

3. SAMPLING AND ANALYTICAL PROGRAM

This section summarizes the sampling and analytical program conducted by Science Applications International Corporation (SAIC) at the Deseret Chemical Depot (DCD). The sampling and analytical program was conducted as part of the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the Group 3 suspected releases solid waste management units (SWMUs). The sampling methodology, general field investigation procedures, planned and actual field activities, laboratory chemical analysis program, and data quality assessment are discussed.

3.1 SAMPLING METHODOLOGY

The Phase II RFI field investigation program was designed to characterize the environmental setting, define the nature and extent of contamination, and complete human health and ecological risk assessments. Field investigation activities at the Group 3 SWMU were conducted at various times from 1982 (pre-Phase I) through 2000 (Phase IIB). The Phase II field investigation activities performed by SAIC were initiated in 1994 and conducted during three phases (Phase II [1994-95], Phase IIA [1998-99], and Phase IIB [2000]). Table 3-1 presents the chronology, scope of activities, and rationale for each Group 3 SWMU investigation phase (pre-Phase I through Phase IIB), in addition to background sampling activities. Each additional phase of field investigation activities was conducted to gain additional historical site information, further define the extent of identified contamination, and respond to Utah Department of Environmental Quality (UDEQ) comments on the RFI data reports. References in this section to Phase II include activities also conducted during Phases IIA and IIB unless specifically noted.

Data obtained during previous investigations were incorporated into the Phase II analysis and evaluation of the five Group 3 SWMUs. The majority of the ecological information and data used to prepare the ecological risk assessment were obtained from previous ecological field investigations. The ecological data were used in conjunction with the SWMU-specific chemical data collected during the Group 3 Phase I and Phase II field activities. The human health risk assessment also addresses the SWMU-specific chemical data collected during the Group 3 Phase I and Phase II field activities.

The Group 3 Phase II field investigation program was conducted in accordance with the DCD Well Drilling and Installation Plan (TEAD 1993a); the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) Quality Assurance Program, PAM 11-41, January 1990 for environmental sample collection and analysis; and the Data Collection Quality Assurance Plan (DCQAP) (SAIC 1995a), DCQAP Addendum 1 (SAIC 1999a) and DCQAP Addendum 2 (SAIC 1999b) that were specifically prepared for the Group 3 Phase II, IIA, and IIB investigations, respectively. Soil and groundwater samples collected during Phases I and II, and Phase IIA groundwater samples were analyzed using USATHAMA analytical methods. The additional mercury soil samples, which were collected at SWMU 33 in October 1995, and the soil samples collected during Phases IIA and IIB, were analyzed according to U.S. Environmental Protection Agency (EPA) SW846 methods. The DCQAP was reviewed and approved by DCD, the U.S. Army Environmental Center (USAEC), and UDEQ prior to initiation of field activities. All parties participated in the scoping of each phase of the Group 3 RFI field activities.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah**

SWMU	Phase/Year Conducted	Activity	Rationale
Background	Group 1 SWMU Phase I/ 1990-1992 (EBASCO) Group 2 SWMU Phase II/ 1990-1992 (Rust) Group 3 SWMU Phase IIB/ 2000 (SAIC)	<ul style="list-style-type: none"> • Collected composite soil samples from 0 to 3 feet BLS at 10 background locations in the northeastern portion of the installation; analyzed for metals. • Collected soil samples from 0 to 2 inches and 2 to 3 feet BLS at 10 background locations in the southeastern portion of the installation; analyzed for metals. • Collected groundwater samples from monitoring wells located upgradient of SWMU under investigation. • Collected soil samples from 0 to 0.5, 5, and 10 feet BLS at 10 background locations in the northwestern portion of the installation; analyzed for metals. 	<ul style="list-style-type: none"> • Identify the naturally occurring inorganic concentrations in soil and groundwater. • Bolster the existing background data base with soil samples collected in the area of the Group 3 SWMUs.
SWMU 11	Pre-Phase I/ 1982, 1987, 1988 (ERTEC, NUS, EAES&T) Phase I/ 1990-1992 (EBASCO) Phase II/1994-95 (SAIC)	<ul style="list-style-type: none"> • Installed/sampled monitoring well S-3; analyzed for VOCs, SVOCs, agent breakdown products, explosives, and metals. • Collected sediment sample along western boundary (S-SD3). • Installed monitoring wells S-45-90, S-46-90, S-74-90, and S-75-90 southwest and downgradient from SWMU 11; analyzed samples from all wells for VOCs, SVOCs, agent breakdown products, explosives, and metals. • Conducted UXO survey. • Collected 20 surface (0 to 0.5 feet BLS) soil samples and 20 subsurface (2 feet BLS) soil samples; analyzed for VOCs, metals, cyanide, and agent breakdown products; analyzed 21 of the 40 samples for SVOCs and PCBs. • Conducted two rounds of groundwater sampling from the five existing SWMU 11 monitoring wells; analyzed for VOCs, SVOCs, metals, cyanide, PCBs, and agent breakdown products. 	<ul style="list-style-type: none"> • Determine if contaminants are present in the groundwater downgradient from SWMU 11. • Determine if contaminants are migrating from SWMU 11. • Determine if contaminants are present in the groundwater downgradient from SWMU 11. • Fulfill RCRA permit requirement; evaluate potential presence of UXO. • Determine if residual chemical constituents are present from potential past spills/releases. • Determine if contaminants are present in the groundwater downgradient from SWMU 11.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah (Continued)**

SWMU	Phase/Year Conducted	Activity	Rationale
SWMU 11 (Continued)	Phase IIA/1998 (SAIC)	<ul style="list-style-type: none"> Conducted one round of groundwater sampling from the five existing SWMU 11 monitoring wells; analyzed for VOCs, SVOCs, metals, cyanide, PCBs, explosives, and agent breakdown products. Identified the location and delineation of vegetation within 500 feet of the SWMU. 	<ul style="list-style-type: none"> Inconsistent results between first two sampling events.
	Groundwater Monitoring/1999 (Kleinfelder)	<ul style="list-style-type: none"> Conducted groundwater sampling of monitoring wells S-3, S-46-90, S-74-90, and S-75-90; analyzed for VOCs, SVOCs, and explosives. 	<ul style="list-style-type: none"> Establish groundwater quality data base.
SWMU 19	Phase I-A/1990-1992 (EBASCO)	<ul style="list-style-type: none"> Collected SOV samples from six locations; analyzed for benzene, toluene, xylene, dichloroethylene, tetrachloroethylene, and trichloroethylene. Collected two soil samples; analyzed for VOCs, SVOCs, TPH, and metals. 	<ul style="list-style-type: none"> Preliminary evaluation for potential contaminants based on SWMU history. Confirm SOV results.
	Phase I-B/1990-1992 (EBASCO)	<ul style="list-style-type: none"> Collected seven soil samples from within and below sumps and between railroad tracks; analyzed for PCBs and VOCs. Collected one sediment sample from the former sump; analyzed for VOCs and PCBs. 	<ul style="list-style-type: none"> Determine if contaminants are present as a result of past site practices. Determine if contaminants were discharged from the former building into the septic system.
	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none"> Conducted UXO survey. Conducted SOV survey at 28 sampling locations and collected a total of 162 samples; analyzed samples for aromatic hydrocarbons, chlorinated hydrocarbons, and TPH. Drilled seven soil borings in vicinity of Building 533's foundation and septic tank; boring depths ranged from 22 to 40 feet BLS. Collected three samples from each boring; analyzed for VOCs, SVOCs, and PCBs. Collected one sludge sample from septic holding tank; analyzed for VOCs, SVOCs, and PCBs. 	<ul style="list-style-type: none"> Fulfill RCRA permit requirement; evaluate potential presence of UXO. Preliminary screening to define extent of organic contamination and focus confirmatory soil sampling locations. Determine extent of contamination. Determine if contaminants were discharged from the former building into the septic system; confirm Phase I results.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah (Continued)**

SWMU	Phase/Year Conducted	Activity	Rationale
SWMU 19 (Continued)	Phase II/1994-95 (SAIC) (Continued)	<ul style="list-style-type: none"> • Installed four groundwater monitoring wells in the area of Building 533 (S-113-94, S-114-94, S-115-94, and S-116-94). Conducted two rounds of groundwater sampling from all SWMU 19 wells; analyzed for VOCs, SVOCs, and PCBs. • Conducted aquifer recharge testing on all four monitoring wells at SWMU 19. 	<ul style="list-style-type: none"> • Determine if site contaminants migrated into groundwater.
	Phase IIA/1998 (SAIC)	<ul style="list-style-type: none"> • Conducted one round of groundwater sampling from all SWMU 19 wells; analyzed for VOCs, SVOCs, PCBs, and water quality parameters. Identified the location and delineation of vegetation within 500 feet of the SWMU. 	<ul style="list-style-type: none"> • Evaluate the aquifer characteristics in the area of SWMU 19. • Inconsistent results between Phase II groundwater sampling events.
	Groundwater Monitoring/1998, 1999 (Kleinfelder)	<ul style="list-style-type: none"> • Conducted groundwater sampling of monitoring wells S-115-94 (1998, 1999) and S-116-94 (1999); analyzed for water quality parameters (S-115-94) (1998), and VOCs, SVOCs, and explosives (S-115-94, S-116-94) (1999). 	<ul style="list-style-type: none"> • Establish groundwater quality data base.
SWMU 20	Phase I/1990-1992 (EBASCO)	<ul style="list-style-type: none"> • Collected one sludge sample from a septic holding tank associated with Building 520; analyzed for VOCs, SVOCs, agent breakdown products, and metals. 	<ul style="list-style-type: none"> • Determine if contaminants were discharged from the former building into the septic system.
	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none"> • Conducted UXO survey. 	<ul style="list-style-type: none"> • Fulfill RCRA permit requirement; evaluate potential presence of UXO.
	Phase IIA/1998 (SAIC)	<ul style="list-style-type: none"> • Drilled two soil borings to 20.5 feet BLS in the vicinity of the septic tank; collected two samples from each boring at 10 and 20 feet BLS; analyzed for SVOCs, PCBs, metals, and cyanide. • Conducted site reconnaissance (records review, personnel interviews). 	<ul style="list-style-type: none"> • Determine if contaminants had leaked from the septic tank and migrated into the subsurface soils. • Obtain more detailed information on the history and operations of Building 520 that may have contributed to contaminants discharged to the associated septic tank and leach field.
		<ul style="list-style-type: none"> • Collected samples of sludge in septic tank (Structure 521); analyzed samples for TCLP VOCs, TCLP SVOCs, TCLP metals, and agent breakdown products. • Identified the location and delineation of vegetation within 500 feet of the SWMU. 	<ul style="list-style-type: none"> • Determine if contaminants were discharged from the former building into the septic system; confirm Phase I results.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah (Continued)**

SWMU	Phase/Year Conducted	Activity	Rationale
SWMU 20 (Continued)	Phase IIB/2000 (SAIC)	<ul style="list-style-type: none">• Unearthed effluent pipe from building septic tank; segregated the soil collected from above the pipe; analyzed sample of pipe and soil above pipe for TCLP VOCs, TCLP SVOCs, and TCLP metals.• Collected soil samples at 10-foot intervals along the length of the pipe from 0 to 6 inches and 5 and 10 feet below the pipe; analyzed all samples for VOCs and SVOCs.	<ul style="list-style-type: none">• Locate the leach field associated with the former septic tank.• Sampling conducted because of the presence of a listed chemical (MEK) identified in septic tank sludge during Phase I.• Determine if discharge water from the septic tank has contaminated the effluent pipe and/or subsurface soils.• Determine if effluent pipe and/or subsurface soils are TCLP hazardous.
SWMU 33 Inside Building 536	Phase I/1992 (EBASCO)	<ul style="list-style-type: none">• Collected six surface soil samples; analyzed for agent breakdown products and metals.	<ul style="list-style-type: none">• Determine if drums stored in the building had leaked into the surface soils.
	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none">• Collected 15 surface (0 to 0.5 feet BLS) and seven subsurface (0.5 to 1 feet BLS); analyzed for metals, cyanide, and agent breakdown products.	<ul style="list-style-type: none">• Collect additional samples throughout building to define extent of agent breakdown contamination.
	Phase IIA/1999 (SAIC)	<ul style="list-style-type: none">• Drilled/sampled 19 borings; collected samples at depths ranging from 0.5 to 15 feet BLS; analyzed for metals, cyanide, and agent breakdown products.	<ul style="list-style-type: none">• Further define the extent of agent breakdown contamination identified in Phases I and II.
SWMU 33 Outside Building 536	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none">• Conducted UXO survey.• Collected seven surface and four subsurface soil samples; analyzed for metals, cyanide, and agent breakdown products.• Collected 13 additional surface soil samples outside Building 536; analyzed for mercury.	<ul style="list-style-type: none">• Fulfill RCRA permit requirement; evaluate potential presence of UXO.• Determine if agent breakdown products had migrated outside Building 536.• Define the extent of mercury detected during initial sampling outside the building.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah (Continued)**

SWMU	Phase/Year Conducted	Activity	Rationale
SWMU 33 Outside Building 536 (Continued)	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none"> • Conducted SOV survey at 20 locations in vicinity of drainage swale south of Building 536; collected samples from 10 feet BLS; analyzed for chlorinated hydrocarbons, aromatic hydrocarbons, and TPH. • Excavated 8 test pits to 10 feet BLS within drainage swale; collected 4 soil samples from surface to 10 feet BLS in each test pit; analyzed for metals, cyanide, VOCs, SVOCs, PCBs, explosives, and agent breakdown products. 	<ul style="list-style-type: none"> • Determine if contaminants are present as a result of past site practices. • Determine if contaminants are present as a result of past site practices.
	Phase IIA/1999 (SAIC)	<ul style="list-style-type: none"> • Drilled/sampled nine borings north of Building 536; collected samples at depths ranging from 0.5 to 5 feet BLS; analyzed for mercury. • Identified the location and delineation of vegetation within 500 feet of the SWMU. 	<ul style="list-style-type: none"> • Further delineate the extent of mercury contamination identified north of Building 536.
	Phase IIB/2000 (SAIC)	<ul style="list-style-type: none"> • Drilled and sampled 18 boring locations in a grid pattern north of Building 536. • Collected samples at 2 locations north of Blume Street and 16 locations south of Blume Street from 0 to 6 inches, 1 foot, 5 feet, and 10 feet BLS (SB-33B-39 through SB-33B-55); collected samples from previous location SB-33B-37 at 10 feet BLS; analyzed all samples for mercury. 	<ul style="list-style-type: none"> • Further delineate the vertical and horizontal extent of mercury contamination. Locations compliment previous Phase II and Phase IIA results and fill existing data gaps.
SWMU 37	Phase I/1990-1992 (EBASCO)	<ul style="list-style-type: none"> • Drilled five soil borings at surface (0 to 0.5 feet BLS), 1 foot BLS, and 3 feet BLS; analyzed for VOCs, SVOCs, metals, and explosives. • Conducted UXO survey. 	<ul style="list-style-type: none"> • Determine if contaminants are present as a result of past site practices. • Fulfill RCRA permit requirement; evaluate potential presence of UXO.
	Phase II/1994-95 (SAIC)	<ul style="list-style-type: none"> • Excavated two test pits to native soils at slag pile locations (approximately 1.5 feet below the surface of the slag piles); collected four samples from each test pit (two from the slag material and two from native material); analyzed native material for SVOCs, PCBs, metals, cyanide, and explosives. • Containerized and analyzed slag for TCLP metals, TCLP SVOCs, cyanide, PCBs, and explosives; disposed of slag in onsite landfill. 	<ul style="list-style-type: none"> • Determine if contaminants associated with slag had migrated into the subsurface soils. • Remove nonhazardous slag from site.

**Table 3-1. Group 3 SWMU Field Investigation Activities and Rationale
Deseret Chemical Depot, Tooele, Utah (Continued)**

SWMU	Phase/Year Conducted	Activity	Rationale
SWMU 37 (Continued)	Phase II/1994-95 (SAIC) (Continued)	<ul style="list-style-type: none">• Sampled 10 soil borings at surface (0 to 0.5 feet BLS) and 3 feet BLS; analyzed for SVOCs, PCBs, metals, cyanide, and explosives.	<ul style="list-style-type: none">• Determine if contaminants are present as a result of past site practices.
	Phase IIA/1999 (SAIC)	<ul style="list-style-type: none">• Drilled/sampled 10 test pits in area of metal debris/bomb fragments; collected samples from 0.5 to 5 feet BLS; analyzed for metals and explosives.• Identified the location and delineation of vegetation within 500 feet of the SWMU.	<ul style="list-style-type: none">• Determine if contaminants are present in the area of metal debris and stressed surface vegetation. Determine the nature and extent of contamination associated with metal debris.
	Phase IIB/2000 (SAIC)	<ul style="list-style-type: none">• Collected samples from 10 and 15 feet BLS at six previous test pit excavation locations (SB-37-012, SB-37-015, SB-37-016, SB-37-017, SB-37-018, and SB-37-019); analyzed all samples for metals.• Excavated exploratory test pits to delineate the extent of thermate bomb disposal trench.	<ul style="list-style-type: none">• Determine vertical extent of magnesium identified in Phase IIA at sample locations where the deepest samples exceed the Phase IIA background UTL₉₅ (16,260 µg/g).• Identify the vertical and horizontal extent of thermate bomb disposal trench.

Adherence to the requirements outlined in these documents helped ensure that the project data quality objectives (DQOs) were met. Based on U.S. Environmental Protection Agency (EPA) guidance for environmental studies, the DQOs for the Group 3 Phase II RFI activities included precision, accuracy, representativeness, comparability, and completeness (PARCC). During the course of the Phase II RFI, all activities and analyses were conducted using standard procedures so that known and acceptable PARCC properties were achieved. Data use requirements indicated that the minimum appropriate analytical level was equivalent to EPA DQO Level III. Section 3.4 presents a detailed assessment of data quality.

Field investigation activities that were conducted to help meet the project requirements included:

- Unexploded ordnance (UXO) evaluation (all Group 3 SWMUs)
- Soil organic vapor (SOV) sampling and analysis (SWMU 19 and 33)
- Soil boring, test pit excavation, and surface and subsurface soil sampling and analysis (all Group 3 SWMUs)
- Site reconnaissance (records search and personnel interviews) (SWMU 20 and 37)
- Slag containerization (SWMU 37)
- Sludge sampling and analysis (SWMU 19 and 20)
- Monitoring well installation and groundwater sampling and analysis (SWMU 11 and 19)
- Rising head permeability aquifer tests (i.e., slug tests) (SWMU 11 and 19)
- Topographic survey (SWMU 11 and 19).

The field investigation activities required the services of various specialty subcontractors. These subcontractors provided their expertise prior to, during, and following completion of the field program. These specialty subcontractors and their roles are as follows:

- ***Human Factors Applications, Inc. (HFA); UXB International, Inc. (UXB), American Technologies, Inc. (ATI)***—UXO evaluation and test pit excavation/UXO screening
- ***Transglobal Environmental Geochemistry (TEG)***—SOV sampling and analysis
- ***Layne Environmental Services, Inc.***—Soil boring and monitoring well drilling and installation
- ***Delta Geotechnical Consultants, Inc.***—Geotechnical analysis
- ***DataChem Laboratories, Inc. (DCL)***—Laboratory analytical services
- ***QST (formerly Environmental Science and Engineering, Inc. [ES&E])***—Laboratory analytical services
- ***Dan's Field Service***—Monitoring well development/purging, direct push soil boring, groundwater sampling, and test pit excavation

- *Hill, Jamison & Associates*—Monitoring well surveying
- *Safety Kleen*—Investigation-derived waste (IDW) transport and disposal
- *DCD Chemical Surety*—Chemical agent screening.

3.1.1 Sample Selection

The selection of the type of sampling activities and sample locations was based on the history of the SWMU, type of materials handled, and results of previous investigations. The type, quantity, and quality of the data that would ensure meeting the objectives of the RFI and project DQOs also were considered.

3.1.2 Parameter Selection

Target compound and element lists were prepared to account for the specific requirements and criteria of each SWMU. These chemicals were identified based on the history of the operations at the SWMU, contaminants that could be expected based on these past operations, results of previous investigations, and input from DCD, USAEC, and UDEQ. Table 3-2 summarizes the types of samples that were collected at each Group 3 SWMU and the associated analytical parameters.

3.2 GENERAL FIELD INVESTIGATION PROCEDURES

The DCD Well Drilling and Installation Plan (TEAD 1993a) was used as the guidance document to establish the procedures for multi-media sampling conducted during the Group 3 Phase II RFI field investigation. This document was developed to identify requirements for drilling, data acquisition, and report preparation for environmental investigations conducted at the installation. The requirements were incorporated into SAIC's standard operating procedures (SOPs) and the procedures and specifications outlined in the DCQAP (SAIC 1995a), DCQAP Addendum 1 (SAIC 1999a), and DCQAP Addendum 2 (SAIC 1999b).

This section summarizes the field procedures followed during sampling of various media; drilling and excavation of soil borings; monitoring well installation and sampling; ecological, land, and UXO surveys; sample handling; and management of IDW. If the field investigation procedures and specifications outlined in the DCQAP and associated addenda were followed, they are not detailed in the following sections. This section presents an overview of the procedures and any deviations.

3.2.1 Soil Organic Vapor Sampling

SOV surveys were conducted by TEG at SWMU 19 and 33 to help determine the vertical and horizontal extent of volatile organic compounds (VOCs) identified during Phase I and provide field data that would be used to locate soil borings. Figure 3-1 shows the locations of SOV sampling points for SWMU 19 and 33. Soil vapor probes were hydraulically driven with samples collected at 5-foot intervals from 5 to 50 feet below land surface (BLS) using

**Table 3-2. Group 3 Phase II RFI Analytical Parameters and Methods
Deseret Chemical Depot, Tooele, Utah**

Parameters ^a	EPA		USAEC	
	Soil	Water	Soil	Water
VOCs	SW8260	SW8260	LM19	UM20
SVOCs	SW8270	SW8270	LM18	UM18
Explosives	SW8330/8332	SW8330/8332	LW12	UW19/UW32
PCBs	SW8082	SW8082	LH16	UH02
Agent Breakdown Products ^b	N/A	N/A	LT04/LL09/ LW18/LT03	UT04/UL09/ UT03/UW22
Metals:				
ICP ^c	SW6010	SW6010	JS16	SS10/SS18
Zinc	SW6010	SW6010	JS16	N/A
Trace ICP (As, Se, Pb, Tl)	SW6010	SW6010	JD19/JD15/JD17	SD22/SD21/SD20/S303
Mercury	SW7471	SW7470	JB01	SB01
Cyanide	SW9012	SW9012	KY01	TF18
Acidity	N/A	E305.1	N/A	N/A
Alkalinity	N/A	E310.1	N/A	N/A
Specific Conductance	N/A	E120.1	N/A	N/A
Hardness	N/A	E130.2	N/A	N/A
Carbonate/Bicarbonate	N/A	Calculation	N/A	N/A
Sulfate/Chloride	N/A	N/A	N/A	TT10
Total Phosphate	N/A	N/A	N/A	TF27
Nitrate/Nitrite	N/A	N/A	N/A	TF22
TOC	N/A	E415.1	N/A	N/A
BOD	N/A	E405.1	N/A	N/A
COD	N/A	E410.1	N/A	N/A
TDS	N/A	E160.1	N/A	N/A
pH	N/A	SW9040	N/A	N/A
TCLP	SW1311	N/A	N/A	N/A
Pesticides	SW8080	N/A	N/A	N/A
Herbicides	SW8151	N/A	N/A	N/A
Trace Metals	SW6010/SW7470	N/A	N/A	N/A

a The analytical parameters of interest are those listed in the original delivery order statement of work (Contract Number DAAA15-D-91-0017/0007).

b Chemical agent breakdown products are defined as follows:

HD breakdown products include: thiodiglycol

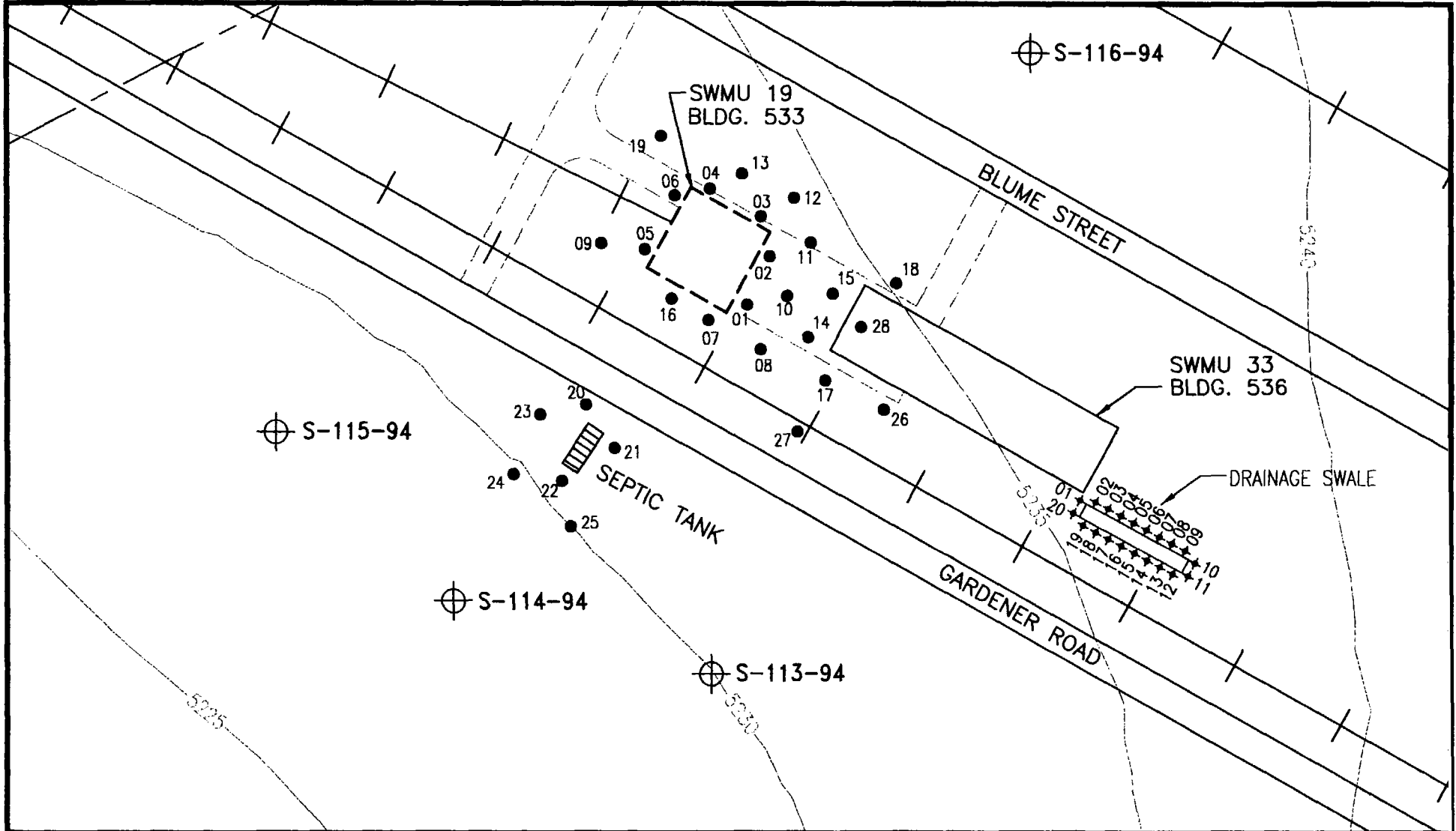
GB breakdown products include: isopropylmethyl phosphonic acid, methyl phosphonic acid, and fluoracetic acid

VX breakdown products include: ethylmethyl phosphonic acid

(There is not an EPA method for chemical agent breakdown products.)

c ICP metals – silver, aluminum, antimony, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, sodium, nickel, thallium, vanadium, and zinc.

3-11

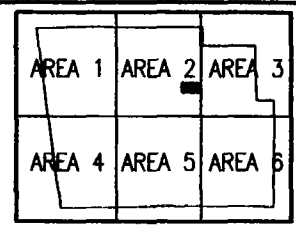
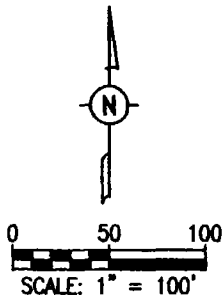


LEGEND:

- +++++..... RAILROAD
- EXIST. WATER LINES
- ABANDONED ROADS
- ELEVATION CONTOUR
- ⊕..... MONITORING WELL LOCATION
- SOIL GAS POINT
SWMU 19
- ◆..... SOIL GAS POINT
SWMU 33

NOTES:

1.) BASE MAP INFO. WAS SCANNED AND IS ACCURATE TO 1:1000.



KEY MAP
NOT TO SCALE



Deseret Chemical Depot
Tooele, Utah

PHASE II SOIL GAS LOCATIONS

Figure: 3-1	Project: 01-0827-03-6523-042	File: 7109/RFISGL	Date: NOV. 2000
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TEG's STRATAPROBE™ sample collection system for onsite analysis. SOV samples were collected by driving the probe to the desired sample depth, attaching an approximate ¼-inch inside diameter (I.D.) nyaflow tube to the drive rod, and extracting the sample using a 20 cubic centimeter (cc) syringe. Prior to sampling, three 20-cc volumes of soil gas were withdrawn from the tube and discarded. This purge volume ensures that representative samples were collected from each depth.

The sampling syringe was delivered to the onsite laboratory for direct injection into a gas chromatograph (GC) immediately following sample collection. Samples were analyzed for aromatic hydrocarbons (using EPA Method SW8020), halogenated hydrocarbons (using EPA Method SW8010), and total petroleum hydrocarbons (TPH) (using the California Department of Health Services modified EPA Method SW8015). The GC was equipped with a photoionization detector (PID) in series with an electron capture detector (ECD) on a megabore capillary column, and a flame ionization detector (FID) on a separate column. Appendix B provides information on the instrument specifications and quality control (QC) procedures that were followed during the SOV survey.

Initial SOV sample locations at SWMU 19 were placed around the foundation of former Building 533 and in close proximity to a septic holding tank associated with a septic system originating in former Building 533. The septic system runs below ground from former Building 533 in a southwesterly direction to the tank located due south across Gardener Road. Based on the analytical results of the initial SOV sampling points, subsequent SOV points were located in areas with the highest measured VOC concentrations to define further the horizontal extent of VOCs. Twenty-eight SOV locations were sampled at SWMU 19. Twenty SOV sampling points were sampled at SWMU 33 directly adjacent to a drainage swale southeast of Building 536; no additional borings were required to define the extent of contamination.

3.2.2 Soil Sampling

During the Phase II field investigation, soil samples were collected for chemical analysis at depths ranging from 0.5 to 40 feet BLS. This section presents the procedures used to collect samples from the surface (0 to 6 inches BLS) and shallow subsurface (0 to 4 feet BLS). These samples were collected by means other than drill/direct push rigs (e.g., hand tools). The sample collection methods identified below were used for either the surface or shallow subsurface samples depending on the site conditions (e.g., area not conducive for power-driven tools), soil type (e.g., soil dominated by gravels and/or cobbles, prohibiting the use of slide hammer), and/or depth (e.g., deeper sampling points inaccessible for hand tools). Specific sampling procedures were required for SWMU 11 because of the inherent risks associated with the chemical and biological agents stored at this SWMU.

All sampling equipment, tools, and sampling sleeves were decontaminated prior to use; all soil sample jars were glass with Teflon® septa and were certified clean by the manufacturer. Stainless steel sampling sleeves were used for soil samples identified for inorganic and/or organic analysis; brass sampling sleeves were used only for soil samples identified for organic analysis. The stainless steel sleeves were placed in the leading position to prevent material intended for inorganic analysis from contacting the brass sleeves. The sleeves were sealed with Teflon® tape and plastic end-caps and labeled. All sample containers were placed in a cooler and

maintained at 4°C ± 2°C pending shipment to the laboratory. All shipments were forwarded to the laboratory using overnight express. Site-specific details, boring logs, and specific sample depths were recorded in field logbooks for each sample point (see Appendix C). The sample collection techniques and methods that were used at the Group 3 SWMU are summarized below.

Hand Tools—Surface and shallow soil samples were collected using stainless steel sampling tools (e.g., spoons, hand augers, and trowels) and placed into stainless steel bowls. Samples designated for VOC analyses were placed directly into either a glass sample container or brass sampling sleeve. The remaining sample material was homogenized and placed into its respective sample container (i.e., glass jar or sampling sleeve).

Slide Hammer—Shallow soil samples were collected in a 6-inch core barrel sampler attached to a hand-operated slide hammer. As the sampler was driven into the soil, the sample material filled brass and stainless steel sampling sleeves that lined the core barrel.

Power Driven Hand Auger—A two-man power hand auger was used to drill to a desired sampling depth to facilitate collection of shallow soil samples and to penetrate densely compacted and/or cobble-ridden soil. Samples then were collected using either hand tools or a slide hammer. The power hand auger was constructed of an auger connected to a transmission adapter, drive-head assembly. The power hand auger combined the rotational action of the auger with downward pressure provided by the operator to advance the auger to the predetermined depth. Large cobbles or other obstacles that inhibited drilling with the power auger were removed using hand tools (i.e., digging bar and/or shovel).

SWMU 11 Specific Sampling Procedures—The specific sampling procedures and requirements for SWMU 11 were identified during the field investigation and are not presented in the DCQAP (SAIC 1995a). These procedures and requirements were developed and enforced by DCD:

- Original samples were collected using one of the techniques described above and maintained at 4°C under the custody of SAIC. The DCD Chemical Surety Chemist then was informed of the collection status.
- In the presence and under the supervision of the DCD Chemical Surety Chemist, SAIC opened each sample, removed a representative fraction of the sample from the sample container, and placed the sample fraction in a plastic bag. All sample containers then were closed and returned to the sample cooler.
- Fractions from all samples to be analyzed were homogenized within another plastic bag. The DCD Chemical Surety Chemist then assumed custody of sample splits and the cooler with the original samples. (Custody seals were applied to the sample cooler, and the cooler was locked in a building within SWMU 11.)
- DCD Chemical Surety forwarded a sample split from the homogenized split sample to Dugway Proving Grounds (DPG) to be analyzed for Lewisite. DCD Chemical Surety analyzed the sample for all chemical agents at SWMU 11 (e.g., Sarin and mustard agent) using a Miniature Chemical Agent Monitor (MINICAM) or an Automatic Air Monitoring System (ACAM) real-time monitor.

- DCD Chemical Surety and DPG identified no agent in any of the split samples collected at SWMU 11. All samples were released for offsite laboratory analysis. Samples containing chemical agent would have been retained by DCD. Appendix D presents the results of the chemical agent screening.

3.2.3 Soil Boring Drilling and Sampling

Subsurface soil samples (i.e., generally greater than 5 feet BLS) were collected using the following drilling methods: direct push, hollow stem, and percussion hammer. Hollow stem and dual-walled percussion hammer drilling techniques were conducted by Layne Environmental Services, Inc. of Salt Lake City during Phase II to collect samples from SWMU 19 and 20 at depths ranging from 20 to 40 feet BLS. Samples were collected during hollow stem and percussion hammer drilling using stainless steel split-spoons lined with brass and/or stainless steel sampling sleeves. The percussion hammer drilling method also was used to drill and install the monitoring wells; specific procedures related to this drilling method are presented in the DCQAP (SAIC 1995a) and summarized in Section 3.2.6.

Dan's Field Service of Salt Lake City conducted direct push drilling techniques during Phases IIA and IIB to collect samples to 15 feet BLS at background (inorganic analyses only) and SWMU 33 (mercury analyses only) locations. Direct push soil sampling was conducted using a small-diameter (1- to 3-inch outside diameter [O.D.]) steel probing tool or rod with a retractable drive point pushed or driven to the desired sampling depth. Once the sampling depth was reached, the probe or drive point was retracted and the sample collected. Downhole samples were collected in either 3- or 6-inch long stainless steel sleeves lining the sample rod. Appendix B of the DCQAP Addendum 2 outlines the procedures for direct push sampling (SAIC 1999b).

Samples collected in split-spoons lined with sample sleeves during hollow stem and percussion hammer drilling were handled according to the procedures outlined in Section 3.2.2 (i.e., stainless steel or brass depending on analytical parameter, Teflon[®] tape, plastic end caps). The sample material collected in the direct push stainless steel sleeves was extruded from the sleeve, homogenized, and placed in glass sample containers. This technique was viable because samples collected using direct push drilling techniques were not analyzed for VOCs. The locations of the soil borings were selected based on site history, previous sampling results, physical characteristics of the site (e.g., underground utilities and railroad tracks), and field screening results (i.e., SOV survey results). The depths where samples were collected for chemical analysis were chosen based on geologic/drilling conditions (e.g., adequate sample recovery), previous sampling results, and field screening results. Samples were collected from all of the soil borings for geologic/lithologic descriptions and chemical analysis. Boreholes were abandoned either by returning cuttings to the hole, filling with a cement/bentonite grout mixture, or filling with bentonite chips or pellets. Appendix C presents logs detailing the lithology and drilling activities for each soil boring.

3.2.4 Test Pit Excavation and Sampling

Test pits were categorized as sample locations where excavation was conducted using a backhoe. Test pits were excavated at SWMU 20 (septic line), 33 (drainage swale), and 37 (bomb disposal trench). Excavation activities at SWMU 20 during Phase IIB included unearthing the septic line and collecting samples at intervals along the line. Excavation in this area was necessary because the cobble-ridden soil prohibited the use of the direct push drill rig. After reaching the desired sample depth, soil was collected directly from the excavation bottom using stainless steel hand tools.

Sample points at the SWMU 33 drainage swale were excavated to 10 feet BLS. In addition to the UXO surface screening that was conducted prior to sampling activities at all SWMUs, UXO screening was conducted using a magnetometer at approximately every 2 feet in the test pit because of the unknown history of the drainage swale at SWMU 33. Samples at the SWMU 33 drainage swale were collected from the backhoe bucket using stainless steel hand tools. Excavated soil was returned to the original excavation pit.

Excavation activities were conducted at SWMU 37 during Phase IIB to determine the horizontal and vertical extent of a thermate bomb disposal trench. Test pits were excavated within the pit and samples collected at varying depths within and below the residual metal debris in the trench. After desired sample depths were reached, soil was collected from the excavation using a decontaminated stainless steel hand auger, transferred into a stainless steel bowl for homogenization, and then placed into respective sample containers. Test pits also were excavated throughout the area of the disposal trench to define the trench perimeter. Samples for chemical analysis were not collected from these exploratory test pits. All excavation activities at SWMU 37 were conducted and monitored by a UXO contractor. Excavated soil was returned to the original excavation pit.

3.2.5 Sludge Sampling

A sludge sample was collected from the bottom of the septic tank associated with SWMU 19 and 20. It was anticipated that a liquid sample would be collected from SWMU 19; however, no liquid was present while the field investigation activities were being conducted. The sludge was collected from the bottom of the SWMU 19 septic tank using the hand-operated slide hammer with an attached extension. Samples were collected in stainless steel and brass sampling sleeves according to the procedures outlined in Section 3.2.2. A sample was collected from the sludge in the SWMU 20 septic tank during Phase IIA using a decontaminated glass sample container with an extension arm.

3.2.6 Monitoring Well Installation, Development, and Sampling

Four monitoring wells were installed at SWMU 19 and sampled as part of the field investigation activities. Five existing monitoring wells associated with SWMU 11 also were sampled. The following sections detail the procedures that were used during the drilling, soil sampling, installation, and development of the new wells, and the purging and sampling of all of the wells. All of the monitoring well activities were conducted in accordance with the DCD

Well Drilling and Installation Plan (TEAD 1993a), DCQAP (SAIC 1995a), and DCQAP Addendum 1 (SAIC 1999a).

3.2.6.1 Monitoring Well Drilling

All four of the monitoring wells at SWMU 19 (S-113-94, S-114-94, S-115-94, and S-116-94) were drilled and installed by Layne Environmental Services, Inc. using the dual-walled percussion hammer drilling method. This method employed a diesel-powered, pile-driving hammer that advanced 20-foot sections of dual-walled casing using percussion as the driving force. Cuttings generated during these activities were discharged continuously from the borehole through a cyclone separator using compressed air. The vapors vented from the cyclone were monitored using a PID. The continuous removal of soil cuttings provided the potential for the field geologist to immediately identify zones of concern at the time they were encountered. The specific drilling procedures employed during the field investigation were the same as those outlined in the DCQAP (SAIC 1995a). Appendix C presents boring logs detailing the drilling and installation of the monitoring wells.

3.2.6.2 Monitoring Well Soil Sampling

Subsurface geology and stratigraphy were characterized by collecting and logging samples at 10-foot intervals, or at each change in subsurface lithology, during monitoring well installation. Samples were collected using 2-foot by 2½-inch split-spoons, or by collecting drill cuttings extruded at the cyclone (grab samples). Grab samples were collected at the cyclone when split-spoon sampling proved ineffective (i.e., strata contained very coarse gravels) or when the lithology had remained the same for greater than 10 feet. Samples collected from these boreholes were obtained for stratigraphic and geotechnical characterization; soil samples collected from these boreholes were not submitted for chemical analyses. All samples were screened for VOCs using a PID and logged to identify physical characteristics, including soil type, color, plasticity, angularity, and density. Upon completion of the sample examination, a portion of the sample was containerized and stored at DCD for archive purposes.

Seven of the soil samples collected during monitoring well installation subsequently were submitted to Delta Geotechnical Consultants, Inc. for geotechnical analysis. Samples identified for geotechnical evaluation were chosen based upon changes in lithology (i.e., different soil type), potential for geohydrological characterization (i.e., in the saturated zone), and availability (i.e., adequate sample recovery). Parameters for geotechnical evaluation included moisture content, Atterberg limits, grain size analysis, and Unified Soil Classification System (USCS) classification. The data from the geotechnical analysis were used to physically characterize the soils and to augment visual soil classifications made in the field. The samples collected for geotechnical analysis included:

- A sample from each saturated zone in monitoring well borings S-113-94 and S-115-94. Attempts were made to collect samples from the saturated zone aquifers in monitoring well borings S-114-94 and S-116-94; however, no sample could be collected because of the gravelly nature of the soils.

- A sample from sandy clay and sandy silt lithological units from monitoring well borings S-114-94, S-115-94, and S-116-94.
- A sample from the alluvial outwash material identified in well boring S-113-94.
- A sample from the 89-foot-thick clay layer encountered in well boring S-116-94.

Section 7.2 summarizes the geotechnical soil analysis results associated with these boreholes. Appendix E presents a complete set of the geotechnical laboratory data.

3.2.6.3 Monitoring Well Installation

Monitoring wells were installed according to the geotechnical specifications outlined in the DCD Well Drilling and Installation Plan (TEAD 1993a). These specifications differed from the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD) (EPA 1986) in the following specifications:

- The TEGD recommends that the monitoring well sand pack be placed no more than 2 feet above the top of the well screen. TEAD geotechnical specifications require a minimum of 5 feet of sand pack above the screen. For the monitoring wells installed during the Group 3 Phase II RFI, a minimum of 5 feet of sand was above the well screen.
- The TEGD recommends a sediment trap (sump) be placed below the monitoring well screen. TEAD geotechnical specifications do not allow a sump. A sump was not used on the monitoring wells installed during this investigation.

Monitoring wells were installed according to the procedures outlined in the TEAD Well Drilling and Installation Plan (TEAD 1993a) so as to maintain continuity with the procedures employed during previous investigations at DCD. These specifications and procedures were included in the DCQAP (SAIC 1995a), which was used as the governing document for all field investigation activities. The identified deviations from the TEGD in no way affected the integrity of the monitoring well construction.

A field change to the monitoring well construction specification was required because of conditions encountered during drilling activities. Existing potentiometric contour maps of the site area indicated that the water level of the first encountered aquifer in the vicinity of SWMU 19 was approximately 150 feet BLS. However, during the installation of well S-116-94 (the well upgradient of SWMU 19), an adequate water-producing zone was not encountered until approximately 210 feet BLS. At that depth, the ability of the proposed Schedule 40 polyvinyl chloride (PVC) casing to withstand operational stresses was suspect. Increased applied stresses associated with the additional depth of the well may have caused fractures or separated the thin-walled Schedule 40 casing. Therefore, a field change was instituted to utilize Schedule 80 PVC casing for this monitoring well. The thicker casing wall of the Schedule 80 material was determined to be more resistant to installation and formation stresses and better able to maintain the well integrity. This change was approved in the field by the USAEC Project Geologist.

3.2.6.4 Monitoring Well Development

Each of the four new monitoring wells was developed to enhance the well's hydraulic connection to the aquifer by removing sediment, mobile particulants, and entrapped gases from within and adjacent to the wells. A submersible pump was used during development to remove formation water. Pumping activities continued until the following properties of the well water were achieved: nephelometric units (NTUs) equaled 5 or less; specific conductance, temperature, and pH were stable (i.e., values within 10 percent); and a minimum of five casing volumes of water were removed. All new monitoring wells were able to produce a sufficient volume of water to meet these criteria. Development occurred no sooner than 48 hours and no later than 7 days following placement of the monitoring well's internal mortar collar. Development was completed a minimum of 14 days prior to well sampling. Well development was conducted by Dan's Field Service of Salt Lake City using a custom designed pump truck equipped with stainless steel bailers and adjustable flow-rate submersible pumps. The specific development procedures employed during the field investigation were the same as those outlined in the DCQAP (SAIC 1995a). All development water was containerized and handled according to DCD IDW requirements and specifications. Appendix C presents logs detailing the development activities.

3.2.6.5 Monitoring Well Purging and Sampling

The nine groundwater monitoring wells associated with SWMU 11 and 19 were purged and sampled as part of the Phase II field investigation activities. Purging and sampling activities were conducted in October 1994, January 1995, and November 1998. The multiple rounds of sampling were conducted to confirm previous results. Prior to groundwater sample collection, a minimum of five casing volumes of groundwater was removed from the respective monitoring well. The volume of water to be removed was determined based on the total depth of the well, diameter of the well, annular borehole diameter, and static water level. Wells were purged by Dan's Field Service using a decontaminated stainless steel submersible pump. During purging activities, water that was removed from the well was monitored for pH, specific conductivity, temperature, and NTU value. For wells that could not produce enough water to maintain a sufficient recharge rate, the well was purged to dryness twice, allowed to sufficiently recharge, and then a sample was collected. All purge water was containerized and handled according to DCD IDW requirements and specifications.

Samples were collected from each well in October 1994 and January 1995 using the dedicated bailer located in the respective monitoring well. Each bailer was steam-cleaned and rinsed with deionized (DI) water prior to sample collection. Bailer rope was discarded following sample collection. Groundwater sampling in November 1998 was conducted using EPA low-flow (minimal drawdown) sampling procedures (EPA 1996a). All sample containers, except those used for VOC analysis, were triple rinsed prior to sample collection with groundwater from the well that was being sampled. Sample preservation was conducted in accordance with the specifications outlined in the DCQAP (SAIC 1995a) and DCQAP Addendum 1 (SAIC 1999a). Sample jars for organic analysis were glass with Teflon[®] septa and were certified clean by the manufacturer. Rigid plastic containers were used for samples collected for metals analysis.

3.2.7 Aquifer Testing

A rising head permeability (slug) test was conducted in October 1994 on each of the newly installed monitoring wells at SWMU 19 (S-113-94, S-114-94, S-115-94, and S-116-94) using a pressure transducer and In-Situ[®] Hermit data logger. The slug test was conducted by removing a volume of formation water from the monitoring well and recording the response of the aquifer to the induced water level change. The volume of the slug was sufficiently large to produce a measurable change in groundwater elevations in the monitoring well. Slug tests were conducted immediately following monitoring well purging activities. The test procedures included the following:

- The depth to groundwater in the monitoring well to be tested was recorded.
- The pressure transducer was attached approximately 2 feet directly above the intake of the pump used during purging.
- The test parameters were programmed into the Hermit data logger so as to record water level elevations.
- A known volume of water was pumped from the monitoring well such that sufficient drawdown could occur; the pump was shut off and the data logger was immediately activated.
- The test was stopped when the water level has recharged to within 0.01 feet of the initial water level or three equivalent readings was recorded.

The rising head permeability test provided data that could be used to determine characteristics of the monitored aquifer (e.g., transmissivity) underlying SWMU 19. Appendix F presents the slug test results.

3.2.8 Chemical Transport Estimates

Because of the lack of groundwater analytical data at SWMU 20, 33A, and 33B, chemical transport of selected constituents from the shallow soil to the groundwater table was estimated using the Pesticide Root Zone Model (PRZM-2) developed by EPA (1993). Parameters for the model were obtained from site data, literature values, and model default values. Literature values were obtained from the following sources: Kingery (1994), Howard (1997), Howard et al. (1991), Montgomery (1991), Small (1993), McNaughton (1994), USACHPPM (1999), EPA (1997), and HSDB (2000). The range of compounds evaluated with the models included mobile compounds, such as isopropyl methyl phosphonic acid (IMPA) for SWMU 33A; less mobile constituents, such as polycyclic aromatic hydrocarbons (PAHs) (i.e., benzo[a]pyrene) that can be degraded in the environment (SWMU 20); and much less mobile inorganic constituents, such as mercury, that are not readily degraded in the environment (SWMU 33B). The model estimates assume that the initial (maximum) concentrations obtained during Phase II activities are representative of site conditions and that the source of the chemical constituents has been abated. Historical meteorological conditions as represented by conditions at Salt Lake City, Utah, are assumed to estimate conditions sufficiently at DCD. The subsurface conceptual model was based on the observations recorded during the drilling and sampling of monitoring well borings at SWMU 19. This assumption is based on the fact that the soil sampling at SWMU 20, 33A,

and 33B was confined to the upper 15 feet; the lithologic sampling of the well borings at SWMU 19 extended to the groundwater table (approximately 117 feet BLS); and SWMU 20, 33A, and 33B are located in the vicinity of SWMU 19.

PRZM-2 is a one-dimensional, compartmental model used to simulate chemical movement in unsaturated or variably saturated soil systems. The model is capable of estimating dissolved, adsorbed, and vapor-phase concentrations in soil by considering the processes of pesticide uptake by plants, surface runoff, erosion, decay, volatilization, advection, dispersion, biodegradation, and retardation (EPA 1993). The estimation of chemical transport through the unsaturated zone at DCD was accomplished by:

- Developing a conceptual model for subsurface layering between the ground surface and the groundwater table
- Selecting compounds of interest
- Identification and assessment of chemical properties for compounds of interest
- Model parameterization and estimation of chemical concentrations.

3.2.8.1 Conceptual Model

A conceptual model of the geologic and hydrogeologic conditions underlying DCD was developed using deep boring logs from monitoring wells installed at SWMU 19 (S-113-94, S-114-94, S-115-94, and S-116-94) and the results of aquifer tests conducted during the Phase II site investigation. The vicinity of SWMU 19, 20, and 33 is substantially underlain by clay with interlayered sand and gravel. The depth to groundwater underlying this area based on the boring logs is approximately 117 feet BLS. The hydraulic conductivity of the subsurface layers was estimated to be between 8.84×10^{-3} and 3.83×10^{-4} cm/sec (see Appendix F). Sand and gravel occurs as both laterally discontinuous lenses and layers within the clay. The upper 20 feet of material underlying the site area consists of sand and gravel and is the most readily impacted layer.

Meteorological data for Salt Lake City, Utah, for the period between 1948 and 1983 were used as input for the model. The data were obtained from the National Oceanic and Atmospheric Administration (NOAA) archives and included information for daily precipitation, pan evaporation, temperature, wind speed, and solar radiation. Parameter inputs for the PRZM-2 model were developed from site data, literature values, and model default values. Building structures overlying study areas were conservatively disregarded in the development of the conceptual model. Foliar canopy was kept to a minimum (1%) over the model area and hydrologic parameters consistent with bare soil conditions were selected in the hydrologic input.

The effects of chemical degradation (hydrolysis) in the environment are treated as a lumped first order decay process for dissolved and adsorbed phases in the DCD model. Potential effects of biodegradation are not evaluated in the present model configuration. Chemical dispersion was set to zero in the PRZM-2 program to conservatively maximize the downward movement of the chemicals of interest. The impact of biodegradation and chemical dispersion

phenomena on the chemical transport estimates would be to reduce the estimated chemical concentrations over time and to broaden the concentration gradients.

Initial concentrations in the soil underlying each SWMU were developed using site-specific chemical concentration data collected during the Phase II investigations at DCD. The maximum detected concentrations in each 1-foot increment of the sampled horizons were used as the starting concentrations for the chemical transport estimates.

3.2.8.2 Chemical Transport Compounds of Interest

Compounds of interest at the various SWMU include benzo(a)pyrene (SWMU 20), IMPA (SWMU 33A), and mercury (SWMU 33B). Chemical properties associated with the transport of these compounds in the environment are summarized in Table 3-3. In general, constituents with elevated Henry's Law constant (air/water partition), low water solubility, or elevated water/soil partition coefficient (K_d) will be readily inhibited in the environment with limited transport potential. Appendix F presents the model's calculations.

3.2.9 Topographic Survey

Each newly installed monitoring well at SWMU 19 was topographically surveyed by a certified, licensed surveyor (Hill, Jamison & Associates) to determine the map coordinates referenced to the State Planar Coordinate System (SPCS). This survey was connected to the SPCS by third order, Class II control surveys in accordance with the Standards and Specifications for Geodetic Control Networks contained in the DCD Well Drilling and Installation Plan (TEAD 1993a). Locations for each well site were surveyed to within 0.5 feet.

Elevations for the natural ground surface and a designated point on the rim of the uncapped well casing (notched) for each well site were surveyed to within 0.01 feet and referenced to the National Geodetic Vertical Datum (NGVD) of 1929. This survey was connected by third order leveling to the NGVD of 1929 in accordance with the Standards and Specifications for Geodetic Control Networks contained in the DCD Well Drilling Plan and Installation (TEAD 1993a). Appendix G presents the surveyor's report that was prepared for the SWMU 19 monitoring wells.

3.2.10 Ecological Sampling/Survey

Ecological investigations included vegetation mapping (both areal and ground truthing) and key species identification to determine potential ecological receptors and their ranges. The area of investigation included not only the SWMUs, but also all of DCD to account for mobile species that use areas beyond the SWMU boundaries. The area surrounding DCD also was evaluated for the presence of threatened and endangered (T&E) species, some of which may not have been recorded on DCD, but may be influenced by installation activities.

Vegetation mapping of DCD was conducted by EBASCO during site-wide mapping activities in the summer of 1993 (EBASCO 1993a). These efforts were followed by studies to identify key species within the mapped vegetation habitats, and T&E species on and surrounding

**Table 3-3. Properties of Selected Constituents for Chemical Transport Model
Deseret Chemical Depot, Tooele, Utah**

	Solubility mg/L	log K _{oc}	K _d cm ³ /g	Vapor Pressure mm Hg	Molecular Weight	Henry's Law atm m ³ /mol	Henry's Law dim	Degradation Rate Constant (day ⁻¹)	D _{air} [*] cm ² /sec	D _{air} [*] cm ² /day
IMPA	4.80E+04	1.079	0.12	1.19E-02	138.1	6.88E-09	2.79479E-07	2.88E-03	0.102519	8857.6
MPA	1.00E+06	0.149	0.014	2.00E-06	96.02	1.22E-11	4.95587E-10	6.96E-01	0.132429	11441.8
Mercury	Insoluble	6.76	57,544	1.80E-03	200.59	7.10E-10	2.88416E-08	3.30E-06	0.054398	4700.0
Benzo(a)pyrene	4.00E-03	5.95	8,913	5.36E-09	252.32	2.40E-06	9.75E-05	1.31E-03	0.067466	5829.1

¹ Small. 1983. *Soil Detection Limits for Potential Chemical Warfare-Related Contaminants at Fort McClellan, Alabama.*

² USACHPPM. 1999. Preliminary Assessment of Health Effects NO. 39EJ678899.

³ Kingery and Allen. 1994. *Environmental Fate of Alkyl Methyphosphonates Arising from Chemical Surety Material (CSM) and Potential Non-CSM Sources in Soil and Aqueous Media.*

⁴ EPA. 1997. *Mercury Study Report to Congress; Volume 1.*

⁵ CRC. 1997. *Physical Properties of Organic Chemicals.* CRC Press.

⁶ Howard et al. 1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers.

⁷ Montgomery, J.H. 1991. *Groundwater Chemicals Desk Reference, Vol I and II.* Lewis Publishers.

DCD. Species were identified from field observations and data presented in previous investigations (EBASCO 1993a and 1994a, Rust 1994b), T&E species data bases, and unpublished lists developed by Rust and Utah Department of Wildlife (UDOW) wildlife coordinators. SAIC performed an ecological reconnaissance (i.e., visual inspection) of SWMU 11, 19, 20, and 33 in March 1994.

3.2.10.1 Vegetation Mapping

The vegetation map prepared by EBASCO for DCD provides the basis for characterizing the wildlife habitat, analyzing potential contaminant migration pathways, and identifying potential receptors at all SWMU sites and land adjacent to the SWMUs. The investigation initially included a review of the following existing vegetation and soil mapping data:

- Soil Conservation Service (SCS) range site maps and soil maps—"Soil and Range Survey of the Tooele Army Depot" (SCS no date)
- Bureau of Land Management (BLM) ecological site mapping information—Areas in proximity to DCD were investigated and mapped as part of the Tooele Grazing Draft Environmental Impact Statement (BLM 1983)
- U.S. Forest Service, Vegetation and Environmental Features of Forest and Range Ecosystems (Garrison et al. 1977)—Descriptions of sagebrush and desert shrub ecosystems were compared to areas in proximity to DCD.

The classification schemes, which are based on assessments of potential vegetation, employed in these existing maps emphasize range management requirements. These schemes do not necessarily reflect man-made disturbances and natural disturbance regimes that create various successional stages of the potential climax vegetation. To better reflect actual conditions, field biologists developed a vegetation map of DCD using a modified classification system related to broad ecological requirements (i.e., habitats).

The first task in creating the vegetation map was to conduct onsite field surveys. EBASCO performed these surveys in 1993. From high elevation points on and around DCD, vegetation patterns and specific species that were observed were recorded on a map of DCD. This was followed by walk-over surveys of specific areas where long-range identification could not provide the necessary level of detail. In general, it was observed that the boundaries between vegetation types were transitional, and where onsite observation did not provide sufficient detail to delineate the boundaries, aerial photographs were used to supplement the field data. The boundaries between vegetation types then were drawn directly on color infrared aerial photographs taken in June 1987.

3.2.10.2 Key Species Identification

The key species list was compiled by combining data from the RFI Phase II report for known releases SWMU (Rust 1994b) and the ecological risk assessment of the Group 1 SWMU (EBASCO 1994a) with new field data acquired during the seasonal field work conducted by DCD in 1993. This new field work included raptor and small bird surveys in

March 1993, vegetation and general wildlife surveys in June 1993, and small mammal trapping and bird surveys in August and September 1993. All species in the Rush Valley, the valley within which DCD lies, were considered to be potential receptors. The surveys were conducted both along transects inside the Group 1 SWMU and in adjacent areas to effectively inventory more mobile species. Species were identified and their habitat usage was recorded on field data sheets and later combined with data from the previously conducted surveys. The new field data included information on large and small mammal, raptor, and small bird populations.

Considerable qualitative data on the flora and fauna of Rush Valley are available in the published literature (SCS no date, BLM 1988, UDOW 1993). These literature sources were used to review the adequacy of the compiled species list, as were discussions with BLM biologists and state wildlife coordinators to reaffirm the adequacy of the species identified.

3.2.10.3 Threatened and Endangered Species

Federal or state-listed T&E species known to be or potentially present on DCD were determined through T&E data base searches (USFWS 2000) and the onsite surveys associated with the Group 1 SWMU and known releases SWMUs. Critical habitats for federally listed species on DCD and in the Rush Valley, which are administratively designated and protected, also were documented. Table 2-2 presents the Federal and State of Utah status for DCD species of concern.

3.2.11 Explosive Risk/Unexploded Ordnance Survey

The DCD RCRA Part B Hazardous Waste Permit specifies that an evaluation be conducted to determine the explosive risks at SWMU under investigation. A UXO evaluation was conducted at all Group 3 SWMU except SWMU 11. Field screening for UXO was not deemed necessary at SWMU 11 due to the fact that this is an industrialized igloo storage area that would have required extensive excavation, grading, and screening prior to any type of construction activities. Prior to any intrusive activities associated with the remaining Group 3 SWMUs, a qualified subcontractor (HFA, UXB, or ATI) conducted a UXO evaluation. This evaluation included a review of historical records, a visual surface inspection of the SWMU areas, a surface magnetometer survey of sample locations, and subsurface magnetometer surveys of sample areas with no recorded history (i.e., the drainage swale at SWMU 33 and SWMU 37). The procedures for conducting these activities are detailed in the DCQAP (SAIC 1995a). Appendix H presents the UXO field notes for each investigation phase (Phases II, IIA, and IIB).

3.2.12 Sample Identification

A sample identification (ID) system developed by SAIC was used to identify and track each environmental sample collected and field QC blank prepared during the field investigation. This I.D. system allowed precise tracking to document and retrieve information about a given location and sample. The U.S. Army's Installation Restoration Data Management Information System (IRDMIS) was used as the primary driver for the site ID codes and field sample numbers

were assigned to every environmental and field QC sample collected. The format of field sample numbers and site IDs is as follows:

Site Identification—A site ID served as a unique identification code for each location sampled. These site IDs were assigned before the start of the field investigation. The following are typical identifiers that were used for the field investigation at DCD.

<u>Code</u>	<u>Media Description</u>
SB-19-001	Soil boring number 1 at SWMU 19
S-113-94	Monitoring well number 113 installed in 1994
SB-BK-001	Soil boring number 1 at a background location.

The first letter(s) represent the site type as defined by IRDMIS. The following two- or three-digit number or letter designates the SWMU number or background sample location. The last three digits represent the sample location number within the identified SWMU.

Field Sample Number—The field sample number was a unique designation assigned by the field team to each environmental sample and field QC sample collected. This numerical code indicated the sample number for its corresponding site ID. Different field sample numbers were used for Phase II and Phases IIA and IIB. For example, a field sample number of 001B (Phase II designation) or SAIC02 (Phase IIA, IIB designation) for site ID SB-19-001 indicates that it is the second soil sample collected from soil boring number 1 at SWMU 19.

Duplicate and Field QC Blanks—The following QC test and flagging codes were used to identify duplicate environmental and field QC blank samples:

- “D” entered in the flagging code field was used to identify all field duplicates collected in the field.
- “R” entered in the QC test code field was used to identify all rinsate blanks collected in the field.
- “T” entered in the QC test code field was used to identify all trip blanks prepared by the analytical laboratory.
- “F” entered in the flagging code field was used to identify all field blanks collected in the field.

An in-depth discussion of IRDMIS, site IDs, field sample numbers, and QC test codes is presented in the Data Management Plan (DMP) (SAIC 1995b).

3.2.13 Sample Handling, Storage, and Shipping

The procedures followed during the transportation of environmental samples and field QC blanks from DCD to the analytical laboratory are summarized below:

- The outer surface of all sample containers was cleaned with USAEC-approved water and paper towels, and the sample label was covered with clear tape. Sample containers

then were placed in a shipping container with ice to maintain a maximum temperature of 4°C.

- Sample collection points, depth increments, and sampling devices documented in the field logbooks were verified with the information on the sample label and chain-of-custody (CoC) form.
- Logbook entries, sample tags, CoC forms, and field record sheets with sample identification points, date, time, and names or initials of all persons handling the sample in the field were completed prior to sample shipping.
- One custody seal was placed over the neck and down the side of each sample container. Glass sample containers were wrapped with plastic insulating material (bubble wrap) to prevent contact with other sample containers or the inner walls of the cooler.
- Samples were packaged in thermally insulated, rigid coolers, according to the U.S. Department of Transportation (DOT) Specifications 173 Subparts A and B, and 172 Subparts B, C, and D. Environmental samples and field QC blanks submitted to the laboratory were placed in a sample cooler along with ice and coolant blanks, and the final cooler temperature was recorded prior to sealing the cooler. After a cooler was filled, the appropriate CoC form was placed inside a resealable plastic bag and taped to the inside lid of the cooler, the outer surface of the cooler was cleaned, and the cooler was sealed.
- Custody tape was attached in two separate locations on the outside of each cooler. The sample containers were transported either directly to the laboratory or delivered using overnight express shipments. A signed CoC either was obtained upon delivery or transmitted immediately to SAIC from the laboratory following sample receipt to document and trace sample possession. Samples collected during Phase II and the groundwater sampling portion of Phase IIA were transported via overnight courier to QST, Inc.; soil samples and associated field QC collected during Phase IIA and IIB were hand delivered to DCL for analysis. A detailed discussion of CoC procedures is presented in Section 6.2 of the DCQAP (SAIC 1995a).

3.2.14 Decontamination Procedures

To prevent cross-contamination of samples, all equipment was decontaminated before sampling activities began, between drilling and sampling activities, and at the conclusion of field sampling. To help ensure consistent equipment decontamination, only water from USAEC-approved sources was used. These sources were identified, sampled, and approved for use by the USAEC Chemistry Branch prior to the conduct of field activities. The approved water sources included DCD pumping wells 2-S (sampled in March 1994 as part of Phase II) and 1-S (sampled in July 1998 and January 2000 as part of Phases IIA and IIB, respectively) and the DI water provided by the laboratory. The analyses for the pumping wells are presented in Appendix I. DI water certificates of analysis are maintained in the project files. The decontamination procedures used during the RFI are summarized below.

Drilling Equipment Decontamination—Decontamination of large equipment associated with sampling during the 1994 Phase II field activities, such as drill rigs, augers, and all

downhole equipment, was accomplished using a high pressure steam cleaner; equipment was vigorously scrubbed, triple-rinsed with USAEC-approved water, and given a final rinse with USAEC-approved water. During Phases IIA and IIB, equipment that did not contact sample equipment (e.g., backhoe bucket and direct push rods) were steam-cleaned between sample points. If soils did not adhere to the backhoe bucket during test pit excavation, the bucket was decontaminated between sample locations. (This was due to the fact that samples were collected directly from the excavation using a decontaminated hand auger.) All decontamination liquids generated were handled according to the procedures presented in Section 3.2.14.

Sampling Equipment Decontamination—The 1994 Phase II decontamination procedures for sampling equipment that contacted sample media required that the equipment be completely disassembled and decontaminated using source water and a high-pressure steam cleaner between sampling intervals. All loose material was removed by scrubbing with brushes and triple-rinsing with USAEC-approved water. The Phase IIA and IIB decontamination procedures for equipment contacting sample media included: source-water/phosphate-free detergent scrub, source-water rinse, and DI water rinse. The inclusion of the phosphate-free detergent was based on UDEQ comments following the 1994 Phase II activities. Phases II, IIA, and IIB decontamination procedures minimized the potential for cross-contamination between samples. All decontaminated sampling equipment, including split-spoons and augers, was wrapped in clean plastic or aluminum foil while being transported from the decontamination area to the sampling site. The stainless steel or brass liners for the split-spoons and direct push sample liners, and the aquifer testing equipment were decontaminated according to the procedures associated with the respective investigation phase. All sample liners were wrapped in aluminum foil until used at the sampling site.

3.2.15 Control, Sampling, and Disposal of Investigation-derived Wastes

The Phase II field sampling activities generated IDW, which was handled and controlled in accordance with Federal, state, and DCD Environmental Risk Management Division (RM-E) requirements and policies. The procedures that were followed are outlined in the DCD Industrial Risk Management Policy Statement (TEAD 1993b). Material generated as part of the field activities that required specific handling requirements included personal protective equipment (PPE); drill cuttings; slag material; and development, purge, and decontamination water. DCD provided guidance on and determined the final disposition of all IDW. The following sections describe the disposal and sampling protocols, procedures, and requirements for each different type of IDW.

3.2.15.1 Personal Protective Equipment

As part of the field investigation activities, disposable PPE (i.e., Tyvek[®] coveralls, latex gloves, and overboots) was worn during sampling activities to protect against chemical contamination. When clothing or equipment was visibly soiled, the clothing/equipment was washed with a high-pressure steam-cleaner, screened with a PID and, if clean (i.e., soil removed and PID screening indicated no VOCs), the clothing was discarded in the DCD solid waste disposal system. All PPE used during the field investigation activities was identified as clean.

3.2.15.2 Drill Cuttings and Slag Material

Drilling and soil cuttings were generated during soil boring, test pit excavation, and monitoring well installation activities. Handling of this material depended on whether the soil was nonsaturated (i.e., above the water table and dry), saturated (i.e., below the water table and wet), or visibly discolored (e.g., slag material at SWMU 37). All nonsaturated soil cuttings generated during surface/shallow soil sampling, soil boring drilling, and test pit excavation activities were screened with a PID and, if PID readings were nondetect, returned to the original borehole/excavation after sampling activities were completed. No elevated PID readings were registered; all soil cuttings were returned to the original borehole/excavation.

All saturated soils generated during monitoring well installation activities at SWMU 19 were containerized in 55-gallon drums and handled according to the DCD Industrial Risk Management Policy Statement (TEAD 1993b). Composite samples were collected from the saturated cuttings and analyzed for the SWMU 19 chemicals of concern (COCs). Analysis included RCRA F001-F005 solvents, toxicity characteristics leaching procedure (TCLP) metals, TCLP VOCs, TCLP semivolatiles organic compounds (SVOCs), and polychlorinated biphenyls (PCBs). Organic compounds were not detected in the saturated soils and metals were not detected above regulatory TCLP levels. All drums containing saturated soil cuttings were determined by DCD to be nonhazardous and were disposed of in the DCD-permitted onsite landfill.

During the 1994 Phase II sampling and excavation activities at SWMU 37, all visible and identified slag material was containerized in 55-gallon drums and handled according to the DCD Industrial Risk Management Policy Statement (TEAD 1993b) (i.e., properly labeled, transported, and stored at an onsite location). Environmental samples and composite samples were collected from the slag material and analyzed for TCLP metals, TCLP SVOCs, explosives, and PCBs. Organic compounds were not detected in the slag material and metals were not detected above regulatory TCLP levels. All drums containing saturated soil cuttings were determined by DCD to be nonhazardous and were disposed of in the DCD permitted onsite landfill.

3.2.15.3 Development/Purge Water

Development/purge water was generated during the sampling of monitoring wells at SWMU 11 and 19. As part of the development/purging activities, all formation water that was removed from the well was containerized in 55-gallon drums and handled according to the DCD Industrial Risk Management Policy Statement (TEAD 1993b) (i.e., properly labeled, transported, and stored at an onsite location). Water generated during the decontamination of groundwater sampling tools (e.g., bailers and submersible pumps) was combined with the development/purge water. During the 1994 Phase II sampling activities, the disposition of the development/purge water was based on the analytical results of the groundwater samples collected from the respective wells. During the Phase IIA sampling activities, composite samples for TCLP metals, TCLP VOCs, and TCLP SVOCs were collected from the containerized development/purge water. This information, in addition to the primary groundwater samples from the wells, was used to determine the disposition of the water.

None of the development or purge water generated during the 1994 groundwater sampling event was determined by DCD to be hazardous, and therefore, was disposed of in the DCD permitted onsite landfill. However, toluene (16 µg/L) was detected in purge water from the second round of groundwater sampling (January 1995). The drums containing this purge water were disposed of by DCD RM-E in accordance with RCRA requirements and the protocols of the DCD Industrial Risk Management Policy Statement (TEAD 1993b). Purge water generated during Phase IIA (November 1998) was determined by DCD to be nonhazardous and was disposed of offsite by a contractor.

3.2.15.4 Decontamination Water

Decontamination of all soil sampling equipment (e.g., drilling rods and hand tools) was conducted either at the drill rig decontamination point located in the vicinity of SWMU 19 and 33, in the vicinity of the respective sampling location, or in the SAIC field office. Water generated as part of these activities was containerized in 55-gallon drums and handled in accordance with DCD IDW policies and requirements (i.e., properly labeled, transported, and stored at an onsite location). During the 1994 Phase II activities, samples of the soil sampling decontamination water were collected and analyzed for contaminants specific to the SWMU from which the decontamination water was generated, in addition to RCRA F001-F005 solvents and TCLP metals. The 1994 decontamination water was determined by DCD to be nonhazardous and was disposed of in the DCD permitted onsite landfill. Decontamination water from soil sampling equipment generated during the Phase IIA and IIB sampling activities was sampled for TCLP VOCs, TCLP SVOCs, TCLP metals, and SWMU-specific parameters. All soil sampling equipment decontamination water generated during Phases IIA and IIB was determined by DCD to be nonhazardous and was disposed of offsite by a contractor.

3.3 LABORATORY CHEMICAL ANALYSIS PROGRAM

This section summarizes the laboratory chemical analysis program implemented as part of the Group 3 Phase II, Phase IIA, and Phase IIB RFI at DCD. Sample handling procedures, equipment calibration, analytical methods, data reduction, validation, and reporting, and sample data quality assurance/quality control (QA/QC) are summarized. Detailed information on these topics is presented in the DCQAP (SAIC 1995a).

Soil and groundwater samples collected by SAIC during Phase II and Phase IIA groundwater samples were analyzed by QST using USATHAMA analytical methods. The additional mercury soil samples collected at SWMU 33 in 1995 and the soil samples collected during Phases IIA and IIB were analyzed by DCL according to U.S. Environmental Protection Agency (EPA) SW846 methods.

3.3.1 Sample Handling Procedures

The Field Operations Manager or his designee (i.e., Sample Manager) was responsible for sample custody from the time the samples were collected until they were properly packaged, documented, and released to the analytical laboratory. The laboratory was responsible for sample custody thereafter. Custody was documented throughout all Group 3 RFI activities by

the CoC record initiated for each day in which samples were collected. This record accompanied the samples from the site to the laboratory and was returned to the QA Officer. All personnel with sample custody responsibilities were required to sign, date, and note the time on the CoC record when they received samples into or relinquished samples from their immediate custody. Any discrepancies were noted and immediately corrected.

3.3.1.1 Establishment of Sample Lots

A lot is the maximum number of samples, including QC samples, that can be processed through a step of the analytical method during a single time period (not to exceed 1 day), as determined by time or by the equipment limiting step of the method. All samples collected during the RFI activities were analyzed by lot. Analysis of samples within a lot was as continuous as possible with all samples processed through the entire analytical method without deviating from the performance-demonstrated method. For methods requiring second-column confirmation, such confirmation was conducted within 10 days of sample analysis.

3.3.1.2 Laboratory Sample Receipt

All samples were received by the Sample Custodian or his designee. The Sample Custodian compared the information on the CoC form with the information on the sample labels. If problems were noted, the Sample Custodian signed the form and noted the problems in the remarks box or referenced other forms that describe the problems in detail. If discrepancies were found (e.g., if the temperature of the coolant blank was below 2°C or above 6°C), they were reported within 24 hours to the Field Operations Manager or QA Officer. Samples whose coolant blank fell outside of the 4°C ± 2°C limits were not analyzed without permission from USAEC.

As samples for a particular aliquot were received at QST and DCL, they were assigned a sample sequence number and sample identification number. These numbers were grouped by lot.

3.3.1.3 Chain-of-Custody Record

CoC forms were used to document the traceability and integrity of all samples. A CoC form was filled out to maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory. This form was filled out for each sample set at each sampling location, and signed and dated by each sample custodian.

When sample possession was transferred, the individual relinquishing the samples and the individual receiving the samples signed, dated, and noted the time of transferal on the CoC document. This record represented the official documentation for all transferal of sample custody until the samples arrived at the laboratory.

Samples received at the analytical laboratory were considered to be physical evidence and were handled according to procedural safeguards established by EPA. In addition, all data generated from the sample analyses, including all associated calibrations, method blanks, and

other supporting QC analyses, were identified with the project name, project number, and lot designation. All data were maintained under the proper custody. The laboratory provided complete security for samples, analyses, and data.

3.3.2 Laboratory Equipment Calibration

To ensure that daily variances did not adversely affect the operation of the instrument, a series of calibration standards was analyzed according to specific methodologies before any samples were analyzed. Standards were prepared relative to physical or chemical standards traceable to USAEC, EPA, or the National Institute of Standards and Technology (NIST). The calibration was verified with another calibration standard each day. QST satisfied all calibration requirements, as specified in the *USATHAMA Quality Assurance Program, PAM 11-41* (January 1990) including adherence to Class 1, 1A, and 1B calibration procedures for metals, cyanide, explosives, PCBs, organic acids, chemical agent breakdown products, anions, total phosphate, VOCs, and SVOCs. Phase IIA soils, all Phase IIB samples, IDW being analyzed for TCLP parameters, and F001 through F005 listed solvents analysis used EPA SW846 or Methods for Chemical Analysis of Water and Waste (MCAWW) methods. In each instance, DCL satisfied all calibration requirements as specified in the EPA-approved method.

3.3.3 Laboratory Analytical Methods

The chemical analysis program for the Group 3 RFI at DCD conforms to the analytical requirements presented in the DCQAP (SAIC 1995a), *USATHAMA Quality Assurance Program, PAM 11-41* (January 1990), and the EPA analytical method requirements for the chemical analysis of water and soil samples. Samples collected during the DCD Group 3 Phase RFI were analyzed by QST and DCL. QST and DCL are USAEC-approved laboratories and are approved by the State of Utah Department of Health Services as environmental chemistry laboratories. The additional mercury samples collected in October 1995 were analyzed by Mountain States Laboratory, a UDEQ-certified laboratory. SAIC prepared target compound and element lists on the basis of the type of activities conducted or the contaminants suspected at each site.

QST and DCL analyzed environmental samples collected at DCD for VOCs, SVOCs, chemical agent breakdown products, organic acids, thiodiglycol, explosives, PCBs, metals, cyanide, total phosphate, biological oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (TOC) using USAEC-performance demonstrated methods for all Phase II samples and Phase IIA waters and EPA-approved methods (i.e., SW846 and MCAWW) for Phase IIA soils and all Phase IIB samples. Specified samples and associated field QC blanks collected at DCD were analyzed for F001 through F005 listed solvents and TCLP parameters using EPA-approved methods. All analytical data were entered into IRDMIS. Not all samples were analyzed for all parameters specified. Methods used for the analysis of soil, surface soil, and groundwater samples and associated field QC samples collected during the Group 3 Phase II, Phase IIA, and Phase IIB RFI at DCD are listed in Table 3-2. Method documentation is kept on file at USAEC, QST, DCL, and SAIC. Section 3.4 describes the internal laboratory QC requirements for each analytical lot of samples.

3.3.4 Data Reduction, Validation, and Reporting

QST and DCL submitted all analysis results for both analytical samples and QC samples to IRDMIS. QST and DCL recorded and group-checked all transfer files before the data were submitted to IRDMIS. IRDMIS data were transported to Potomac Research, Inc. (PRI) by modem or diskette.

Laboratory QA data were reported separately from the environmental data, but grouped by analysis method. Data necessary for calculation of percent recoveries were included with the analytical results. Analytical reporting requirements are described in Section 6 of the DCQAP (SAIC 1995a).

3.3.5 Sample Data Quality Assurance/Quality Control

This section presents the QA/QC procedures applied during the laboratory analysis and field investigation.

3.3.5.1 Laboratory Quality Assurance/Quality Control

Various internal laboratory QC checks, USAEC QC checks, and control checks were conducted as part of the laboratory analysis. The laboratory QA/QC controls included the following:

Method Blanks—Method blanks were used to monitor the possibility of laboratory-induced contamination by running a volume of USAEC-approved reagent water or standard soil processed through the entire analytical scheme (i.e., extraction, concentration, and analysis).

Matrix Spike/Matrix Spike Duplicates—Matrix spike/matrix spike duplicates (MS/MSDs) were analyzed to evaluate the accuracy and precision of the analysis and sample matrix effects on the analytical methodology by dividing one sample into three sample portions. One portion was routinely analyzed. A known amount of selected compounds at known concentrations was added to each of the two remaining sample portions. Accuracy was expressed as the percent recovery of each added compound. Precision was expressed as the relative percent difference (RPD) of the two spiked compounds. A pair of MS/MSD samples was analyzed for every 20 samples of similar matrix received at the laboratory. Samples identified as field QC samples (i.e., equipment rinsate blanks, trip blanks, and field duplicates) were not used for MS/MSD analysis.

Laboratory Control Sample—Laboratory control samples (LCSs) were analyzed to evaluate the accuracy of the analysis on the analytical methodology. A known amount of selected compounds at known concentrations was added to the LCS. Accuracy was expressed as the percent recovery of each added compound. An LCS was analyzed with each analytical lot analyzed by EPA-approved methods.

Laboratory Duplicates—Laboratory duplicates were analyzed to evaluate the precision of the inorganics analytical methodology. This was accomplished by subdividing one sample and routinely analyzing both samples of the duplicate pair. Precision was expressed as the RPD of

the detected compounds. A duplicate pair of samples was analyzed for every 20 inorganic samples of similar matrix received at the laboratory and analyzed by EPA-approved methods. Samples identified as field QC samples (i.e., equipment rinsate blanks, trip blanks, and field duplicates) were not used for duplicate analysis.

USAEC Internal Laboratory QC Checks—In accordance with the *USATHAMA Quality Assurance Program, PAM 11-41* (January 1990), laboratory QC check samples were analyzed with each lot of environmental samples. The QC samples were used to monitor the performance of the analytical method by which a particular lot was being analyzed. The numbers and types of USAEC QC samples varied with each USAEC method class. The methods that were used for analyzing laboratory QC check samples are described in Section 6 of the DCQAP (SAIC 1995a).

3.3.5.2 Field Quality Assurance/Quality Control

Collection and analysis of source water samples, equipment rinsate blanks, trip blanks, and field duplicates were provided as QC checks on the integrity of sample handling, collection, and equipment decontamination procedures. Equipment rinsates were prepared using USAEC-approved water and sample bottles randomly selected from the bottles prepared for environmental samples. USAEC-approved water was used to prepare these field check samples, regardless of the environmental medium being sampled.

The field QC samples that were collected during the Group 3 RFI at DCD included:

- One trip blank (i.e., two 40 mL volatile organic analysis [VOA] vials filled with USAEC-approved water) was included with each shipping container that contained groundwater, surface water, soil, or sediment samples analyzed for VOCs.
- One clean water source was specified by the USAEC Project Manager. The clean water source was at DCD supply well WW-3. Duplicate water samples were collected from WW-3 and submitted to QST and DCL for analysis using those analytical methods proposed. The reagent-grade water used as the final rinse in the decontamination procedures also was collected in duplicate and submitted to QST and DCL for analysis. The results were submitted to USAEC for approval before the field investigation began.
- One set of equipment rinsate blanks was prepared every day for each medium (i.e., soil, surface soil, or groundwater) sampled. These blanks were analyzed for the same compounds and elements as the environmental samples collected.
- One field duplicate for every 10 environmental samples and each medium was collected at a pre-selected monitoring point. Field duplicates were collected at the same time and in the same manner as the other samples. Field duplicates were a separate sample, obtained from the same monitoring point. Results of the field duplicate analyses were used to assess the precision of the field sampling techniques, not that of the analytical techniques.

3.4 DATA QUALITY ASSESSMENT

This section summarizes the results of the data quality assessment conducted for the analytical data resulting from the RFI. A comparison of the RFI analytical results to project DQOs, as defined in the DCQAP (SAIC 1995a), formed the basis for evaluating the quality of the analytical data. Data verification and validation were conducted on 30 to 100 percent of the resulting analytical data packages to ensure that QST and DCL produced an acceptable quality level for results. One hundred percent of the data were evaluated for contamination due to field activities by evaluating all field QC blanks (i.e., trip blanks, equipment rinsates, and field blanks). The following were used during the evaluation of the QC data: QC requirements contained within the guidelines and specifications presented in the DCQAP; User's Guide, IRDMIS, Volume II Data Dictionary, PRI, 1994; *USATHAMA Quality Assurance Program, PAM 11-41* (January 1990); *EPA Contract Laboratory Program (CLP) Statement of Work for Inorganic Analysis*; the *EPA CLP Statement of Work for Organic Analysis*; the *EPA CLP National Functional Guidelines for Inorganic Data Review* (EPA 1994a), and the *EPA CLP National Functional Guidelines for Organic Data Review* (EPA 1994b). The following sections summarize the DQOs for the PARCC and sensitivity parameters obtained during the RFI at DCD. A detailed project data quality assessment is presented in Appendix J. Data validation flags and qualifiers applied by QST, DCL, and SAIC to the data (i.e., detected and nondetected values) are presented in Appendix J (Sections J.2 through J.4).

3.4.1 Precision

Precision is defined in Section 6 of the DCQAP (SAIC 1995a) and was evaluated based on the analysis of three different types of QC samples: spiked QC samples (USAEC Class 1, 1A, and 1B); MS/MSDs; and duplicate sample analyses (laboratory and field).

The first type of QC sample, USAEC spiked QC samples, is required as part of the USAEC analytical program for all methods. The results were compiled on single-day and 3-day control charts (i.e., X-bar and range) and submitted to the USAEC chemist for approval before sample results may be loaded into the IRDMIS data base. The QC charts (i.e., single-day and 3-day range control charts) show that all analyses performed by gas chromatography/mass spectrometry (GC/MS), GC, ion chromatography (IC), high performance liquid chromatography (HPLC), inductively coupled argon plasma (ICAP), graphite furnace atomic absorption (GFAA), cold vapor, and colorimetric techniques have acceptable precision with a few exceptions. The range for the precision control chart (i.e., 3-day average range) for one PCB (i.e., PCB1016) from lot NGOB (38.2 percent) was above the upper control limits (UCLs). The high spike ranges (i.e., 7.4 and 10.6 percent) for 1,3,5-trinitrobenzene (1,3,5-TNB) (7.4 percent), 2,4,6-trinitrotoluene (TNT) (10.6 percent), and 2,4-dinitrotoluene (2,4-DNT) (13.5 percent) in lot THHE were above the UCLs. These exceptions were attributable to the fluctuations in analytical sensitivity and are considered to have a minimal impact on data usability.

The second type of QC sample used to assess the precision of the data quality was the RPDs of the MS/MSD samples. All MS/MSD RPD values were within the control limits specified within Section 6 of the DCQAP (SAIC 1995a) with the exceptions listed in Appendix J. These MS/MSD RPD outliers are considered to have little impact on the environmental data quality, and are considered more likely the result of matrix variability

because all other required analytical QC criteria were met. No data validation qualifiers were applied based on MS/MSD RPDs results with the exception of copper and nickel results in 20 Phase IIA soil samples. These qualified data points (“J”) are considered acceptable, but estimates, and will be used in the risk assessment. Table J-23 of Appendix J lists the samples that were qualified “J” due to MS/MSD RPDs.

The third type of sample used to assess the precision of the data quality was the RPDs of the laboratory duplicate. Laboratory duplicate RPDs were within the expected ranges with the exceptions discussed in Appendix J. Six Phase IIB soil RPDs for barium, calcium, copper, iron, nickel, and sodium did not meet the required QC criteria. As a result, 18 barium, calcium, copper, iron, nickel, and sodium soil data points were qualified as estimated “J.” These qualified data points are considered acceptable, but estimates, and will be used in the risk assessment. Table J-38 lists the samples that were qualified as estimated “J” due to duplicate RPDs.

Duplicate sample pairs were collected to ascertain the contribution of variability (i.e., precision) due to environmental media and sampling precision technique. Field duplicate samples were included as part of the RFI and were collected at a rate of 1 duplicate per 10 field samples using the same techniques as those used to collect the environmental samples. The RPD between field duplicate analysis results traditionally has been used to evaluate precision of sampling techniques. Field duplicate data have not been evaluated relative to their data quality because the User Guide, IRDMIS, and CLP *National Functional Guidelines for Organic and Inorganic Data Review* (EPA 1994a and b) do not include control limits for RPD values.

Based on an evaluation of USAEC QC spike samples, MS/MSD, laboratory duplicate, and field duplicate RPDs, overall precision is acceptable. As a result, the laboratory DQO for precision is considered to have been met. A comprehensive discussion of USAEC QC spike, MS/MSD, and duplicate results, and all data validation qualifiers applied to the data, are presented in Appendix J.

3.4.2 Accuracy

Analytical accuracy is defined in Section 6 of the DCQAP (SAIC 1995a) and was evaluated based on the analysis of Class 1,1A, and 1B USAEC spiked QC samples (low and high spike recoveries), surrogate spiked QC samples (only GC/MS), surrogate field samples (only GC/MS), MS/MSD samples, and LCSs.

The USAEC QC control charts show that all analyses performed by GC, ion chromatography, HPLC, ICAP, GFAA, cold vapor, and colorimetric technique had acceptable accuracy, except for lots NCHD, NCID, THHE, WFLD, PHSC, PHUC, UBDD, ZKCC, QBDC, WCNC, SGVA, and QHGC. Standards, daily calibration, and check standards for these lots were within the control limits. These out-of-control situations in the control charts should have minimal impact on the corresponding data. The field sample data may be quantitated slightly low.

Various individual low and high spike recoveries were slightly outside the control limit. The magnitude of these points was attributed to normal variation in the distribution of recovery

values for the method. The impact of these individual points on data quality is believed to be negligible.

The second type of QC used to assess the accuracy of the data quality was the percent recoveries of the surrogates spiked into standard matrix method blanks for VOC and SVOC analyses. Two individual SVOC recoveries in lot OEED for surrogates spiked into the standard method matrix blank were slightly above the UCL, but are not deemed to affect the field data, since all internal standards, instrument tunes, and calibrations are acceptable. The magnitude of these points was attributed to normal variation in the distribution of recovery values for the method.

The third type of QC used to assess the accuracy of the data quality was the percent recoveries of the surrogates for VOC and SVOC analyses. All technical review criteria were met for surrogates with the exceptions listed below and in Appendix J. Fifty-nine VOC (of 319 values reviewed) and 37 SVOC (of 666 values reviewed) surrogate percent recoveries were outside the applicable control limits. Phase IIB data associated with five water surrogate percent recovery outliers were qualified as estimated "UJ" or "J." These qualified data points are considered acceptable, but estimates, and will be used to support further studies (e.g., risk calculations). No qualifiers were applied to the Phase II or IIA data because all recoveries were only slightly outside the method limits and other method criteria were met.

Various MS/MSD percent recoveries for SVOCs, PCBs, and chemical agent breakdown products were outside the acceptable QC limits, as discussed in Appendix J. However, no data validation qualifiers were applied based on these MS/MSD results. These results are considered to have little impact on the environmental data quality because all other required analytical QC criteria were met.

Various antimony, nickel, silver, arsenic, and thallium MS/MSD percent recoveries were outside the acceptable QC limits in the Phase IIA and IIB soil samples. As a result, soil samples associated with these outliers were qualified as estimated "UJ" or "J" for antimony, nickel, silver, arsenic, and thallium. These qualified data points are considered acceptable, but estimates, and will be used in the risk assessment.

Sixty-seven soil samples were qualified as rejected "R" for antimony due to matrix spike recoveries being less than 30 percent. The rejected samples are listed in Section 3.4.5 and Appendix J (Tables J-23 and J-38). Data points that were rejected are considered unusable and will not be used in the risk assessment.

The LCS was the fourth QC type used to assess analytical accuracy. Based on an evaluation of the data, all criteria were met with the exceptions presented in Appendix J. Nine cyanide results in Phase IIA soil samples associated with an LCS recovery outside the QC limits were qualified as estimated "S." These qualified data points are considered acceptable, but estimates, and will be used in the risk assessment.

All supporting QC information cited above also was qualitatively evaluated with respect to the analytical accuracy DQO. Based on the evaluation of the USAEC QC spike, surrogate, MS/MSD, and LCS results and the associated laboratory QC results summarized in Appendix J,

the laboratory accuracy has been determined to be acceptable for all analyses, with the exception of the rejected data points noted above. The analytical DQO for accuracy has been met, except where noted.

Based on an evaluation of all method blanks, aluminum, calcium, iron, magnesium, potassium, barium, manganese, di-n-butyl phthalate (DNBP), bis(2-ethylhexyl)phthalate (B2EHP), toluene, 2-butanone, and tetryl were detected at concentrations and frequencies that might bias the analytical results. As a result, the IRDMIS code flag (i.e., "B+") was applied to 23 B2EHP, 1 DNBP, 5 toluene, 3 tetryl, 2 copper, and 5 aluminum data points and the data validation qualifier "U" was applied to 16 toluene data points to indicate that the reported concentrations were 5 to 10 times less than that detected in the associated method blank. Therefore, these qualified results may be biased high due to method blank contamination and should be considered nondetects. These qualified data points are considered to be acceptable, but nondetects, and will be used in the risk assessment.

Field QC blanks (i.e., trip blanks, field blanks, and equipment rinsate blanks) were obtained to determine the degree of cross-contamination or ensure successful decontamination procedures. Based on an evaluation of all field blanks analyzed for the DCD RFI sampling program, the qualifier "T+" was applied to 10 B2EHP and 3 nitroglycerin concentrations in environmental samples to indicate that these qualified concentrations are biased high due to field blank contamination. The majority of the trip blank results were generally below the certified reporting limits (CRLs). The data validation qualifier "U" was applied to five methylene chloride concentrations detected in soil samples to indicate that these concentrations are biased high due to trip blank contamination and should be treated as nondetected values. Chloroform, dimethyl phthalate (DMP), B2EHP, pentaerythritol tetranitrate (PETN), sodium, mercury, aluminum, calcium, chromium, potassium, and magnesium were detected at various levels in the equipment rinsate blanks. The IRDMIS code flag (i.e., "G+") was applied to 1 chloroform, 9 DMP, 14 B2EHP, 3 PETN, 20 mercury, 2 aluminum 8 calcium, 8 chromium, 8 potassium, 8 magnesium, and 38 sodium data points to indicate that these qualified results may be biased high due to equipment rinsate blank contamination and should be considered nondetects. These qualified data points are considered to be acceptable, but nondetects, and will be used in the risk assessment.

Based on an evaluation of the compounds and elements detected in the blanks, the overall accuracy is acceptable, except where noted. As a result, the laboratory DQO for accuracy is considered to have been met. A comprehensive discussion of the method blank results is presented in Appendix J.

3.4.3 Representativeness

Based on an evaluation of the sample precision and accuracy, the samples collected during the RFI are considered to be representative of the environmental conditions at DCD.

3.4.4 Comparability

Based on the precision and accuracy assessment presented above, the data collected during the RFI are considered to be comparable with the data collected during previous investigations.

3.4.5 *Completeness*

Completeness measures the amount of valid data obtained from the sampling and laboratory analysis process. For data to be considered valid, each data point must meet all acceptance criteria, including accuracy and precision, as well as any other criteria specified by the analytical methods used. Furthermore, project completeness was defined as the percentage of data used to prepare a preliminary human health-based risk evaluation and upon which recommendations for site remediation are to be based. For analytical data to be considered usable for the preliminary risk evaluation and remediation recommendations, each data point must be satisfactorily validated.

Results that have been flagged or qualified "U," "UJ," "J," "B+," "G+," "A+," "T+," or "S" for various reasons encountered minor problems with limited impact on the data quality. Data were qualified as rejected "R" when significant errors were identified. Rejected results will not be included in the risk assessment. The following summarizes the rejected data points:

Antimony in SB-33A-20 (SAIC02 and SAIC03), SB-33A-21 (SAIC02, SAIC03, SAIC04, and SAIC05), SB-33A-23 (SAIC02, SAIC03, SAIC04, and SAIC05), SB-33A-25 (SAIC04 and SAIC05), SB-33A-26 (SAIC02, SAIC03, and SAIC04), SB-33A-27 (SAIC03 and SAIC04), SB-37-12 (SAIC03), SB-37-13 (SAIC03), SB-37-14 (SAIC03), SB-37-15 (SAIC02 and SAIC03D), SB-37-16 (SAIC02), SB-37-17 (SAIC01, SAIC02, and SAIC03), SB-37-18 (SAIC02 and SAIC03), SB-37-19 (SAIC03), SB-37-20 (SAIC02 and SAIC03), SB-37-21 (SAIC01, SAIC02, and SAIC03), SB-BK-04 (SAIC01, SAIC02, and SAIC03), SB-BK-05 (SAIC01, SAIC02, SAIC03, and SAIC04), SB-BK-06 (SAIC01, SAIC01D, SAIC02, SAIC03, and SAIC04), SB-BK-07 (SAIC01, SAIC02, SAIC03, and SAIC04), SB-BK-08 (SAIC01, SAIC02, and SAIC03), SB-BK-09 (SAIC01, SAIC02, and SAIC03), SB-BK-010 (SAIC01, SAIC02, and SAIC03), SB-37-12 (SAIC04 and SAIC05), SB-37-17 (SAIC04 and SAIC05), SB-37-18 (SAIC04, SAIC04D, and SAIC05), and SB-37-19 (SAIC04).

DQOs for the RFI were set at 90 percent for field sampling and laboratory completeness. Based on the evaluation of the field and laboratory QC results presented in Appendix J (Sections J.2 through J.4), 99.5 percent of the total environmental sample data collected during the Phase II, Phase IIA, and Phase IIB RFI were used as the basis for all recommendations presented in this report.

3.4.6 *Detection and Quantitation Limits*

To ensure maximum confidence in chemical identification and detection levels, the CRL was used for reporting all of the target chemicals analyzed by the USAEC methods. The CRL is the lowest sample concentration that may be reported and is higher than the instrument detection limit (IDL). The CRLs were determined from a comparison of found versus actual concentrations for spiked standard matrix samples and calculated according to the USAEC reporting limit program with a 95 percent confidence limit.