aroclor 1254	1	1	0.06	0.06	0	N/A	N/A	n/a	n/a
Aroclor 1260	1	1	0.06	0.06	0	N/A	N/A	n/a	n/a
Aroclor (Mixed-)	1	1	0.06	0.06	0	N/A	N/A	n/a	0.09
Arsenic	21	2	1.8	1.8	19	2.57	18.6	11.6	n/a
Barium	20	0	N/A	N/A	20	31	949	1142	5600
Benzene	4	3	0.005	0.006	1	0.38	0.38	n/a	0.67
Beryllium	25	0	N/A	N/A	25	0.23	2.3	3.31	n/a
Beta[d]	2	0	N/A	N/A	2	34.1	41.1	n/a	n/a
Bromobenzene	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Bromochloromethane	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Bromodichloromethane	4	4	0.005	0.029	0	N/A	N/A	n/a	11
Bromoform	4	4	0.005	0.029	0	N/A	N/A	n/a	69
Bromomethane	4	4	0.01	0.057	0	N/A	N/A	n/a	0.43
Butanone [2-]	4	4	0.02	0.11	0	N/A	N/A	n/a	4000
Butylbenzene [n-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Butylbenzene [sec-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Butylbenzene [tert-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Cadmium	22	10	0.4	0.83	12	0.5	30	2.7	80
Calcium	2	2	615	670	0	N/A	N/A	54362	n/a
Carbon disulfide	4	4	0.005	0.029	0	N/A	N/A	n/a	7.4
Carbon tetrachloride	4	4	0.005	0.029	0	N/A	N/A	n/a	0.21
Cesium-137[d]	22	14	0.1641	0.65	8	0.54	1.54	1.4	4
Chlorobenzene	4	4	0.005	0.029	0	N/A	N/A	n/a	67
Chlorodibromomethane	4	4	0.005	0.029	0	N/A	N/A	n/a	63
Chloroethane	4	4	0.01	0.057	0	N/A	N/A	n/a	2000
Chloroform	4	3	0.005	0.006	1	0.009	0.009	n/a	0.21
Chloromethane	4	3	0.01	0.012	1	0.13	0.13	n/a	0.4
Chlorotoluene [o-]	4	4	0.005	0.029	0	N/A	N/A	n/a	1600
Chlorotoluene [p-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Chromium	22	2	0.76	0.76	20	2.1	36	34.2	n/a
Cobalt	2	2	1.2	1.2	0	N/A	N/A	61.1	n/a
Copper	22	2	1.0	1.0	20	1.0	97	15.7	3000
Dibromo-3-chloropropane [1,2-]	4	4	0.01	0.057	0	N/A	N/A	n/a	0.5
Dibromoethane [1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Dibromomethane	4	4	0.005	0.029	0	N/A	N/A	n/a	0.0082
Dichlorobenzene (1,2) [o-]	4	4	0.005	0.029	0	N/A	N/A	n/a	1600
Dichlorobenzene (1,3) [m-]	4	4	0.005	0.029	0	N/A	N/A	n/a	7200
Dichlorobenzene (1,4) [p-]	4	4	0.005	0.029	0	N/A	N/A	n/a	29
Dichlorodifluoromethane	4	4	0.01	0.057	0	N/A	N/A	n/a	10000
Dichloroethane [1,1-]	4	3	0.005	0.006	1	0.2	0.2	n/a	410
Dichloroethane [1,2-]	4	3	0.005	0.006	1	0.01	0.01	n/a	0.2
Dichloroethene [1,1-]	4	2	0.005	0.006	2	0.044	20	n/a	0.4
Dichloroethene [trans-1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	1600
Dichloroethylene [cis-1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	800
Dichloropropane [1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	0.5
Dichloropropane [1,3-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Dichloropropane [2,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Dichloropropene [1,1-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Dichloropropene [cis-1,3-]	4	3	0.005	0.006	1	0.054	0.054	n/a	0.17
Dichloropropene [trans-1,3-]	4	4	0.005	0.029	0	N/A	N/A	n/a	0.17
Ethylbenzene	4	3	0.005	0.006	1	0.023	0.023	n/a	3100
Hexanone [2-]	4	4	0.02	0.11	0	N/A	N/A	n/a	n/a
Iron	2	0	N/A	N/A	2	4270	4340	35580	n/a

TABLE A-1 (CONTINUED)

SUMMARY OF THE RANGE OF CONCENTRATIONS MEASURED FOR SOIL ANALYTES

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NON-DETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		UTL	SAL
			MIN	MAX		MIN	MAX		
Isopropylbenzene	4	4	0.005	0.029	0	N/A	N/A	n/a	3200
Isopropyltoluene [4-]	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Lead	24	0	N/A	N/A	24	3.3	1400	39	400
Lead-212 [d]	2	0	N/A	N/A	2	1.331	1.365	n/a	n/a
Lead-214 [d]	2	0	N/A	N/A	2	1.058	1.552	n/a	n/a
Magnesium	2	2	227	228	0	N/A	N/A	16147	n/a
Manganese	22	0	N/A	N/A	22	150	530	1030	11000
Mercury	93	9	0.06	0.2	84	0.00194	680	0.1	24
Methyl iodide	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Methyl-2-pentanone [4-]	4	4	0.02	0.11	0	N/A	N/A	n/a	510
Methylene chloride	4	4	0.005	0.029	0	N/A	N/A	n/a	5.6
Nickel	22	5	2	3.5	17	1.4	13	26.7	1600
Plutonium-238 [d]	27	0	N/A	N/A	27	-0.0009	0.038	0.014	20
Plutonium-239 [d]	27	0	N/A	N/A	27	0.001	1.55	0.052	18
Potassium	2	2	433	546	0	N/A	N/A	6179	n/a
Potassium-40 [d]	2	0	N/A	N/A	2	28.9	31.99	n/a	n/a
Propylbenzene	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Radium-224 [d]	1	0	N/A	N/A	1	4.882	4.882	n/a	n/a
Radium-226 [d]	1	0	N/A	N/A	1	1.356	1.356	n/a	5
Radon Tritium Screening [d]	15	0	N/A	N/A	15	0	8.92	n/a	n/a
Selenium	21	7	0.2	0.45	14	0.29	0.75	1.7	400
Silver	22	22	0.82	1	0	N/A	N/A	1.61	400
Sodium	2	2	113	130	0	N/A	N/A	1884	n/a
Styrene	4	4	0.005	0.029	0	N/A	N/A	n/a	3300
Tetrachloroethane [1,1,1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	270
Tetrachloroethane [1,1,2,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	3.9
Tetrachloroethylene	4	4	0.005	0.029	0	N/A	N/A	n/a	5.9
Thallium	20	2	0.69	0.69	18	0.14	0.5	0.9	6.4
Thallium-208 [d]	2	0	N/A	N/A	2	0.3713	0.689	n/a	n/a
Toluene	4	3	0.005	0.006	1	0.29	0.28	n/a	910
TPH	22	0	N/A	N/A	22	10	37600	n/a	n/a
Trichloro-1,2,2-trifluoroethane [1,1,2-	4	4	0.005	0.029	0	N/A	N/A	n/a	n/a
Trichloroethane [1,1,1-]	4	0	N/A	N/A	4	0.03	100	n/a	1000
Trichloroethane [1,1,2-]	4	4	0.005	0.029	0	N/A	N/A	n/a	6.3
Trichloroethene	4	4	0.005	0.029	0	N/A	N/A	n/a	3.2
Trichlorofluoromethane	4	4	0.005	0.057	0	N/A	N/A	n/a	24000
Trichloropropane [1,2,3-]	4	4	0.005	0.029	0	N/A	N/A	n/a	480
Trimethylbenzene [1,2,4-]	4	4	0.005	0.029	0	N/A	N/A	n/a	40
Trimethylbenzene [1,3,5-]	4	4	0.005	0.029	0	N/A	N/A	n/a	32
Tritium [d]	25	0	N/A	N/A	25	0.0028	562.1	n/a	510
Uranium	5	0	N/A	N/A	5	1.6	3.7	n/a	n/a
Vanadium	22	2	1.6	1.9	20	11	33	66	560
Vinyl acetate	1	1	0.01	0.01	0	N/A	N/A	n/a	80000
Vinyl chloride	4	4	0.01	0.057	0	N/A	N/A	n/a	0.013
Xylenes (o + m + p) [Mixed-]	4	3	0.005	0.006	1	0.029	0.029	n/a	160000
Zinc	24	0	N/A	N/A	24	30.9	230	101	24000

[a] UTL = Upper tolerance limit.
[b] SAL = Screening action level.
[c] n/a = Not available.
[d] Results are in pCi/g. All other results are in mg/kg.
[e] N/A = Not applicable.

TABLE A-2

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1003	PF-3-1	Acetone	SS		0.036	mg/kg	8000	n/a	0.0–0.3 ft
03-1003	PF-3-1	Benzene	SS	<	0.005	mg/kg	0.67	n/a	0.0–0.3 ft
03-1003	PF-3-1	Chloroform	SS	<	0.005	mg/kg	0.21	n/a	0.0–0.3 ft
03-1003	PF-3-1	Chloromethane	SS	<	0.01	mg/kg	6.4	n/a	0.0–0.3 ft
03-1003	PF-3-1	Dichloroethane [1,1-]	SS	<	0.005	mg/kg	410	n/a	0.0–0.3 ft
03-1003	PF-3-1	Dichloroethane [1,2-]	SS	<	0.005	mg/kg	0.2	n/a	0.0–0.3 ft
03-1003	PF-3-1	Dichloroethene [1,1-]	SS	<	0.005	mg/kg	0.4	n/a	0.0–0.3 ft
03-1003	PF-3-1	Dichloropropene [cis-1,3-]	SS	<	0.005	mg/kg	0.17	n/a	0.0–0.3 ft
03-1003	PF-3-1	Ethylbenzene	SS	<	0.005	mg/kg	3100	n/a	0.0–0.3 ft
03-1003	PF-3-1	Mercury	SS	>	2	mg/kg	24	0.1	0.0–0.3 ft
03-1003	PF-3-1	TPH	SS		37100	mg/kg	100	n/a	0.0–0.3 ft
03-1003	PF-3-1	Plutonium-238	SS		0.005	PCI/g	20	0.014	0.0–0.3 ft
03-1003	PF-3-1	Plutonium-239	SS		0.139	PCI/g	18	0.052	0.0–0.3 ft
03-1003	PF-3-1	Toluene	SS	<	0.005	mg/kg	910	n/a	0.0–0.3 ft
03-1003	PF-3-1	Trichloroethane [1,1,1-]	SS		0.16	mg/kg	1000	n/a	0.0–0.3 ft
03-1003	PF-3-1	Tritium	SS		41,181	PCI/g	810	4.64	0.0–0.3 ft
03-1003	PF-3-1	Xylenes (o + m + p) [Mixed-]	SS	<	0.005	mg/kg	160000	n/a	0.0–0.3 ft
03-1013	AAA2362	Arsenic	SS		4.56	mg/kg	n/a	11.6	0.0–0.3 ft
03-1013	AAA2363	Arsenic	SS		5.94	mg/kg	n/a	11.6	0.0–1.7 ft
03-1013	AAA2364	Arsenic	SS		5.45	mg/kg	n/a	11.6	0.5–3.3 ft
03-1013	AAA2365	Arsenic	SS		6.12	mg/kg	n/a	11.6	1.5–6.6 ft
03-1013	AAA2379	Arsenic	SS		4.33	mg/kg	n/a	11.6	0.0–0.3 ft
03-1013	AAA2362	Cadmium	SS		15	mg/kg	80	2.7	0.0–0.3 ft
03-1013	AAA2362	Cadmium	SS		17	mg/kg	80	2.7	0.0–0.3 ft
03-1013	AAA2363	Cadmium	SS		17	mg/kg	80	2.7	0.0–1.7 ft
03-1013	AAA2364	Cadmium	SS	<	0.4	mg/kg	80	2.7	0.5–3.3 ft
03-1013	AAA2365	Cadmium	SS	<	0.4	mg/kg	80	2.7	1.5–6.6 ft
03-1013	AAA2379	Cadmium	SS		0.5	mg/kg	80	2.7	0.0–0.3 ft
03-1013	AAA2362	Cesium-137	SS		0.69	PCI/g	4	1.4	0.0–0.3 ft
03-1013	AAA2362	Cesium-137	SS		1.13	PCI/g	4	1.4	0.0–0.3 ft
03-1013	AAA2363	Cesium-137	SS	<	0.47	PCI/g	4	1.4	0.0–1.7 ft
03-1013	AAA2364	Cesium-137	SS	<	0.51	PCI/g	4	1.4	0.5–3.3 ft
03-1013	AAA2365	Cesium-137	SS	<	0.58	PCI/g	4	1.4	1.5–6.6 ft
03-1013	AAA2379	Cesium-137	SS		0.79	PCI/g	4	1.4	0.0–0.3 ft
03-1013	AAA2362	Chromium	SS		23	mg/kg	n/a	34.2	0.0–0.3 ft
03-1013	AAA2362	Chromium	SS		34	mg/kg	n/a	34.2	0.0–0.3 ft
03-1013	AAA2363	Chromium	SS		18	mg/kg	n/a	34.2	0.0–1.7 ft
03-1013	AAA2364	Chromium	SS		13	mg/kg	n/a	34.2	0.5–3.3 ft
03-1013	AAA2365	Chromium	SS		15	mg/kg	n/a	34.2	1.5–6.6 ft
03-1013	AAA2379	Chromium	SS		10	mg/kg	n/a	34.2	0.0–0.3 ft
03-1013	AAA2362	Copper	SS		69	mg/kg	3000	15.7	0.0–0.3 ft
03-1013	AAA2362	Copper	SS		83	mg/kg	3000	15.7	0.0–0.3 ft
03-1013	AAA2363	Copper	SS		53	mg/kg	3000	15.7	0.0–1.7 ft
03-1013	AAA2364	Copper	SS		6.8	mg/kg	3000	15.7	0.5–3.3 ft
03-1013	AAA2365	Copper	SS		6.8	mg/kg	3000	15.7	1.5–6.6 ft
03-1013	AAA2379	Copper	SS		7.8	mg/kg	3000	15.7	0.0–0.3 ft
03-1013	AAA2362	Lead	SS		390	mg/kg	400	39	0.0–0.3 ft
03-1013	AAA2363	Lead	SS		900	mg/kg	400	39	0.0–1.7 ft
03-1013	AAA2364	Lead	SS		21	mg/kg	400	39	0.5–3.3 ft
03-1013	AAA2365	Lead	SS		16	mg/kg	400	39	1.5–6.6 ft
03-1013	AAA2379	Lead	SS		49	mg/kg	400	39	0.0–0.3 ft
03-1013	AAA2362	Mercury	SS		430	mg/kg	24	0.1	0.0–0.3 ft
03-1013	AAA2362	Mercury	SS		540	mg/kg	24	0.1	0.0–0.3 ft
03-1013	AAA2362	Mercury	SS		720	mg/kg	24	0.1	0.0–0.3 ft
03-1013	AAA2363	Mercury	SS		30	mg/kg	24	0.1	0.0–1.7 ft
03-1013	AAA2363	Mercury	SS		43	mg/kg	24	0.1	0.0–1.7 ft
03-1013	AAA2363	Mercury	SS		53	mg/kg	24	0.1	0.0–1.7 ft
03-1013	AAA2364	Mercury	SS		7.7	mg/kg	24	0.1	0.5–3.3 ft
03-1013	AAA2364	Mercury	SS		8.4	mg/kg	24	0.1	0.5–3.3 ft
03-1013	AAA2364	Mercury	SS		20	mg/kg	24	0.1	0.5–3.3 ft
03-1013	AAA2365	Mercury	SS		3.6	mg/kg	24	0.1	1.5–6.6 ft
03-1013	AAA2365	Mercury	SS		3.8	mg/kg	24	0.1	1.5–6.6 ft
03-1013	AAA2365	Mercury	SS		4	mg/kg	24	0.1	1.5–6.6 ft
03-1013	AAA2379	Mercury	SS		530	mg/kg	24	0.1	0.0–0.3 ft
03-1013	AAA2379	Mercury	SS		570	mg/kg	24	0.1	0.0–0.3 ft
03-1013	AAA2379	Mercury	SS		700	mg/kg	24	0.1	0.0–0.3 ft

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1013	AAA2362	TPH	SS		27400	mg/kg	100	n/a	0.0–0.3 ft
03-1013	AAA2363	TPH	SS		3150	mg/kg	100	n/a	0.0–1.7 ft
03-1013	AAA2364	TPH	SS		2530	mg/kg	100	n/a	0.5–3.3 ft
03-1013	AAA2365	TPH	SS		3640	mg/kg	100	n/a	1.5–6.6 ft
03-1013	AAA2379	TPH	SS		20800	mg/kg	100	n/a	0.0–0.3 ft
03-1013	AAA2362	Plutonium-238	SS		0.013	PCI/g	20	0.014	0.0–0.3 ft
03-1013	AAA2363	Plutonium-238	SS		0.002	PCI/g	20	0.014	0.0–1.7 ft
03-1013	AAA2364	Plutonium-238	SS		0.004	PCI/g	20	0.014	0.5–3.3 ft
03-1013	AAA2365	Plutonium-238	SS		0.003	PCI/g	20	0.014	1.5–6.6 ft
03-1013	AAA2379	Plutonium-238	SS		0.012	PCI/g	20	0.014	0.0–0.3 ft
03-1013	AAA2362	Plutonium-239	SS		1.405	PCI/g	18	0.052	0.0–0.3 ft
03-1013	AAA2363	Plutonium-239	SS		0.039	PCI/g	18	0.052	0.0–1.7 ft
03-1013	AAA2364	Plutonium-239	SS		0.015	PCI/g	18	0.052	0.5–3.3 ft
03-1013	AAA2365	Plutonium-239	SS		0.001	PCI/g	18	0.052	1.5–6.6 ft
03-1013	AAA2379	Plutonium-239	SS		0.98	PCI/g	18	0.052	0.0–0.3 ft
03-1013	AAA2362	Tritium	SS		102.306	PCI/g	810	4.64	0.0–0.3 ft
03-1013	AAA2363	Tritium	SS		26.419	PCI/g	810	4.64	0.0–1.7 ft
03-1013	AAA2364	Tritium	SS		17.267	PCI/g	810	4.64	0.5–3.3 ft
03-1013	AAA2365	Tritium	SS		15.677	PCI/g	810	4.64	1.5–6.6 ft
03-1013	AAA2379	Tritium	SS		562.104	PCI/g	810	4.64	0.0–0.3 ft
03-1013	AAA2362	Zinc	SS		160	mg/kg	24000	101	0.0–0.3 ft
03-1013	AAA2362	Zinc	SS		160	mg/kg	24000	101	0.0–0.3 ft
03-1013	AAA2363	Zinc	SS		140	mg/kg	24000	101	0.0–1.7 ft
03-1013	AAA2364	Zinc	SS		44	mg/kg	24000	101	0.5–3.3 ft
03-1013	AAA2365	Zinc	SS		46	mg/kg	24000	101	1.5–6.6 ft
03-1013	AAA2379	Zinc	SS		45	mg/kg	24000	101	0.0–0.3 ft
03-1018	AAA2366	Arsenic	SS		4.21	mg/kg	n/a	11.6	0.0–0.3 ft
03-1018	AAA2367	Arsenic	SS		5.02	mg/kg	n/a	11.6	0.0–1.7 ft
03-1018	AAA2368	Arsenic	SS		6.11	mg/kg	n/a	11.6	0.5–3.3 ft
03-1018	AAA2369	Arsenic	SS		6.63	mg/kg	n/a	11.6	1.5–6.6 ft
03-1018	AAA2366	Cadmium	SS		4.1	mg/kg	80	2.7	0.0–0.3 ft
03-1018	AAA2367	Cadmium	SS		3.3	mg/kg	80	2.7	0.0–1.7 ft
03-1018	AAA2368	Cadmium	SS		0.5	mg/kg	80	2.7	0.5–3.3 ft
03-1018	AAA2369	Cadmium	SS	<	0.4	mg/kg	80	2.7	1.5–6.6 ft
03-1018	AAA2366	Cesium-137	SS		1.06	PCI/g	4	1.4	0.0–0.3 ft
03-1018	AAA2367	Cesium-137	SS	<	0.85	PCI/g	4	1.4	0.0–0.3 ft
03-1018	AAA2368	Cesium-137	SS	<	0.63	PCI/g	4	1.4	0.5–3.3 ft
03-1018	AAA2369	Cesium-137	SS	<	0.76	PCI/g	4	1.4	1.5–6.6 ft
03-1018	AAA2366	Chromium	SS		14	mg/kg	n/a	34.2	0.0–0.3 ft
03-1018	AAA2367	Chromium	SS		31	mg/kg	n/a	34.2	0.0–1.7 ft
03-1018	AAA2368	Chromium	SS		12	mg/kg	n/a	34.2	0.5–3.3 ft
03-1018	AAA2369	Chromium	SS		15	mg/kg	n/a	34.2	1.5–6.6 ft
03-1018	AAA2366	Copper	SS		33	mg/kg	3000	15.7	0.0–0.3 ft
03-1018	AAA2367	Copper	SS		38	mg/kg	3000	15.7	0.0–1.7 ft
03-1018	AAA2368	Copper	SS		10	mg/kg	3000	15.7	0.5–3.3 ft
03-1018	AAA2369	Copper	SS		8.2	mg/kg	3000	15.7	1.5–6.6 ft
03-1018	AAA2366	Lead	SS		750	mg/kg	400	39	0.0–0.3 ft
03-1018	AAA2367	Lead	SS		420	mg/kg	400	39	0.0–1.7 ft
03-1018	AAA2368	Lead	SS		51	mg/kg	400	39	0.5–3.3 ft
03-1018	AAA2369	Lead	SS		29	mg/kg	400	39	1.5–6.6 ft
03-1018	AAA2366	Mercury	SS		370	mg/kg	24	0.1	0.0–0.3 ft
03-1018	AAA2366	Mercury	SS		680	mg/kg	24	0.1	0.0–0.3 ft
03-1018	AAA2366	Mercury	SS		880	mg/kg	24	0.1	0.0–0.3 ft
03-1018	AAA2367	Mercury	SS		360	mg/kg	24	0.1	0.0–1.7 ft
03-1018	AAA2367	Mercury	SS		370	mg/kg	24	0.1	0.0–1.7 ft
03-1018	AAA2367	Mercury	SS		640	mg/kg	24	0.1	0.0–1.7 ft
03-1018	AAA2368	Mercury	SS		19	mg/kg	24	0.1	0.5–3.3 ft
03-1018	AAA2368	Mercury	SS		21	mg/kg	24	0.1	0.5–3.3 ft
03-1018	AAA2368	Mercury	SS		32	mg/kg	24	0.1	0.5–3.3 ft
03-1018	AAA2369	Mercury	SS		14	mg/kg	24	0.1	1.5–6.6 ft
03-1018	AAA2369	Mercury	SS		19	mg/kg	24	0.1	1.5–6.6 ft
03-1018	AAA2369	Mercury	SS		22	mg/kg	24	0.1	1.5–6.6 ft
03-1018	AAA2366	TPH	SS		23300	mg/kg	100	n/a	0.0–0.3 ft
03-1018	AAA2367	TPH	SS		15200	mg/kg	100	n/a	0.0–1.7 ft
03-1018	AAA2368	TPH	SS		5710	mg/kg	100	n/a	0.5–3.3 ft

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1018	AAA2369	TPH	SS		5950	mg/kg	100	n/a	1.5–6.6 ft
03-1018	AAA2366	Plutonium-238	SS		0.011	PCI/g	20	0.014	0.0–0.3 ft
03-1018	AAA2367	Plutonium-238	SS		0.004	PCI/g	20	0.014	0.0–1.7 ft
03-1018	AAA2368	Plutonium-238	SS		0.002	PCI/g	20	0.014	0.5–3.3 ft
03-1018	AAA2369	Plutonium-238	SS		0	PCI/g	20	0.014	1.5–6.6 ft
03-1018	AAA2366	Plutonium-239	SS		1.085	PCI/g	18	0.052	0.0–0.3 ft
03-1018	AAA2367	Plutonium-239	SS		0.195	PCI/g	18	0.052	0.0–1.7 ft
03-1018	AAA2368	Plutonium-239	SS		0.025	PCI/g	18	0.052	0.5–3.3 ft
03-1018	AAA2369	Plutonium-239	SS		0.014	PCI/g	18	0.052	1.5–6.6 ft
03-1018	AAA2366	Tritium	SS		551.852	PCI/g	810	4.64	0.0–0.3 ft
03-1018	AAA2367	Tritium	SS		63.964	PCI/g	810	4.64	0.0–1.7 ft
03-1018	AAA2368	Tritium	SS		19.899	PCI/g	810	4.64	0.5–3.3 ft
03-1018	AAA2369	Tritium	SS		9.097	PCI/g	810	4.64	1.5–6.6 ft
03-1018	AAA2366	Zinc	SS		130	mg/kg	24000	101	0.0–0.3 ft
03-1018	AAA2367	Zinc	SS		110	mg/kg	24000	101	0.0–1.7 ft
03-1018	AAA2368	Zinc	SS		39	mg/kg	24000	101	0.5–3.3 ft
03-1018	AAA2369	Zinc	SS		42	mg/kg	24000	101	1.5–6.6 ft
03-1023	AAA2370	Arsenic	SS		6.25	mg/kg	n/a	11.6	0.0–0.3 ft
03-1023	AAA2371	Arsenic	SS		5.26	mg/kg	n/a	11.6	0.0–1.7 ft
03-1023	AAA2372	Arsenic	SS		6.18	mg/kg	n/a	11.6	0.5–3.3 ft
03-1023	AAA2373	Arsenic	SS		6.25	mg/kg	n/a	11.6	1.5–6.6 ft
03-1023	AAA2370	Cadmium	SS		30	mg/kg	80	2.7	0.0–0.3 ft
03-1023	AAA2371	Cadmium	SS		4.4	mg/kg	80	2.7	0.0–1.7 ft
03-1023	AAA2372	Cadmium	SS		3.6	mg/kg	80	2.7	0.5–3.3 ft
03-1023	AAA2373	Cadmium	SS	<	0.4	mg/kg	80	2.7	1.5–6.6 ft
03-1023	AAA2370	Cesium-137	SS	<	0.77	PCI/g	4	1.4	0.0–0.3 ft
03-1023	AAA2371	Cesium-137	SS	<	0.3	PCI/g	4	1.4	0.0–1.7 ft
03-1023	AAA2372	Cesium-137	SS	<	0.4	PCI/g	4	1.4	0.5–3.3 ft
03-1023	AAA2373	Cesium-137	SS	<	0.43	PCI/g	4	1.4	1.5–6.6 ft
03-1023	AAA2370	Chromium	SS		36	mg/kg	n/a	34.2	0.0–0.3 ft
03-1023	AAA2371	Chromium	SS		19	mg/kg	n/a	34.2	0.0–1.7 ft
03-1023	AAA2372	Chromium	SS		18	mg/kg	n/a	34.2	0.5–3.3 ft
03-1023	AAA2373	Chromium	SS		14	mg/kg	n/a	34.2	1.5–6.6 ft
03-1023	AAA2370	Copper	SS		87	mg/kg	3000	15.7	0.0–0.3 ft
03-1023	AAA2371	Copper	SS		44	mg/kg	3000	15.7	0.0–1.7 ft
03-1023	AAA2372	Copper	SS		13	mg/kg	3000	15.7	0.5–3.3 ft
03-1023	AAA2373	Copper	SS		8.3	mg/kg	3000	15.7	1.5–6.6 ft
03-1023	AAA2370	Lead	SS		1400	mg/kg	400	39	0.0–0.3 ft
03-1023	AAA2371	Lead	SS		32	mg/kg	400	39	0.0–1.7 ft
03-1023	AAA2372	Lead	SS		32	mg/kg	400	39	0.5–3.3 ft
03-1023	AAA2373	Lead	SS		17	mg/kg	400	39	1.5–6.6 ft
03-1023	AAA2370	Mercury	SS		6	mg/kg	24	0.1	0.0–0.3 ft
03-1023	AAA2370	Mercury	SS		6.2	mg/kg	24	0.1	0.0–0.3 ft
03-1023	AAA2370	Mercury	SS		6.6	mg/kg	24	0.1	0.0–0.3 ft
03-1023	AAA2371	Mercury	SS		104	mg/kg	24	0.1	0.0–1.7 ft
03-1023	AAA2371	Mercury	SS		132	mg/kg	24	0.1	0.0–1.7 ft
03-1023	AAA2371	Mercury	SS		150	mg/kg	24	0.1	0.0–1.7 ft
03-1023	AAA2372	Mercury	SS		45	mg/kg	24	0.1	0.5–3.3 ft
03-1023	AAA2372	Mercury	SS		47	mg/kg	24	0.1	0.5–3.3 ft
03-1023	AAA2372	Mercury	SS		77	mg/kg	24	0.1	0.5–3.3 ft
03-1023	AAA2373	Mercury	SS		11	mg/kg	24	0.1	1.5–6.6 ft
03-1023	AAA2373	Mercury	SS		15	mg/kg	24	0.1	1.5–6.6 ft
03-1023	AAA2373	Mercury	SS		35	mg/kg	24	0.1	1.5–6.6 ft
03-1023	AAA2370	TPH	SS		37600	mg/kg	100	n/a	0.0–0.3 ft
03-1023	AAA2371	TPH	SS		4560	mg/kg	100	n/a	0.0–1.7 ft
03-1023	AAA2372	TPH	SS		4300	mg/kg	100	n/a	0.5–3.3 ft
03-1023	AAA2373	TPH	SS		7730	mg/kg	100	n/a	1.5–6.6 ft
03-1023	AAA2370	Plutonium-238	SS		0.013	PCI/g	20	0.014	0.0–0.3 ft
03-1023	AAA2371	Plutonium-238	SS		0.002	PCI/g	20	0.014	0.0–1.7 ft
03-1023	AAA2372	Plutonium-238	SS		0.003	PCI/g	20	0.014	0.5–3.3 ft
03-1023	AAA2373	Plutonium-238	SS		0.002	PCI/g	20	0.014	1.5–6.6 ft
03-1023	AAA2373	Plutonium-238	SS		0.002	PCI/g	20	0.014	1.5–6.6 ft
03-1023	AAA2370	Plutonium-239	SS		0.894	PCI/g	18	0.052	0.0–0.3 ft
03-1023	AAA2371	Plutonium-239	SS		0.091	PCI/g	18	0.052	0.0–1.7 ft
03-1023	AAA2372	Plutonium-239	SS		0.015	PCI/g	18	0.052	0.5–3.3 ft

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1023	AAA2373	Plutonium-239	SS		0.012	PCI/g	18	0.052	1.5–6.6 ft
03-1023	AAA2373	Plutonium-239	SS		0.013	PCI/g	18	0.052	1.5–6.6 ft
03-1023	AAA2370	Tritium	SS		480.936	PCI/g	810	4.64	0.0–0.3 ft
03-1023	AAA2371	Tritium	SS		27.222	PCI/g	810	4.64	0.0–1.7 ft
03-1023	AAA2372	Tritium	SS		11.233	PCI/g	810	4.64	0.5–3.3 ft
03-1023	AAA2373	Tritium	SS		12.533	PCI/g	810	4.64	1.5–6.6 ft
03-1023	AAA2370	Zinc	SS		230	mg/kg	24000	101	0.0–0.3 ft
03-1023	AAA2371	Zinc	SS		70	mg/kg	24000	101	0.0–1.7 ft
03-1023	AAA2372	Zinc	SS		57	mg/kg	24000	101	0.5–3.3 ft
03-1023	AAA2373	Zinc	SS		40	mg/kg	24000	101	1.5–6.6 ft
03-1038	PF-3-2	Mercury	SS		1.709	mg/kg	24	0.1	N/A
03-1038	PF-3-2	Plutonium-238	SS		0.028	PCI/g	20	0.014	N/A
03-1038	PF-3-2	Plutonium-239	SS		1.55	PCI/g	18	0.052	N/A
03-1038	PF-3-2	Tritium	SS		67.267	PCI/g	810	4.64	N/A
03-1051	AAA2374	Arsenic	SS		17.7	mg/kg	n/a	11.6	0.0–1.0 ft
03-1051	AAA2374	Arsenic	SS		18.8	mg/kg	n/a	11.6	0.0–1.0 ft
03-1051	AAA2380	Arsenic	SS		15.64	mg/kg	n/a	11.6	0.0–1.0 ft
03-1051	AAA2374	Cadmium	SS		0.6	mg/kg	80	2.7	0.0–1.0 ft
03-1051	AAA2380	Cadmium	SS		0.6	mg/kg	80	2.7	0.0–1.0 ft
03-1051	AAA2374	Cesium-137	SS		1.54	PCI/g	4	1.4	0.0–1.0 ft
03-1051	AAA2380	Cesium-137	SS		1.39	PCI/g	4	1.4	0.0–1.0 ft
03-1051	AAA2374	Chromium	SS		17	mg/kg	n/a	34.2	0.0–1.0 ft
03-1051	AAA2380	Chromium	SS		14	mg/kg	n/a	34.2	0.0–1.0 ft
03-1051	AAA2374	Copper	SS		34	mg/kg	3000	15.7	0.0–1.0 ft
03-1051	AAA2380	Copper	SS		25	mg/kg	3000	15.7	0.0–1.0 ft
03-1051	AAA2374	Lead	SS		190	mg/kg	400	39	0.0–1.0 ft
03-1051	AAA2380	Lead	SS		250	mg/kg	400	39	0.0–1.0 ft
03-1051	AAA2374	Mercury	SS		0.4	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2374	Mercury	SS		0.5	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2374	Mercury	SS		0.7	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2380	Mercury	SS		0.3	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2380	Mercury	SS		0.6	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2380	Mercury	SS		1.5	mg/kg	24	0.1	0.0–1.0 ft
03-1051	AAA2374	TPH	SS		1220	mg/kg	n/a	n/a	0.0–1.0 ft
03-1051	AAA2380	TPH	SS		1080	mg/kg	n/a	n/a	0.0–1.0 ft
03-1051	AAA2374	Plutonium-238	SS		0.011	PCI/g	20	0.014	0.0–1.0 ft
03-1051	AAA2380	Plutonium-238	SS		0.008	PCI/g	20	0.014	0.0–1.0 ft
03-1051	AAA2374	Plutonium-239	SS		0.04	PCI/g	18	0.052	0.0–1.0 ft
03-1051	AAA2380	Plutonium-239	SS		0.046	PCI/g	18	0.052	0.0–1.0 ft
03-1051	AAA2374	Tritium	SS		2.1	PCI/g	810	n/a	0.0–1.0 ft
03-1051	AAA2380	Tritium	SS		0.44	PCI/g	810	n/a	0.0–1.0 ft
03-1051	AAA2374	Zinc	SS		170	mg/kg	24000	101	0.0–1.0 ft
03-1051	AAA2380	Zinc	SS		140	mg/kg	24000	101	0.0–1.0 ft
03-1051A	PF-3-3	Mercury	SS		0.0495	mg/kg	24	0.1	N/A
03-1051A	PF-3-3	Plutonium-238	SS		0.001	PCI/g	20	0.014	N/A
03-1051A	PF-3-3	Plutonium-239	SS		0.008	PCI/g	18	0.052	N/A
03-1051A	PF-3-3	Tritium	SS		2.32	PCI/g	810	n/a	N/A
03-1052	AAA2375	Arsenic	SS		3.61	mg/kg	n/a	11.6	0.0–1.0 ft
03-1052	AAA2375	Cadmium	SS	<	0.4	mg/kg	80	2.7	0.0–1.0 ft
03-1052	AAA2375	Cesium-137	SS		1.04	PCI/g	4	1.4	0.0–1.0 ft
03-1052	AAA2375	Chromium	SS		6.1	mg/kg	n/a	34.2	0.0–1.0 ft
03-1052	AAA2375	Copper	SS		14	mg/kg	3000	15.7	0.0–1.0 ft
03-1052	AAA2375	Lead	SS		51	mg/kg	400	39	0.0–1.0 ft
03-1052	AAA2375	Mercury	SS		0.5	mg/kg	24	0.1	0.0–1.0 ft
03-1052	AAA2375	Mercury	SS		0.7	mg/kg	24	0.1	0.0–1.0 ft
03-1052	AAA2375	Mercury	SS		0.7	mg/kg	24	0.1	0.0–1.0 ft
03-1052	AAA2375	TPH	SS		211	mg/kg	n/a	n/a	0.0–1.0 ft
03-1052	AAA2375	Plutonium-238	SS		0.01	PCI/g	20	0.014	0.0–1.0 ft
03-1052	AAA2375	Plutonium-239	SS		0.038	PCI/g	18	0.052	0.0–1.0 ft
03-1052	AAA2375	Tritium	SS		2.22	PCI/g	810	n/a	0.0–1.0 ft
03-1052	AAA2375	Zinc	SS		79	mg/kg	24000	101	0.0–1.0 ft
03-1052A	PF-3-4	Mercury	SS		0.00194	mg/kg	24	0.1	N/A
03-1052A	PF-3-4	Plutonium-238	SS		0.001	PCI/g	20	0.014	N/A
03-1052A	PF-3-4	Plutonium-239	SS		0.002	PCI/g	18	0.052	N/A
03-1052A	PF-3-4	Tritium	SS		0.071	PCI/g	810	n/a	N/A
03-1053	AAA2376	Arsenic	SS		3.22	mg/kg	n/a	11.6	0.0–1.0 ft
03-1053	AAA2376	Cadmium	SS	<	0.4	mg/kg	80	2.7	0.0–1.0 ft
03-1053	AAA2376	Cesium-137	SS		0.54	PCI/g	4	1.4	0.0–1.0 ft
03-1053	AAA2376	Chromium	SS		4.8	mg/kg	n/a	34.2	0.0–1.0 ft
03-1053	AAA2376	Copper	SS		2.9	mg/kg	3000	15.7	0.0–1.0 ft

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1053	AAA2376	Lead	SS		21	mg/kg	400	39	0.0–1.0 ft
03-1053	AAA2376	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1053	AAA2376	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1053	AAA2376	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1053	AAA2376	TPH	SS		425	mg/kg	n/a	n/a	0.0–1.0 ft
03-1053	AAA2376	Plutonium-238	SS		0.002	PCI/g	20	0.014	0.0–1.0 ft
03-1053	AAA2376	Plutonium-239	SS		0.003	PCI/g	18	0.052	0.0–1.0 ft
03-1053	AAA2376	Tritium	SS		0.381	PCI/g	810	n/a	0.0–1.0 ft
03-1053	AAA2376	Zinc	SS		42	mg/kg	24000	101	0.0–1.0 ft
03-1053A	PF-3-5	Mercury	SS		1.942	mg/kg	24	0.1	N/A
03-1053A	PF-3-5	Plutonium-238	SS		0.036	PCI/g	20	0.014	N/A
03-1053A	PF-3-5	Plutonium-239	SS		0.24	PCI/g	18	0.052	N/A
03-1053A	PF-3-5	Tritium	SS		16.45	PCI/g	810	n/a	N/A
03-1054	AAA2377	Arsenic	SS		2.57	mg/kg	n/a	11.6	0.0–1.0 ft
03-1054	AAA2377	Cadmium	SS	<	0.4	mg/kg	80	2.7	0.0–1.0 ft
03-1054	AAA2377	Cadmium	SS	<	0.4	mg/kg	80	2.7	0.0–1.0 ft
03-1054	AAA2377	Cesium-137	SS	<	0.56	PCI/g	4	1.4	0.0–1.0 ft
03-1054	AAA2377	Chromium	SS		2.1	mg/kg	n/a	34.2	0.0–1.0 ft
03-1054	AAA2377	Chromium	SS		4.7	mg/kg	n/a	34.2	0.0–1.0 ft
03-1054	AAA2377	Copper	SS		1.9	mg/kg	3000	15.7	0.0–1.0 ft
03-1054	AAA2377	Copper	SS		3.3	mg/kg	3000	15.7	0.0–1.0 ft
03-1054	AAA2377	Lead	SS		25	mg/kg	400	39	0.0–1.0 ft
03-1054	AAA2377	Lead	SS		16	mg/kg	400	39	0.0–1.0 ft
03-1054	AAA2377	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1054	AAA2377	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1054	AAA2377	Mercury	SS	<	0.2	mg/kg	24	0.1	0.0–1.0 ft
03-1054	AAA2377	TPH	SS		126	mg/kg	n/a	n/a	0.0–1.0 ft
03-1054	AAA2377	Plutonium-238	SS		0.003	PCI/g	20	0.014	0.0–1.0 ft
03-1054	AAA2377	Plutonium-239	SS		0.001	PCI/g	18	0.052	0.0–1.0 ft
03-1054	AAA2377	Tritium	SS		0.022	PCI/g	810	n/a	0.0–1.0 ft
03-1054	AAA2377	Zinc	SS		43	mg/kg	24000	101	0.0–1.0 ft
03-1054	AAA2377	Zinc	SS		43	mg/kg	24000	101	0.0–1.0 ft
03-1261	AAB2015	Acetone	SS		0.25	mg/kg	8000	n/a	0.0–8.0 ft
03-1261	AAB2015	Benzene	SS		0.38	mg/kg	0.67	n/a	0.0–8.0 ft
03-1261	AAB2015	Chloroform	SS		0.069	mg/kg	0.21	n/a	0.0–8.0 ft
03-1261	AAB2015	Chloromethane	SS		0.13	mg/kg	6.4	n/a	0.0–8.0 ft
03-1261	AAB2015	Dichloroethane [1,1-]	SS		0.2	mg/kg	410	n/a	0.0–8.0 ft
03-1261	AAB2015	Dichloroethane [1,2-]	SS		0.91	mg/kg	0.2	n/a	0.0–8.0 ft
03-1261	AAB2015	Dichloroethene [1,1-]	SS		29	mg/kg	0.4	n/a	0.0–8.0 ft
03-1261	AAB2015	Dichloropropene [cis-1,3-]	SS		0.054	mg/kg	0.17	n/a	0.0–8.0 ft
03-1261	AAB2015	Ethylbenzene	SS		0.023	mg/kg	3100	n/a	0.0–8.0 ft
03-1261	AAB2015	Mercury	SS		0.9	mg/kg	24	0.1	0.0–8.0 ft
03-1261	AAA2015	TPH	SS		15000	mg/kg	100	n/a	0.0–8.0 ft
03-1261	AAB2015	Toluene	SS		0.28	mg/kg	910	n/a	0.0–8.0 ft
03-1261	AAB2015	Trichloroethane [1,1,1-]	SS		100	mg/kg	1000	n/a	0.0–8.0 ft
03-1261	AAB2015	Xylenes (o + m + p) [Mixed-]	SS		0.029	mg/kg	160000	n/a	0.0–8.0 ft
03-1262	AAB2016	Acetone	SS	<	0.024	mg/kg	8000	n/a	0.0–4.5 ft
03-1262	AAB2016	Benzene	SS	<	0.006	mg/kg	0.67	n/a	0.0–4.5 ft
03-1262	AAB2016	Chloroform	SS	<	0.006	mg/kg	0.21	n/a	0.0–4.5 ft
03-1262	AAB2016	Chloromethane	SS	<	0.012	mg/kg	6.4	n/a	0.0–4.5 ft
03-1262	AAB2016	Dichloroethane [1,1-]	SS	<	0.006	mg/kg	410	n/a	0.0–4.5 ft
03-1262	AAB2016	Dichloroethane [1,2-]	SS	<	0.006	mg/kg	0.2	n/a	0.0–4.5 ft
03-1262	AAB2016	Dichloroethene [1,1-]	SS		0.044	mg/kg	0.4	n/a	0.0–4.5 ft
03-1262	AAB2016	Dichloropropene [cis-1,3-]	SS	<	0.006	mg/kg	0.17	n/a	0.0–4.5 ft
03-1262	AAB2016	Ethylbenzene	SS	<	0.006	mg/kg	3100	n/a	0.0–4.5 ft
03-1262	AAB2016	Mercury	SS		1.2	mg/kg	24	0.1	0.0–4.5 ft
03-1262	AAA2016	TPH	SS		2000	mg/kg	100	n/a	0.0–4.5 ft
03-1262	AAB2016	Toluene	SS	<	0.006	mg/kg	910	n/a	0.0–4.5 ft
03-1262	AAB2016	Trichloroethane [1,1,1-]	SS		1.1	mg/kg	1000	n/a	0.0–4.5 ft
03-1262	AAB2016	Xylenes (o + m + p) [Mixed-]	SS	<	0.006	mg/kg	160000	n/a	0.0–4.5 ft
03-1263	AAB2017	Acetone	SS	<	0.024	mg/kg	8000	n/a	0.0–9.0 ft
03-1263	AAB2017	Benzene	SS	<	0.006	mg/kg	0.67	n/a	0.0–9.0 ft
03-1263	AAB2017	Chloroform	SS	<	0.006	mg/kg	0.21	n/a	0.0–9.0 ft
03-1263	AAB2017	Chloromethane	SS	<	0.012	mg/kg	6.4	n/a	0.0–9.0 ft
03-1263	AAB2017	Dichloroethane [1,1-]	SS	<	0.006	mg/kg	410	n/a	0.0–9.0 ft
03-1263	AAB2017	Dichloroethane [1,2-]	SS	<	0.006	mg/kg	0.2	n/a	0.0–9.0 ft
03-1263	AAB2017	Dichloroethene [1,1-]	SS	<	0.006	mg/kg	0.4	n/a	0.0–9.0 ft
03-1263	AAB2017	Dichloropropene [cis-1,3-]	SS	<	0.006	mg/kg	0.17	n/a	0.0–9.0 ft
03-1263	AAB2017	Ethylbenzene	SS	<	0.006	mg/kg	3100	n/a	0.0–9.0 ft
03-1263	AAB2017	Mercury	SS	<	0.11	mg/kg	24	0.1	0.0–9.0 ft
03-1263	AAA2017	TPH	SS		10	mg/kg	100	n/a	0.0–9.0 ft
03-1263	AAB2017	Toluene	SS	<	0.006	mg/kg	910	n/a	0.0–9.0 ft

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-1263	AAB2017	Trichloroethane [1,1,1-]	SS		0.03	mg/kg	1000	n/a	0.0–9.0 ft
03-1263	AAB2017	Xylenes (o + m + p) [Mixed-]	SS	<	0.006	mg/kg	160000	n/a	0.0–9.0 ft
03-2605	AAB7698	Cesium-137	SS	<	0.1842	PCI/g	4	1.4	N/A
03-2605	AAB7699	Cesium-137	SS	<	0.1841	PCI/g	4	1.4	N/A
03-2605	AAB7698	Lead	SS		9.5	mg/kg	400	39	N/A
03-2605	AAB7699	Lead	SS		7.4	mg/kg	400	39	N/A
03-2605	AAB7698	Plutonium-238	SS	-	0.0009	PCI/g	20	0.014	N/A
03-2605	AAB7699	Plutonium-238	SS	-	0.0007	PCI/g	20	0.014	N/A
03-2605	AAB7698	Plutonium-239	SS		0.0078	PCI/g	18	0.052	N/A
03-2605	AAB7699	Plutonium-239	SS		0.0069	PCI/g	18	0.052	N/A
03-2605	AAB7698	Radvan Tritium Screening	SS		8.82	PCI/g	n/a	n/a	N/A
03-2605	AAB7699	Radvan Tritium Screening	SS		7.02	PCI/g	n/a	n/a	N/A
03-2606	AAB7700	Cesium-137	SS	<	0.1739	PCI/g	4	1.4	N/A
03-2606	AAB7700	Lead	SS		7.4	mg/kg	400	39	N/A
03-2606	AAB7700	Plutonium-238	SS		0.0027	PCI/g	20	0.014	N/A
03-2606	AAB7700	Plutonium-239	SS		0.0027	PCI/g	18	0.052	N/A
03-2606	AAB7700	Radvan Tritium Screening	SS		0	PCI/g	n/a	n/a	N/A
03-2669	AAC0470	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2669	AAC0470	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2669	AAC0470	Mercury	SS		0.3	mg/kg	24	0.1	0.0–0.3 ft
03-2669	AAC0470	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2670	AAC0471	Mercury	SS		0.4	mg/kg	24	0.1	0.0–0.3 ft
03-2670	AAC0471	Mercury	SS		0.4	mg/kg	24	0.1	0.0–0.3 ft
03-2670	AAC0471	Mercury	SS		0.5	mg/kg	24	0.1	0.0–0.3 ft
03-2670	AAC0471	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2671	AAC0472	Mercury	SS		1	mg/kg	24	0.1	0.0–0.3 ft
03-2671	AAC0472	Mercury	SS		1	mg/kg	24	0.1	0.0–0.3 ft
03-2671	AAC0472	Mercury	SS		1.4	mg/kg	24	0.1	0.0–0.3 ft
03-2671	AAC0472	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2672	AAC0473	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2672	AAC0473	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2672	AAC0473	Mercury	SS		0.3	mg/kg	24	0.1	0.0–0.3 ft
03-2672	AAC0473	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2673	AAC0474	Mercury	SS		0.5	mg/kg	24	0.1	0.0–0.3 ft
03-2673	AAC0474	Mercury	SS		0.6	mg/kg	24	0.1	0.0–0.3 ft
03-2673	AAC0474	Mercury	SS		0.7	mg/kg	24	0.1	0.0–0.3 ft
03-2673	AAC0474	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2674	AAC0475	Mercury	SS		10	mg/kg	24	0.1	0.0–0.3 ft
03-2674	AAC0475	Mercury	SS		10	mg/kg	24	0.1	0.0–0.3 ft
03-2674	AAC0475	Mercury	SS		10	mg/kg	24	0.1	0.0–0.3 ft
03-2674	AAC0475	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2675	AAC0476	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2675	AAC0476	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2675	AAC0476	Mercury	SS		0.1	mg/kg	24	0.1	0.0–0.3 ft
03-2675	AAC0476	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2676	AAC0477	Mercury	SS		0.07	mg/kg	24	0.1	0.0–0.3 ft
03-2676	AAC0477	Mercury	SS		0.07	mg/kg	24	0.1	0.0–0.3 ft
03-2676	AAC0477	Mercury	SS		0.07	mg/kg	24	0.1	0.0–0.3 ft
03-2676	AAC0477	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2677	AAC0478	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2677	AAC0478	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2677	AAC0478	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2677	AAC0478	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-2678	AAC0479	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2678	AAC0479	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2678	AAC0479	Mercury	SS		0.2	mg/kg	24	0.1	0.0–0.3 ft
03-2678	AAC0479	Radvan Tritium Screening	SS		0	PCI/g	810	n/a	0.0–0.3 ft
03-SM30	AAB7712	Arsenic	SS	<	1.8	mg/kg	n/a	11.6	N/A
03-SM30	AAB7713	Arsenic	SS	<	1.8	mg/kg	n/a	11.6	N/A
03-SM30	AAB7712	Cadmium	SS	<	0.82	mg/kg	80	2.7	N/A
03-SM30	AAB7713	Cadmium	SS	<	0.83	mg/kg	80	2.7	N/A
03-SM30	AAB7712	Chromium	SS	<	0.76	mg/kg	n/a	34.2	N/A
03-SM30	AAB7713	Chromium	SS	<	0.76	mg/kg	n/a	34.2	N/A
03-SM30	AAB7712	Copper	SS	<	1.9	mg/kg	3000	15.7	N/A
03-SM30	AAB7713	Copper	SS	<	1.9	mg/kg	3000	15.7	N/A
03-SM30	AAB7712	Lead	SS		3.4	mg/kg	400	39	N/A
03-SM30	AAB7713	Lead	SS		3.3	mg/kg	400	39	N/A
03-SM30	AAB7712	Lead-214	SS		1.058	PCI/g	n/a	n/a	N/A
03-SM30	AAB7713	Lead-214	SS		1.552	PCI/g	n/a	n/a	N/A
03-SM30	AAB7712	Mercury	SS	<	0.06	mg/kg	24	0.1	N/A
03-SM30	AAB7713	Mercury	SS	<	0.06	mg/kg	24	0.1	N/A

TABLE A-2 (CONTINUED)

ALL DETECTED ANALYTES BY SAMPLE ID

LOCATION ID	SAMPLE ID	ANALYTE	MATRIX	SYM	RESULTS	UNITS	SAL	UTL	DEPTH
03-SM30	AAB7713	Radium-226	SS		1.356	PCi/g	5	n/a	N/A
03-SM30	AAB7712	Radium Tritium Screening	SS		0	PCi/l	n/a	n/a	N/A
03-SM30	AAB7713	Radium Tritium Screening	SS		0	PCi/l	n/a	n/a	N/A
03-SM30	AAB7712	Tritium	SS		0.0028	PCi/l	510	n/a	N/A
03-SM30	AAB7713	Tritium	SS		0.0059	PCi/l	510	n/a	N/A
03-SM30	AAB7712	Zinc	SS		33.9	mg/kg	24000	101	N/A
03-SM30	AAB7713	Zinc	SS		30.9	mg/kg	24000	101	N/A

N/A Depths are not currently available.
n/a Not available.

TABLE A-3

SUMMARY OF STORM WATER RUNOFF SAMPLES

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NONDETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		SAL [a]
			MIN	MAX		MIN	MAX	
Antimony	4	4	2	2	0	N/A [b]	N/A	6
Arsenic	4	0	N/A	N/A	4	5.9	7.18	50
Barium	4	0	N/A	N/A	4	11	25	2 000
Beryllium	4	4	1	1	0	N/A	N/A	4
Cadmium	4	4	3	3	0	N/A	N/A	5
Cesium-137 [c]	8	0	N/A	N/A	8	-34.6	89	110
Chromium	4	4	4	4	0	N/A	N/A	100
Lead	4	0	N/A	N/A	4	5	32	50
Manganese	4	0	N/A	N/A	4	18	30	160
Mercury	16	16	0.2	0.2	0	N/A	N/A	2
Nickel	4	3	10	10	1	20	20	100
TPH	12	10	100	2000	2	2450	6410	n/a [d]
Plutonium-238 [c]	8	0	N/A	N/A	8	-0.015	0.005	15
Plutonium-239 [c]	8	0	N/A	N/A	8	-0.006	0.128	15
Selenium	4	4	2	2	0	N/A	N/A	50
Silver	4	4	10	10	0	N/A	N/A	170
Thallium	4	4	5	5	0	N/A	N/A	2
Tritium [c]	8	0	N/A	N/A	8	-200	300	20 000
Vanadium	4	4	4	4	0	N/A	N/A	240
Zinc	4	0	N/A	N/A	4	34	90	10 000

[a] SAL = Screening action level.
[b] N/A Not applicable.
[c] Results are in pCi/L. All other results are in ug/L.
[d] n/a Not available.

TABLE A-4

ANALYTES DETECTED IN STORM WATER RUNOFF

LOCATION ID	SAMPLE ID	ANALYTE	RESULTS	UNITS	SAL [a]
03-1051	AAA2693	Arsenic	7.18	ug/L	50
03-1052	AAA2694	Arsenic	6.13	ug/L	50
03-1053	AAA2695	Arsenic	5.8	ug/L	50
03-1054	AAA2696	Arsenic	6.71	ug/L	50
03-1051	AAA2693	Barium	11	ug/L	2 000
03-1052	AAA2694	Barium	20	ug/L	2 000
03-1053	AAA2695	Barium	25	ug/L	2 000
03-1054	AAA2696	Barium	21	ug/L	2 000
03-1051	AAA2689	Cesium-137	20.9	pCi/L	110
03-1051	AAA2697	Cesium-137	34.9	pCi/L	110
03-1052	AAA2690	Cesium-137	9.3	pCi/L	110
03-1052	AAA2698	Cesium-137	41.4	pCi/L	110
03-1053	AAA2691	Cesium-137	13.7	pCi/L	110
03-1053	AAA2699	Cesium-137	50.6	pCi/L	110
03-1054	AAA2692	Cesium-137	-34.6	pCi/L	110
03-1054	AAA2700	Cesium-137	89	pCi/L	110
03-1051	AAA2693	Lead	32	ug/L	50
03-1052	AAA2694	Lead	13	ug/L	50
03-1053	AAA2695	Lead	8	ug/L	50
03-1054	AAA2696	Lead	8	ug/L	50
03-1051	AAA2693	Manganese	16	ug/L	180
03-1052	AAA2694	Manganese	30	ug/L	180
03-1053	AAA2695	Manganese	23	ug/L	180
03-1054	AAA2696	Manganese	23	ug/L	180
03-1051	AAA2693	Nickel	< 10	ug/L	100
03-1052	AAA2694	Nickel	20	ug/L	100
03-1053	AAA2695	Nickel	< 10	ug/L	100
03-1054	AAA2696	Nickel	< 10	ug/L	100
03-1051	AAA2689	TPH	8410	ug/L	n/a [b]
03-1051	AAA2693	TPH	< 2 000	ug/L	n/a
03-1051	AAA2697	TPH	< 100	ug/sample	n/a
03-1052	AAA2690	TPH	< 2 000	ug/L	n/a
03-1052	AAA2694	TPH	< 2 000	ug/L	n/a
03-1052	AAA2698	TPH	< 100	ug/sample	n/a
03-1053	AAA2691	TPH	< 2 000	ug/L	n/a
03-1053	AAA2695	TPH	< 2 000	ug/L	n/a
03-1053	AAA2699	TPH	< 100	ug/sample	n/a
03-1054	AAA2692	TPH	2 450	ug/L	n/a
03-1054	AAA2696	TPH	< 2 000	ug/L	n/a
03-1054	AAA2700	TPH	< 100	ug/sample	n/a
03-1051	AAA2689	Plutonium-238	0.005	pCi/L	15
03-1051	AAA2697	Plutonium-238	-0.005	pCi/L	15
03-1052	AAA2690	Plutonium-238	0.005	pCi/L	15
03-1052	AAA2698	Plutonium-238	-0.015	pCi/L	15
03-1053	AAA2691	Plutonium-238	-0.005	pCi/L	15
03-1053	AAA2699	Plutonium-238	-0.012	pCi/L	15
03-1054	AAA2692	Plutonium-238	0.005	pCi/L	15
03-1054	AAA2700	Plutonium-238	0	pCi/L	15

TABLE A-4 (CONTINUED)

ANALYTES DETECTED IN STORM WATER RUNOFF

03-1051	AAA2689	Plutonium-239	0.072	pCi/L	15
03-1051	AAA2697	Plutonium-239	0.034	pCi/L	15
03-1052	AAA2690	Plutonium-239	0.128	pCi/L	15
03-1052	AAA2698	Plutonium-239	0	pCi/L	15
03-1053	AAA2691	Plutonium-239	0.093	pCi/L	15
03-1053	AAA2699	Plutonium-239	-0.006	pCi/L	15
03-1054	AAA2692	Plutonium-239	0.068	pCi/L	15
03-1054	AAA2700	Plutonium-239	0.031	pCi/L	15
03-1051	AAA2693	Tritium	100	pCi/L	20 000
03-1051	AAA2697	Tritium	200	pCi/L	20 000
03-1052	AAA2694	Tritium	200	pCi/L	20 000
03-1052	AAA2698	Tritium	-200	pCi/L	20 000
03-1053	AAA2695	Tritium	300	pCi/L	20 000
03-1053	AAA2699	Tritium	300	pCi/L	20 000
03-1054	AAA2696	Tritium	300	pCi/L	20 000
03-1054	AAA2700	Tritium	0	pCi/L	20 000
03-1051	AAA2693	Zinc	90	ug/L	10 000
03-1052	AAA2694	Zinc	82	ug/L	10 000
03-1053	AAA2695	Zinc	71	ug/L	10 000
03-1054	AAA2696	Zinc	34	ug/L	10 000

[a] SAL = Screening action level.
[b] n/a = Not available.

TABLE A-5

SUMMARY OF PHASE II SURFACE WATER DATA

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NONDETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		SAL[a]
			MIN	MAX		MIN	MAX	
Acetone	3	3	20	100	0	N/A[b]	N/A	3 500
Benzene	3	3	5	10	0	N/A	N/A	5
Bromobenzene	3	3	5	10	0	N/A	N/A	n/a[c]
Bromochloromethane	3	3	5	10	0	N/A	N/A	n/a
Bromodichloromethane	3	3	5	10	0	N/A	N/A	0.56
Bromoform	3	3	5	10	0	N/A	N/A	4.4
Bromomethane	3	3	10	20	0	N/A	N/A	49
Butanone [2-]	3	3	20	100	0	N/A	N/A	1 700
Butylbenzene [n-]	3	3	5	10	0	N/A	N/A	n/a
Butylbenzene [sec-]	3	3	5	10	0	N/A	N/A	n/a
Butylbenzene [tert-]	3	3	5	10	0	N/A	N/A	n/a
Carbon disulfide	3	3	5	10	0	N/A	N/A	3 500
Carbon tetrachloride	3	3	5	10	0	N/A	N/A	5
Chlorobenzene	3	3	5	10	0	N/A	N/A	100
Chlorodibromomethane	3	3	5	10	0	N/A	N/A	4.2
Chloroethane	3	3	10	20	0	N/A	N/A	14 000
Chloroform	3	3	5	10	0	N/A	N/A	100
Chloromethane	3	3	10	20	0	N/A	N/A	27
Chlorotoluene [o-]	3	3	5	10	0	N/A	N/A	700
Chlorotoluene [p-]	3	3	5	10	0	N/A	N/A	n/a
Dibromo-3-chloropropane [1,2-]	3	3	10	20	0	N/A	N/A	0.2
Dibromoethane [1,2-]	3	3	5	10	0	N/A	N/A	n/a
Dibromomethane	3	3	5	10	0	N/A	N/A	0.0004
Dichlorobenzene (1,2) [o-]	3	3	5	10	0	N/A	N/A	600
Dichlorobenzene (1,3) [m-]	3	3	5	10	0	N/A	N/A	600
Dichlorobenzene (1,4) [p-]	3	3	5	10	0	N/A	N/A	75
Dichlorodifluoromethane	3	3	10	20	0	N/A	N/A	7 000
Dichloroethane [1,1-]	3	3	5	10	0	N/A	N/A	3 500
Dichloroethane [1,2-]	3	3	5	10	0	N/A	N/A	5
Dichloroethene [1,1-]	3	3	5	10	0	N/A	N/A	7
Dichloroethene [trans-1,2-]	3	3	5	10	0	N/A	N/A	100
Dichloroethylene [cis-1,2-]	3	3	5	10	0	N/A	N/A	70
Dichloropropane [1,2-]	3	3	5	10	0	N/A	N/A	5
Dichloropropane [1,3-]	3	3	5	10	0	N/A	N/A	n/a
Dichloropropane [2,2-]	3	3	5	10	0	N/A	N/A	n/a
Dichloropropene [1,1-]	3	3	5	10	0	N/A	N/A	n/a
Dichloropropene [cis-1,3-]	3	3	5	10	0	N/A	N/A	0.19
Dichloropropene [trans-1,3-]	3	3	5	10	0	N/A	N/A	0.19
Ethylbenzene	3	3	5	10	0	N/A	N/A	700
Hexanone [2-]	3	3	20	100	0	N/A	N/A	n/a
Isopropylbenzene	3	3	5	10	0	N/A	N/A	1 400
Isopropyltoluene [4-]	3	3	5	10	0	N/A	N/A	n/a
Methyl iodide	3	3	5	10	0	N/A	N/A	n/a
Methyl-2-pentanone [4-]	3	3	20	100	0	N/A	N/A	1 700
Methylene chloride	3	3	5	20	0	N/A	N/A	5
Petroleum Hydrocarbons, Total Recoverable	2	1	1 000	1 000	1	5 000	5 000	n/a
Propylbenzene	3	3	5	10	0	N/A	N/A	n/a
Styrene	3	3	5	10	0	N/A	N/A	100
Tetrachloroethane [1,1,1,2-]	3	3	5	10	0	N/A	N/A	13
Tetrachloroethane [1,1,2,2-]	3	3	5	10	0	N/A	N/A	1.8
Tetrachloroethylene	3	3	5	10	0	N/A	N/A	5
Toluene	3	3	5	10	0	N/A	N/A	1 000
Trichloro-1,2,2-trifluoroethane [1,1,2-]	3	3	5	10	0	N/A	N/A	n/a
Trichloroethane [1,1,1-]	3	0	N/A	N/A	3	7.9	13	200
Trichloroethane [1,1,2-]	3	3	5	10	0	N/A	N/A	5
Trichloroethene	3	3	5	10	0	N/A	N/A	5
Trichlorofluoromethane	3	3	5	10	0	N/A	N/A	11 000
Trichloropropane [1,2,3-]	3	3	5	10	0	N/A	N/A	210
Trimethylbenzene [1,2,4-]	3	3	5	10	0	N/A	N/A	18
Trimethylbenzene [1,3,5-]	3	3	5	10	0	N/A	N/A	14
Tritium[d]	2	0	N/A	N/A	2	413	458	20 000
Vinyl chloride	3	3	10	20	0	N/A	N/A	2
Xylenes (o + m + p) [Mixed-]	3	3	5	10	0	N/A	N/A	10 000

[a] SAL = Screening action level
[b] N/A = Not applicable.
[c] n/a Not available.
[d] Results in PCi/L. All other results are in UG/L.

TABLE A-6

SUMMARY OF BOREHOLE WATER DATA

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NONDETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		SAL [a]
			MIN	MAX		MIN	MAX	
Acetone	3	3	100	100	0	N/A [b]	N/A	3 500
Benzene	3	3	10	10	0	N/A	N/A	5
Bromobenzene	3	3	10	10	0	N/A	N/A	n/a [c]
Bromochloromethane	3	3	10	10	0	N/A	N/A	n/a
Bromodichloromethane	3	3	10	10	0	N/A	N/A	0.56
Bromoform	3	3	10	10	0	N/A	N/A	4.4
Bromomethane	3	3	20	20	0	N/A	N/A	49
Butanone [2-]	3	3	100	100	0	N/A	N/A	1 700
Butylbenzene [n-]	3	3	10	10	0	N/A	N/A	n/a
Butylbenzene [sec-]	3	3	10	10	0	N/A	N/A	n/a
Butylbenzene [tert-]	3	3	10	10	0	N/A	N/A	n/a
Carbon disulfide	3	3	10	10	0	N/A	N/A	3 500
Carbon tetrachloride	3	3	10	10	0	N/A	N/A	5
Chlorobenzene	3	3	10	10	0	N/A	N/A	100
Chlorodibromomethane	3	3	10	10	0	N/A	N/A	4.2
Chloroethane	3	3	20	20	0	N/A	N/A	14 000
Chloroform	3	3	10	10	0	N/A	N/A	100
Chloromethane	3	3	20	20	0	N/A	N/A	27
Chlorotoluene [o-]	3	3	10	10	0	N/A	N/A	700
Chlorotoluene [p-]	3	3	10	10	0	N/A	N/A	n/a
Dibromo-3-chloropropane [1,2-]	3	3	20	20	0	N/A	N/A	0.2
Dibromoethane [1,2-]	3	3	10	10	0	N/A	N/A	n/a
Dibromomethane	3	3	10	10	0	N/A	N/A	0.0004
Dichlorobenzene (1,2) [o-]	3	3	10	10	0	N/A	N/A	600
Dichlorobenzene (1,3) [m-]	3	3	10	10	0	N/A	N/A	600
Dichlorobenzene (1,4) [p-]	3	3	10	10	0	N/A	N/A	75
Dichlorodifluoromethane	3	3	20	20	0	N/A	N/A	7 000
Dichloroethane [1,1-]	3	2	10	10	1	18	18	3 500
Dichloroethane [1,2-]	3	2	10	10	1	12	12	5
Dichloroethene [1,1-]	3	2	10	10	1	34	34	7
Dichloroethene [trans-1,2-]	3	3	10	10	0	N/A	N/A	100
Dichloroethylene [cis-1,2-]	3	3	10	10	0	N/A	N/A	70
Dichloropropane [1,2-]	3	3	10	10	0	N/A	N/A	5
Dichloropropane [1,3-]	3	3	10	10	0	N/A	N/A	n/a
Dichloropropane [2,2-]	3	3	10	10	0	N/A	N/A	n/a
Dichloropropene [1,1-]	3	3	10	10	0	N/A	N/A	n/a
Dichloropropene [cis-1,3-]	3	3	10	10	0	N/A	N/A	0.19
Dichloropropene [trans-1,3-]	3	3	10	10	0	N/A	N/A	0.19
Ethylbenzene	3	3	10	10	0	N/A	N/A	700
Hexanone [2-]	3	3	100	100	0	N/A	N/A	n/a
Isopropylbenzene	3	3	10	10	0	N/A	N/A	1 400
Isopropyltoluene [4-]	3	3	10	10	0	N/A	N/A	n/a
Methyl iodide	3	3	10	10	0	N/A	N/A	n/a
Methyl-2-pentanone [4-]	3	3	100	100	0	N/A	N/A	1 700
Methylene chloride	3	3	10	20	0	N/A	N/A	5
Petroleum Hydrocarbons, Total Recoverable	2	2	1 000	1 000	0	N/A	N/A	n/a
Propylbenzene	3	3	10	10	0	N/A	N/A	n/a
Styrene	3	3	10	10	0	N/A	N/A	100
Tetrachloroethane [1,1,1,2-]	3	3	10	10	0	N/A	N/A	13
Tetrachloroethane [1,1,2,2-]	3	3	10	10	0	N/A	N/A	1.8
Tetrachloroethylene	3	3	10	10	0	N/A	N/A	5
Toluene	3	3	10	10	0	N/A	N/A	1 000
Trichloro-1,2,2-trifluoroethane [1,1,2-]	3	0	N/A	N/A	3	26	230	n/a
Trichloroethane [1,1,1-]	3	0	N/A	N/A	3	130	180	200
Trichloroethane [1,1,2-]	3	3	10	10	0	N/A	N/A	5
Trichloroethene	3	3	10	10	0	N/A	N/A	5
Trichlorofluoromethane	3	3	10	10	0	N/A	N/A	11 000
Trichloropropane [1,2,3-]	3	3	10	10	0	N/A	N/A	210
Trimethylbenzene [1,2,4-]	3	3	10	10	0	N/A	N/A	18
Trimethylbenzene [1,3,5-]	3	3	10	10	0	N/A	N/A	14
Tritium [d]	2	0	N/A	N/A	2	540	2 710	20 000
Vinyl chloride	3	3	20	20	0	N/A	N/A	2
Xylenes (o + m + p) [Mixed-]	3	3	10	10	0	N/A	N/A	10 000

[a] SAL = Screening action level.
[b] N/A = Not applicable.
[c] n/a = Not available.
[d] Results are in pCi/L. All other results are in µg/L.

TABLE A-7

SUMMARY OF SOIL VAPOR DATA

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NON-DETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS	
			MIN	MAX		MIN	MAX
Acetone	64	64	20	30	0	N/A[b]	N/A
Benzene	64	61	5	5	3	10	30
Bromobenzene	64	64	5	5	0	N/A	N/A
Bromochloromethane	64	64	5	5	0	N/A	N/A
Bromodichloromethane	64	64	5	5	0	N/A	N/A
Bromoform	64	64	5	5	0	N/A	N/A
Bromomethane	64	64	10	10	0	N/A	N/A
Butanone [2-]	64	64	20	30	0	N/A	N/A
Butylbenzene [n-]	64	64	5	5	0	N/A	N/A
Butylbenzene [sec-]	64	64	5	5	0	N/A	N/A
Butylbenzene [tert-]	64	64	5	5	0	N/A	N/A
Carbon disulfide	64	64	5	5	0	N/A	N/A
Carbon tetrachloride	64	64	5	5	0	N/A	N/A
Chlorobenzene	64	64	5	5	0	N/A	N/A
Chlorodibromomethane	64	64	5	5	0	N/A	N/A
Chloroethane	64	64	10	10	0	N/A	N/A
Chloroform	64	63	5	5	1	18	18
Chloromethane	64	64	10	10	0	N/A	N/A
Chlorotoluene [o-]	64	64	5	5	0	N/A	N/A
Chlorotoluene [p-]	64	64	5	5	0	N/A	N/A
Dibromo-3-chloropropane [1,2-]	64	64	10	10	0	N/A	N/A
Dibromoethane [1,2-]	64	64	5	5	0	N/A	N/A
Dibromomethane	64	64	5	5	0	N/A	N/A
Dichlorobenzene (1,2) [o-]	64	64	5	5	0	N/A	N/A
Dichlorobenzene (1,3) [m-]	64	64	5	5	0	N/A	N/A
Dichlorobenzene (1,4) [p-]	64	64	5	5	0	N/A	N/A
Dichlorodifluoromethane	64	64	10	10	0	N/A	N/A
Dichloroethane [1,1-]	64	26	5	5	38	6	660
Dichloroethane [1,2-]	64	48	5	5	16	5.8	200
Dichloroethene [1,1-]	64	12	5	5	52	11	1 800
Dichloroethene [trans-1,2-]	64	64	5	5	0	N/A	N/A
Dichloroethylene [cis-1,2-]	64	64	5	5	0	N/A	N/A
Dichloropropane [1,2-]	64	64	5	5	0	N/A	N/A
Dichloropropane [1,3-]	64	64	5	5	0	N/A	N/A
Dichloropropane [2,2-]	64	64	5	5	0	N/A	N/A
Dichloropropene [1,1-]	64	64	5	5	0	N/A	N/A
Dichloropropene [cis-1,3-]	64	64	5	5	0	N/A	N/A
Dichloropropene [trans-1,3-]	64	64	5	5	0	N/A	N/A
Ethylbenzene	64	64	5	5	0	N/A	N/A
Hexanone [2-]	64	64	20	30	0	N/A	N/A
Isopropylbenzene	64	64	5	5	0	N/A	N/A
Isopropyltoluene [4-]	64	63	5	5	1	16	16
Methyl iodide	64	64	5	5	0	N/A	N/A
Methyl-2-pentanone [4-]	64	64	20	30	0	N/A	N/A
Methylene chloride	64	64	5	5	0	N/A	N/A
Propylbenzene	64	64	5	5	0	N/A	N/A
Styrene	64	64	5	5	0	N/A	N/A
Tetrachloroethane [1,1,1,2-]	64	64	5	5	0	N/A	N/A
Tetrachloroethane [1,1,2,2-]	64	64	5	5	0	N/A	N/A
Tetrachloroethylene	64	61	5	5	3	9	17
Toluene	64	64	5	5	0	N/A	N/A
Trichloro-1,2,2-trifluoroethane [1,1,2-]	64	16	5	5	48	6	450
Trichloroethane [1,1,1-]	64	2	5	5	62	11	3 600
Trichloroethane [1,1,2-]	64	64	5	5	0	N/A	N/A
Trichloroethene	64	34	5	5	30	7	280
Trichlorofluoromethane	64	64	5	5	0	N/A	N/A
Trichloropropane [1,2,3-]	64	64	5	5	0	N/A	N/A
Trimethylbenzene [1,2,4-]	64	64	5	5	0	N/A	N/A
Trimethylbenzene [1,3,5-]	64	64	5	5	0	N/A	N/A
Vinyl chloride	64	64	10	10	0	N/A	N/A
Xylenes (o + m + p) [Mixed-]	64	64	5	5	0	N/A	N/A

[a] All results are in µg/L.
[b] N/A Not applicable.

TABLE A-8

SUMMARY OF SOIL BOREHOLE DATA

ANALYTE	TOTAL NUMBER OF SAMPLES	NUMBER OF NONDETECTED SAMPLES	RANGE OF DETECTION LIMITS		NUMBER OF DETECTED SAMPLES	RANGE OF DETECTIONS		UTL [a]	SAL [b]
			MIN	MAX		MIN	MAX		
Acetone	62	62	0.1	0.35	0	N/A [c]	N/A	n/a [d]	8 000
Benzene	62	62	0.01	0.01	0	N/A	N/A	n/a	0.67
Bromobenzene	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Bromochloromethane	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Bromodichloromethane	62	62	0.01	0.01	0	N/A	N/A	n/a	11
Bromoform	62	62	0.01	0.01	0	N/A	N/A	n/a	89
Bromomethane	62	62	0.02	0.02	0	N/A	N/A	n/a	0.43
Butanone [2-]	62	62	0.1	0.1	0	N/A	N/A	n/a	4 000
Butylbenzene [n-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Butylbenzene [sec-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Butylbenzene [tert-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Carbon disulfide	62	62	0.01	0.01	0	N/A	N/A	n/a	7.4
Carbon tetrachloride	62	62	0.01	0.01	0	N/A	N/A	n/a	0.21
Chlorobenzene	62	62	0.01	0.01	0	N/A	N/A	n/a	67
Chlorodibromomethane	62	62	0.01	0.01	0	N/A	N/A	n/a	83
Chloroethane	62	62	0.02	0.02	0	N/A	N/A	n/a	2 900
Chloroform	62	62	0.01	0.01	0	N/A	N/A	n/a	0.21
Chloromethane	62	62	0.02	0.02	0	N/A	N/A	n/a	6.4
Chlorotoluene [o-]	62	62	0.01	0.01	0	N/A	N/A	n/a	1 600
Chlorotoluene [p-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Dibromo-3-chloropropane [1,2-]	62	62	0.02	0.02	0	N/A	N/A	n/a	0.5
Dibromoethane [1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Dibromomethane	62	62	0.01	0.01	0	N/A	N/A	n/a	0.0082
Dichlorobenzene (1,2) [o-]	62	62	0.01	0.01	0	N/A	N/A	n/a	1 600
Dichlorobenzene (1,3) [m-]	62	62	0.01	0.01	0	N/A	N/A	n/a	7 200
Dichlorobenzene (1,4) [p-]	62	62	0.01	0.01	0	N/A	N/A	n/a	29
Dichlorodifluoromethane	62	62	0.02	0.02	0	N/A	N/A	n/a	16 000
Dichloroethane [1,1-]	62	57	0.01	0.01	5	0.011	0.029	n/a	410
Dichloroethane [1,2-]	62	51	0.01	0.01	11	0.012	0.15	n/a	0.2
Dichloroethene [1,1-]	62	59	0.01	0.01	3	0.013	0.049	n/a	0.4
Dichloroethene [trans-1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	1 600
Dichloroethylene [cis-1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	800
Dichloropropane [1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	6.5
Dichloropropane [1,3-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Dichloropropane [2,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Dichloropropene [1,1-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Dichloropropene [cis-1,3-]	62	62	0.01	0.01	0	N/A	N/A	n/a	0.17
Dichloropropene [trans-1,3-]	62	62	0.01	0.01	0	N/A	N/A	n/a	0.17
Ethylbenzene	62	62	0.01	0.01	0	N/A	N/A	n/a	3100
Hexanone [2-]	62	62	0.1	0.1	0	N/A	N/A	n/a	n/a
Isopropylbenzene	62	62	0.01	0.01	0	N/A	N/A	n/a	3 200
Isopropyltoluene [4-]	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Methyl iodide	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Methyl-2-pentanone [4-]	62	62	0.1	0.1	0	N/A	N/A	n/a	510
Methylene chloride	62	62	0.01	0.01	0	N/A	N/A	n/a	5.6
Petroleum hydrocarbons, total recoverable	56	35	1	1	21	1	2200	n/a	100
Propylbenzene	62	62	0.01	0.01	0	N/A	N/A	n/a	n/a
Styrene	62	62	0.01	0.01	0	N/A	N/A	n/a	3 300
Tetrachloroethane [1,1,1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	270
Tetrachloroethane [1,1,2,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	3.9
Tetrachloroethylene	62	62	0.01	0.01	0	N/A	N/A	n/a	5.9
Toluene	62	62	0.01	0.01	0	N/A	N/A	n/a	910
Trichloro-1,2,2-trifluoroethane [1,1,2-]	62	60	0.01	0.01	2	0.013	0.049	n/a	n/a
Trichloroethane [1,1,1-]	62	25	0.01	0.01	37	0.011	1.8	n/a	1 000
Trichloroethane [1,1,2-]	62	62	0.01	0.01	0	N/A	N/A	n/a	6.3
Trichloroethene	62	60	0.01	0.01	2	0.018	0.052	n/a	3.2
Trichlorofluoromethane	62	62	0.01	0.01	0	N/A	N/A	n/a	24 000
Trichloropropane [1,2,3-]	62	62	0.01	0.01	0	N/A	N/A	n/a	480
Trimethylbenzene [1,2,4-]	62	62	0.01	0.01	0	N/A	N/A	n/a	40
Trimethylbenzene [1,3,5-]	62	62	0.01	0.01	0	N/A	N/A	n/a	32
Tritium [e]	20	0	N/A	N/A	20	0.128	10.989	n/a	810
Vinyl chloride	62	62	0.02	0.02	0	N/A	N/A	n/a	0.013
Xylenes (o + m + p) [mixed-]	62	62	0.01	0.01	0	N/A	N/A	n/a	160 000

[a] UTL = Upper tolerance limit.
[b] SAL = Screening action level.
[c] N/A Not applicable.
[d] n/a Not available.
[e] Results in pCi/g. All other results are in mg/kg.

APPENDIX B: BOREHOLE CORE LOGGING

LOS ALAMOS NATIONAL LABORATORY ENVIRONMENTAL RESTORATION PROGRAM

SAMPLE MANAGEMENT FACILITY | **CORE SAMPLE LOG**

Borehole ID B37, 02-2680 TA/OU 3/1114 Drill Depth From 0 To 15.00 Page 1 of 4

Driller Stewart Bros. Box #(s) 1-3 Start Date/Time 10/6/94, 1156 End Date/Time 10/6/94, 1045

Drilling Equip./Method CME-750 Hollow Stem Auger Sampling Equip./Method Stainless Steel Split Spoon / Barrel

Depth (feet)	Recovery (feet per feet / %)	Field Analytical Sample Number	Field Screening Results	Top/Bottom of Core in Box	Lithology-Petrology - Soil	Graphic Log	Lithologic Unit	Notes
0	1.3/2.5 Run #1		RO PY 0-10 ppm CNDA	Box 1 of 1 S.O. to 5.0 ft	Dark to medium brown, tan to cinnamon against sanding SILT, cobbles of tuff extremely moist ~ 20% organics core loss due to tree-roots		FILL	Entered zone 1135 Drilling 1156 1203
2.5	2.2/2.5 Run #2	AA5B0B1	CNDA 1200 PY 0-10 ppm		2.5 to 2.9 ft core loss due to wooden bit -- small piece of asphalt light to medium tan, [illegible] fluidized sand pumice fragments, pinkish gray [illegible] minor [illegible] pumice and moderately [illegible] moderately welded [illegible] material in the bottom of the barrel		Tshirege Member Bandelier Tuff	1239
5	2.5/2.5 Run #3		CNDA RO PY 0-10 ppm	Box 2 of 5 S.O. to 10.0 ft	rest at top of barrel 120 ppm core in fragments up - pumice chips light in barrel - dusting SAA			1269
7.5	2.5/2.5 Run #4	AA5B0B2	CNDA RO PY 0-10 ppm		SAA			1315 Break for lunch 1324
10	2.2/2.5 Run #5		CNDA RO PY 0-10 ppm	Box 3 of 5 10.0 to 12.5 ft	Dark brown fine-grained sandy SILT with tuff fragments as described above & possibly unconsolidated ash and tuff non-welded tuff w/ unconsolidated lithic fragments			Back in zone 1325 1525
12.5	1.4/2.5 Run #6	AA5B0B3	CNDA RO PY 0-10 ppm	Box 4 of 5 12.5 to 15.0 ft	SAA			1558

Prepared by D. Ross Date 17 Oct. 94 Checked By S. Callahan Date 10/20/94

LOS ALAMOS NATIONAL LABORATORY ENVIRONMENTAL RESTORATION PROGRAM

SAMPLE MANAGEMENT FACILITY | **CORE SAMPLE LOG**

Borehole ID 53-03-2680 TA/OU 3/1114 Drill Depth From 15.0 To 45.0 Page 2 of 4

Driller Stewart Bro. Box #(s) 3-9 Start Date/Time 10/6/94 1150 End Date/Time 10/6/94 1045

Drilling Equip./Method CME-750 Hollow Stem Auger Sampling Equip./Method Stainless Steel Split Spoon/Barrel

Depth (feet)	Recovery (feet per feet / %)	Field Analytical Sample Number	Field Screening Results	Top/Bottom of Core in Box	Lithology-Petrology - Soil	Graphic Log	Lithologic Unit	Notes
15	2.1/2.5 Run #2		OVA 180 ppm 0.0 ppm	Box 3 of 9	SAA - discing		Tshirege Member Bandelier Tuff	Change in scale
17.5	2.3/2.5 Run #3	AN8077	OVA 210 ppm 0.0 ppm	Box 4 of 9	SAA - discing			1603
20	2.5/2.5 Run #4		OVA 200 ppm	Box 5 of 9	Pinkish brown, rhyolitic lapilli tuff - pheno-cryst-rich - quartz, feldspar, pumice - phase - crystal rich pumice - discing			1620 - end of day; RUM not working; esc 10/13/94
22.5	2.2/2.5 Run #10	AN8078	OVA 200 ppm 0.0 ppm	Box 5 of 9	SAA - possible fracturing at 25.5 ft			Dropped core down hole - trip out 1903
25	2.2/2.5 Run #11		OVA 200 ppm 0.0 ppm	Box 6 of 9	SAA - discing			1911
27.5	2.5/2.5 Run #12	AN8079	OVA 210 ppm 0.0 ppm	Box 6 of 9	SAA			1924
30	2.5/2.5 Run #13		OVA 240 ppm 0.0 ppm	Box 7 of 9	SAA - softer - less consolidated than pheno-cryst			1932
32.5	1.6/2.5 Run #14	AN8080	OVA 190 ppm 0.0 ppm	Box 7 of 9	SAA - unconsolidated			1939
35	2.5/2.5 Run #15		OVA 220 ppm 0.0 ppm	Box 8 of 9	SAA - slightly more consolidated but still powdery in texture			1943 - Quartz latite clasts - some
37.5	1.8/2.5 Run #16	AN8081	OVA 190 ppm 0.0 ppm	Box 8 of 9	SAA - unconsolidated - ash same possible sample - bad material, but unconsolidated			1948
40	2.0/2.5 Run #17		OVA 200 ppm 0.0 ppm	Box 9 of 9	SAA - intermixed ash, light gray with brown silts homogeneous - nonpumiceous			1957
42.5	1.8/2.5 Run #18	AN8083	OVA 220 ppm 0.0 ppm	Box 9 of 9	SAA			1110
45								

Prepared by D. Foss Date 12 and 13 of 94 Checked By S. Calhoun Date 10/20/94

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 9/20/94 Time: 1120 hrs	Phase II work for SWMU 3-010(a) Mercury Site – Borehole drilling and subsurface sampling to define suspected VOC plume
Borehole #: B10326664	
SSO: J. Bucha Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: Photovac HL-2000	SS #: PA910647
Instrument: Eberline FSP-1, Ludlum Model 139	SS #: 008021, 007614
Distribution: Project File	

Depth*	Upper Core Level	in ppm
0 >		0.0
1124 9/20/94	α NDA 190 βγ 0.3 ppm B/G	
		0.5
		VOC-TPH
		0.6
		tritium
Run #1		0.4
	FILL - mixture [illegible]	0.4
2.5 >		0.6
1136	α NDA 240 βγ .5 ppm B/G	0.5
		0.5
		tritium
		1.3
		VOC-TPH
Run #2		0.7
		1.1
5 >	Air Sample taken	0.5 AAC0457
1401	α NDA 200 βγ .8 B/G	1.9
		VOC-TPH
		1.7
		tritium
Run #3		1.5
		1.6
		1.2
7.5 >		1.2
1411	α NDA 200 βγ 1.2 ppm B/G	1.8
		1.9
		1.6
Run #4		2.0
		VOC-TPH
		2.0
		tritium
10 >	Air Sample Taken	2.0 AAC0458

Depth*	Lower Core Level	in ppm
10 >		2.1
1425	α NDA 220 βγ 2.3 B/G	
		3.0
		2.8
Run #5		3.8
	Soil - tuff interface w/ 11.5 ft	3.9 AAC0458
		VOC/TPH
	11.5 to 12.0 VOC-TPH	2.7 AAC0467
12.5 >		3.2
1540	α NDA 200 βγ 2.9 ppm B/G	3.5
		2.9
		tritium
Run #6		3.6
		VOC-TPH
		3.3
	14.5-15.0 VOC-TPH	
15 >	Air Sample taken	3.1 AAC0459
0820 9/21/94	α NDA 240 βγ 1.6 ppm B/G	1.1
		1.8
		VOC-TPH
		2.0
		tritium
Run #7		1.7
		1.8
		1.7
17.5 >		2.8
0848	α NDA 173 βγ 1.6 B/G	tritium
		2.8
		VOC-TPH
Run #8		2.4
	18.5 to 19.0 VOC-TPH	
19.0	Air Sample taken	2.3 AAC0460
	core loss center bit used	
19.5		
1153	α NDA 230 βγ 0.8 ppm B/G	0.9 Run #9
20 >		1.2

* = Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 9/21/94 Time: _____ hrs	
Borehole #: B10326664	
SSO: J. Bucha Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: _____	SS #: _____
Instrument: _____	SS #: _____

Distribution: Project File

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level
20 >	α NDA 220 βγ 0.8 ppm B/G	1.2	30 >	
1153 Run #9		1.5		
21.0	core loss - contractor bit used	1.5		
21.5 1505	α NDA 170 βγ 0.0 ppm B/G	0.0		
Run #10		0.0		
22.5 >	core loss .. contractor bit used	0.0	32.5 >	
23.0 1507	α NDA 140 βγ 23.0 ppm AAC0 0.0 ppm B/G	5.3 VOC, TPH high 0.2 moisture		
23.5 1535	α NDA 180 βγ 0.0 ppm B/G	0.0		
24.0	α NDA 250 βγ 1.8 ppm B/G	0.0 AAC0451 ▼ Composited tritium	34.5 >	
		2.1 VOC, TPH		
25 >		2.2 tritium 2.1	35 >	
26.0	AAC0469 - H2O core loss	2.1 sampled for VOC		
27.0 1025	α NDA 230 βγ 0.0 ppm B/G			
27.5 >		1.7 VOC-TPH AAC0368	37.5 >	
		2.1 tritium 1.0 tritium 2.0		
	AAC0468 29.0-29.5	VOC-TPH 1.4		
29.5	TD-29.5 ft			
30 >			40 >	

* = Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 9/26/94 Time: 1310 hrs	Phase II work for SWMU 3-010(a) Mercury Site - Borehole drilling and subsurface sampling to suspected VOC plume
Borehole #: B2.03-2665	
SSO: J. Burba Printed Name: D. Foes	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: Photovac HL-2000 SS #: PA91062	
Instrument: Eberline FSP-1, Ludlum Model 19 SS #: 008021, 007614	
Distribution: Project File	

Depth*	Upper Core Level	in ppm
0 >		
Run #1	no recovery, reverse bit used	
2.5 >		
5 >		
5.5 ft 1331	Air sample taken AAC0480; αNDA 200 βγ 1.4 ppm B/G; in tuff	14
Run #2		237
7.5 >		230
8.0 ft 1351	αNDA 200 βγ 1.4 ppm B/G	VOC-TPH 1387
Run #3		tritium 311
10 >		48 114 148 VOC-TPH 134 tritium 79 65

Depth*	Lower Core Level	in ppm
10 >	slightly moist	25 VOC-TPH
10.5 ft 1435	air sample taken; αNDA 200 βγ 1.4 ppm B/G	25 AAC0481 28
Run #4		17 65
12.5 >		95 32
13.0 ft 1440	αNDA 190 βγ 1.4 ppm B/G	8 7.1 31 VOC-TPH
Run #5		59 tritium AAC0490 48
15 >		14 VOC-TPH
15.5 ft 0740	air sample taken; αNDA 215 βγ 1.5 ppm B/G	28 AAC0482 12.5
Run #6		33.5 VOC-TPH 109 Tcit 15.6
17.5 >		10.2
18.0 0900	αNDA 200 βγ 1.5 ppm B/G	4.5 21 12.5
Run #7		25.0 24.1 tritium 31.2
20 >		

*Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	OTHER DESCRIPTION
D: 9/27/94 Time: _____ hrs	
Borehole #: B2 03-2665	
SSO: J. Burka Printed Name: D Foss.	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: _____ SS #: _____	
Instrument: _____ SS #: _____	

Distribution: Project File

Depth*	Upper Core Level		Depth*	Lower Core Level	
20 >		21.2	30 >		3.1
20.5	air sample taken	VOC - TPH 2.8 AAC0453	30.5	air sample taken	VOC - TPH 3.1 AAC0455
0826	α NDA 220 βγ 1.5 ppm B/G	1.5	1046	α NDA 210 βγ 1.5 ppm B/G	1.5
		1.5			3.1
		9.3			1.5
Run #8		VOC - TPH	Run #12		
		9.3			1.5
		tritium			
22.5 >		6.2	32.5 >		1.5
23.0		1.5	33.0		1.5
0940	α NDA 190 βγ 1.5 ppm B/G	1.5	1055	α NDA 190 βγ 1.5 ppm B/G	6.2
		4.6			3.1
		VOC - TPH			
		9.3			3.1
Run #9		tritium AAC0481	Run #13		VOC - TPH
		6.2			6.2
					tritium
25 >		1.5	35 >		3.1
		VOC - TPH			VOC - TPH
25.5	air sample taken	1.5 AAC0484	35.5	air sample taken	1.5 AAC0486
0908	α NDA 200 βγ 1.5 ppm B/G	1.5	1350	α NDA 215 βγ 1.5 ppm βγ	1.5
		1.5			1.5
		6.2			1.5
Run #10		VOC - TPH	Run #14		
		9.3			1.5
		tritium			
27.5 >		4.6	37.5 >		1.5
28.0		1.5	38.0		1.5
0915	α NDA 190 βγ 1.5 ppm B/G		1407	α NDA 190 βγ 1.5 ppm B/G	1.5
		empty sleeve			4.6
		1.5			1.5
Run #11		VOC - TPH	Run #15		
		6.2			1.5
		tritium			
30 >		3.1	40 >		1.5

* = Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	OBS DESCRIPTION
Date: 9/27/94 Time: _____ hrs	
Borehole #: B2.03-2665	
SSO J. Bucha Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: _____ SS #: _____	
Instrument: _____ SS #: _____	
Distribution: Project File	

Depth*	Upper Core Level		Depth*	Lower Core Level	
40 >		1.5 VOC-TPH	5/30 >		1.7 VOC-TPH
40.5	air sample taken	1.5 AAC.0487	510	air sample taken TD 51.0 ft	1.7 AAC.0489 sample not submitted
		no recovery			
2.5 >			5/32.5 >		
41.0 0925 1/28/94	α NDA 200 pCi 1.7 ppm B/G	1.7 sedimentary layer			
25 >	air sample taken	1.7 VOC-TPH 1.7 AAC.0488	5/35 >		
037 Pur #17		no recovery			
46.0 1101	α NDA 200 pCi 1.7 ppm B/G	1.7			
Pur #18		1.7			
7.5 >		1.7	5/37.5 >		
		1.7			
8.5 1116	α NDA 230 pCi 1.7 B/G	1.7			
		1.7			
Pur #19		1.7 VOC-TPH			
TD 50 >		1.7 tritium AAC.0492 1.7	60/50 >		

Depth measured in feet

Core Instrument Survey Log

Date: 9/28/94 Time: 1454 hrs	Phase II work for SWMU 3-010(a) Mercury Site - Borehole drilling and subsurface sampling to suspected VOC plume
Borehole #: B3-03-2666	
SSO: J. Bucha Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: Ortec HL-2000 SS #: PA910062	
Instrument: Eberline ESP-1, Ludlum Model 139 SS #: 008021, 007614	
Distribution: Project File	

Depth*	Upper Core Level		Depth*	Lower Core Level	in ppm
0 > 1454	αNDA 170 βγ 1.7 ppm B/G	1.7	10 > 0906 9/29/94	αNDA 170 βγ 1.3 ppm B/G	1.3
		1.7			1.3
		1.7			1.3
Run #1	light brown fine-grained sandy SILT 30% organics low moisture	1.7	Run #5		2.7
		1.7			5.3 tritium
		1.7			1.3
2.5 > 1514	αNDA 200 βγ 1.7 ppm B/G	1.7	12.5 > 0924	αNDA 180 βγ 1.3 ppm B/G	1.3
		3.4 tritium			1.3
		1.7			0.3
#2	soil-tuff transition zone	1.7	Run #6		0.3
		1.7			0.3
		1.7 VOC-TPH			0.3 VOC - TPH
5 > 1548	air sample taken αNDA 190 βγ 1.7 ppm B/G	1.7 AAC0493	15 > 1044	air sample taken αNDA 200 βγ 1.6 ppm B/G	0.3 AAC0495
		1.7			1.6
		1.7			1.6
Run #3	Bandelier Tuff	1.7	Run #7		1.6
		1.7			1.6
		1.7 VOC-TPH			1.6
7.5 >	air sample taken	1.7 AAC0494	17.5 >		1.6
1602	αNDA 200 βγ 1.7 ppm B/G	1.7	1056	αNDA 180 βγ 1.6 ppm B/G	1.6
		1.7			1.6
Run #4		1.7	Run #8		1.6
		1.7			1.6
		1.7 VOC-TPH			1.6 VOC-TPH
10 >	air sample taken	1.7 AAC0494	20 >	air sample taken	1.6 AAC0496

* = Depth measured in feet

Core Instrument Survey Log

AUTHORIZED BY (OPERATOR)	JOB DESCRIPTION
Date: 9/29/94 Time: 1454 hrs	
Borehole #: B3, 03-2666	
SSO: J. Burlu. Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: SS #:	
Instrument: SS #:	

Distribution: Project File

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level	
0 >		1.6	30 >		2.2
130	αNDA 170 βγ 1.6 ppm B/G	1.6	0821	αNDA 200 βγ 2.0-2.2 ppm B/G	2.2
		1.6			2.2
Run #9		1.6	Run #13		2.2
		1.6			2.2
5 >		1.6	32.5 >		2.2
144	αNDA 170 βγ 1.6 ppm B/G	1.6	0824	αNDA 180 βγ 2.0-2.2 B/G	2.2
		1.6			2.2
Run #10		1.6	Run #14		2.2
		1.6 tritium			2.2 tritium
		1.6 VOC-TPH			2.2 VOC-TPH AAC0600
3 >	air sample taken	1.6 AAC0497	35 >	air sample taken	2.2
422	αNDA 180 βγ 1.6 ppm B/G	QA - AAC0498	0843	αNDA 160 βγ 2.0 to 2.2 ppm B/G	2.2
		1.6			2.2
Run #11		1.6	Run #15		2.2
		1.6			2.2
5 >		1.6	37.5 >		2.2
236	αNDA 170 βγ 1.6 ppm B/G	1.6	0851	αNDA 170 βγ 2.0-2.2 ppm B/G	2.2
		1.6			2.2
		1.6			2.2
Run #12		1.6 tritium AAC0500	Run #16		2.2 tritium AAC
		1.6			2.2
		1.6 VOC-TPH			2.2 VOC-TPH
10 >		1.6 AAC0499	40 >	air sample taken	2.2 AAC0501

Depth measure in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	SOIL DESCRIPTION
Date: 9/29/94 Time: _____ hrs	
Borehole #: B3, 03-26666	
SSO J. Buche Printed Name: D. Foss.	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: _____ SS #: _____	
Instrument: _____ SS #: _____	

Distribution: Project File

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level	in ppm
20 >		2.2	30 >		2.2
0911	α NDA 200 βγ 2.2 ppm B/G	2.2	1125	α NDA 210 βγ 2.2 ppm B/G	2.2
		2.2			2.2
Run #17		2.2	Run #21		2.2
		2.2			2.2
22.5 >		2.2	32.5 >		2.2
0917	α NDA 170 βγ 2.2 ppm B/G	2.2	1140	α NDA 200 βγ 2.2 ppm βγ	2.2
		2.2			2.2
Run #18		2.2	Run #22		2.2
		tritium			tritium
		2.2			2.2
		VOC - TPH			VOC - TPH
25 >	air sample taken	2.2 AAC0502	35 >	air sample taken	2.2 AAC0504
1040	α NDA 180 βγ 2.2 ppm B/G	2.2	1318	α NDA 190 βγ 2.2 ppm B/G	2.2
		2.2			2.2
Run #19		2.2	Run #23		2.2
		2.2			2.2
27.5 >		2.2	37.5 >		2.2
1047	α NDA 220 βγ 2.2 ppm B/G	2.2	1356	α NDA 200 βγ 2.2 ppm B/G	2.2
		2.2			2.2
Run #20		2.2	Run #24		2.2
		tritium			tritium AAC0508
		2.2			2.2
		VOC - TPH			VOC - TPH
30 >	air sample taken	2.2 AAC0503	40 >	air sample taken	2.2 AAC0505

TD 60.0 ft

*Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/3/94 Time: 0945 hrs	Phase II work for SWMU 3-006 Mercury Site - Borehole drilling and subsurface sampling for suspect VOC plume
Borehole #: B4 03-26667	
SSOE: Humbert Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: Photo Vac HL-2000 SS #: PA9162	
Instrument: Fiberline ESP-1, Ludlum Model 19 SS #: 008021, 0876614	
Distribution: Project File	

Depth*	Upper Core Level	ppm	Depth*	Lower Core Level	ppm
0 >			10 >		
			11.04		
			Run #3		no recovery
Run #1		*no recovery			
2.5 >			12.5 >		
				α NDA 180 pX 0.0 ppm B/G	0.0
					0.0
4.0		0.0	Recovery	Soil-tuff transition	0.0
		tritium AAC0857			tritium AAC0858
	α NDA 180 pX 0.0 ppm	0.0			0.0
		VOC-TPH AAC0509			VOC-TPH AAC0511
5 >		0.0 air sample taken	15 >	air sample taken	0.0
5.27					no recovery
Run #2		no recovery	Run #4	α NDA 180 pX 0.0 ppm B/G weathered tuff	0.0
					0.0
					0.0
7.5 >			17.5 >		0.0
	α NDA 200 pX 0.0 ppm B/G	0.0	11.51	α NDA 200 pX 0.0 ppm B/G	0.0
		0.0			0.0
	dark brown fine-medium sandy SILT w/ organics very moist	0.0	Run #5		0.0
		tritium			tritium
		0.0			0.0
		VOC-TPH			VOC-TPH AAC0512
10 >	air sample taken	0.0 AAC0510	20 >	air sample taken	0.0

*Depth measured in feet

*Did 5 ft. runs for first 15.0 feet - then went

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/3 /94 Time: 0945 hrs	Phase II work for SWMU 3-010(a) Mercury Site - Borehole drilling and subsurface sampling for suspect VOC plume
Borehole #: B4,03-2667	
SSO E. Humbert Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument:	SS #:
Instrument:	SS #:

Distribution: Project File

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level
20 >			30 >	
K430		no recovery		
Run #6	α NDA 180 pCi 0.0 ppm clay 21.0 to 21.5	7.6 AAC0849 VOC 0.0 AAC0852 0.0 tritium		
22.5 >		0.0	32.5 >	
K449				
	<NDA 215 pCi 0.0 ppm very wet	0.0 0.0 tritium 0.0 VOC TPH AAC0850		
25 >	air sample taken	0.0	35 >	
	abandon hole due to water approximately 11 feet water standing in hole AAC0856 taken for VOC TPH and tritium of water in hole			
27.5 >			37.5 >	
30 >			40 >	

* Depth measured in feet

Recovery was assumed to be at the top of the core [illegible] elevation

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/4/94 Time: 1322 hrs	Phase II work for SWMU 3-010a) Mercury Site - Borehole drilling and Subsurface sampling for suspected VOC plume
Borehole #: BS-03, 2668	
SSO L. McDaugh Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: Photovac HL-2000 SS #: DA910162	
Instrument: Eberline ESP-1, Ludlum Model 139 SS #: 008021, 0071614	
Distribution: Project File	

Depth*	Upper Core Level	in ppm
0 > 1324		no recovery
Run #1	α NDA 170 βγ 0-5 ppm B/G soil - tuff transition	
2.5 > 1339		no recovery
Run #2	α NDA 180 βγ 0-5 ppm B/G	tritium; VOC - TPH AAC0851
5 > 1404		no recovery
Run #3	α NDA 230 βγ 0-5 ppm B/G	
7.5 > 1430		no recovery
Run #4	α NDA 190 βγ 0-5 ppm B/G	tritium; VOC - TPH AAC0853
10 >	air sample AAC0854	

Depth*	Lower Core Level	in ppm
10 > 0815 10/5/94		no recovery
Run #5	α NDA 170 βγ 0-3.8 ppm B/G	
12.5 > 0826	α NDA 180 βγ 0-3.8 ppm B/G	
Run #6		tritium; VOC - TPH AAC0855
15 > 0902	air sample taken	no recovery
Run #7	α NDA 180 βγ 0-7.6 ppm B/G	
17.5 > 0911	α NDA 210 βγ 3.8-7.6 ppm B/G	3.8; 3.8-7.6
Run #8		7.6-15.3 tritium AAC0869; 7.6-15.3 VOC - TPH AAC0859
20 >	air sample taken	3.8-7.6

Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/4 /94 Time: 1322 hrs	
Borehole #: BS-02, 2668	
SSO L. McDargh Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: SS #:	
Instrument: SS #:	
Distribution: Project File	

Depth*	Upper Core Level		Depth*	Lower Core Level	
20 > 0937		no recovery	30 > 1057		no recovery
Run #9	αNDA 40 βγ 3.8-7.6 ppm B/G	3.8-7.6 3.8-7.6 3.8 3.8	Run #13	αNDA 200 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 0-3.8
22.5 > 0945	αNDA	no recovery	32.5 > 1110		no recovery
Run #10	αNDA 200 βγ 0-3.8 ppm B/G	3.8 3.8 tritium 0-3.8 VOC-TPH AAC0860	Run #14	αNDA 220 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 0-3.8 tritium 0-3.8 VOC-TPH AAC0862
25 > 1031	in sample taken	0-3.8 no recovery	35 > 1136	in sample taken	0-3.8
Run #11	αNDA 40 βγ 0-3.8 ppm βγ	0-3.8 0-3.8 0-3.8 0-3.8	Run #15	αNDA 200 βγ 0-3.8 βγ	no recovery 0-3.8
27.5 > 1035		0-3.8	37.5 > 1144		0-3.8 no recovery
Run #12	αNDA 200 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 tritium AAC0870 0-3.8 VOC-TPH AAC0861	Run #16	αNDA 210 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 tritium 0-3.8 VOC-TPH AAC0863
30 >	in sample taken	0-3.8	40 >	in sample taken	0-3.8

* Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/4 /94 Time: _____ hrs	
Borehole #: B5, 03-2668	
SSO L. McDonald Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument: _____	SS #: _____
Instrument: _____	SS #: _____
Distribution: Project File	

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level	in ppm
40 > 1345		no recovery	50 > 0824 10/6/94		no recovery
Run #17	αNDA 200βγ 0-3.8 ppm	0-3.8 0-3.8 0-3.8 0-3.8 0-3.8	Run #21	αNDA 150βγ 0-5.5 ppm B/G	0-5.5 0-5.5 0-5.5 0-5.5
42.5 > 1353		no recovery	52.5 > 0834		no recovery
Run #18	αNDA 210 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 0-3.8 tritium 0-3.8 VOC-TPH AAC0816	Run #22	αNDA 200βγ 0 5.5 ppm B/G	0-5.5 tritium A 0-5.5 VOC-TPH AAC0860
45 > 1415	air sample taken	0-3.8 no recovery	55 > 0856	air sample taken	0-5.5 no recovery
Run #19	αNDA 200 βγ 0-3.8 ppm B/G	0-3.8 0-3.8 0-3.8	Run #23	αNDA 200 βγ 0-5.5 ppm B/G	0-5.5 0-5.5 0-5.5
57.5 > 1423		0-3.8	57.5 > 0908		0-5.5 no recovery
Run #20	αNDA 210βγ 0 3.8 ppm B/G	0-3.8 0-3.8 tritium 0-3.8 VOC-TPH AAC0805	Run #24	αNDA 215βγ 0-5.5 ppm	0-5.5 0-5.5 tritium AAC0871 0-5.5 VOC-TPH AAC0867
60 >	air sample taken	0-3.8 AAC0868 taken 10/6/94	60 >	air sample taken	0-5.5 TD-60.0 ft

* Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION

Date: 10/6/94 Time: 1345 hrs
Borehole #: B6, 03-2679
SSO L. McDough Printed Name: D. Foss
Mail Stop: M327 Phone #: 662-3700
Instrument: PhotoVac HL-2000 SS #: DA910162
Instrument: Eberline ESP-1, Ludlum Mod. 139 SS #: 008021, 0076014

JOB DESCRIPTION

Phase II work for SWMU 13-010(a) Mercury Site - Borehole Drilling and Subsurface Sampling for suspect VOC Plume

Distribution: Project File

Depth*	Upper Core Level	in ppm
0 > 1356		no recovery
Run #1	∝NDA 0-5.5 ppm ~~BZ~~ B/G 190 BX moderate brown medium grained sandy SILT	0-5.5
		0-5.5
		0-5.5
		0-5.5
2.5 > 1404		no recovery
Run 2	∝NDA 160 BX 0-5.5 B/G	0-5.5
		0-5.5
		tritium
		0-5.5
		VOC-TPH
5 > 1432	air sample taken	0-5.5 AAC0872
		no recovery
Run #3	∝NDA 170 BX 0-5.5 ppm	0-5.5
		0-5.5
		~~0-5.5~~ OAF 10/6/94
		0-5.5
7.5 1442		0-5.5
		no recovery
Run #4	∝NDA 160 BX 0-5.5 ppm silt-fine grained tuff	0-5.5
		tritium
		0-5.5
		VOC-TPH AAC0873
10 >	air sample taken	0-5.5

Depth*	Lower Core Level	in ppm
10 > 1501		no recovery
Run #5	∝NDA 150 BX 0-5.5 ppm BX	5.5
		5.5
		33.3
12.5 > 1507		no recovery
Run #6	∝NDA 170 BX 0-5.5 ppm	0-5.5
		tritium
		0-5.5
		VOC-TPH AAC0874
15 > 1525	air sample taken	0-5.5
		no recovery
Run #7	∝NDA 160 BX 0-5.5 ppm B/G	0-5.5
		0-5.5
17.5 > 1536		0-5.5
		no recovery
Run #8	∝NDA 190 BX ~~[illegible]~~ 0-5.5 ppm B/G tuff	0-5.5
		0-5.5
		tritium
		0-5.5
		VOC-TPH AAC0875
20 >	air sample taken	0-5.5

* = Depth measured in feet

Core Instrument Survey Log

Date: 10/6/94 Time: 1345 hrs
Borehole #: B16.03-2079
SSO L. McDargh Printed Name: D. Foss
Mail Stop: M 327 Phone #: 662-3700
Instrument: SS #:
Instrument: SS #:
Distribution: Project File

Depth*	Upper Core Level	in ppm
20 > 0806 10/6/94		AAC0880 - water in tube no recovery
Run #9	αNDA 180 βγ 0-5.5 ppm B/G unfrozen sample	0-5.5
		0-5.5
		0-5.5
22.5 > 0821		0-5.5 no recovery
Run #10	αNDA 190 βγ 0-5.5 ppm B/G	0-5.5
		0-5.5
		0-5.5 tritium AAC0886
		0-5.5
		VOC-TPH AAC0886
25 > 0906	air sample taken	0-5.5 no recovery
Run #11	αNDA 180 βγ 0-5.5 ppm	0-5.5
		0-5.5
		0-5.5 - 11.1
		0-5.5 - 11.1
27.5 > 0918		0-5.5 - 11.1 no recovery
Run #12	αNDA 210 βγ 0-5.5 ppm B/G	0-5.5
		0-5.5
		tritium
		0-5.5
		VOC-TPH AAC0887
30 >	air sample taken	0-5.5

Depth*	Lower Core Level	in ppm
30 > 0941	αNDA 160 βγ 0-5.5 ppm	0-5.5
		0-5.5
		0-5.5
Run #13		0-5.5
		0-5.5
		0-5.5
32.5 > 0949		0-5.5
Run #14	αNDA 150 βγ 0-5.5 ppm	5.5 - 11.1
		5.5 - 11.1
		tritium AAC0888
		5.5 - 11.1
		VOC-TPH AAC0888
35 > 1320	air sample taken	5.5 - 11.1 no recovery
Run #15	αNDA 180 βγ 0-5.5 ppm βγ	0-5.5
		0-5.5
		0-5.5
37.5 > 1332		0-5.5 no recovery
Run #16	αNDA 190 βγ 0-5.5 ppm B/G	
		tritium
40 >	air sample taken	VOC-TPH AAC0889

* = Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/6/94 Time: 1245 hrs	
Borehole #: B10,03 -21679	
SSO: L. McDaugh Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument:	SS #:
Instrument:	SS #:
Distribution: Project File	

Depth*	Upper Core Level		Depth*	Lower Core Level	
40 > 1355		ppm 0-5.5	50 > 0906 10/12/94	α NDA 180 βγ 0-4.7 ppm B/G	0-4.7
Run #17	α NDA 180 βγ 0-5.5 ppm B/G	0-5.5	Run #21		0-4.7
		0-5.5			0-4.7
		0-5.5			0-4.7
		0-5.5			0-4.7
42.5 > 1401		0-5.5	52.5 > 0912	α NDA 190 βγ 0-4.7 ppm B/G	0-4.7
		no recovery			0-4.7
Run #18	α NDA 190 βγ 0-5.5 ppm B/G	0-5.5	Run #22		0-4.7
		0-5.5			0-4.7
		0-5.5			0-4.7
		tritium			tritium
		0-5.5			0-4.7
		NOC-TPH AAC0881			NOC-TPH AAC0883
45 > 1424	air sample taken	0-5.5	55 > 0935	air sample taken	0-4.7
	α NDA 190 βγ 0-5.5 ppm βγ	0-5.5			no recovery
Run #19		0-5.5	Run #23	α NDA 180 βγ 0-4.7 ppm B/G	0-4.7
		0-5.5			0-4.7
		0-5.5			0-4.7
		0-5.5			0-4.7
47.5 > 1438	α NDA 200 βγ 0-5.5 ppm	0-5.5	57.5 > 0940		0-4.7
		0-5.5			no recovery
Run #20		0-5.5	Run #24	α NDA 190 βγ 0-4.7 ppm B/G	
		tritium			0-4.7
		0-5.5			tritium
		NOC-TPH AAC0882			0-4.7
		0-5.5			NOC-TPH AAC0884
		no recovery			0-4.7
50 >	air sample taken		60 >	air sample taken	

* Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/6/94 Time: 1345 hrs	
Borehole #: B6, 03-2679	
SSO L McDaugh Printed Name: D. Fass	
Mail Stop: M 327 Phone #: 662-3700	
Instrument:	SS #:
Instrument:	SS #:

Distribution: Project File

Depth*	Upper Core Level	in ppm	Depth*	Lower Core Level	in ppm
60 >			70 > 1121	α NDA 200 βγ 0-4.7 ppm B/G	0-4.7
					0-4.7
			Run #29		0-4.7
					0-4.7
					0-4.7
62.5 > 0910		no recovery	72.5 > 1126	α NDA 190 βγ 0-4.7 ppm B/G	0-4.7
	α NDA 210 βγ 0-4.7 ppm B/G	0-4.7			0-4.7
Run #26		0-4.7	Run #30		0-4.7
		tritium			tritium
		0-4.7			0-4.7
		VOC-TPH AAC0885			VOC-TPH AAC0896
65 >	air sample taken	0-4.7	75 >	air sample taken	0-4.7
1057	α NDA 200 βγ 0-4.7 ppm B/G	0-4.7	1400	α NDA 200 βγ 0-4.7 ppm B/G	0-4.7
		0-4.7			0-4.7
Run #27		0-4.7	Run #31		0-4.7
		0-4.7			0-4.7
67.5 >		0-4.7	77.5 >		0-4.7
1102	α NDA 200 βγ 0-4.7 ppm B/G	0-4.7	1406	α NDA 170 βγ 0-4.7 ppm B/G	0-4.7
		0-4.7			0-4.7
Run #28		0-4.7	Run #32		0-4.7
		tritium			tritium
		0-4.7			0-4.7
		VOC-TPH AAC0895			VOC-TPH AAC0897
70 >	air sample taken	0-4.7	80 >	air sample taken	0-4.7

* = Depth measured in feet

Core Instrument Survey Log

SAMPLE DESCRIPTION	JOB DESCRIPTION
Date: 10/16/94 Time: 1345 hrs	
Borehole #: B16, 03-2679	
SSO L. McDough Printed Name: D. Foss	
Mail Stop: M 327 Phone #: 662-3700	
Instrument:	SS #:
Instrument:	SS #:
Distribution: Project File	

Depth*	Upper Core Level	mppm	Depth*	Lower Core Level	mppm
80 >		0-4.7	90 >		
1428	XNDA 190BX 0-4.7 ppm BX	0-4.7	1539		
		0-4.7	Run #37		no recovery
Run #33		0-4.7		XNDA 190BX 0-4.7 ppm B/G	
		0-4.7			0-4.7
82.5 >		0-4.7	92.5 >		0-4.7
1436	XNDA 210BX 0-4.7 ppm BX	0-4.7			
		0-4.7	Run #38		no recovery
Run #34		0-4.7 tritium			
		0-4.7 VOC-TPH AAC0898			
85 >	air sample taken	0-4.7	95 >	air sample taken	AAC0900
1505		no recovery	0925 10/13/94	Blank-air sample	AAC0902
	XNDA 220BX 0-4.7 ppm		Run #39		
Run #35		0-4.7		XNDA 130BX 0-4.7 B/G	0-4.7 ppm
		0-4.7		TD 96.5A	
87.5 >		0-4.7	97.5 >		
1512	XNDA 200BX 0-4.7 ppm	0-4.7			
		0-4.7			
Run #36		0-4.7 tritium AAC0888			
		0-4.7 VOC-TPH			
90 >	air sample taken	0-4.7 AAC0899	100 >		

* = Depth measured in feet

APPENDIX C: PLOTTING COORDINATES

SURV-TEK, Inc.
Consulting Surveyors
5643 Paradise Blvd. N.W. Albuquerque, New Mexico 87114
Phone: 505-897-3368 Fax: 505-897-3377

010(A).ASC

OU-1114 , TA-3 - SWMU 3-010(a)

STATION	NORTHING	EASTING	ELEVATION	FIMAD ID
1261	1773300.94	1616665.20	7451.2	"03-1261"
1262	1773297.37	1616642.68	7442.45	"03-1262"
1263	1773302.97	1616662.01	7450.21	"03-1263"
1264	1773299.22	1616665.43	7451.8	"03-1264"
1265	1773305.82	1616656.65	7450.99	"03-1265"
1266	1773295.39	1616654.83	7449.83	"03-1266"
1267	1773301.32	1616652.83	7445.43	"03-1267"
1268	1773297.33	1616647.23	7443.71	"03-1268"
1269	1773298.80	1616643.44	7442.77	"03-1269"
1270	1773292.81	1616641.91	7444.73	"03-1270"
1271	1773303.80	1616664.90	7451.47	"03-1271"
1272	1773299.89	1616648.34	7443.77	"03-1272"
1273	1773296.76	1616640.99	7442.11	"03-1273"
1274	1773289.99	1616636.62	7443.11	"03-1274"
1275	1773301.57	1616655.14	7446.33	"03-1275"
1276	1773274.71	1616657.40	7451.54	"03-1276"
1277	1773300.19	1616656.02	7446.81	"03-1271"
2608	1773287.80	1616672.25	7457.69	"03-2608"
2609	1773286.04	1616663.22	7454.13	"03-2609"
2610	1773283.56	1616654.12	7450.25	"03-2610"
2611	1773281.88	1616645.59	7447.13	"03-2611"
2612	1773279.03	1616635.68	7444.07	"03-2612"
2613	1773276.32	1616626.18	7441.87	"03-2613"
2614	1773286.39	1616624.56	7440.69	"03-2614"
2615	1773296.24	1616621.80	7439.93	"03-2615"
2616	1773305.76	1616619.27	7440.71	"03-2616"
2617	1773308.19	1616629.00	7440.02	"03-2617"
2618	1773310.84	1616638.52	7444.35	"03-2618"
2619	1773312.79	1616647.14	7448.45	"03-2619"
2620	1773314.81	1616656.16	7452.77	"03-2620"
2621	1773316.75	1616665.26	7457.67	"03-2621"
2622	1773278.23	1616673.73	7457.61	"03-2622"
2623	1773276.13	1616665.52	7452.83	"03-2623"
2624	1773273.51	1616656.30	7451.47	"03-2624"
2625	1773271.64	1616646.93	7446.53	"03-2625"
2626	1773254.59	1616660.31	7451.1	"03-2626"

2627	1773269.21	1616638.48	7444.8	"03-2627"
2628	1773266.68	1616628.75	7442.75	"03-2628"
2629	1773315.70	1616617.46	7442.38	"03-2629"
2630	1773318.17	1616626.36	7442.17	"03-2630"
2631	1773320.34	1616637.56	7443.73	"03-2631"
2632	1773321.52	1616645.73	7447.47	"03-2632"
2633	1773325.20	1616654.38	7453.02	"03-2633"
2634	1773327.66	1616663.98	7456.85	"03-2634"
2635	1773268.50	1616675.98	7457.35	"03-2635"
2636	1773265.97	1616666.48	7454.55	"03-2636"
2637	1773263.56	1616657.17	7450.83	"03-2637"
2638	1773261.86	1616648.71	7447.39	"03-2638"
2639	1773259.74	1616639.19	7444.61	"03-2639"
2640	1773257.66	1616631.98	7446.03	"03-2640"
2641	1773254.94	1616622.43	7440.75	"03-2641"
2642	1773264.76	1616619.39	7439.21	"03-2642"
2643	1773274.14	1616617.16	7439.49	"03-2643"
2644	1773283.37	1616614.87	7439.07	"03-2644"
2645	1773293.77	1616612.41	7440.59	"03-2645"
2646	1773326.30	1616617.56	7444.35	"03-2646"
2647	1773328.52	1616626.12	7442.93	"03-2647"
2648	1773330.27	1616636.25	7443.03	"03-2648"
2649	1773333.19	1616645.37	7447.77	"03-2649"
2650	1773243.07	1616664.29	7451.47	"03-2650"
2651	1773333.14	1616616.44	7446.03	"03-2651"
2652	1773306.47	1616548.06	7452.53	"03-2652"
2654	1773335.52	1616663.40	7457.75	"03-2654"
2655	1773334.62	1616653.43	7453.05	"03-2655"
2656	1773300.19	1616600.13	7441.09	"03-2656"
2657	1773291.75	1616602.74	7439.76	"03-2657"
2658	1773280.70	1616605.00	7438.45	"03-2658"
2659	1773271.40	1616607.78	7437.83	"03-2659"
2660	1773260.65	1616610.41	7439.11	"03-2660"
2661	1773251.94	1616612.96	7439.99	"03-2661"
2663	1773302.49	1616680.08	7457.7	"03-2663"
2664	1773314.26	1616678.91	7457.7	"03-2664"
2665	1773300.77	1616653.17	7449.4	"03-2665"
2666	1773246.43	1616660.81	7451.00	"03-2666"
2667	1773331.52	1616651.14	7451.54	"03-2667"
2668	1773281.24	1616586.17	7440.98	"03-2668"
2679	1773350.69	1616652.08	7451.94	"03-2679"
2680	1773237.96	1616659.54	7450.28	"03-2680"
2681	1773129.89	1616505.16	7405.13	"00-2681"
2019	1773292.53	1616669.98		"SE COR"
2020	1773310.77	1616665.62		"NE COR"
2021	1773299.59	1616629.99		"NW COR"
2022	1773286.03	1616631.95		"SW COR"
2023	1773317.17	1616634.69		"CULV"
2024	1773269.01	1616703.69		"BLDG COR"
2025	1773307.49	1616689.36		"SHED COR"
2026	1773348.33	1616689.38		"BLDG LN"
2027	1773348.50	1616677.60		"COM PAD"

GENERAL NOTES

1. Horizontal and Vertical Data is based on LANL Monument A0302, having New Mexico State Plane Coordinates , Central Zone, (NAD 83), X=1617204.1740, Y=1773584.5940, Z=7457.60, as provided by LANL Central Point.

2. All Coordinates are New Mexico State Plane Grid, Central Zone, NAD 83.

3. Project CSF = 0.9996877.

APPENDIX D: RISK CALCULATIONS

Los Alamos National Laboratory
Solid Waste Management Unit SWMU 3-010(a)

Soil Saturation Concentration (Csat)

Csat = (S/Rb x [(Kd x B) + (Pw) + (H' x Pa)]

where: Kd = Koc x foc H' = H x 41 Pw = Pt - Pa Pa = Pt - (Grav/theta x B) Pt = 1 - (B/Ps)

Chemical	S (1) (mg/L)	Koc (1) (L/kg)	H (1) (atm-m³/mol)	Di (2) (cm²/sec)
1,2-DCA	8600	14.13	1.10E-03	0.081
1,1-DCE	400	64.58	1.54E-01	0.079

(1) EPA/540-2-90/011 (October 1990)
(2) USEPA Region IX PRG February 1995

Calculation of Soil Saturation Concentration:

Chemical	S (mg/L)	B (kg/L)	Koc (L/kg)	foc (fraction)	Grav/theta (cm³/g)	H' (unitless)	Pa (g/cm³)	Csat [ ] (mg/kg)
1,2-DCA	8600	1.25	14.13	0.0040	0.050	4.51E-02	2.65	1461
1,1-DCE	400	1.25	64.58	0.0040	0.050	6.31	2.65	990

Soil-to-Air Volatilization Factor (VF)

VF (m³/kg) = (SB x V x DH)/A) x (3.14 x alpha x T)^1/2)/(2 x Del x Pa x Kas x 10^-3 kg/g)

where: alpha = (Del x Pa)/Pb + [(Pa) x (1-Pa)/Kas] Del = Di x [(Pa)^3.33/(Pb)^2] Kas = (H/Kd) x 41 Pa = Pt - (Grav/theta x B) Pt = 1 - (B/Ps)

Calculation of Soil-to-Air Volatilization Factor (VF):
Long-Term Worker

Chemical	LB (m)	V (m/s)	DH (m)	A (cm²)	alpha	T (sec)	Del (cm²/sec)	B (kg/L)	Grav/theta (cm³/g)	Pa (g/cm³)	Kas (cm³/cm³)	CF (kg/g)	VF (m³/kg)
1,2-DCA	45	2.25	2	1.00E+07	2.64E-03	7.88E+08	1.79E-02	1.3	0.00	2.65	0.04E-01	0.001	2597
1,1-DCE	45	2.25	2	1.00E+07	1.32E-02	7.88E+08	1.55E-02	1.3	0.00	2.65	21.29	0.001	211

Trail User (adult)

Chemical	LB (m)	V (m/s)	DH (m)	A (cm²)	alpha	T (sec)	Del (cm²/sec)	B (kg/L)	Grav/theta (cm³/g)	Pa (g/cm³)	Kas (cm³/cm³)	CF (kg/g)	VF (m³/kg)
1,2-DCA	45	2.25	2	1.00E+07	2.64E-03	2.84E+08	1.79E-02	1.3	0.00	2.65	0.04E-01	0.001	1558
1,1-DCE	45	2.25	2	1.00E+07	1.32E-02	2.84E+08	1.55E-02	1.3	0.00	2.65	21.29	0.001	127

Los Alamos National Laboratory
Solid Waste Management Unit SWMU 3-010(a)

Estimation of Excess Cancer Risk: Inhalation of Vapors from Subsurface Soil Using the 95th Percent Upper Confidence Limit of the Weighted Average

Dose = (Soil Conc. x IRa x ET x EF x ED) / (VF x BW x AT)
Risk = Dose x SFi

Long-Term Worker

Chemical	Soil Conc. (mg/kg)	IRa (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	SFi (mg/kg-day)-1	Risk
1,2-DCA	0.024	1.7	8	250	25	2597	70	25550	4.36E-07	0.081	4E-08
1,1-DCE	0.30	1.7	8	250	25	211	70	25550	8.58E-05	0.18	2E-05
									TOTAL LONG-TERM WORKER:		2E-05

Trail User (adult)

Chemical	Soil Conc. (mg/kg)	IRa (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	SFi (mg/kg-day)-1	Risk
1,2-DCA	0.024	2.1	2	170	8	1558	70	25550	5.53E-08	0.081	5E-09
1,1-DCE	0.30	2.1	2	170	8	127	70	25550	1.06E-05	0.18	2E-06
									TOTAL TRAIL USER (ADULT):		2E-06

Los Alamos National Laboratory
Solid Waste Management Unit SWMU 3-010(a)

Estimation of Hazard Index: Inhalation of Vapors from Subsurface Soil Using the 95th Percent Upper Confidence Limit of the Weighted Average

Dose = (Soil Conc. x IFs x ET x EF x ED) / (VF x BW x AT)
Hazard Quotient = Dose / RfCi

Long-Term Worker

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	RfCi (mg/kg-day)	Hazard Quotient
1,2-DCA	0.024	1.7	8	250	25	2587	70	9125	1.33E-06	ND	ND
1,1-DCE	0.36	1.7	8	250	25	211	70	9125	2.40E-04	0.000	9E-02
								HAZARD INDEX LONG-TERM WORKER:			9E-02

Trail User (adult)

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	RfCi (mg/kg-day)	Hazard Quotient
1,2-DCA	0.024	2.1	2	170	9	1550	70	3285	4.20E-07	ND	ND
1,1-DCE	0.36	2.1	2	170	9	127	70	3285	8.20E-05	0.000	9E-03
								HAZARD INDEX TRAIL USER (ADULT):			9E-03

Los Alamos National Laboratory
Solid Waste Management Unit SWMU 3-010(a)

Estimation of Excess Cancer Risk: Inhalation of Vapors from Subsurface Soil Using the Weighted Average

Dose = (Soil Conc. x IFs x ET x EF x ED) / (VF x BW x AT)
Risk = Dose x SFi

Long-Term Worker

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	SFi (mg/kg-day)-1	Risk
1,2-DCA	0.0024	1.7	8	250	25	2587	70	25550	1.84E-07	0.091	1E-08
1,1-DCE	0.036	1.7	8	250	25	211	70	25550	1.28E-05	0.10	2E-06
								TOTAL LONG-TERM WORKER:			2E-06

Trail User (adult)

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	SFi (mg/kg-day)-1	Risk
1,2-DCA	0.0024	2.1	2	170	9	1550	70	25550	1.84E-08	0.091	2E-09
1,1-DCE	0.036	2.1	2	170	9	127	70	25550	1.36E-06	0.10	9E-07
								TOTAL TRAIL USER (ADULT):			9E-07

Los Alamos National Laboratory
Solid Waste Management Unit SWMU 3-010(a)

Estimation of Hazard Index: Inhalation of Vapors from Subsurface Soil Using the Weighted Average

Dose = (Soil Conc. x IFs x ET x EF x ED) / (VF x BW x AT)
Hazard Quotient = Dose / RfCi

Long-Term Worker

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	RfCi (mg/kg-day)	Hazard Quotient
1,2-DCA	0.0024	1.7	8	250	25	2587	70	9125	4.51E-07	ND	ND
1,1-DCE	0.036	1.7	8	250	25	211	70	9125	8.53E-05	0.000	4E-03
								HAZARD INDEX LONG-TERM WORKER:			4E-03

Trail User (adult)

Chemical	Soil Conc. (mg/kg)	IFs (m³/hour)	ET (hours/day)	EF (days/year)	ED (years)	VF (m³/kg)	BW (kg)	AT (days)	Dose (mg/kg-day)	RfCi (mg/kg-day)	Hazard Quotient
1,2-DCA	0.0024	2.1	2	170	9	1550	70	3285	1.51E-07	ND	ND
1,1-DCE	0.036	2.1	2	170	9	127	70	3285	1.24E-05	0.000	1E-03
								HAZARD INDEX TRAIL USER (ADULT):			1E-03

APPENDIX C

CERTIFICATION OF COMPLETION

Certification of Completion

I certify that all work pertaining to the expedited cleanup (EC) PRS 18-003(e) has been completed in accordance with the Department of Energy-approved EC plan entitled **EC Plan for Solid Waste Management Unit 18-003(e)**. Based on my personal involvement or inquiry of the person or persons who managed this cleanup, a review of all data gathered, and a visit to the site, to the best of my knowledge and belief, all criteria of the plan have been met or exceeded. I believe that the completion of this EC is protective to both human health and the environment. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Gene Gould
Field Unit Two Project Leader
Environmental Restoration Project
Los Alamos National Laboratory

9/28/95
Date Signed

Dave McInroy
Compliance Manager, Independent Review
Environmental Restoration Project Office
Los Alamos National Laboratory

9/29/95
Date Signed

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Factors Affecting Radionuclide Availability to Vegetables Grown at Los Alamos

G. C. WHITE, T. E. HAKONSON, AND A. J. AHLQUIST

Factors Affecting Radionuclide Availability to Vegetables Grown at Los Alamos[1]

G. C. WHITE, T. E. HAKONSON, AND A. J. AHLQUIST[2]

ABSTRACT

A field study was conducted in 1977 on ^{238,239}Pu and ^{137}Cs availability to zucchini squash (*Curcurbita melopepo*, hybrid seneca) and green bush beans (*Phaseolus vulgaris*, Landreths stringless) grown under home-garden conditions in an area at Los Alamos National Laboratory used for treated radioactive liquid waste disposal. Radionuclide concentrations were measured as a function of tissue type, height above the soil, fertilization regime, and for the squash, food-cleansing procedures. Analysis of variance procedures were used to analyze the data.

Ratios of the concentration of a radionuclide in oven-dried vegetation to dry soil ranged from 0.0004 to 0.116 for the Pu isotopes, and from 0.051 to 0.255 for ^{137}Cs. Fertilization with cattle manure reduced the Pu concentration ratios by 30% and ^{137}Cs by 50%. Vegetative parts sampled within 20 cm of the ground surface were contaminated about four times as much as those parts growing further from the ground surface. About 65% of the contamination was removed by washing, indicating the presence of surficial contamination. The 50-year radiation dose commitment to humans consuming vegetables from the garden plot would be less than 0.05 mrem and would be due almost entirely to ^{137}Cs.

Additional Index Words: **radiation, fertilizer, soil splash-up.**

White, G.C., T. E. Hakonson, and A. J. Ahlquist. 1981. Factors affecting radionuclide availability to vegetables grown at Los Alamos. J. Environ. Qual. 10:294–299.

The need for information on transuranic element transfer into human food chains has prompted many studies on plutonium (Pu) uptake by agricultural plants. Most studies have been conducted under controlled laboratory or greenhouse conditions using known chemical forms of Pu (Price, 1973; Schreckhise and Cline, 1980; Schulz, 1977). Fewer studies deal with contaminated field sites where Pu transport to vegetation is likely a function of the contaminant source and local environmental factors (Adriano et al., 1980; Hakonson, 1975; Watters et al., 1980; Little and Whicker, 1978). Studies dealing with a wide variety of contaminant sources and ecological settings are required to identify the generic and site-specific attributes of environmental Pu behavior.

This paper presents the results of a field study conducted in 1977 on Pu and ^{137}Cs availability to zucchini squash (*Curcurbita melopepo*, hybrid seneca) and green beans (*Phaseolus vulgaris*, Landreths stringless) grown in Mortandad Canyon, an area at Los Alamos used for treated radioactive liquid waste disposal. The study was designed to simulate a home vegetable garden. Concentrations of radionuclides were determined in the two vegetable crops as a function of tissue, height above the ground surface, fertilization with steer manure, and food preparation treatment. The radiation doses to humans from eating the vegetable crop were calculated to assess the potential hazard from agricultural use of the area.

MATERIALS AND METHODS

Industrial liquid wastes generated by the Los Alamos National Laboratory are collected at a central location, treated to reduce the levels of radioactive contaminants to below Federal guidelines for drinking water, and then released to the local environs (USDOE, 1979).

Mortandad Canyon has been used for disposal of this liquid waste since 1963. The quantities of ^{238}Pu, ^{239,240}Pu (denoted as ^{239}Pu in this paper), and ^{137}Cs released to the canyon from 1963 through 1977 were 0.051, 0.039, and 0.85 Ci, respectively (USDOE, 1979). Prior to 1968 the isotopic composition of Pu in the waste was predominately ^{239}Pu. Subsequently, more ^{238}Pu than ^{239}Pu was processed so that the ^{238}Pu inventory is now greater than the ^{239}Pu inventory.

A 9- by 13-m plot was established in Mortandad Canyon about 2,500 m downstream from the liquid effluent outfall on an alluvial floodplain formed from storm runoff. The plot was fenced and commercial garden preparation (6%N–12%P–6%K) was applied just prior to cultivation of the soil. The soil is an unnamed member of the Typic Ustorthents group. One-half of the plot received an additional amendment of cattle manure (hereafter referred to as the fertilization treatment) applied at the rate of 5 kg/m^2 (dry weight). A garden rototiller was used to cultivate the plot to a 15-cm depth. The plot was seeded with zucchini squash and green beans.

The term "plant" as used in this paper refers to the above-ground vegetative parts. The term "fruit" refers to the edible reproductive parts. Plant roots were not sampled during this study. Green beans were sampled at maturity by pooling beans from four randomly selected plants within each plot. A total of 13 samples of bean fruit was collected. Green bean plants were also collected and bagged separately.

Squash fruits were collected at maturity from individual plants. Squash plants were sampled as a function of height above the ground surface with a 1-m^2 template divided into four equal quadrants; the heights from which samples were taken were 0–20 cm and >20 cm above the ground surface. Bean plants were not collected as a function of height above the ground.

To evaluate the effect of washing on radionuclide concentrations, squash plants and fruit from two of the quadrants in a particular height strata were pooled together for a wash treatment, while the samples from the remaining two quadrants were analyzed for radionuclide content without the wash treatment. All squash fruit and plant samples designated for the wash treatment were thoroughly washed with water in an attempt to remove surficially attached soil particles. Although the wash treatment appeared to be effective in removing coarse particles, it may not have effectively removed the smaller sized particles. All bean plant and fruit samples were washed before the radionuclide analyses.

Soil (minus roots) was collected for chemical, physical, and radionuclide analyses from the rooting zone of individual plant samples. Thus, the depth to which soil samples were taken varied depending on the depth of root penetration by the two vegetable species.

Samples were dried at 100°C and then ashed at 400°C. Samples were analyzed for ^{137}Cs on 10- by 20-cm NaI(Tl) detector coupled to a multichannel analyzer. The samples were then subjected to wet chemical techniques followed by alpha spectroscopy to quantify the Pu content (USDOE, 1979). Most of the chemical and physical analyses on garden-plot soils were conducted by Colorado State University's Soil Testing Laboratory in Fort Collins, Colo (Soltanpour et al., 1979). Soil particle size analyses were performed in our laboratory using mechanical sonic sieving methods (Nyhan et al., 1976).

[1] Research funded under Contract No. W-7405-ENG-36 between the U.S. Department of Energy and the Los Alamos National Laboratory, Los Alamos, NM 87545. Received 23 June 1980.

[2] Biometrician, radiation ecologist, and health physicist, respectively.

STATISTICAL ANALYSIS

Analysis of variance (ANOVA) procedures involving nested factors were used to analyze the vegetable crop data. Calculations were made with the multivariate ANOVA (MANOVA) procedure (Cohen and Burns, 1977) of SPSS (Nie et al., 1975). Because nested factors are random effects, e.g., the ANOVA model is a mixture of fixed and random effects, the F ratios are not constructed with a common error term in the denominators. Rather, the F ratios utilize different error terms depending on the nesting structure. The complexity of the linear models used necessitates the following complete descriptions.

Bean data were analyzed as a three-factor experiment (Winer 1971:361–363, 514–539) with plants nested within fertilization plots. The linear model utilized was

$$y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + \gamma_k + \alpha\gamma_{ik} + \beta\gamma_{j(i)k} + e_{ijk}, \quad [1]$$

where

y_{ijk} is the radionuclide concentration for the ijk^{th} cell;
μ is the overall mean;
α_i with $i = 1, 2$ is the fertilizer effect;
$\beta_{j(i)}$ with $j = 1, \ldots, 13$ is the plant effect nested within fertilizer plots;
γ_k with $k = 1, 2$ is the tissue effect, e.g., stem and leaves or fruit; and
e_{ijk} is the error term for the ijk^{th} cell.

Squash plant data were analyzed as a four-factor design (Winer 1971:539–559) with plants nested within fertilization plots. The linear model utilized was

$$y_{ijkl} = \mu + \alpha_i + \beta_{j(i)} + \gamma_k + \delta_l + \alpha\gamma_{ik} + \alpha\delta_{il} + \gamma\delta_{kl} + \alpha\gamma\delta_{ikl} + \beta\gamma_{j(i)k} + \beta\delta_{j(i)l} + \beta\gamma\delta_{j(i)kl} + e_{ijkl}, \quad [2]$$

where

y_{ijkl} is the radionuclide concentration for the $ijkl^{th}$ cell,
α_i with $i = 1, 2$ is the effect either with or without fertilizer,
$\beta_{j(i)}$ with $j = 1, \ldots, 8$ is the plant effect nested within fertilizer plots,
γ_k with $k = 1, 2$ is either the lower or upper portions of plant (height),
δ_l with $l = 1, 2$ is either the washed or unwashed tissue effect, and
e_{ijkl} is the error term for the $ijkl^{th}$ cell.

Squash fruit were also analyzed with a four-factor hierarchial design. The linear model utilized was

$$y_{ijkl} = \mu + \alpha_i + \beta_{j(i)} + \gamma_{k(j)} + \delta_l + \alpha\delta_{il} + \beta\delta_{j(i)l} + \gamma\delta_{k(j)l} + e_{ijkl}$$

where

y_{ijkl} is the radionuclide concentration for the $ijkl^{th}$ cell,
α_i with $i = 1, 2$ is the effect either with or without fertilizer,
$\beta_{j(i)}$ with $j = 1, \ldots, 8$ is the plant effect nested within fertilizer plots,
$\gamma_{k(j)}$ with $k = 1, \ldots, 3$ is the fruit effect nested within plants,
δ_l with $l = 1, 2$ is the fruit peel or meat effect, and
e_{ijkl} is the error term for the $ijkl^{th}$ cell.

Each of the radionuclides was analyzed separately for each of the above designs, and was also analyzed for MANOVA for each of the above designs where the observed concentration is a vector of concentration:

$$y = [^{238}Pu, ^{239}Pu, ^{137}Cs].$$

The multivariate tests give overall tests of the various hypotheses for each of the models above, and provide a means of evaluating the three radionuclides simultaneously rather than trying to interpret them separately. Significance levels of multivariate tests utilized Pillai's method (Morrison, 1976).

Radionuclide concentrations were analyzed both untransformed and with logarithmic transformations. Conclusions from the two analyses were identical for the effects of interest, and so only the analyses for untransformed data are presented.

RESULTS AND DISCUSSION

Study plot soils receiving the fertilization treatment differed significantly ($p < 0.01$, *t-test*) in chemical composition from those receiving no fertilizer treatment (Table 1). Of the parameters measured, only Ca, Cu, and pH remained unchanged in soil after addition of the fertilizer.

Table 1—Chemical and physical characteristics of soils from Mortandad Canyon garden plot in 1977.

Constituent	Soil treatment: Fertilization‡	Soil treatment: None	Significance
	mean (SD)†		
Ca, meq/liter	4.9 (2.2)	3.6 (0.91)	NS
Mg, meq/liter	1.7 (0.66)	0.93 (0.22)	<0.01
Na, meq/liter	3.9 (1.3)	1.1 (0.12)	<0.01
K, meq/liter	5.3 (0.91)	0.27 (0.05)	<0.01
Sodium absorption ratio	2.2 (0.59)	0.75 (0.15)	<0.01
pH	8.1 (0.20)	7.9 (0.10)	NS
Conductivity, mmhos/cm	1.6 (0.49)	0.60 (0.10)	<0.01
Organic matter, %	1.4 (0.29)	0.60 (0.07)	<0.01
P, ppm	52 (6.1)	16 (4.9)	<0.01
K, ppm	557 (71)	66 (4.9)	<0.01
NO_3-N, ppm	16 (7.1)	7.3 (3.7)	<0.01
Zn, ppm	2.6 (0.22)	1.9 (0.22)	<0.01
Fe, ppm	15 (0.93)	12 (1.9)	<0.01
Cu, ppm	2.2 (0.27)	2.1 (0.20)	NS
Mn, ppm	4.2 (0.39)	2.8 (0.59)	<0.01

† means based on sample size of six.
‡ Fertilized with cow manure.

Table 2—Radionuclide concentrations in oven-dry soil and soil size fractions from Mortandad garden plot.

	<43 μm	53–100 μm	100–500 μm	0.5–0.1 mm	1.0–2.0 mm	2.0–23 mm
	mean (SD)†					
% Soil weight	9.0 (5.0)	14 (5.0)	22 (4.0)	19 (4.0)	21 (4.0)	16 (6.1)
pCi ^{137}Cs/g	217 (43)	196 (47)	125 (36)	69 (35)	54 (30)	114 (67)
% ^{137}Cs in fraction	17	23	23	11	10	16
pCi ^{238}Pu/g	14 (2.4)	17 (3.4)	10 (6.1)	8.1 (5.6)	5.4 (3.9)	6.8 (4.1)
% ^{238}Pu in fraction	12	22	32	14	10	10
pCi ^{239,240}Pu/g	2.6 (0.52)	3.7 (3.2)	2.8 (0.87)	1.7 (0.83)	0.95 (0.46)	1.3 (0.55)
% ^{239,240}Pu/g in fraction	11	25	30	15	10	10

† Mean and SD based on sample size of 26.

Table 3—Effect of soil fertilization on concentrations of Pu and ^{137}Cs in plants (above-ground biomass minus fruits) and fruits of bush beans (mean ± one SD of 13 determinations).

Radionuclide	Unfertilized	Fertilized†
	pCi/g oven-dry tissue	
	Plant	
^{238}Pu	0.92 ± 0.41	0.52 ± 0.23
^{239}Pu	0.14 ± 0.06	0.08 ± 0.04
^{137}Cs	17.3 ± 3.7	8.0 ± 3.7
	Fruit	
^{238}Pu	0.26 ± 0.60	0.31 ± 0.72
^{239}Pu	0.04 ± 0.09	0.05 ± 0.11
^{137}Cs	5.9 ± 4.1	2.8 ± 1.2

† Fertilized with cow manure.

Table 5—Effects of soil fertilization, washing, and height of material sampled on concentrations of Pu and ^{137}Cs in the above-ground biomass of squash plants (minus fruits) (mean ± one SD of eight determinations).

	Unfertilized		Fertilized	
Radionuclide	0–20 cm	20 cm	0–20 cm	20 cm
	pCi/g oven-dry tissue			
	Washed			
^{238}Pu	1.34 ± 0.40	0.34 ± 0.25	0.81 ± 0.31	0.17 ± 0.09
^{239}Pu	0.19 ± 0.04	0.05 ± 0.04	0.12 ± 0.05	0.02 ± 0.01
^{137}Cs	24.9 ± 7.5	1.9 ± 1.4	10.5 ± 5.4	4.5 ± 3.3
	Unwashed			
^{238}Pu	3.3 ± 1.4	0.63 ± 0.50	2.26 ± 0.76	0.44 ± 0.22
^{239}Pu	0.56 ± 0.25	0.10 ± 0.88	0.36 ± 0.13	0.07 ± 0.04
^{137}Cs	66 ± 36	22 ± 11	33.5 ± 7.7	10.5 ± 4.0

Radionuclide concentrations in soils (Table 2) did not differ significantly ($p > 0.05$) between treatments (fertilizer vs. no fertilizer) and, overall, averaged 85 pCi ^{137}Cs/g dry weight, 10 pCi ^{238}Pu/g, and 1.9 pCi ^{239}Pu/g. The soil was sandy with over 90% of the soil mass consisting of particles >53 μm. In addition, over 80% of the radionuclide inventories were present in sand size fractions. Relatively little of the radionuclide inventory was present in the silt-clay (<53 μm) fraction; these particles contained only about 10% of the radionuclide inventory (Table 2), even though the radionuclide concentrations in this fraction were relatively high (Table 3).

Treatment Effects

The fertilization treatment had no significant effect ($p > 0.26$, Table 4) on Pu concentrations in beans (Table 3), although it decreased ^{137}Cs concentrations. Bean fruits had lower concentrations ($p < 0.001$, Tables 3 and 4) of all three radionuclides than bean plants did.

The differences for tissue effects (e.g., fruits vs. plants) are explainable due to the differential times of the material being available for contamination by soil from wind or water movement, and to the fruits usually having lower radionuclide concentrations (Schulz, 1977; Schreckhise and Cline, 1980). The leaves and stems had been exposed to raindrop splash-up and/or wind erosion for the full growing season, while the fruits appeared late in the growing season and were soon harvested. The potential for the fruits to become contaminated by physical processes was much less than for the remainder of the plant.

The differences between the effect of fertilization (Table 4) for Pu ($p = 0.26$) and ^{137}Cs ($p < 0.001$) is attributed to the increase of K, a biological analog of Cs. The increased K concentrations in the soil (8.4 times greater in fertilized soil, Table 2) decreased the uptake of ^{137}Cs by 55% (Table 3). The significant ($p = 0.004$, Table 4) fertilization × tissue effect for ^{137}Cs further indicates the importance of biological uptake for this radionuclide.

The three main effects (fertilizer treatment, washing, and height above the ground; Table 5) were each significant (Table 6) for all three radionuclides. The fact that washing significantly reduced radionuclide concentrations by about 65% (Table 5) indicates that much of the measured radioactive materials must have been associated with the plant surface. Likewise, because the lower portions of the plant had about four times higher concentrations than the upper portions (Table 5), surface contamination of the plant by soil is further supported. The lower radionuclide concentrations ($p = 0.066$, Tables 5 and 6) on the fertilized plot (35% for Pu, 50% for Cs) is attributed to the increase in organic matter, which stabilizes the soil and decreases mobility from wind- and water-driven processes. This hypothesis is further substantiated by the significant interaction term ($p = 0.055$, Table 6) for fertilization × height. Fertilization

Table 4—Analysis of variance table for the beans.

Source	Radionuclide	Sum of squares	Degrees of freedom	F	Significance	Multivariate significance
Fertilization	^{238}Pu	0.397	1	1.306	0.264	
	^{239}Pu	0.009	1	1.329	0.260	<0.001
	^{137}Cs	503.332	1	47.367	<0.001	
Plants within fertilization	^{238}Pu	7.304	24			
	^{239}Pu	0.165	24			
	^{137}Cs	255.023	24			
Tissue	^{238}Pu	2.459	1	9.980	0.004	
	^{239}Pu	0.054	1	9.847	0.004	<0.001
	^{137}Cs	904.890	1	71.932	<0.001	
Fertilization × tissue	^{238}Pu	0.621	1	2.521	0.125	
	^{239}Pu	0.014	1	2.558	0.123	0.014
	^{137}Cs	125.800	1	10.000	0.004	
Tissue × plants within fertilization	^{238}Pu	5.914	24			
	^{239}Pu	0.132	24			
	^{137}Cs	301.917	24			

Table 6—Analysis of variance for squash plants.

Source	Radionuclide	Sum of squares	Degrees of freedom	F	Significance	Multivariate significance
Fertilization	^{238}Pu	3.677	1	5.813	0.030	
	^{239}Pu	0.110	1	6.970	0.019	0.066
	^{137}Cs	3064.038	1	9.783	0.007	
Plants with fertilization	^{238}Pu	8.855	14			
	^{239}Pu	0.220	14			
	^{137}Cs	4384.757	14			
Washing	^{238}Pu	15.688	1	37.832	<0.001	
	^{239}Pu	0.471	1	38.993	<0.001	<0.001
	^{137}Cs	8075.943	1	34.273	<0.001	
Fertilization × washing	^{238}Pu	0.247	1	0.597	0.453	
	^{239}Pu	0.017	1	1.399	0.257	0.254
	^{137}Cs	1014.343	1	4.305	0.057	
Washing × plants within fertilization	^{238}Pu	5.806	14			
	^{239}Pu	0.169	14			
	^{137}Cs	3298.900	14			
Height	^{238}Pu	37.305	1	157.885	<0.001	
	^{239}Pu	0.966	1	111.601	<0.001	<0.001
	^{137}Cs	9097.583	1	74.877	<0.001	
Fertilization × height	^{238}Pu	1.434	1	6.069	0.027	
	^{239}Pu	0.043	1	4.989	0.042	0.055
	^{137}Cs	1406.906	1	11.579	0.004	
Height × plants within fertilization	^{238}Pu	3.308	14			
	^{239}Pu	0.121	14			
	^{137}Cs	1701.010	14			
Washing × height	^{238}Pu	8.042	1	23.311	<0.001	
	^{239}Pu	0.254	1	24.250	<0.001	0.006
	^{137}Cs	1403.345	1	12.605	0.003	
Fertilization × washing × height	^{238}Pu	0.219	1	0.633	0.439	
	^{239}Pu	0.016	1	1.482	0.244	0.286
	^{137}Cs	12.311	1	0.111	0.744	
Washing × height × plants within fertilization	^{238}Pu	4.830	14			
	^{239}Pu	0.149	14			
	^{137}Cs	1558.684	14			

reduced the accumulation of contaminants more on the upper parts of the plant than it did on the lower portions (Table 5).

The above explanation of the decrease in splash-up due to fertilization would also suggest that the fertilization × washing interaction should have been significant (Table 6). More material should have been washed off of the unfertilized plants than the fertilized plants because there was more material present to wash. The ^{137}Cs term was marginally significant (p = 0.057), but neither of the Pu terms were significant (Table 6). We believe this interaction term was not significantly rejected because the amount of additional material to be washed off was small in relation to detection limits, and the variation in the data obscured the interaction.

Table 7—Effect of soil fertilization on concentration of Pu and ^{137}Cs in washed fruits of squash. Three fruits were taken from each of eight plants in each fertilization plot (mean ± SD of 24 determinations).

Radionuclide	Unfertilized	Fertilized
	pCi/g oven-dry tissue	
	Peel	
^{238}Pu	0.024 ± 0.012	0.017 ± 0.031
^{239}Pu	0.006 ± 0.003	0.005 ± 0.012
^{137}Cs	9.5 ± 7.1	4.6 ± 2.3
	Meat	
^{238}Pu	0.006 ± 0.017	0.002 ± 0.001
^{239}Pu	0.006 ± 0.022	0.002 ± 0.004
^{137}Cs	6.2 ± 4.8	4.1 ± 1.8

Cesium-137 concentrations in plant material from the fertilized plot were even further reduced (Table 5) than were Pu concentrations. The greater decrease for ^{137}Cs from fertilization can be attributed to the increase in K and, hence, discrimination against ^{137}Cs by the plant, illustrating the greater biological activity of ^{137}Cs.

The reduction of radionuclide concentration in squash fruit due to fertilization (Table 7) was not significant (p >0.174, Table 8) for Pu. We attribute the lack of a fertilization effect for Pu to the short time that the squash fruits were in the garden and thus subject to surface contamination, and to the low levels of activity observed in the fruits with the effect thus obscured by the variation due to fallout background. As the fruits reached the sizes where they are normally utilized for food, they were harvested from the garden and stored until analyses. They were washed before being prepared for analyses, and thus, as illustrated in Table 5, some of the surficial contamination was removed. In addition, the greater biological activity of ^{137}Cs increased the fertilization effect, and thus a significant difference was found for ^{137}Cs but not for Pu.

For ^{238}Pu, the washing did not remove all the activity on the peel (Table 7), with the ^{238}Pu concentration in meat being only 20% of the concentration in peel. We attribute the difference to surficial contamination, although biologically active Pu could have been preferentially deposited in the peel of the fruit rather than the meat. The difference in ^{239}Pu concentration between the peel and the meat of the fruits was not significant (p = 0.48, Table 8), which suggests that there was little con-

Table 8—Analysis of variance for squash fruit.

Source	Radionuclide	Sum of squares	Degrees of freedom	F	Significance	Multivariate significance
Fertilization	^{238}Pu	8.0×10^{-4}	1	2.053	0.174	
	^{239}Pu	1.2×10^{-4}	1	0.736	0.405	0.238
	^{137}Cs	2.9×10^{2}	1	4.245	0.058	
Plants within fertilization	^{238}Pu	5.4×10^{-3}	14			
	^{239}Pu	2.2×10^{-3}	14			
	^{137}Cs	9.6×10^{2}	14			
Fruit within plants	^{238}Pu	6.0×10^{-3}	16			
	^{239}Pu	2.6×10^{-3}	16			
	^{137}Cs	2.0×10^{2}	16			
Peeling	^{238}Pu	6.5×10^{-3}	1	19.770	<0.001	
	^{239}Pu	6.0×10^{-5}	1	0.527	0.480	0.006
	^{137}Cs	8.7×10^{1}	1	10.174	0.007	
Peeling × fertilization	^{238}Pu	4.0×10^{-5}	1	0.136	0.715	
	^{239}Pu	9.0×10^{-5}	1	0.505	0.483	0.261
	^{137}Cs	4.4×10^{1}	1	3.385	0.075	
Peeling × plants within fertilization	^{238}Pu	4.6×10^{-3}	14			
	^{239}Pu	2.2×10^{-3}	14			
	^{137}Cs	1.2×10^{2}	14			
Peeling × fruits within plants	^{238}Pu	5.4×10^{-3}	16			
	^{239}Pu	2.7×10^{-3}	16			
	^{137}Cs	1.8×10^{2}	16			

tamination by Pu, and that any difference in concentration was obscured by variation due to the fallout background. Concentration of ^{239}Pu was only 20% of that for ^{238}Pu in the soil (Table 2).

In contrast, both fertilization and peeling the fruit produced significant differences (Table 8) for ^{137}Cs. The decrease in ^{137}Cs concentrations due to fertilization (Table 7) can be attributed to the increase of K in the fertilized plot, although the effect was only marginally significant ($p = 0.058$, Table 8). The greater concentration of ^{137}Cs in the peel vs. the meat (Table 7) may be explained by surficial contamination that was not removed by wash treatment. The higher concentrations of ^{137}Cs allowed smaller differences to be detected than for Pu.

Concentration Ratios

The dimensionless ratio of concentration in plant tissue to concentration in soil was calculated for the five plant tissues analyzed in this study (Table 9). Combined cell means were used for each tissue, thus the concentration ratio varied for fertilized vs. unfertilized plots, washed vs. unwashed, and lower vs. upper strata. These concentration ratios were calculated using the soil data in Table 2 and tissue data from Tables 3, 5, and 7. All of the statistical results discussed for Tables 4, 6, and 8 apply to the concentration ratios, as the only difference in the data is the constant factor, soil concentration.

In Table 9, we see that the largest concentration ratios for Pu were in squash plants, followed by bean plants. We would expect these results, as squash plants are better collectors of soil than bean plants because of their large flat leaves close to the ground surface.

The ^{137}Cs concentration ratios were always greater than those for Pu (Table 9), substantiating the fact that ^{137}Cs is biologically more active than Pu. Because greenhouse studies have shown that biological uptake is <1% of the total Pu content of vegetation (ERDA, 1976), we can use the concentration ratios in Table 9 to partition the amount of ^{137}Cs splashed up on the plant

Table 9—Concentration ratios (pCi/g dry weight vegetable ÷ pCi/g dry weight soil) for various plant tissues from the Mortandad garden plot.

Tissue	^{238}Pu	^{239}Pu	^{137}Cs
Bean plant	7.2×10^{-2}	5.8×10^{-2}	1.5×10^{-1}
Bean fruit	2.9×10^{-2}	2.4×10^{-2}	5.1×10^{-2}
Squash plant	1.2×10^{-1}	9.7×10^{-2}	2.5×10^{-1}
Squash peel	2.0×10^{-2}	2.6×10^{-2}	8.3×10^{-2}
Squash meat	4.0×10^{-4}	2.1×10^{-3}	6.1×10^{-2}

as opposed to the amount taken up biologically. The squash plant data are taken as an example to illustrate the calculations. The average concentration ratio for Pu was about 0.11, while the concentration ratio for ^{137}Cs was 0.25. Thus if no biological uptake were present for ^{137}Cs, we would expect a concentration ratio of 0.11 as for Pu. Instead, the concentration ratio of 0.25 suggests that 43% of the ^{137}Cs on the squash plant was due to splash-up, while 60% was due to biological uptake. Similar calculations for bean plants, bean fruits, squash peel, and squash meat gave the percent of ^{137}Cs splashed onto the tissue as 43, 52, 28, and 2, respectively. These values illustrate that about 45% of the ^{137}Cs on the unwashed plant material was due to splash-up. The squash fruits were washed as in normal food preparation, so the amount of ^{137}Cs remaining on the peel surface was lower than for the unwashed plants. The 2% figure for squash meat illustrates the obvious—nothing was splashed into squash meat.

Radiation Doses

Radiation doses to humans consuming vegetables from the garden plot were calculated for all vegetable combinations. Doses from zucchini squash (meat only) and for green beans from the unfertilized plot are presented in Table 10. Unfertilized plot data were chosen because contamination concentrations were higher than in the fertilized plot. Thus, calculated doses represent the upper portion of the range of calculated doses. Doses were dominated by the ^{137}Cs contamination. The

Table 10—Estimated radiation doses to humans from ingestion of garden vegetables grown in the unfertilized garden plot contaminated with $^{238,239}Pu$ and ^{137}Cs.

Vegetable	Annual ingestion†	1st-year dose‡			50-year dose commitment‡		
		Total body	Bone	Liver	Total body	Bone	Liver
	kg	mrem					
Zucchini squash	0.23	2.5×10^{-3}	2.5×10^{-3}	4.2×10^{-3}	4.0×10^{-3}	4.7×10^{-3}	6.3×10^{-3}
Green beans	0.68	1.6×10^{-2}	1.6×10^{-2}	2.8×10^{-2}	2.7×10^{-2}	4.2×10^{-2}	4.4×10^{-2}

† Ingestion rates taken from USDA, 1978.
‡ Radiation Dose Factors (mrem/μCi intake) taken from Corley et al., 1977; concentrations of ^{137}Cs and $^{238,239}Pu$ in vegetables taken from Tables 3 and 7. Calculated dose includes contributions from both ^{137}Cs and $^{238,239}Pu$.

only place where $^{238,239}Pu$ made a significant contribution (38%) was in the 50-year dose commitment to bone from green bean ingestion. As can be seen from the data, doses are extremely low and represent no hazard. The largest total body dose in the table (0.027 mrem) is equivalent to the dose received from cosmic radiation in 7 min from flying at typical jet aircraft altitude of 9,144 m (30,000 feet). This dose represents 0.23% of the estimated 138 mrem Los Alamos residents received from natural radiation in 1979 (Environmental Surveillance Group, 1979).

SUMMARY AND CONCLUSIONS

The results of this study demonstrate that a major source of contamination of green beans and zucchini squash by ^{137}Cs and $^{238,239}Pu$ was due to soil on the plant surfaces. The lower portions (0–20 cm) of zucchini and squash plants were contaminated about four times the higher portions (>20 cm). About 65% of the contamination on zucchini squash plants could be washed off with normal food preparation techniques. Fertilization of the garden plot with cattle manure reduced contamination by about 30% for Pu and even greater (about 50%) for ^{137}Cs. The reduction due to fertilization is attributed to a stabilization of the soil surface, and, in the case of ^{137}Cs, reduction in ^{137}Cs uptake in the plant was due to increased K concentrations.

Fifty-year radiation doses to humans consuming vegetables from the garden plot would be <0.05 mrem and would be due almost entirely to ^{137}Cs.

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LITERATURE CITED

1. Adriano, D. C., J. C. Corey, and R. C. Dahlman. 1980. Plutonium content of field crops in the southeastern United States. p. 381–402. *In* W. C. Hanson (ed.) Transuranic elements in the environment. U.S. Dep. of Energy Rep. no. DOE/TIC22800, Washington, D.C.
2. Cohen, E., and P. Burns. 1977. SPSS-MANOVA multivariate analysis of variance and covariance. Document no. 413 (revision A). Vogelback Computing Ctr., Northwestern Univ., Chicago.
3. Corley, J. P., D. H. Denham, P. E. Michels, A. R. Olsen, and E. A. White. 1977. A guide for environmental radiological surveillance at ERDA installations. Energy Res. and Dev. Admin., Rep. no. ERDA 77-24. Washington, D.C.
4. Environmental Surveillance Group. 1979. Environmental surveillance at Los Alamos during 1979. LA-8200-ENV. Los Alamos Natl. Lab., Los Alamos, N. Mex.
5. Hakonson, T. E. 1975. Environmental pathways of plutonium into terrestrial plants and animals. Health Phys. 29:583–588.
6. Little, C. A., and F. W. Whicker. 1978. Plutonium distribution in Rocky Flats soil. Health Phys. 34:451–457.
7. Morrison, D. F. 1976. Multivariate statistical methods. 2nd ed. McGraw-Hill, New York. p. 233.
8. Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Brent. 1975. SPSS-statistical package for the social sciences. 2nd ed. McGraw-Hill, New York.
9. Nyhan, J. W., F. R. Miera, Jr., and R. J. Peters. 1976. Distribution of plutonium in soil particle size fractions of liquid effluent-receiving area at Los Alamos. J. Environ. Qual. 5:50–56.
10. Price, K. R. 1973. A review of transuranic elements in soil, plants, and animals. J. Environ. Qual. 2:62–66.
11. Schreckhise, R. G., and J. F. Cline. 1980. Comparative uptake and distribution of plutonium, americium, curium and neptunium in four plant species. p. 361–370. *In* W. C. Hanson (ed.) Transuranic elements in the environment, U.S. Dep. of Energy, Rep. no. DOE/TIC-22800. Washington, D.C.
12. Schulz, R. K. 1977. Root uptake of transuranic elements. p. 231–330. *In* M. G. White and P. B. Dunaway (ed.) Transuranics in natural environments. NVO-178, Nevada Applied Ecology Group, Las Vegas, Nev.
13. Soltanpour, P. N., S. M. Workman, and A. P. Schwab. 1979. Use of inductively coupled plasma spectrometry for the simultaneous determination of macro- and micro nutrients in NH_4HCO_3-DTPA extracts of soils. Soil Sci. Soc. Am. J. 43:75–78.
14. U.S. Department of Agriculture. 1978. Food consumption prices, and expenditures. Supplement to the 1976 Agriculture Economic Report no. 138. USDA, Washington, D.C.
15. U.S. Department of Energy. 1979. Final Environmental Impact Statement Los Alamos National Laboratory, Los Alamos, New Mexico. U.S. Dep. of Energy Rep. no. DOE/ETS-0018. Washington, D.C.
16. U.S. Energy and Research Development Administration. 1976. Environmental research for transuranic elements. Proc. Workshop on Environ. Res. for Transuranic Elements. ERDA-76/134. Energy Res. and Dev. Admin., Washington, D.C.
17. Watters, R. L., D. N. Edgington, T. E. Hakonson, W. C. Hanson, M. H. Smith, F. W. Whicker, and R. E. Wildung. 1980. Synthesis of research literature. p. 1–44. *In* W. C. Hanson (ed.) Transuranic elements in the environment. U.S. Dep. of Energy, Rep. no. DOE/TIC-22800. Washington, D.C.
18. Winer, B. J. 1971. Statistical principles in experimental design. 2nd ed. McGraw-Hill, New York.