



**TOOELE
ARMY
DEPOT**

SECOND REVISED FINAL

**PLANNING DOCUMENTS
KNOWN RELEASES SWMUs
TOOELE ARMY DEPOT
TOOELE, UTAH**

**Volume I:
CORRECTIVE MEASURES STUDY WORK PLAN**

**Contract No. DACA31-94-D-0060
Delivery Order No. 1**

Prepared for:

TOOELE ARMY DEPOT
Tooele, Utah 84074

Prepared by:

20070502775

DAMES & MOORE
7101 Wisconsin Avenue, Suite 700
Bethesda, Maryland 20814

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FEBRUARY 2000

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ACRONYMS AND ABBREVIATIONS

AT	Averaging time
bgs	Below ground surface
BRAC	Base Realignment and Closure
CAEPA	California Environmental Protection Agency
CAO	Corrective action objective
CAP	Corrective Action Permit
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cm ²	Square centimeter
cm/sec	Centimeters per second
CMS	Corrective Measures Study
COC	Contaminant of concern
COPC	Contaminant of potential concern
CRDL	Contract required detection limit
DCD	Deseret Chemical Depot
DCQAP	Data Collection Quality Assurance Plan
DNT	Dinitrotoluene
DOD	U.S. Department of Defense
DRE	Destruction and removal efficiency
DTSC	Department of Toxic Substances Control (California EPA)
ED	Exposure duration
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
°F	Degrees Fahrenheit
FFA	Federal Facility Agreement
ft ²	Square foot
ft/day	Feet per day

ACRONYMS AND ABBREVIATIONS (cont'd)

ft/mi	Feet per mile
ft/yr	Feet per year
GAC	Granular activated carbon
HEAST	Health Effects Assessment Summary Tables
HI	Hazard index
HMX	Cyclotetramethylenetetranitramine
HSP	Health and Safety Plan
HQ	Hazard quotient
IEUBK	Uptake/biokinetic model
in./yr	Inches per year
IR	Inhalation rate
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IWL	Industrial Waste Lagoon
JMM	James M. Montgomery, Inc.
µg/g	Micrograms per gram
µg/L	Micrograms per liter
µg/dL	Micrograms per deciliter
µm	Micrometer
MCL	Maximum contaminant level
MEP	Multiple extraction procedure
m ³ /day	Cubic meters per day
m ³ /hr	Cubic meters per hour
mg/kg-day	Milligram per kilogram per day
msl	Mean sea level
NPL	National Priorities List
OCDD	Octachlorodibenzo-p-dioxin
OIWL	Old Industrial Waste Lagoon

ACRONYMS AND ABBREVIATIONS (cont'd)

ORNL	Oak Ridge National Laboratory
OSWER	Office of Solid Waste and Emergency Response (EPA)
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
POTW	Publicly owned treatment works
ppm	parts per million
PRG	Preliminary remediation goal
PVC	Polyvinyl chloride
RA	Risk assessment
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine
RfC	Reference concentration
RfD	Reference dose
RFI	RCRA Facility Investigation
RSA	Reference study area
Rust E&I	Rust Environment & Infrastructure
SA	Surface area
SF	Slope factor
SHRTSC	Superfund Health Risk Technical Support Center
SVOC	Semivolatile organic compound
SWERA	Site-wide ecological risk assessment
SWMU	Solid waste management unit
TBV	Toxicity benchmark value
TCA	Trichloroethane
TCE	Trichloroethylene
TCEDC	Tooele County Economic Development Corporation
TCLP	Toxicity characteristic leaching procedure
TEAD	Tooele Army Depot
TEAD-N	Tooele Army Depot - North Area

ACRONYMS AND ABBREVIATIONS (cont'd)

TEAD-S	Tooele Army Depot - South Area
TECA	Tooele Chemical Activity
TNB	Trinitrobenzene
TNT	Trinitrotoluene
TPHC	Total petroleum hydrocarbon
µg/dL	Micrograms per deciliter
µg/g	Micrograms per gram
µg/L	Micrograms per liter
µg/m ³	Micrograms per cubic meter
UAC	Utah Administrative Code
UDEQ	Utah Department of Environmental Quality
USACE	U.S. Army Corps of Engineers
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency (now USAEC)
UTL	Upper tolerance level
UV	Ultraviolet
VOC	Volatile organic compound
WOE	Weight of evidence
yd ³	Cubic yard

EXECUTIVE SUMMARY

This document is the Corrective Measures Study (CMS) Work Plan for the Known Releases Solid Waste Management Units (SWMUs) at Tooele Army Depot (TEAD; formerly the North Area), Tooele, Utah. It has been prepared for TEAD, in cooperation with the U.S. Army Environmental Center (USAEC), in accordance with the Corrective Action Permit (CAP; UT3213820894) issued to TEAD by the State of Utah.

The CMS Work Plan addresses seven of the nine SWMUs that were identified in the *Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report for the Known Releases SWMUs* (Rust Environment & Infrastructure (E&I), 1995) as posing a potential risk to human health or the environment. These SWMUs are:

- X-Ray Lagoon (SWMU 3)
- Trinitrotoluene (TNT) Washout Facility (SWMU 10)
- Laundry Effluent Pond and Waste Pile Areas (SWMU 11)
- Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)
- Battery Shop (SWMU 25)
- Old Industrial Waste Lagoon (OIWL; SWMU 30).

The two other SWMUs identified in the Phase II RFI as posing a potential risk to human health or the environment – the Industrial Waste Lagoon (IWL; SWMU 2) and the Battery Pit (SWMU 24) – are not included in the CMS process.

Additional sampling is proposed for SWMU 2 to address soil contamination in the portion of the site regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The results of this sampling and a revised human health risk assessment (RA) will be presented as a separate report.

In November 1996, Davy International removed potentially contaminated soil to a depth of 9 feet from the Battery Pit (SWMU 24) and collected confirmatory soil samples from the sidewalls and the bottom of the excavation. Based on these sample results, and the human health RA presented in the Phase II RFI (Rust E&I, 1995), no elevated risk to a future construction worker was identified. Therefore, no further action is warranted at SWMU 24.

In 1993, TEAD was placed on the list of facilities scheduled for realignment under the Base Realignment and Closure (BRAC) Program. A portion of SWMU 30 is located within the Maintenance Area, which is scheduled for transfer under the BRAC process. The *Tooele Army Depot Conversion and Reuse Plan* (Tooele County Economic Development Corporation (TCEDC), 1995) identifies the primary land uses planned for the Maintenance Area as commercial and industrial. These anticipated land uses provide the basis for recommendations in this report.

The Phase II RFI Report identified contaminants of potential concern (COPCs; i.e., constituents above background concentrations) in surface soil, subsurface soil, or groundwater at the Known Releases SWMUs (Rust E&I, 1995). The human health RA indicated that some of these COPCs pose a human health cancer risk above 1×10^{-6} or a noncancer hazard index (HI) greater than 1.0 under the hypothetical future residential land use scenario. Therefore, according to the State of Utah Administrative Code (UAC) R315-101-1(b)4, a site management plan – the requirements of which are fulfilled by the performance of a RCRA CMS – must be prepared.

The goal of the CMS Work Plan is to identify potential corrective measures alternatives for each of the SWMUs that were determined to pose a human health or environmental risk. (Note that the alternatives will be evaluated in the CMS Report, to be prepared upon completion of the CMS Work Plan.) The Work Plan accomplishes this goal by first identifying corrective action objectives (CAOs) for the COPCs. The development of CAOs considers land use and potential receptor assumptions, exposure pathways, results of the human health RA, health effects criteria, and background sample results. Both quantitative (surface soil) and qualitative (soil and groundwater) CAOs are identified to focus the development of treatment technologies on those that are capable of achieving the appropriate target levels. In addition, U.S. Environmental Protection Agency (EPA) guidance (Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-04) and U.S. Army policy (Radkiewicz, 1995) direct that CAOs should reflect the reasonably anticipated future land use to focus on developing practicable and cost-effective corrective measures alternatives and to streamline the environmental cleanup process.

The next step in the CMS process is to compare the COPCs identified in the Phase II RFI Report to the CAOs. Those COPCs whose maximum concentrations exceed CAOs are contaminants of concern (COCs). The following COCs are identified for soil:

- Metals at SWMUs 11, 12/15, and 25
- Explosives at SWMU 10
- Semivolatile organic compounds (SVOCs) at SWMU 11
- Pesticides at SWMU 12/15.

At some SWMUs, the human health RA performed as part of the Phase II RFI (Rust E&I, 1995) identified unacceptable risks, hazards, or blood lead levels, but the CMS identifies no COCs. Alternatively, COCs may be identified in the CMS without related unacceptable risks, hazards, or blood lead levels. This apparent inconsistency between the results of the human health RA and the COC analyses performed in the CMS is due to differences in the RA and CAO approaches. The human health RA was based on the exposure point concentration (EPC) for each COPC, while the COC analyses conservatively compare the maximum COPC concentration to its respective CAO. (The EPC is a statistically derived value that represents the likely concentration that an individual is exposed to when working in the area of the SWMU.) In addition, RA models differ in the Phase II RFI and in the CAO calculations performed in the CMS. The model used in Appendix A of this Work Plan integrates methodologies from RAs in

all of the RFIs and the Remedial Investigation (RI) performed for different groups of SWMUs at TEAD, and incorporates updated and more realistic assumptions. Different models and assumptions were used in the RFI RAs. The model presented herein is also being used in the CMS Work Plans for the other SWMU groups at TEAD, which will result in uniformly consistent analyses.

The COCs are then evaluated in conjunction with the human health RA, the ecological RA, and the vadose zone modeling results. According to UAC R315-101, management measures (which include land use restrictions), at a minimum, must be evaluated for SWMUs with a calculated cancer risk greater than 1×10^{-6} and an HI greater than 1.0 for the hypothetical future residential land use; active corrective measures (i.e., capping, excavation) must be considered for SWMUs with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0. Corrective measures are identified based on results of the human health RA, the potential for further degradation of groundwater, impacts to ecological receptors, and the extent and concentrations of COCs.

Note that additional sampling has been conducted at SWMUs 3, 10, 11, 12/15, and 30 (see *Addendum to the Data Collection Quality Assurance Plan (DCQAP)*, Volume II of the Planning Documents; Dames & Moore, 1997) to further evaluate the extent of contamination. Groundwater flow and contaminant transport at SWMUs 10 and 12/15 are also being modeled as part of these additional activities. (The results of the sampling and groundwater modeling will be presented as part of the CMS Report, which will reevaluate identified COCs and recommended corrective measures, as warranted.)

Corrective measures – which may include treatment technologies and management measures – are identified and screened for the COCs identified in soil and groundwater. In addition, management measures are presented and evaluated for the SWMUs that have a risk and HI less than 1×10^{-4} and 1.0, respectively, under the current land use scenario and that do not pose an unacceptable risk to the environment. (Per UAC R315-101-6(e), active corrective measures must be evaluated for sites with risk or HI levels above these goals under the current land use scenario; management measures must be considered for sites with risk or HI levels below these goals.) Management measures are identified for these sites to prevent residential development (thus preventing a potentially different exposure scenario and risk) and to meet the requirements of the regulation.

Each treatment technology is compared to standard initial screening criteria, including site characteristics, waste (or COC) characteristics, and technology limitations. Based on this screening, the technologies retained for further consideration include:

- Soil
 - Land use/deed restrictions
 - Fencing
 - Excavation
 - Capping

- Soil covers
 - Composting
 - Slurry treatment (anaerobic/aerobic)
 - Solidification/stabilization
 - Incineration
 - Soil washing
 - Off-post treatment/disposal.
- Groundwater
 - Natural attenuation
 - Monitoring
 - Land use/deed restrictions
 - Vertical recovery wells
 - Granular activated carbon (GAC)
 - Air stripping.

The CMS Work Plan then combines these technologies into corrective measures alternatives. The alternatives address all identified COCs in the various media to meet the SWMU-specific CAOs and to prevent further degradation of the environment in accordance with the State of Utah's "Principle of Non-Degradation" (UAC R315-101-3). The following alternatives are identified for each SWMU:

- X-Ray Lagoon (SWMU 3)
 - Land use restrictions to prevent residential development and well abandonment.
- TNT Washout Facility (SWMU 10)
 - Excavation, composting of explosives in soil at the old TNT washout ponds, groundwater monitoring, and land use restrictions to prevent residential development and the use of groundwater.
 - Excavation, composting of explosives in soil at the old TNT washout ponds, groundwater extraction and treatment using carbon adsorption, and land use restrictions to prevent residential development.
 - Excavation, slurry treatment of explosives in soil at the old TNT washout ponds, groundwater monitoring, and land use restrictions to prevent residential development and the use of groundwater.
 - Excavation, off-post treatment/disposal of explosives in soil at the old TNT washout ponds, groundwater monitoring, and land use restrictions to prevent residential development and the use of groundwater.

- Laundry Effluent Pond and Waste Pile Areas (SWMU 11)
 - Land use restrictions to prevent residential development.
 - Excavation and off-post treatment/disposal of contaminated soil within the waste piles, and land use restrictions to prevent residential development.
- Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)
 - Constructing a multilayer landfill cap in accordance with closure requirements, groundwater monitoring, and land use restrictions to prevent residential development and the use of groundwater.
 - Constructing an evapotranspiration landfill cover in accordance with closure requirements, groundwater monitoring, and land use restrictions to prevent residential development and the use of groundwater.
 - Constructing an evapotranspiration landfill cover in accordance with closure requirements, groundwater extraction and treatment using air stripping, and land use restrictions to prevent residential development and the use of groundwater.
- Battery Shop (SWMU 25)
 - Land use restrictions to prevent residential development.
 - Installation of a soil and vegetative cover over the impacted area to prevent exposure to contaminated soil, and land use restrictions to prevent residential development.
 - Excavation and off-post treatment/disposal of soil, and land use restrictions to prevent residential development.
 - Excavation and solidification/stabilization of soil, and land use restrictions to prevent residential development.
 - Excavation of soil and soil washing, off-post disposal of residuals, and land use restrictions to prevent residential development.
- Old Industrial Waste Lagoon (SWMU 30)
 - No further action.
 - Land use/deed restrictions to prevent residential development.

Table ES-1 summarizes the results of the human health and ecological RAs, identified COCs, and corrective measures alternatives for each of the evaluated Known Releases SWMUs.

The CMS Report, to be prepared upon completion of the CMS Work Plan, will evaluate the corrective measures alternatives. The evaluation criteria consist of technical, environmental, human health, institutional, and cost considerations. To ensure that the alternative selected for each SWMU is cost-effective and protects human health and the environment, each alternative is given a ranking of high, moderate, or low for each of the five evaluation criteria.

TABLE ES-1

Summary of Corrective Measures Alternatives
Known Releases SWMUs

SWMU	Results of Human Health RA (a)						Results of Ecological RA (b)	Potential Effects on Groundwater?	COCs (c)	Corrective Measures Alternatives
	Military			Construction Worker						
	Cancer Risk	HI	Blood Lead	Cancer Risk	HI	Blood Lead				
X-Ray Lagoon (SWMU 3)	1.4×10 ⁻⁷	0.07	NE (d)	NE	NE	NE	No unacceptable risk	No	None	Land use restrictions and well abandonment
TNT Washout Lagoon (SWMU 10)	1.3×10 ⁻⁵	2.1	NE	6.1×10 ⁻⁷	12	NE	Potential unacceptable risk	Yes	Explosives	Excavation, composting, groundwater monitoring, and land use restrictions Excavation, composting, groundwater treatment, and land use restrictions Excavation, slurry treatment, groundwater monitoring, and land use restrictions Excavation, off-post treatment/disposal, groundwater monitoring, and land use restrictions
Laundry Effluent Pond and Waste Pile Areas (SWMU 11)	1.1×10 ⁻⁵	0.74	11.1	NE	NE	NE	Potential unacceptable risk	No	SVOCs, metals	Land use restrictions Excavation, off-post treatment/disposal, and land use restrictions
Sanitary Landfill/ Pesticide Disposal Area (SWMU 12/15)	1.5×10 ⁻⁵	0.18	NE	1.2×10 ⁻⁶	1.6	NE	Potential unacceptable risk	Yes	Metals, SVOCs, pesticides	Multilayer landfill cap, groundwater monitoring, and land use restrictions Evapotranspiration landfill cover, groundwater monitoring, and land use restrictions Evapotranspiration landfill cover, groundwater pump and treat, and land use restrictions

TABLE ES-1 (cont'd)

	Results of Human Health RA (a)						Results of Ecological RA (b)	Potential Effects on Groundwater?	COCs (c)	Corrective Measures Alternatives
	Military			Construction Worker						
	Cancer Risk	HI	Blood Lead	Cancer Risk	HI	Blood Lead				
SWMU Battery Shop (SWMU 25)	6.7×10 ⁻⁶	1.4	6.8	NE	NE	NE	No unacceptable risk	No	Metals	Land use restrictions Soil cover and land use restrictions Excavation, off-post treatment/disposal, and land use restrictions Excavation, solidification/stabilization, and land use restrictions
Old Industrial Waste Lagoon (SWMU 30)	9.2×10 ⁻⁶	0.05	NE	NE	NE	NE	No unacceptable risk	No	None	Excavation, soil washing, and land use restrictions No further action Land use/deed restrictions

(a) Human health RA results from the Phase II RFI Report (Rust E&I, 1995) assuming reasonably anticipated future land use scenarios (continued military use and construction worker scenarios); HI = noncancer hazard index; blood lead levels are expressed in micrograms per deciliter ($\mu\text{g/dL}$) for the 95th percentile. Maximum risk, HI, blood lead reported.

(b) Site-Wide Ecological RA Report (SWERA; Rust E&I, 1997). The HIs for the TEAD SWMUs were compared to a reference study area HI; the ratios of the HIs formed the primary basis for categorization of risk (Rust E&I, 1997).

(c) Human health contaminants of concern.

(d) Pathway incomplete or not evaluated; see text.

1.0 INTRODUCTION

This document, the Corrective Measures Study (CMS) Work Plan, is Volume I of the Planning Documents for the Known Releases Solid Waste Management Units (SWMUs) at Tooele Army Depot (TEAD; formerly the North Area), Tooele, Utah. It has been prepared for TEAD, in cooperation with the U.S. Army Environmental Center (USAEC), under the requirements of Delivery Order No. 1, Alternatives Development and Decision Documents for TEAD - North Area (TEAD-N), Contract No. DACA31-94-D-0060. The CMS Work Plan was developed in accordance with guidance for performing corrective measures under the Resource Conservation and Recovery Act (RCRA; Sperber, 1996) and requirements of the Corrective Action Permit (CAP; UT3213820894) issued to TEAD by the State of Utah Department of Environmental Quality (UDEQ) in January 1991.

As directed by TEAD and USAEC, the CMS Work Plan is based on data analysis and conclusions presented in the *Phase II RCRA Facility Investigation (RFI) Report for the Known Releases SWMUs* (Rust Environment and Infrastructure (E&I), 1995). Dames & Moore did not reassess or reevaluate the data or conclusions presented in the RFI Report.

1.1 PURPOSE AND SCOPE

The CMS Work Plan addresses seven of the nine SWMUs that were identified in the Phase II RFI Report (Rust E&I, 1995) as posing a potential risk to human health or the environment. These seven SWMUs are:

- X-Ray Lagoon (SWMU 3)
- Trinitrotoluene (TNT) Washout Facility (SWMU 10)
- Laundry Effluent Pond and Waste Pile Areas (SWMU 11)
- Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)
- Battery Shop (SWMU 25)
- Old Industrial Waste Lagoon (OIWL; SWMU 30).

The human health risk assessment (RA) in the Phase II RFI Report (Rust E&I, 1995) was conducted in accordance with the State of Utah Administrative Code (UAC) R315-101. The RA reports that, under the hypothetical future residential land use scenario, these seven SWMUs pose a human health cancer risk above 1×10^{-6} or a noncancer hazard index (HI) greater than 1.0. According to UAC R315-101-6(c)3, a risk-based closure will not be granted; and a site management plan – the requirements of which are fulfilled by the performance of a RCRA CMS – must be prepared.

The two other SWMUs identified by the RFI as posing risks to human health or the environment – the Industrial Waste Lagoon (IWL; SWMU 2) and the Battery Pit (SWMU 24) – are not included in the CMS Work Plan for the following reasons:

- Additional sampling is proposed for SWMU 2 to address the soil portion of the site, which is regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This sampling will support a revised human health RA, the Proposed Plan, and the Record of Decision for the previously remediated soil at this SWMU. Sampling will include the collection of 30 soil samples from 10 3-foot soil borings. Samples will be analyzed for chromium and lead. The results of the additional sampling, including a revised human health RA, will be presented as a separate stand-alone report.
- The Battery Pit (SWMU 24), which consisted of a concrete cylinder, was removed by Davy International in November 1996. Nine feet of soil immediately beneath the cylinder was also removed. Confirmatory samples were collected from the sidewalls and the bottom of the excavation and analyzed for metals. Because only subsurface soil contamination was identified, the human health RA considered only the future construction worker scenario. Based on the RA results (a risk of 8.3×10^{-10} and an HI of 1.6×10^{-6}) and the removal action performed by TEAD, no further action is warranted at this SWMU.

In addition to the human health RA, a site-wide ecological RA (SWERA; Rust E&I, 1997) was performed at TEAD. The SWERA recommended consideration of corrective measures at the TNT Washout Facility (SWMU 10), the Laundry Effluent Pond and Waste Pile Areas (SWMU 11), the Sanitary Landfill (SWMU 12/15), and the Battery Shop (SWMU 25) due to potential unacceptable ecological risks to receptors. The SWERA recommended no further action for the X-Ray Lagoon (SWMU 3) and the OIWL (SWMU 30).

The goal of the CMS Work Plan is to identify potential corrective measures alternatives for each SWMU that poses an unacceptable human health or environmental risk. This is accomplished by:

- Developing corrective action objectives (CAOs) for the contaminants of potential concern (COPCs) in the various media under the reasonably anticipated future land use scenarios. The CAOs include quantitative risk-based objectives and qualitative regulatory-driven objectives. COPCs are compared to quantitative CAOs to identify contaminants of concern (COCs), which require corrective measures.
- Identifying and screening corrective measures technologies to meet the CAOs. Site characteristics, waste (or COC) characteristics, and technology limitations are considered in this screening step.
- Assembling the selected technologies into corrective measures alternatives.

The CMS Report will recommend one alternative for implementation at each Known Releases SWMU.

The CMS Work Plan includes collection of additional data and conduct of related analyses to resolve data gaps identified in the Phase II RFI (Rust E&I, 1995). It is one of four Planning Documents prepared for the Known Releases SWMUs, three of which were previously submitted and approved by regulators in 1997 (Dames & Moore, 1997):

- Volume II: *Addendum to Data Collection Quality Assurance Plan (DCQAP)*.
- Volume III: *Addendum to the Data Management Plan*.
- Volume IV: *Health and Safety Plan*.

Based on additional sampling and evaluation, the CMS Report will reevaluate identified COCs and recommended corrective measures, as warranted.

1.2 INSTALLATION BACKGROUND

1.2.1 TEAD Location

TEAD is located in the Tooele Valley in Tooele County, Utah, immediately west of the City of Tooele (population 13,887 (1990 census)) and 30 miles southwest of Salt Lake City (see Figure 1-1). The installation currently covers 24,473 acres; originally, it included an additional 1,700 acres, which was transferred in December 1998 under the Base Realignment and Closure (BRAC) Program. Tooele Valley is bounded to the south by the Stockton Bar and South Mountain, to the north by Grantsville (population 4,500) and the Great Salt Lake, to the east by Tooele and the Oquirrh Mountains, and to the west by the Stansbury Mountains.

The area surrounding TEAD is largely undeveloped, with the exception of Tooele, Grantsville, and Stockton (population 400, located south of TEAD). Land use surrounding the installation includes pasture, cultivation, and rangeland grazing to the west and south. TEAD is bounded to the south by South Mountain, to the north by Highway 112 (Grantsville is located 2 miles to the north), to the east by a right-of-way owned by Union Pacific Railroad and property owned by the City of Tooele, and to the west by State Highway 59.

The Town of Grantsville obtains drinking water from three community water wells (Wells 1, 2, and 3) located downgradient of TEAD. The City of Tooele obtains drinking water from supply wells located cross-gradient of TEAD, from an upgradient well, and from a surface water source (reservoir). Several off-post wells are also used for irrigation and livestock watering. Water supply wells located at TEAD are used intermittently for on-post industrial use, as a drinking water source, and for irrigation of landscaped areas. According to TEAD personnel, groundwater is routinely monitored to comply with regulatory maximum contaminant levels (MCLs; Rust E&I, 1995). Industrial water used at the installation is treated and discharged to the City of Tooele publicly owned treatment works (POTW).

1.2.2 Physical Characteristics

TEAD is located at approximately 4,700 feet above mean sea level (msl) in the Great Salt Lake Basin, a large drainage basin within the Basin and Range physiographic province. This province is characterized by large fault blocks that trend approximately north-south and form a series of interior basins bounded by these fault-block mountain ranges. The Tooele Valley is bounded by the north-trending Stansbury and Oquirrh Mountains, which rise from the valley floor at elevations from 5,000 to more than 10,000 feet above msl. The topography of the valley floor is shaped by coalescing alluvial fans formed by debris washed from the adjacent mountains. The valley floor consists of Lake Bonneville sediments of Tertiary and Quaternary age. The basin fill consists of a sequence of moderately consolidated sand, gravel, silt, and clay overlain by deposits of unconsolidated sand, gravel, silt, and clay. Depth to bedrock varies from 0 (outcrops in the northeastern corner) to more than 2,000 feet in the south-central portion of the installation.

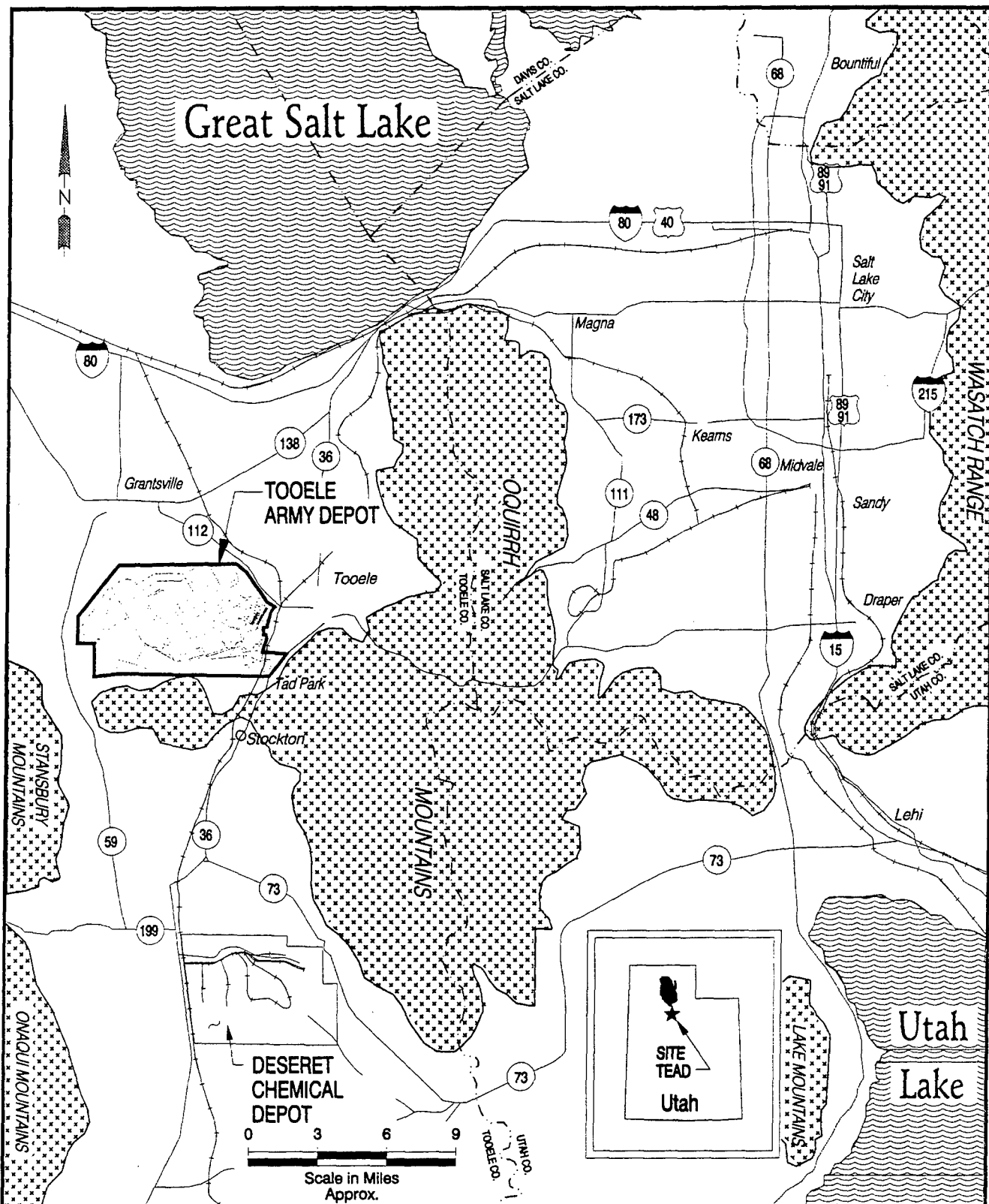
1.2.2.1 Topography. The topography of TEAD is characterized by flat land to gently rolling hills intersected by a series of shallow gullies, which drain the installation. The average topographic gradient of 70 feet per mile (ft/mi) in the northern portion of the installation increases to approximately 150 ft/mi at the southern boundary, which is at a higher elevation.

1.2.2.2 Climatology. The climate in the Tooele Valley ranges from arid to semiarid at the salt flats near the Great Salt Lake and in the surrounding mountains. Average annual precipitation is 17 inches in Tooele and 11 inches in Grantsville; precipitation increases to 40 inches per year (in./yr) in the mountains. The area is characterized by hot dry summers and cold winters, with a normal mean annual air temperature of 51 degrees Fahrenheit (°F). The prevailing wind is from the north-northwest.

1.2.2.3 Soil. Soil that develops in semiarid climates is generally deep, well-drained, moderately permeable, and alkaline. The hydraulic conductivity of the TEAD area soil ranges from 1×10^{-2} to 1×10^{-4} centimeters per second (cm/sec; James M. Montgomery, Inc. (JMM), 1992). Because of the low precipitation and soil conditions, vegetative cover is somewhat sparse, which contributes to the high natural erosion of soil in the area.

1.2.2.4 Groundwater. Unconfined, confined, and artesian conditions are characteristic of the Tooele Valley. Depth to groundwater in the primary alluvial aquifer ranges from less than 10 feet in the northern Tooele Valley to greater than 700 feet below ground surface (bgs) along the southwestern edge of TEAD. Groundwater flows from the southeast to the northwest. The horizontal hydraulic conductivity of the alluvial aquifer is approximately 200 feet per day (ft/day), and the vertical conductivity averages 30 ft/day. Calculated groundwater velocities range from 4 to greater than 9,800 feet per year (ft/yr). The potentiometric surface is relatively flat, with a hydraulic gradient of 0.007. The bedrock aquifer, consisting primarily of low permeability quartzite and limestone, occurs below a relatively small area in the eastern portion of TEAD. The permeability of

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SOURCE: RUST E&I, 1995

FIGURE 1-1
LOCATION MAP OF
TOOELE ARMY DEPOT
AND VICINITY

the bedrock is very low; however, evidence suggests extensive fracturing, which allows considerable groundwater flow within the bedrock (Rust E&I, 1995).

1.2.2.5 Surface Water. Surface water at TEAD consists almost entirely of stormwater drainage. Box Elder Wash and South Willow Creek traverse the installation from south to north, but are diverted for irrigational purposes south of the TEAD boundary. Flow is present in the wash during excessive snow melt.

1.2.3 History, Present Mission, and Future Use

TEAD was originally established in 1942 as the Tooele Ordnance Depot by the U.S. Army Ordnance Department. It was redesignated as TEAD-N in August 1962. TEAD - South Area (TEAD-S) came under the command of TEAD-N later in 1962. Both the North and South Areas of TEAD have been major ammunition storage and equipment maintenance installations that support other U.S. Army installations throughout the western United States. In 1996, TEAD-N and TEAD-S were designated as TEAD and Tooele Chemical Activity (TECA), respectively. In October 1996, TECA was designated as Deseret Chemical Depot (DCD).

The current missions of TEAD are:

- To receive, store, issue, maintain, and dispose of munitions
- To provide installation support to attached organizations
- To operate other facilities as assigned.

The mission of maintaining and repairing equipment was discontinued in 1995.

Developed features at TEAD include igloos, magazines, administration buildings, an industrial maintenance area, military and civilian housing, roads, and vehicle storage hardstands and other allied infrastructure. In 1993, TEAD was placed on the list of facilities scheduled for realignment under the BRAC Program. A portion of one of the Known Releases SWMUs (i.e., SWMU 30) is within the Maintenance Area, which is scheduled for transfer under BRAC. The *Tooele Army Depot Conversion and Reuse Plan* (TCEDC, 1995) identifies the primary land use planned for the Maintenance Area as industrial. TEAD will continue to store conventional ammunition.

1.2.4 Summary of Previous Investigations/Regulatory Overview

As a result of past activities at the installation, TEAD was included in the U.S. Army's Installation Restoration Program (IRP) in 1978. The first component of that program was an Installation Assessment (USATHAMA, 1979), which identified a number of known and potential waste and spill sites and recommended further investigations.

In 1984, TEAD was nominated for inclusion on the National Priorities List (NPL) because of the identified hazardous constituents at some of the sites, primarily

groundwater contamination at the IWL (SWMU 2). However, TEAD was not placed on the NPL until October 1990. In the interim, the U.S. District Court for the State of Utah issued a consent decree to TEAD for the groundwater contamination at SWMU 2.

As part of being placed on the NPL, a Federal Facility Agreement (FFA) was entered into between the U.S. Army, U.S. Environmental Protection Agency (EPA) Region 8, and UDEQ in January 1991. The FFA addresses 17 SWMUs under CERCLA.

In January 1991, TEAD was issued a RCRA Post Closure Permit for the IWL (SWMU 2). The permit included a CAP that required action at 29 SWMUs. Ten more SWMUs have since been added to the RCRA CAP, which is regulated by UDEQ.

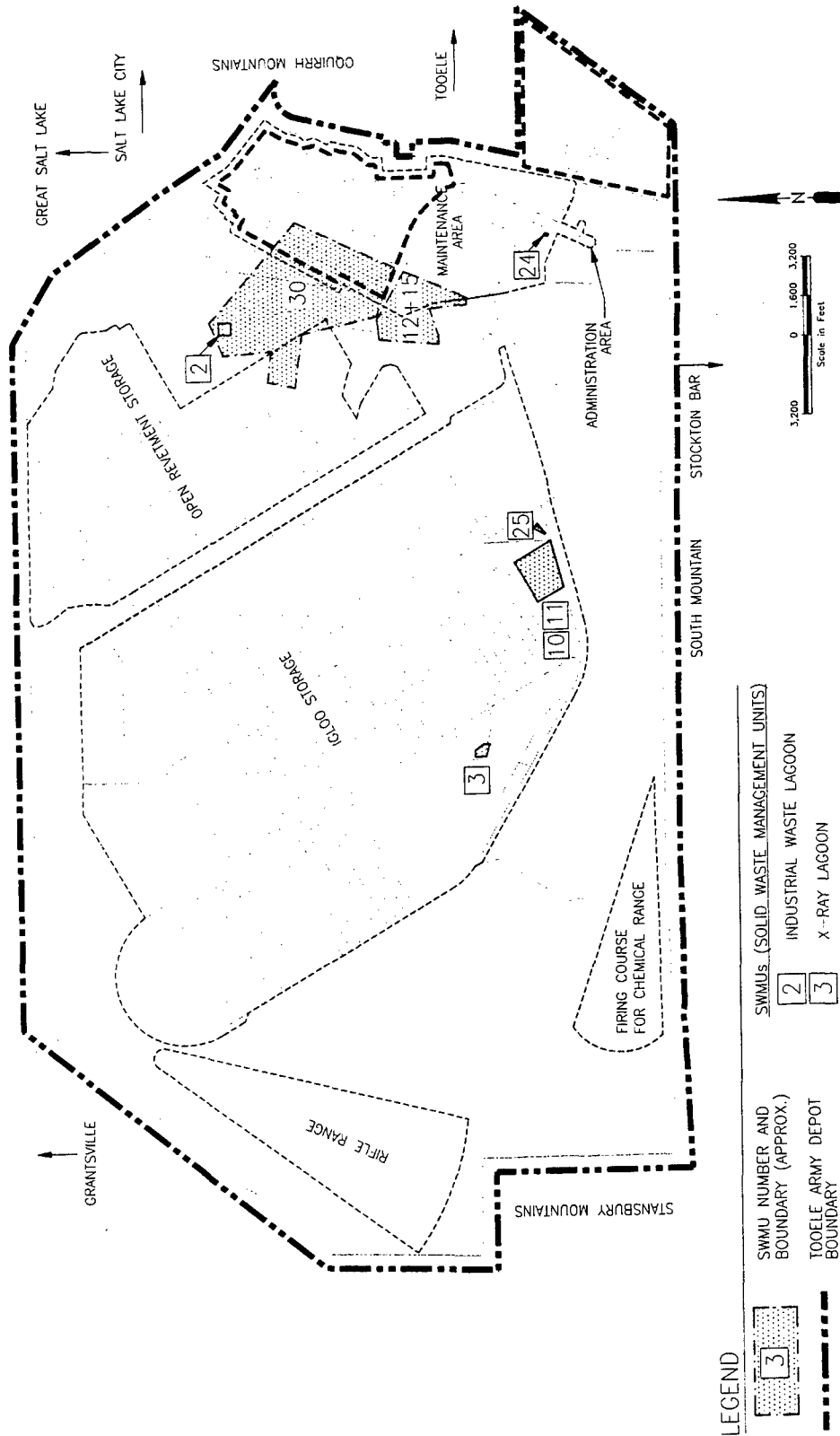
Since the initial assessment of TEAD, a number of environmental investigations have been performed (and are ongoing) under CERCLA or RCRA. At TEAD, these additional investigations have identified 57 sites, including nine SWMUs designated as the Known Releases SWMUs. These SWMUs, listed below, are managed under the RCRA CAP program:

- Industrial Waste Lagoon (SWMU 2)
- X-Ray Lagoon (SWMU 3)
- TNT Washout Facility (SWMU 10)
- Laundry Effluent Pond and Waste Pile Areas (SWMU 11)
- Pesticide Disposal Area (SWMU 12)
- Sanitary Landfill (SWMU 15)
- Battery Pit (SWMU 24)
- Battery Shop (SWMU 25)
- Old Industrial Waste Lagoon (SWMU 30).

Figure 1-2 shows the locations of the Known Releases SWMUs.

The following investigations are directly related to the Known Releases SWMUs:

- Installation Assessment of TEAD (USATHAMA, 1979).
- Closure of the Industrial Waste Lagoon (JMM, 1987).
- Preliminary Assessment/Site Investigation of TEAD (Engineering, Science, and Technology, 1988).
- Groundwater Quality Assessments of the Industrial Waste Lagoon (JMM, 1988; JMM, 1989; ESE, 1990).
- Remedial Investigations of TEAD-N (Weston, 1990; Jordan, 1990).
- Phase I RFI of Known Releases SWMUs (ASI, 1991).



LEGEND

SWMU NUMBER AND BOUNDARY (APPROX.)	SWMU (SOLID WASTE MANAGEMENT UNITS)
[2] TOOELE ARMY DEPOT BOUNDARY	[2] INDUSTRIAL WASTE LAGOON
[3] LAND USE AREAS	[3] X-RAY LAGOON
[10] FACILITY ROADWAY	[10] TNT WASHOUT FACILITY
[11] BASE REALIGNMENT AND CLOSURE (BRAC) PARCEL	[11] LAUNDRY EFFLUENT POND AND WASTE PILE AREAS
	[12+13] SANITARY LANDFILL AND PESTICIDE DISPOSAL AREA
	[24] BATTERY PIT
	[25] BATTERY SHOP
	[30] OLD INDUSTRIAL WASTE LAGOON

FIGURE 1-2
LOCATION OF KNOWN RELEASES SWMUs
TOOELE ARMY DEPOT

- Phase II RFI of Known Releases SWMUs (Rust E&I, 1995).
- Groundwater Monitoring Reports for TEAD-N (Geomatrix, 1997).
- Revised Final Site-wide Ecological Risk Assessment of TEAD-N (Rust E&I, 1997).

These investigations identified risks to human health or the environment at seven of the nine Known Releases SWMUs. The identification of risks requires an evaluation of corrective measures. The CMS Work Plan presents the first part of this evaluation, as discussed in Section 1.1.

1.3 REPORT ORGANIZATION

The organization of the remainder of the CMS Work Plan is as follows:

- Summary of the methodology used to develop corrective measures alternatives for each SWMU (Section 2.0).
- Summary of site-specific information for the SWMUs that were recommended for a CMS in the Phase II RFI Report (Rust E&I, 1995), as follows:
 - X-Ray Lagoon (SWMU 3; Section 3.0).
 - TNT Washout Facility (SWMU 10; Section 4.0).
 - Laundry Effluent Pond and Waste Pile Areas (SWMU 11; Section 5.0).
 - Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15; Section 6.0).
 - Battery Shop (SWMU 25; Section 7.0).
 - Old Industrial Waste Lagoon (SWMU 30; Section 8.0).
- The following information is included for each SWMU:
 - Brief site description and history.
 - Overview of the contamination assessment presented in the Phase II RFI Report and additional information from ongoing investigations.
 - Summary of the results of the human health RA and SWERA.
 - Summary of interim remedial actions (where applicable).

- Identification of COCs – based on comparing the COPCs presented in the Phase II RFI Report to the quantitative CAOs developed in Appendix A.
 - Estimation of the volumes or areas of contaminated soil that may require corrective action (where applicable).
 - Corrective measures alternatives, which are assembled from technologies retained in Appendix B. (Note that the detailed evaluation and selection of corrective measures alternatives is performed as part of the CMS Report.)
- Summary of the corrective measures alternatives identified for each of the seven Known Releases SWMUs (Section 9.0).
 - References (Section 10.0).
 - Discussion of quantitative and qualitative CAOs based on land use and potential receptor assumptions, exposure pathways, results of the human health RA, health effects criteria, and background sample results (Appendix A).
 - Identification and screening of applicable corrective measures that meet the CAOs based on site and waste (i.e., COC) characteristics and technology limitations (Appendix B).
 - Chemical analysis results from the Phase II RFI Report (Rust E&I, 1995) for each of the SWMUs included in the CMS Work Plan (Appendix C).
 - Procedure for evaluating residual ecological risks (after corrective measures are implemented; Appendix D).

2.0 CMS WORK PLAN METHODOLOGY

As discussed in Section 1.0, the results of the human health RA for the Known Releases SWMUs – presented in the Phase II RFI Report (Rust E&I, 1995) – indicate that corrective measures need to be evaluated for seven of the nine SWMUs. Sections 3.0 through 7.0 present the corrective measures evaluations, as outlined below:

- SWMU background – describes site features and past activities that potentially resulted in contamination.
- Summary of contamination assessment – identifies COPCs in various media based on the results of previous investigations. Appendix C presents chemical analysis results from the Phase II RFI Report (Rust E&I, 1995) for each SWMU included in the CMS Work Plan.
- Results of human health and ecological RAs – summarizes the results of risk calculations under current (and reasonably anticipated future) military or industrial land use scenarios and future residential land use scenarios. (Note that the human health RA (Rust E&I, 1995) evaluates the hypothetical residential scenario for future land use according to UAC R315-101-5.2(b)(1). However, as explained in Appendix A, this approach is not to be confused with the development of CAOs in the CMS Work Plan, which uses reasonably anticipated future land use scenarios (i.e., military, industrial, construction, or residential).)

Per UAC R315-101-6(e), corrective action must be considered for sites with a risk greater than 1×10^{-4} or an HI greater than 1.0 under the current land use scenario. Lead must be addressed if blood lead levels exceed the Centers for Disease Control and Prevention (CDC) guideline of 10 micrograms per deciliter ($\mu\text{g/dL}$). For those sites with a risk between 1×10^{-4} and 1×10^{-6} , risk levels, COCs, volume and level of contamination, ecological RA results, groundwater impacts, and regulatory requirements are evaluated to determine appropriate actions or measures, as required by UAC R315-101(b)(4).

This discussion also summarizes the results of the SWERA (Rust E&I, 1997), which supersedes the ecological evaluation in the Phase II RFI Report.

- Interim corrective actions – discusses corrective measures performed by TEAD, if applicable, to mitigate risks identified in previous investigations.
- Identification of CAOs – presents quantitative CAOs developed in Appendix A, which are used to identify COCs for further consideration in the CMS Report.

CAOs consist of medium- and chemical-specific goals for protecting human health and the environment. They are used to assess corrective measures technologies to determine which are likely to achieve appropriate target levels. Selected technologies are then combined to create corrective measures alternatives. In addition, EPA guidance (Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.7-04) and U.S. Army policy (Radkiewicz, 1995) direct that CAOs should reflect the reasonably anticipated future land use to focus on developing practicable and cost-effective corrective measures alternatives and to streamline the environmental cleanup process.

CAOs can be specific and numerical (i.e., quantitative) or general and descriptive (i.e., qualitative). They are achieved by:

- Reducing exposure (e.g., installing a soil cover or limiting access).
- Reducing contaminant levels (e.g., active remediation; USEPA, 1988).

CAOs are used for comparison with site data to evaluate whether corrective measures are necessary, what samples/areas within a site may require corrective measures, and whether corrective measures alternatives are appropriate to protect human health and the environment.

CAOs for the Known Releases SWMUs are based on land use and potential receptor assumptions, exposure pathways, results of the human health RA, regulatory criteria, and background sample results. They were developed in accordance with UAC R315-101, EPA guidance (USEPA, 1991), and the human health RA (Rust E&I, 1995).

As discussed in Appendix A, no quantitative CAOs are calculated for groundwater. Qualitative groundwater CAOs include compliance with State and Federal regulations and standards (e.g., UAC R315-101, "Principle of Non-Degradation"; UAC 315-302, Landfill Closure Requirements; and UAC R317-6, Groundwater Quality Protection).

For soil, quantitative CAOs – which are acceptable residual contaminant concentrations – are determined using human health RA methodology to evaluate intake by assumed exposure pathways, chemical-specific toxicity data in the form of health effects criteria, and assumed target risk level and hazard quotient (HQ). Assumed values for risk (1×10^{-6}) and HQ (1.0) and chemical-specific toxicity data (slope factors (SFs) and reference doses (RfDs)) are used to solve for the concentration term, or the pathway-specific CAO.

Three receptor populations – Depot workers, industrial workers, and construction workers – are used to evaluate potential future exposure to contaminated soil under the continued military and industrial (SWMU 30)

land use scenarios at the Known Releases SWMUs. The exposure pathways evaluated for developing CAOs are inadvertent ingestion, dermal absorption of contaminants following direct contact, and inhalation of contaminants in dust.

- Evaluation of COCs – compares the maximum concentration of each COPC to its quantitative CAO. COPCs that exceed CAOs are identified as COCs. To determine which contaminants require corrective action, consideration is given to whether average concentrations across the site (i.e., exposure point concentration (EPC), as used in the human health RA) exceed the CAO, whether COCs are isolated and at low levels, or whether COCs present unacceptable ecological risks. Engineering judgment may also influence the evaluation of COCs.
- Estimation of contaminated volume – estimates the volumes or areas of contaminated media that may require corrective action, where applicable, based on conservative assumptions. Accordingly, the actual volume of soil that requires remediation is likely to be less than estimated. For purposes of the CMS Work Plan, it is generally assumed that contamination extends both laterally and vertically one-third to one-half of the distance between the sample location with COC concentrations exceeding CAOs, and the sample location where analytical results indicate that no COCs were detected above CAOs. This approach is most appropriate for sites where sufficient data are available to delineate the contaminated area. For sites where there is only an isolated area of contamination, other factors – such as site activities, site conditions, and engineering judgment – are used to estimate the volume of contaminated soil.
- Development of corrective measures alternatives – assembles the technologies considered most appropriate as treatment technologies or management measures for the seven Known Releases SWMUs into SWMU-specific corrective measures alternatives. These alternatives are designed to:
 - Address the COCs identified in soil.
 - Meet the CAOs.
 - Prevent further degradation of the environment in accordance with UAC R315-101-3, the “Principle of Non-Degradation.”

The CMS Report will evaluate the corrective measures alternatives in detail.

Several of the corrective measures technologies and alternatives presented include off-post disposal of contaminated soil. As discussed in Appendix B, the soil may require pretreatment prior to placement in a landfill, depending on the concentration of contaminants and the possible applicability of land

disposal restrictions under RCRA. Pretreatment methods that might be required include off-post incineration for explosives or solidification/stabilization for metals. The CMS Report will further evaluate the need for these and other pretreatment methods.

Figure 2-1 presents a flow diagram of the corrective measures alternative development process.

The CMS Report will evaluate the corrective measures alternatives in detail. As required under UAC R315-101-7(a), it will also include a schedule of work. Each of the corrective measures alternatives is evaluated using RCRA evaluation criteria. According to RCRA guidance on performing a CMS (Sperber, 1996) and Module VII of the RCRA Part B Permit for TEAD, the detailed evaluation of each corrective measures alternative considers technical criteria (including performance, reliability, implementability, and safety), protection of human health, protection of the environment, administrative feasibility, and cost. The CMS Report will address how the alternatives reduce the exposure to contamination, the concentration of contaminants, or their migration.

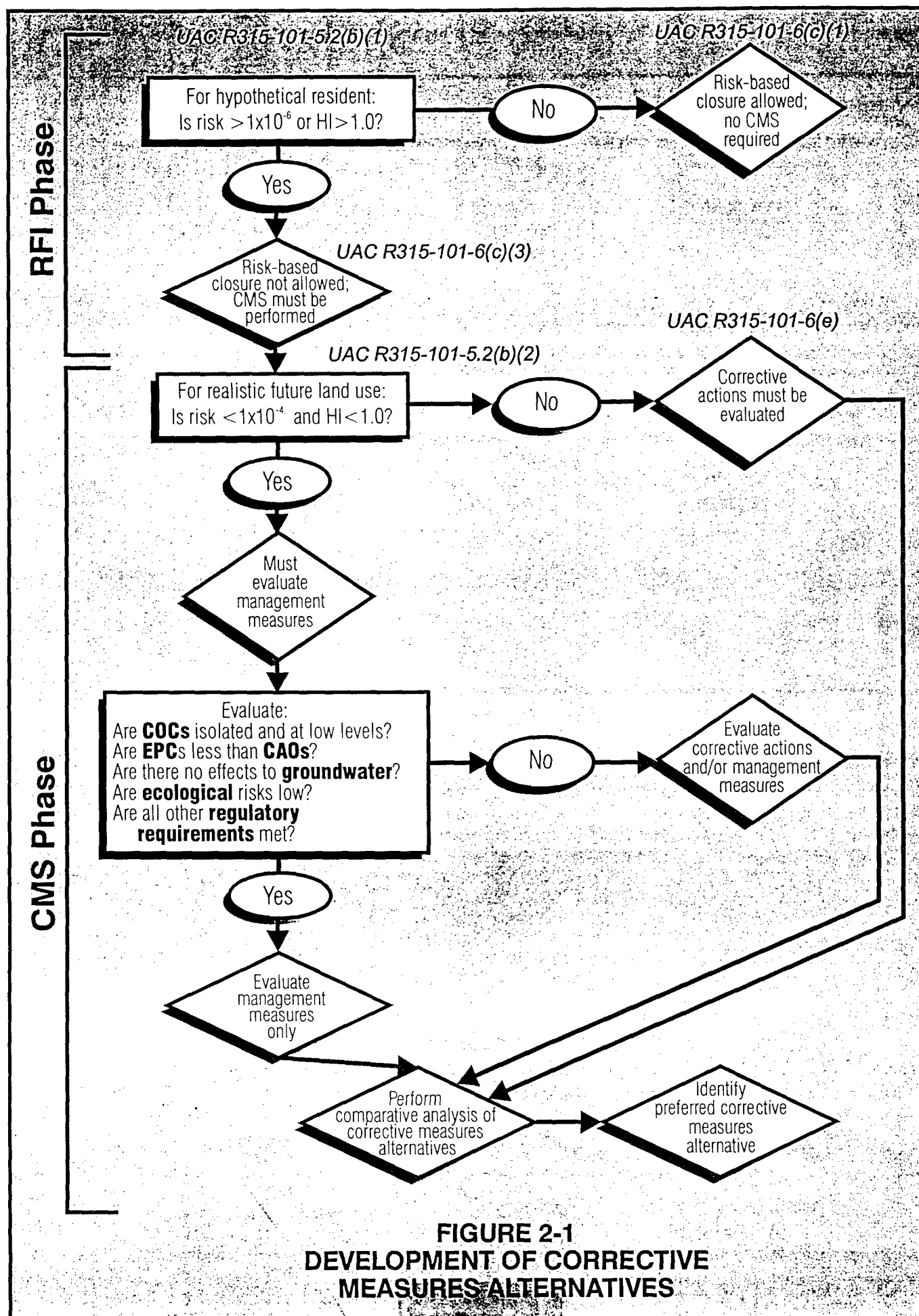


**FIGURE 2-1
DEVELOPMENT OF CORRECTIVE
MEASURES ALTERNATIVES**

3.0 X-RAY LAGOON (SWMU 3)

3.1 SWMU BACKGROUND

The X-Ray Lagoon (SWMU 3) is a 75- by 35-foot lined lagoon located in the southwestern portion of TEAD, across the road from the Film Processing Building (Building 1223; Figure 3-1). This 6-foot-deep lagoon was constructed of 100-mil plastic sheeting overlain by a few inches of gravel. From 1974 through 1990, the X-Ray Lagoon received rinsewater from film washing and diluted spent developer and fixer solutions from Building 1223. Approximately 252,000 gallons of rinsewater and 1,800 gallons of developer and fixer solutions were discharged (via an underground 8-inch ceramic pipe) to the lagoon during its operation. Because silver was produced as a byproduct during the development of X-ray films, the effluent from early operations (prior to the 1980 installation of a silver recovery machine) was presumably high in extractable silver. Other suspected chemicals discharged to the lagoon include aluminum sulfate, sulfuric acid, hydroquinone, potassium hydroxide, acetic acid, and glutaraldehyde.

Little information is available concerning the history of operations prior to 1974, though the Installation Assessment (USATHAMA, 1979) indicated that Building 1223 was the site of the former North Area Redeye Missile Rebuild Facility. However, no explosives contaminants were detected in this area.

An area of dense vegetation (including trees) and standing liquid northwest of Building 1223 and the lagoon was observed in historic aerial photographs during the Phase II RFI. A fire hydrant and a sewer box/septic tank are located in the vicinity and may be associated with the still-active Building 1223 (though wastes are no longer discharged to the lagoon). A leach field is suspected north of the septic tank. However, four soil borings were installed in the area of the suspected leach field, and no evidence of contamination was detected. The standing liquid observed during the Phase II RFI may have been caused by periodic flushing of a fire hydrant and a leak in the water main, which was repaired in November 1993 (Rust E&I, 1995).

3.2 SUMMARY OF CONTAMINATION ASSESSMENT

3.2.1 Soil/Sediment

Six metals – cadmium, copper, lead, mercury, silver, and zinc – were identified in sediment samples collected from the X-Ray Lagoon (in May 1983, June 1983, July 1986, March 1990, and May 1993). Silver was also detected in samples collected below the lagoon, with the highest concentrations at the surface; the detected concentrations steadily decreased with depth.

Analytical results for soil samples collected from the standing liquid area revealed low levels of metals to depths of up to 3 feet bgs. With the exception of low concentrations of di-n-butyl phthalate, which is considered to be a potential laboratory

contaminant, no volatile organic compounds (VOCs) or semivolatile organic compounds (SVOCs) were detected.

A sludge sample collected from the septic tank contained several metals and SVOCs. The SVOCs included polycyclic aromatic hydrocarbons (PAHs), which are commonly associated with petroleum. Sludge samples collected by the U.S. Army Corps of Engineers (USACE)-Sacramento in 1996 confirmed that petroleum constituents are the only contaminants in the septic tank sludge (Geomatrix, 1997). Overflow of the boiler in Building 1223 is considered to be the source of the petroleum contamination (see Section 3.4).

Magnesium and sodium were detected in soil samples from borings advanced during the Phase II RFI in the suspected septic tank discharge area. In addition, several metals were detected in subsurface soil sample borings placed along the pipeline used to discharge liquid wastes from Building 1223 to the lagoon.

3.2.2 Groundwater

Local groundwater flows toward the north and is present in the unconfined alluvial aquifer at depths ranging from 285 to 320 feet bgs. Samples collected from the two stainless-steel and three polyvinyl chloride (PVC) monitoring wells (in May 1993, November 1993, and January 1994) indicated the presence of some metals – arsenic (2.5 micrograms per liter ($\mu\text{g/L}$)), beryllium (1.2 $\mu\text{g/L}$), chromium (2,600 $\mu\text{g/L}$) nickel (317 $\mu\text{g/L}$), and manganese (1,060 $\mu\text{g/L}$). However, metals results may be due to turbidity from sedimentation in the wells and corrosion of the stainless-steel well materials. Toluene was also detected at low concentrations (below 10 $\mu\text{g/L}$) in groundwater and in the standing liquid in the septic tank during the first round of groundwater sampling.

Biannual groundwater sampling, conducted after the Phase II RFI, revealed stable hydrologic conditions at SWMU 3 that were consistent with those described in the Phase II RFI Report (Rust E&I, 1995). Chemical analysis of groundwater from each sampling event identified high chromium, nickel, and manganese concentrations in unfiltered groundwater samples. Because purge water was turbid with brown sediment and metal flakes during the 1995 sampling events, selected wells were redeveloped during the spring 1996 investigation (Geomatrix, 1997).

During the 1996 sampling event, the highest metals concentrations detected in groundwater prior to redevelopment were chromium (11,200 $\mu\text{g/L}$), nickel (2,450 $\mu\text{g/L}$), and manganese (3,920 $\mu\text{g/L}$). Following redevelopment, chromium, nickel, and manganese concentrations in unfiltered groundwater samples were below approximately 60 $\mu\text{g/L}$, 25 $\mu\text{g/L}$, and 80 $\mu\text{g/L}$, respectively. The highest dissolved metals concentrations measured in sample sets taken before redevelopment were 289 $\mu\text{g/L}$ for manganese and 412 $\mu\text{g/L}$ for nickel. Chromium was not detected in the filtered samples. After redevelopment, dissolved manganese and nickel concentrations were less than approximately 25 $\mu\text{g/L}$ and 85 $\mu\text{g/L}$, respectively (Geomatrix, 1997).

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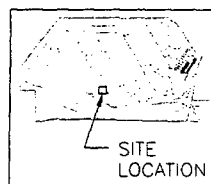
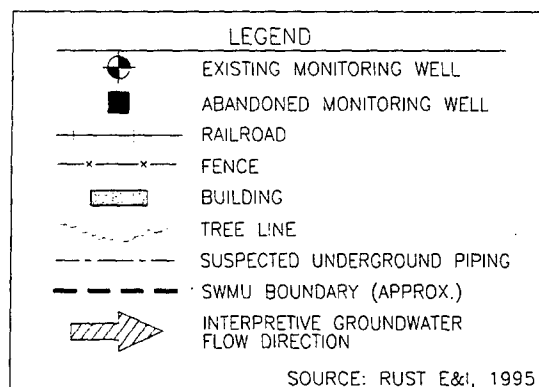
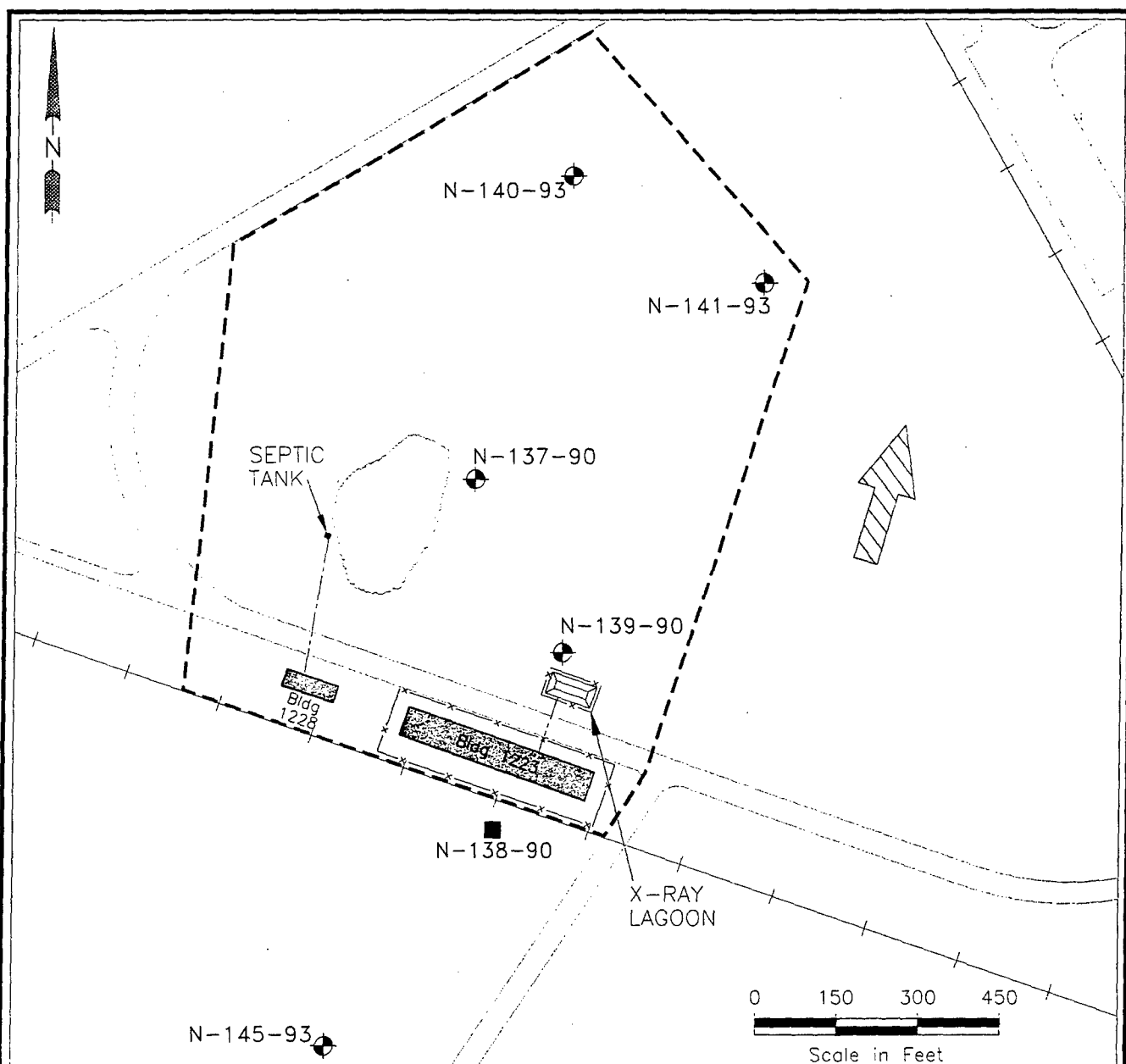


FIGURE 3-1
X-RAY LAGOON (SWMU 3)
TOOELE ARMY DEPOT

The most recent groundwater sampling at SWMU 3 was performed in fall 1997. This voluntary biannual sampling was discontinued by TEAD and USACE-Sacramento with the provision that the CMS Report will make a final determination on further groundwater monitoring.

These results and the high chloride concentrations identified in groundwater at SWMU 3 strongly support the theory that corrosion of the stainless-steel well casings is the source of the high concentrations of metals in groundwater (Geomatrix, 1997).

To further characterize the source of metals contamination in groundwater, a PVC well was installed proximate to the possible source area (X-Ray Lagoon) and near an existing stainless-steel well. All six monitoring wells (four PVC and two stainless steel) were sampled in three rounds, 1 month apart. The details of well installation and sampling are provided in the *Addendum to DCQAP*, Volume II of the Planning Documents; and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report.

The CMS Report will evaluate the collected data to provide information on trends in the occurrence and distribution of metals. Although the number of samples collected is too small to perform a robust statistical analysis, a direct comparison of sampling results for the PVC and the stainless-steel wells will provide an indication of the effect of well construction materials on metals detections in groundwater. The stainless-steel well composition, along with groundwater chemistry, will be evaluated for possible evidence of corrosive conditions.

3.3 SUMMARY OF RA RESULTS

3.3.1 Human Health RA

Table 3-1 summarizes the risks and hazards calculated for SWMU 3. Risks were calculated for two exposure areas – the X-Ray Lagoon and the Former Standing Liquid Area. Results of the human health RA (Rust E&I, 1995) indicate that, under the future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at SWMU 3 exceed the target of 1×10^{-6} for both the adult and child receptors. Noncancer HIs also exceed the regulatory target of 1.0 for both receptors. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 3 per the requirements of UAC R315-101-1(b)(4).

The human health RA (Rust E&I, 1995) does not evaluate the future construction worker scenario for soil-based cancer risks and noncancer HIs resulting from soil exposure. However, the CMS Work Plan evaluates potential exposure to subsurface soil by comparing maximum concentrations of COPCs identified using data and methodology presented in the human health RA to risk-based CAOs for construction workers (developed in Appendix A).

TABLE 3-1

Summary of Human Health RA and
Corrective Measures Recommendations
X-Ray Lagoon (SWMU 3)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level (µg/dL) (a)	Recommendations
X-Ray Lagoon				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identifies potential cancer risks above 1×10^{-6} or an HI above 1.0. However, active corrective measures are not necessarily required because the risks and hazards calculated for the current land use (also the reasonably anticipated future land use) do not exceed 1×10^{-4} (cancer risk) or 1.0 (HI).
Current Land Use (b)				
Depot personnel	1.4×10^{-7}	0.072	NE (c)	
Future Land Use				
Residential- adult (d)	7.6×10^{-5}	19	NE	
Residential- child (d)	4.2×10^{-5}	17	NE	
Construction worker	NE	NE	NE	
Former Standing Liquid Area				
Current Land Use				
Depot personnel	NE	1.6×10^{-4}	NE	
Future Land Use				
Residential– adult (d)	7.6×10^{-5}	18	NE	
Residential– child (d)	4.2×10^{-5}	15	NE	
Construction worker	NE	NE	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter ($\mu\text{g}/\text{dL}$) for 95 percent of the population (should not exceed $10 \mu\text{g}/\text{dL}$).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Pathway incomplete or not evaluated; see text.
- (d) Human health RA results for a conservative future residential land use scenario, as required in UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMU 3.

Under the current military land use scenario, which is also the reasonably anticipated future land use, the greatest cancer risk calculated in the human health RA is 1.4×10^{-7} , and the greatest noncancer HI is 0.072 – both of which occur at the X-Ray Lagoon (Rust E&I, 1995). However, these levels are below State of Utah goals of 1×10^{-4} and 1.0, respectively (above which active corrective measures must be evaluated per UAC R315-101-6(e)). In addition, the risk level is below the lower limit of EPA's target range of 1×10^{-4} to 1×10^{-6} , and the HI is below the goal of 1.0.

The Phase II RFI Report does not estimate blood lead levels at SWMU 3 because the EPC of lead in soil (3 micrograms per gram ($\mu\text{g/g}$)) does not exceed the 400- $\mu\text{g/g}$ screening level set by EPA for CERCLA and RCRA programs.

3.3.2 Ecological RA

Based on the evaluation of concentrations of COPCs in soil and levels of exposure to ecological receptors, the SWERA (Rust E&I, 1997) concluded that the COPCs detected in soil at SWMU 3 present a low ecological risk. Specific factors considered in this risk characterization are as follows:

- Risks to passerine birds, raptors, and mammals are all less than the risks estimated for the reference study area (RSA).
- Risks to plants and soil fauna exceed the risks estimated for the RSA. However, a high degree of uncertainty is associated with these estimates due to limited toxicological information.
- Because ecological habitat at the site is limited (approximately 0.2 acre), there is insufficient space to support significant wildlife and plant communities.

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 3. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 3.

Based on the above factors and the SWERA's conclusion that ecological risk at SWMU 3 is considered to be low, it is recommended that no corrective measures be considered for ecological risk at the X-Ray Lagoon.

3.4 INTERIM CORRECTIVE ACTIONS

On the basis of sludge results from the septic tank, TEAD implemented an inspection program to ensure that contaminants are no longer released to the septic

system. The most recent sampling, conducted by USACE-Sacramento, indicates the presence of petroleum constituents in the septic tank sludge only (Geomatrix, 1997). These constituents are a result of periodic boiler overflow in Building 1223. However, no cleanup of the septic tank is planned because a waste stream that contains petroleum constituents does not meet the definition of a listed or characteristic waste under RCRA.

3.5 IDENTIFICATION OF COCs

Tables 3-2 and 3-3 compare the maximum concentration of each COPC to the corresponding quantitative CAO developed in Appendix A for surface and subsurface soil. Surface soil COPCs are identified in the human health RA of the Phase II RFI Report (Rust E&I, 1995). The human health RA does not evaluate the future construction worker scenario for soil-based cancer risks and noncancer HIs resulting from soil exposure. However, the CMS Work Plan evaluates potential exposure to subsurface soil by comparing the maximum concentrations of COPCs, identified using data and methodology presented in the human health RA, to risk-based CAOs for construction workers (developed in Appendix A). (As explained in Appendix A, there are no CAOs for groundwater because no COPCs or exposure was identified.) Based on this evaluation, there are no surface or subsurface soil COCs at the X-Ray Lagoon.

The Phase II RFI Report concludes that elevated metals concentrations in groundwater are the result of sedimentation due to improper development of the wells and corrosion of stainless-steel well materials – not site-related activities (Rust E&I, 1995). For this reason, no COCs are identified in groundwater, and no qualitative CAOs need to be met. Section 3.6 considers no treatment technologies for groundwater. Additional sampling of groundwater was designed to resolve the issue of the source of metals in groundwater. The CMS Report will reevaluate COCs in groundwater.

3.6 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101, which states that if the cancer risk present at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, the appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the realistic future land use scenario, active corrective measures are required.

To determine which technologies are most appropriate for SWMU 3, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs.

TABLE 3-2

Development of COCs in Surface Soil
X-Ray Lagoon (SWMU 3)

COPC (a)	Maximum Concentration (µg/g)	Depot Personnel CAO (b) (µg/g)	Surface Soil COC? (c)
Metals			
Cadmium	1.77	220	No
Chromium (d)	212	2,000	No
Copper	108	68,000	No
Lead	39	1,800	No
Mercury	0.67	440	No
Selenium	0.78	10,000	No
Silver	400	7,900	No
Zinc	199	490,000	No
SVOCs			
Bis(2-ethyhexyl) phthalate	0.95	78	No
Di-n-butyl phthalate	12.9	120,000	No

- (a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
- (b) Corrective action objectives developed in Appendix A.
- (c) Contaminants of concern (i.e., COPCs greater than CAOs).
- (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.

TABLE 3-3

Development of COCs in Subsurface Soil
X-Ray Lagoon (SWMU 3)

COPC (a)	Maximum Concentration (µg/g)	Construction Worker CAO (b) (µg/g)	Subsurface Soil COC? (c)
Metals			
Arsenic	12.9	32	No
Barium	350	110,000	No
Chromium	24.5	23,000	No
Cobalt	7.4	110,000	No
Silver	71.1	8,400	No
Vanadium	34.6	6,100	No
Zinc	107	510,000	No
SVOCs			
Di-n-butyl phthalate	3.2	(d)	No
Diethyl phthalate	2.1	(d)	No

- (a) Contaminants of potential concern identified from data and methodology presented in the Phase II RFI Report (Rust E&I, 1995).
 (b) Corrective action objectives developed in Appendix A.
 (c) Contaminants of concern (i.e., COPCs greater than CAOs).
 (d) Calculated CAO is greater than 1 million parts per million (ppm; µg/g).

Therefore, based on the above criteria, the following corrective measures technology is considered to apply to SWMU 3:

Corrective Measures Technology (SWMU 3, X-Ray Lagoon)
Land use restrictions and well abandonment

The following corrective measures alternative is identified for SWMU 3 for further evaluation in the CMS Report:

SWMU 3	Corrective Measures Alternative
X-RAY LAGOON	Land use restrictions Impose land use restrictions to prevent residential development, abandon wells, and discontinue monitoring

4.0 TNT WASHOUT FACILITY (SWMU 10)

4.1 SWMU BACKGROUND

The TNT Washout Facility (SWMU 10) was constructed in 1948 and operated through 1986. It consisted of the bomb reconditioning building (Building 1245), a storage facility (Building 1246), eight unlined old TNT washout ponds, one new unlined TNT washout pond, two below-ground steel settling basins, a series of unlined ditches, and underground piping (see Figure 4-1).

Operations at SWMU 10 consisted of decommissioning projectiles, bombs, rocket heads, and other munitions filled with 2,4,6-TNT, composition B, cyclotrimethylenetrinitramine (RDX), and tritonal. Decommissioning consisted of opening munition casings and using steam to remove the explosives. The casings were then rinsed with water to clean residual explosives material, which was contained and sold or destroyed. Metal casings were recovered and recycled; rinsewater was filtered through horsehair filters and discharged to two outdoor steel-lined settling basins. After leaving the settling tanks, the discharged rinsewater traveled 25 to 30 feet through both underground piping and aboveground ditches to the old TNT washout ponds. The ditches and ponds were unlined.

In 1983, the horsehair filters were replaced with a charcoal system, and a new washout pond was built to receive the charcoal-filtered rinsewater. The old washout ponds were closed in fall 1984 (see Section 4.4).

Because grading associated with the interim actions reworked the earthen embankments and pond structure into a relatively flat area, the former features of the pond system (including the unlined ditches that linked the old washout ponds) are now difficult to locate and identify. Section 4.4 discusses two interim actions conducted at the site. One of these actions included covering the old ponds with a PVC liner and soil cover.

Furthermore, because the reworked materials are composed of a heterogeneous mixture of embankment soil and pond sediment, the Phase II RFI identified no continuous or uniform strata of buried sediment (Rust E&I, 1995). Rather, red-stained soil (identified as sediment) was found at depths ranging from immediately below the PVC liner to approximately 5 feet bgs. According to the Phase II RFI, 0 to 1 foot of soil cover is now present over the PVC liner.

In 1986, bomb reconditioning at Building 1245 ceased, along with rinsewater discharge to the new washout pond. During a field reconnaissance of SWMU 10 in September 1992, no liquid or surface staining was observed in the new pond, and the trough and pipeline formerly used to convey rinsewater from Building 1245 to the pond appeared to be in good condition. Rainwater was observed in the steel settling tanks (Rust E&I, 1995).

In 1993, Building 1246 was demolished; the discharge trough and settling tanks were removed from SWMU 10 in 1996 (see Section 4.4).

4.2 SUMMARY OF CONTAMINATION ASSESSMENT

Investigations in the vicinity of the TNT Washout Facility identified surface soil, subsurface soil, surface water, sediment, and groundwater contamination. Constituents detected include acetone, cyclotetramethylenetetranitramine (HMX), RDX, nitrate/nitrite, sulfate, 2,4,6-TNT, 2,4-dinitrotoluene (DNT), and 1,3,5-trinitrobenzene (TNB).

4.2.1 Sediment

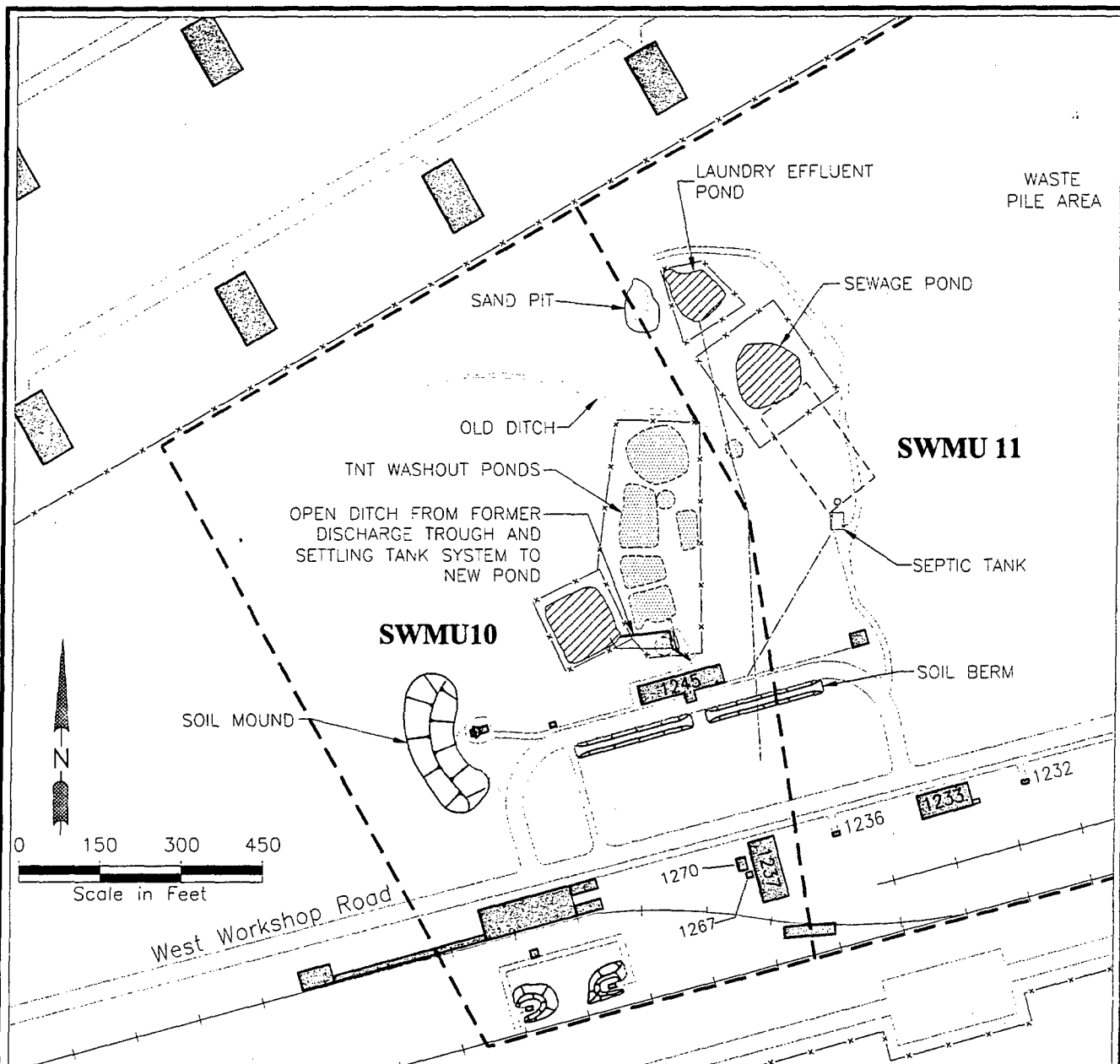
Previous investigations detected elevated concentrations of explosives in sediment from the old washout ponds. The primary COPCs are RDX and 2,4,6-TNT, which were detected in sediment at concentrations as high as 20,700 µg/g. In addition, 1,3,5-TNB, HMX, and 2,4-DNT were present. No contaminants were detected in the new washout pond sediment. Insufficient sediment was present in the steel settling basins for sample collection.

4.2.2 Soil

Elevated concentrations of explosives were detected in soil in the area of the old TNT washout ponds from immediately beneath the PVC cover to a depth of approximately 100 feet bgs. Explosives contamination appears to be laterally confined to the immediate vicinity of the old washout ponds; additional information was necessary to assess the lateral extent of explosives present in soil in the perched zone (17 to 49 feet bgs). Ten soil borings were drilled around the perimeter of the TNT washout ponds to further evaluate the horizontal extent of soil contamination in the perched zone. Additionally, four angled soil borings were drilled under the 35,000-gallon reservoir in Building 1245 to evaluate possible explosives soil contamination. The details of the soil sampling efforts are provided in the *Addendum to DCQAP*, Volume II of the Planning Documents; and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report.

The highest concentrations of explosives are present in soil inside the old washout ponds, from directly below the PVC cover to a depth of approximately 8 feet bgs (see sediment discussion above). 1,3,5-TNB and HMX concentrations were identified in samples collected throughout the soil column to a depth of approximately 45 feet bgs, with elevated levels detected between 30 and 45 feet, the depth of the perched zone. 2,4,6-TNT, 2,4-DNT, and nitrobenzene were detected in samples collected in the perched zone at approximately 40 feet, but these constituents were not present in samples collected above this depth. RDX was detected to depths of 100 feet bgs, with no noticeable increase in concentrations in the perched zone. No contamination was detected in soil samples collected from the ditches north of the old washout ponds. Low concentrations of SVOCs (0.96 to 12 µg/g) and 2,4,6-TNT were detected in subsurface

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LEGEND	
	EXISTING POND
	FORMER POND
	SUSPECTED LEACH FIELD AREA
	WASTE PILE AREA
	BUILDING
	SUSPECTED UNDERGROUND PIPING
	FENCE
	RAILROAD
	MANHOLE
	SWMU BOUNDARY (APPROX.)

SOURCE: RUST E&I, 1995

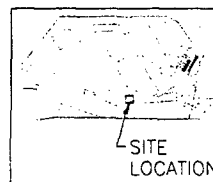


FIGURE 4-1
TNT WASHOUT FACILITY (SWMU 10)
TOOELE ARMY DEPOT



DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

soil beneath the new TNT washout pond. No contaminants were detected at the surface of the new pond.

4.2.3 Surface Water

Elevated concentrations of VOCs, SVOCs, metals, and explosives were detected in surface water samples collected from the two steel settling basins during both rounds of the Phase II RFI sampling (Rust E&I, 1995). No surface water was present in the new washout pond or in the ditches at the time of sampling; the old washout ponds have been filled and covered.

4.2.4 Groundwater

Groundwater in the vicinity of SWMUs 10 and 11 flows toward the north-northwest. Explosives – including RDX, HMX, 1,3,5-TNB, 2,4,6-TNT, and 2,4-DNT – and nitrite/nitrate were detected in groundwater during RFI sampling. Metals, VOCs, and the SVOC bis(2-ethylhexyl) phthalate were also detected.

A localized perched zone, which contained elevated concentrations of explosives in both subsurface soil and groundwater, was defined at 17 to 49 feet bgs. Groundwater in the perched zone is ephemeral, and was likely fed by discharge from the TNT Washout Facility (which has ceased operation) and a leaking water line (which has been repaired). The highest levels of explosives were detected in well N3I, north (downgradient) of the old washout ponds. Sample results also indicated that the clay lenses act as a local aquitard to reduce the downward migration of most explosives (except RDX) and allow lateral migration along the clay layer.

Concentrations of RDX, 2,4,6-TNT, and 1,3,5-TNB have reached the aquifer (250 feet bgs). During the 1988 sampling round, 2,4,6-TNT was detected in wells N-127-88, N-128-88, and N-129-88, approximately 700 feet north of the old TNT washout ponds. During the 1992 sampling round, 2,4,6-TNT was not detected; however, 1,3,5-TNB, a byproduct of 2,4,6-TNT degradation, was detected at low concentrations. Elevated levels of nitrite/nitrate were detected in all wells. Figure 4-2 shows the explosives contamination in groundwater based on November 1993 (round 2) data. The upgradient limit of the explosives plume is not shown because of insufficient data from that sampling round. The CMS Report will outline the plume's trailing edge and area of highest explosives (i.e., hot spot) using data from the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report.

Biannual groundwater sampling, conducted after the Phase II RFI, revealed stable hydrologic conditions at SWMUs 10/11 that were consistent with those described in the Phase II RFI (Rust E&I, 1995). Chemical analysis of groundwater identified high chromium, nickel, and manganese concentrations in unfiltered samples collected at SWMUs 10/11. Arsenic, barium, cobalt, copper, mercury, lead, selenium, thallium, vanadium, and zinc were detected at concentrations near or below MCLs in filtered groundwater samples. Low concentrations of VOCs and explosives were detected

intermittently during the three sampling events at concentrations near method detection limits. In addition, very low concentrations of phthalates (below contract required detection limits (CRDLs)) were reported (Geomatrix, 1997).

During fall 1995, elevated levels of antimony were detected in four wells at reported concentrations between 9.2 µg/L and 172 µg/L (Geomatrix, 1997). Because the purge water was turbid (with brown sediment and metal flakes) during the 1995 sampling events, selected wells were redeveloped during the spring 1996 investigation (Geomatrix, 1997).

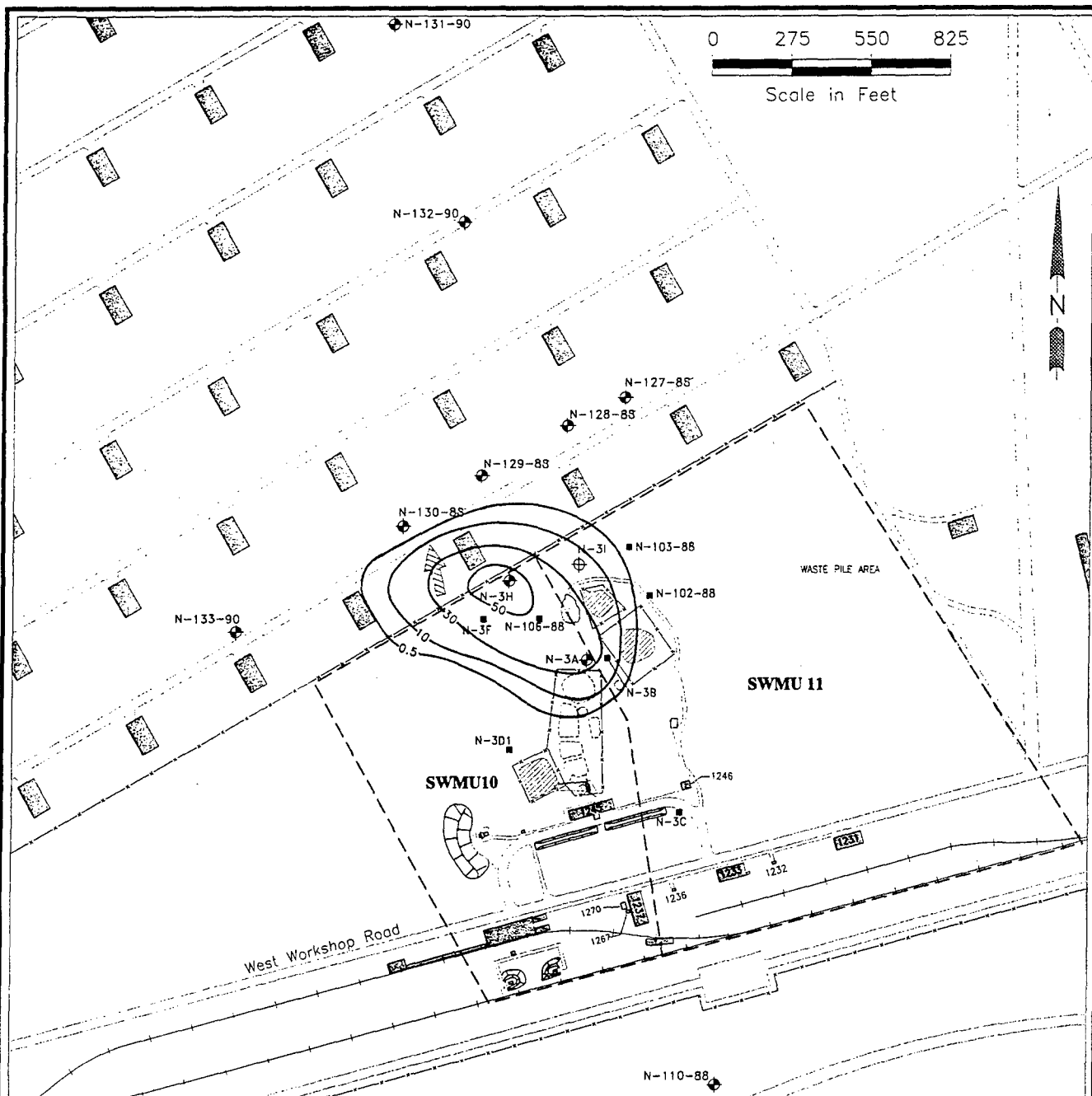
The highest metals concentrations detected in groundwater prior to redevelopment were chromium (37,000 µg/L), nickel (4,280 µg/L), and manganese (3,390 µg/L). Following redevelopment, concentrations for these metals in unfiltered groundwater samples were below approximately 20 µg/L, 30 µg/L, and 140 µg/L, respectively (Geomatrix, 1997).

The highest dissolved metals concentrations measured in sample sets taken before redevelopment were chromium (7 µg/L), manganese (1,020 µg/L) and nickel (2,330 µg/L). After redevelopment of the wells, the maximum concentrations of dissolved chromium, nickel, and manganese were 5 µg/L, 29 µg/L, 125 µg/L, respectively. Chromium, mercury, antimony, and thallium were either not detected or were reported near detection limits in all wells (Geomatrix, 1997).

These results and the high chloride concentrations identified in groundwater at SWMU 10 strongly support the theory that the high concentrations of metals in groundwater are due to corrosion of the stainless-steel well casings (Geomatrix, 1997). To further evaluate this issue and to assess the extent of contaminants present in groundwater, three monitoring wells were installed at SWMUs 10/11 during CMS fieldwork conducted in March and April 1997 (see the *Addendum to DCQAP*, Volume II of the Planning Documents; and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report). The CMS Report will present pertinent data and analysis from this additional investigation.

An attempt was made during three previous investigations to characterize groundwater contamination in the localized perched water zone at SWMU 10. Eight wells were installed; all but one went dry, and they were subsequently abandoned. The water level in the remaining well (N-3I) has decreased, and only 1.6 feet of water was present in May 1996. This well was dry during fall 1997 and 1998 sampling efforts. The source of water in the perched water zone was apparently discharge from the TNT Washout Facility, which has ceased operation. With the artificial recharge removed, the water in the zone appears to be drying up. Therefore, the perched water zone does not meet the UAC R317-6-1 definition of an aquifer as a "geological formation . . . that contains sufficient saturated permeable material to yield usable quantities of water to wells and springs."

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LEGEND	
	SHALLOW MONITORING WELL
	DEEP MONITORING WELL
	ABANDONED MONITORING WELL
	BUILDING
	SWMU BOUNDARY (APPROX.)
	ESTIMATED RDX PLUME (ug/L)
	INTERPRETIVE GROUNDWATER FLOW DIRECTION
	EXISTING POND
	FORMER POND
	WASTE PILE AREA
	RAILROAD
	FENCE

RDX IN GROUNDWATER IS FROM SAMPLING ROUND 2 CONDUCTED IN 1993.

SOURCE: RUST E&I, 1995

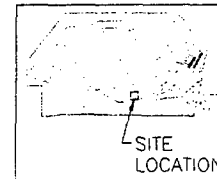


FIGURE 4-2
ESTIMATED EXTENT OF
GROUNDWATER CONTAMINATION
TNT WASHOUT FACILITY
SWMU 10
TOOELE ARMY DEPOT

4.3 SUMMARY OF RA RESULTS

4.3.1 Human Health RA

Table 4-1 summarizes the risks and hazards calculated for SWMU 10. Risks were calculated for two exposure areas – the Old Ponds-South Group and the Old Ponds-North Group. Results of the human health RA (Rust E&I, 1995) indicate that, under the hypothetical future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at SWMU 10 exceed the target of 1×10^{-6} for both receptors (child and adult). Noncancer HIs also exceed the regulatory target of 1.0 for all receptors. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 10 per the requirements of UAC R315-101-1(b)(4).

Under the future construction worker scenario, soil-based cancer risks are less than the target of 1×10^{-4} . The noncancer HI resulting from soil exposure is 12.

Under the current military land use scenario, which is also the reasonably anticipated future land use, the highest cancer risk calculated in the human health RA is 1.3×10^{-5} , and the noncancer HI is 2.1 – both of which occur at the Old Ponds-South Group. Because the HI exceeds the State of Utah goal of 1.0, active corrective measures are evaluated for SWMU 10 per UAC R315-101-6(e).

No models were run to estimate blood lead levels because the EPC of lead in soil ($10.1 \mu\text{g/g}$) at SWMU 10 does not exceed the $400\text{-}\mu\text{g/g}$ screening level set by EPA for CERCLA and RCRA programs.

4.3.2 Ecological RA

Based on the evaluation of COPCs in soil and levels of exposure to ecological receptors, the SWERA (Rust E&I, 1997) concluded that the COPCs detected in soil at SWMU 10 potentially present an unacceptable ecological risk. Specific factors considered in this risk characterization are as follows:

- Risk to passerine birds is estimated to be 1.2 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are dioxin (42 percent), iron (9 percent), and thallium (32 percent). Of these, iron is considered to be an essential nutrient.
- Risks to the deer mouse and jackrabbit are estimated to be 17 and 1.5 times the risks estimated for the RSA, respectively. The primary risk driver (and percent contribution to estimated risk) is RDX (98 percent). However, exposure to RDX is considered to be subchronic due to the relatively small size of the SWMU (approximately 4 acres).

TABLE 4-1

Summary of Human Health RA and
Corrective Measures Recommendations
TNT Washout Facility (SWMU 10)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level ($\mu\text{g/dL}$) (a)	Recommendations
Old Ponds – South Group				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identified potential cancer risks above 1×10^{-6} or an HI above 1.0. Active corrective measures are required because the noncancer HI calculated for the current land use (also the reasonably anticipated future land use) exceeds 1.0 (HI).
Current Land Use (b)				
Depot personnel	1.3×10^{-5}	2.1	NE (c)	
Future Land Use				
Residential - adult (d)	2.5×10^{-2}	2,500	NE	
Residential - child (d)	1.3×10^{-2}	6,600	NE	
Construction worker (e)	6.1×10^{-7}	12	NE	
Old Ponds – North Group				
Current Land Use				
Depot personnel	1.8×10^{-8}	0.14	NE	
Future Land Use				
Residential – adult (d)	3.2×10^{-3}	42	NE	
Residential – child (d)	1.6×10^{-3}	75	NE	
Construction worker (e)	6.1×10^{-7}	12	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter ($\mu\text{g/dL}$) for 95 percent of the population (should not exceed $10 \mu\text{g/dL}$).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Pathway incomplete or not evaluated; see text.
- (d) Human health RA results for a conservative future residential land use scenario, as required under UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMU 10.
- (e) Risk values for the north and south group ponds are combined.

- Risk to plants is estimated to be moderate – at 3.3 times the risk estimated for the RSA.

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 10. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 10.

Based on the above factors, the SWERA (Rust E&I, 1997) concluded that SWMU 10 is likely to pose excessive or unacceptable ecological risks. Therefore, it was recommended that the CMS Report consider ecological risks in assessing corrective measures. As part of the corrective measures selection process, the reduction in ecological risk will be evaluated using the procedure presented in Appendix D.

4.4 INTERIM CORRECTIVE ACTIONS

The old washout ponds were closed in fall 1984 by pushing the berms into the ponds, covering them with a PVC liner, and placing approximately 0.5 foot of soil over the liner (Rust E&I, 1995). In 1996, the discharge trough and two underground steel settling tanks were removed from SWMU 10. The blower attached to Building 1245 and outdoor metal framing were also removed. Figure 4-3 shows the approximate locations of the former ponds and the limits of the capped area.

4.5 IDENTIFICATION OF COCs

Tables 4-2 and 4-3 compare the maximum concentrations of each COC identified in the Phase II RFI (Rust E&I, 1995) to the corresponding quantitative CAOs developed in Appendix A for surface and subsurface soil, respectively. Based on the comparisons made in these tables, the COCs for surface and subsurface soil at SWMU 10 are 2,4,6-TNT and RDX. As shown in Figure 4-4, the CAO exceedances in surface soil at a depth of 1 foot bgs occur at nine locations for RDX and three locations for 2,4,6-TNT. Elevated concentrations of explosives were detected in subsurface samples that targeted the sediment layer in the center of the old washout ponds. 2,4,6-TNT was detected in sediment at a maximum concentration of 20,700 µg/g. Also shown on Figure 4-4, CAO exceedances in subsurface soil occur at two locations for both RDX and 2,4,6-TNT.

The COCs identified at the site are evaluated with the results of the human health RA to determine whether corrective measures need to be evaluated based on criteria specified in State and Federal regulations and existing permit requirements. As stated in the Phase II RFI (Rust E&I, 1995), the human health RA uses the EPC to calculate human health cancer risks and HIs. The EPC is statistically derived and represents the likely concentration that an individual will be exposed to if he or she is working in the

area of the SWMU. To further assess the need for corrective measures for the identified COCs, the EPCs calculated in the Phase II RFI for each of the COCs are compared to CAOs. In the case of surface soil, the comparison of EPCs and CAOs is as follows:

SWMU 10, TNT Washout Facility		
COC (Surface Soil)	EPC (µg/g)	Depot Personnel CAO (µg/g)
RDX	130	31
2,4,6-TNT	2,500	86

For subsurface soil at SWMU 10, the comparison of EPCs and CAOs is summarized below:

SWMU 10, TNT Washout Facility		
COC (Subsurface Soil)	EPC (µg/g)	Construction Worker CAO (µg/g)
RDX	94.2	200
2,4,6-TNT	146.3	710

The EPCs for RDX and 2,4,6-TNT in surface soil are higher than the respective CAOs, and these elevated levels result in unacceptable HI values for the military and construction land use scenarios (Rust E&I, 1995). In addition, the area of explosives contamination within the ponds is extensive. The corrective measures to be evaluated in the CMS Report will focus on RDX and 2,4,6-TNT in both surface and subsurface soil.

The State of Utah's "Principle of Non-Degradation" (UAC R315-101-3) necessitates the identification of contaminants present in groundwater that potentially require corrective action to prevent further degradation. The human health RA (Rust E&I, 1995) is the best vehicle for selecting these contaminants. RDX and 2,6-DNT are the only two contaminants in groundwater for which exposure via the future hypothetical residential scenario poses an unacceptable risk. Therefore, these two contaminants are evaluated like COCs. However, COCs cannot be formally identified in groundwater in the same way as in soil by comparing the data to CAOs because the unlikelihood of exposure under the reasonably anticipated military land use prohibits the calculation of groundwater CAOs (see Appendix A for further discussion).

4.6 ESTIMATION OF CONTAMINATED VOLUME

Figure 4-5 shows the estimated area of explosives concentrations that exceed their CAOs in both surface and subsurface soil. Based on the soil sampling presented in detail in the Phase II RFI (Rust E&I, 1995) and summarized in Section 4.2, the total area and volume of contaminated soil to be evaluated for possible corrective measures are estimated to be 40,000 square feet (ft²) and 10,000 cubic yards (yd³), respectively. This

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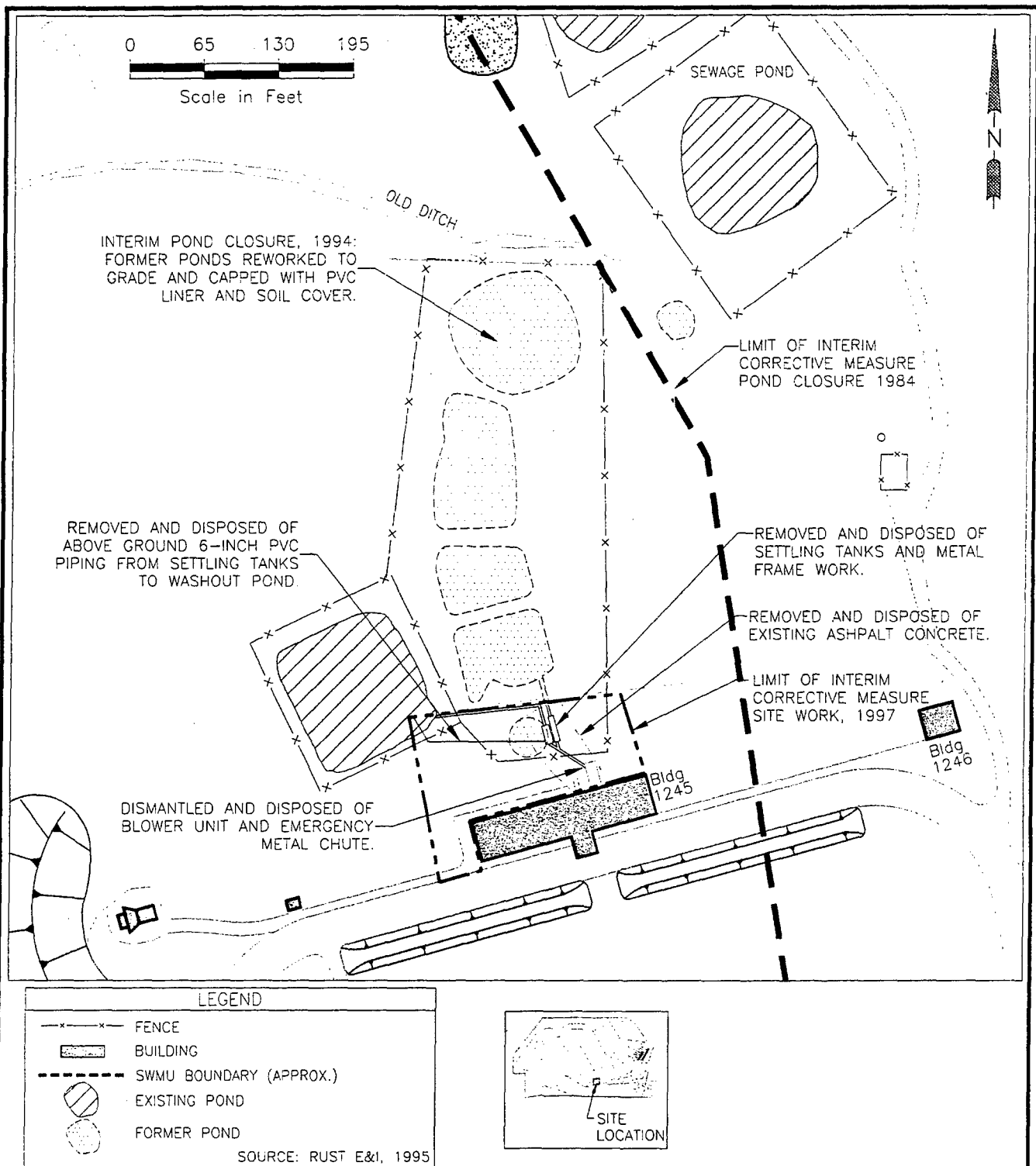


FIGURE 4-3
INTERIM CORRECTIVE MEASURES
TNT WASHOUT FACILITY (SWMU 10)
TOOELE ARMY DEPOT



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TABLE 4-2

Development of COCs in Surface Soil
TNT Washout Facility (SWMU 10) (a)

COPC (b)	Maximum Concentration (µg/g)	Depot Personnel CAO (c) (µg/g)	Surface Soil COC? (d)
Metals			
Cadmium	29.7	220	No
Lead	58	1,800	No
SVOCs			
3,5-Dinitroaniline	2.6	(e)	No
Di-n-butyl phthalate	14.0	120,000	No
VOCs			
Toluene	0.1	220,000	No
Explosives			
2,4,6-TNT	20,700	86	Yes
1,3,5-TNB	148	29,000	No
HMX	104	16,000	No
Nitrobenzene	5.22	600	No
RDX	1,100	31	Yes
Pesticides			
Heptachlorepoxyde	0.0359	0.32	No
PP-DDE	0.00328	8.3	No
PP-DDT	0.01430	8.3	No

- (a) The Phase II RFI Report did not develop surface soil COPCs for SWMU 10; maximum concentrations are based on depths to 3 feet bgs.
- (b) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
- (c) Corrective action objectives developed in Appendix A.
- (d) Contaminants of concern (i.e., COPCs greater than CAOs).
- (e) Relevant health effects criteria are unavailable.

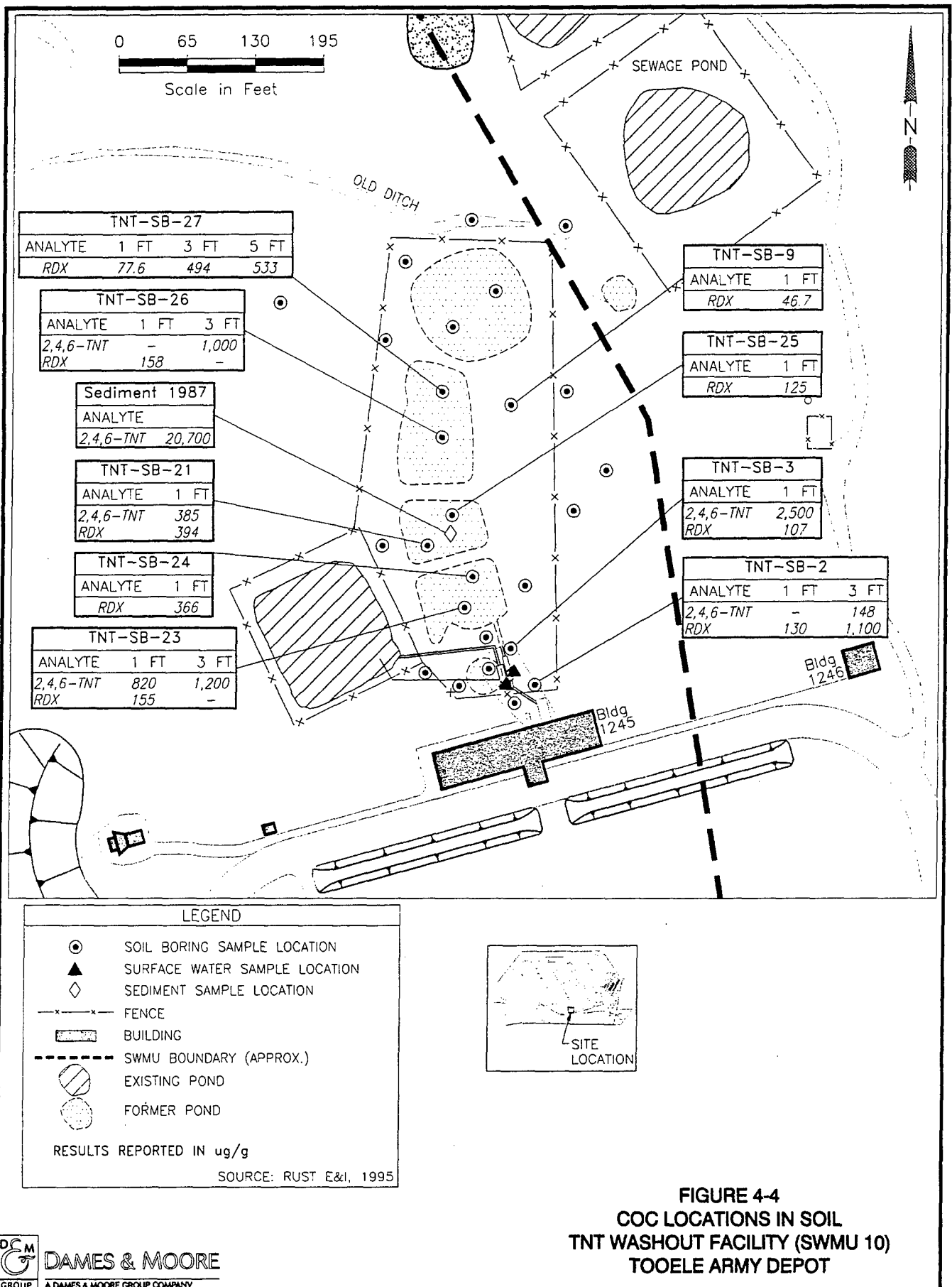
TABLE 4-3

Development of COCs in Subsurface Soil
TNT Washout Facility (SWMU 10)

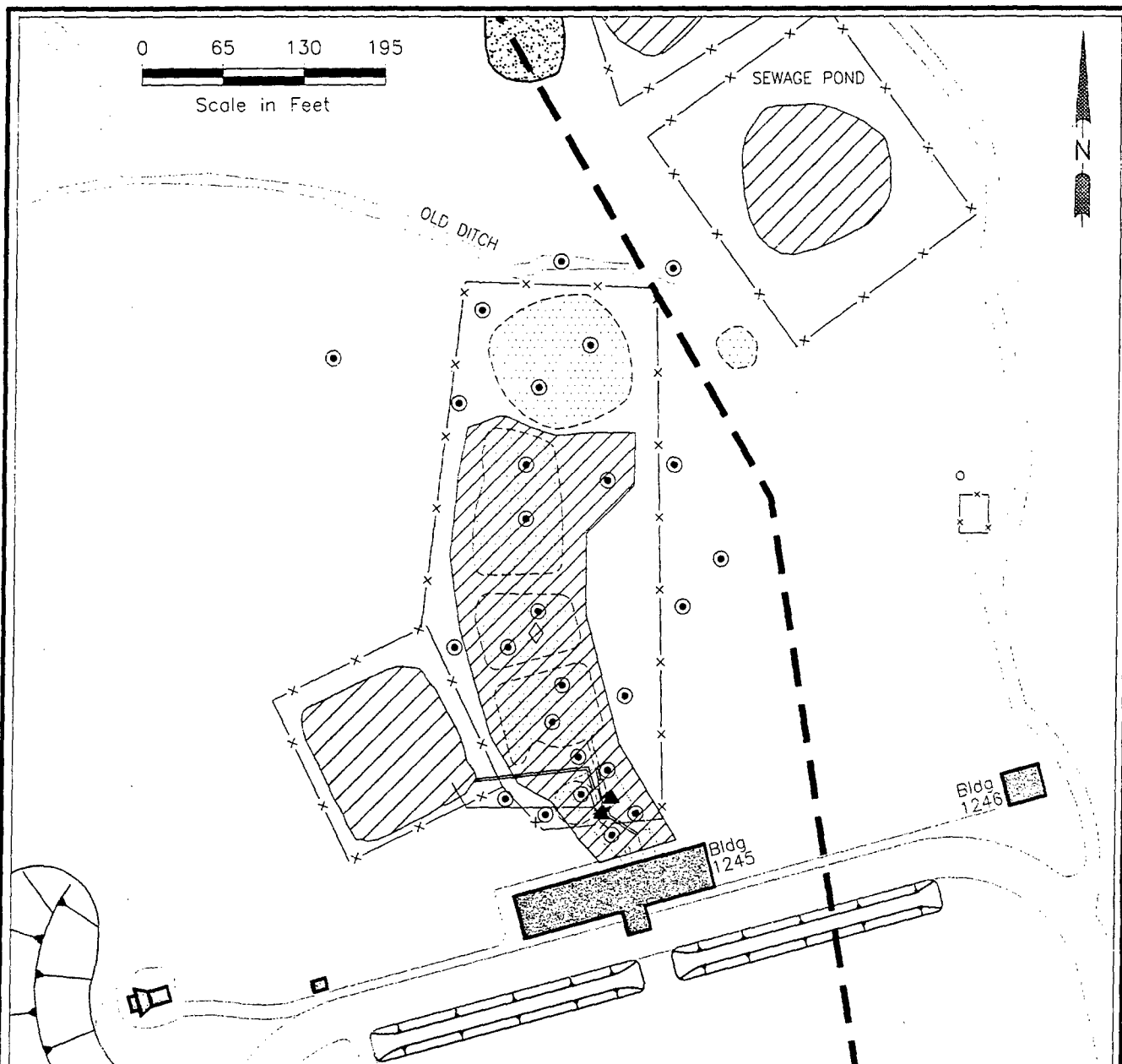
COPC (a)	Maximum Concentration ($\mu\text{g/g}$)	Construction Worker CAO (b) ($\mu\text{g/g}$)	Subsurface Soil COC? (c)
Metals			
Cadmium	2.1	870	No
Lead	10.1	1,800	No
SVOCs			
3,5-Dinitroaniline	2.6	(d)	No
Di-n-butyl phthalate	11	(e)	No
Explosives			
1,3,5-TNB	39.2	46,000	No
2,4,6-TNT	1,200	710	Yes
HMX	104	52,000	No
RDX	553	200	Yes
Nitrobenzene	5.22	8,000	No
Pesticides			
Heptachlor epoxide	0.0359	2.4	No
VOCs			
Toluene	0.1	(e)	No

- (a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
 (b) Corrective action objectives developed in Appendix A.
 (c) Contaminants of concern (i.e., COPCs greater than CAOs).
 (d) Relevant health effects criteria are unavailable.
 (e) Calculated CAO exceeds 1 million ppm ($\mu\text{g/g}$).

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LEGEND

- ⊙ SOIL BORING SAMPLE LOCATION
- ▲ SURFACE WATER SAMPLE LOCATION
- ◇ SEDIMENT SAMPLE LOCATION
- x-x- FENCE
- ▬ BUILDING
- - - SWMU BOUNDARY (APPROX.)
- ◐ EXISTING POND
- ◑ FORMER POND
- ▨ EXTENT OF PROPOSED CORRECTIVE ACTION

RESULTS REPORTED IN ug/g

SOURCE: RUST E&I, 1995

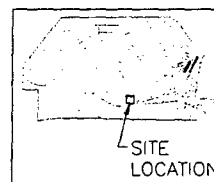


FIGURE 4-5
ESTIMATED EXTENT
OF SOIL CONTAMINATION
TNT WASHOUT FACILITY (SWMU 10)
TOOELE ARMY DEPOT

volume is based on achieving military use CAOs. The actual depth of contamination will likely vary between 3 and 7 feet bgs as determined by confirmatory soil sampling. However, for cost estimation, the depth of contamination is conservatively assumed to be 7 feet bgs to provide a reasonable margin of safety for the actual quantity of soil removed. Figure 4-5 shows the estimated extent of contamination at SWMU 10.

4.7 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101, which states that if the cancer risk present at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, the appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the realistic future land use scenario, active corrective measures are required. UAC R315-101-3, the "Principle of Non-degradation," states that active corrective measures are required to prevent further degradation of a resource, including groundwater.

To determine which technologies are most appropriate for SWMU 10, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs.

The human health RA identified hazards to military and construction workers at the old TNT washout ponds above the goal of 1.0 (UAC R315-101). In addition, the SWERA (Rust E&I, 1997) identified unacceptable risks to ecological receptors at SWMU 10 and recommended consideration of treatment technologies for the mitigation of ecological risks associated with explosives-contaminated surface soil.

The Phase II RFI (Rust E&I, 1995) reported the potential offsite migration of explosives-contaminated groundwater. Because elevated concentrations of explosives have been detected in groundwater wells in the vicinity of the old washout ponds, treatment technologies are considered for both groundwater and explosives-contaminated soil identified at the surface and to a depth of 7.5 feet bgs. However, no treatment technologies are considered for the zone of contaminated soil at 40 feet bgs because there is no exposure to human health or ecological receptors at this depth. In addition, no further impacts to groundwater are expected because there is no longer a source of artificial infiltration.

The following corrective measures technologies are considered to apply to the identified soil and groundwater COCs:

Corrective Measures Technologies (SWMU 10, TNT Washout Facility)
Soil Land use restrictions Slurry treatment Composting Off-post treatment/disposal Groundwater Land use restrictions Monitoring Groundwater extraction Carbon adsorption

To address all media and COCs, the following corrective measures alternatives, which combine the various technologies, are identified for SWMU 10 for further evaluation in the CMS Report:

SWMU 10	Corrective Measures Alternatives
TNT WASHOUT FACILITY	Excavation, composting, groundwater monitoring, and land use restrictions Excavate old washout ponds, compost explosives-contaminated soil on post, and backfill with treated soil Monitor identified contaminants in groundwater Impose land use restrictions to prevent residential development Excavation, composting, groundwater treatment, and land use restrictions Excavate and compost explosives-contaminated soil from old washout ponds on post Extract groundwater and treat using granular activated carbon (GAC) Impose land use restrictions to prevent residential development Excavation, slurry-phase biological treatment, groundwater monitoring, and land use restrictions Excavate and conduct on-post slurry-phase biological treatment of explosives-contaminated soil from old washout ponds Monitor identified contaminants in groundwater Impose land use restrictions to prevent residential development Excavation, off-post treatment/disposal, groundwater monitoring, and land use restrictions Excavate old washout ponds, treat/dispose explosives-contaminated soil off post, and backfill with clean soil Monitor identified contaminants in groundwater Impose land use restrictions to prevent residential development

5.0 LAUNDRY EFFLUENT POND AND WASTE PILE AREAS

5.1 SWMU BACKGROUND

The Laundry Effluent Pond and Waste Pile Areas (SWMU 11) was constructed in 1947 for the collection of laundry and shower discharges from Building 1267, and boiler blowdown from Building 1237. SWMU 11 consists of the laundry effluent pond, sewage pond, sand pit, septic tank and leach field, and the waste pile area located to the east (see Figure 5-1). Discharge to the laundry effluent pond was discontinued in 1990; however, it continued to receive boiler blowdown during the winter months until 1995. The bermed, unlined artificial pond is approximately 16 feet deep, 80 feet wide, and 100 feet long. The laundry effluent pond currently does not contain water, except for pockets of water due to rain, snow melt, or infiltration.

The sewage pond was constructed between 1978 and 1980 for the collection of effluent from Building 1267. This pond is also bermed and unlined and is 8 feet deep, 120 feet wide, and 134 feet long. However, it was never used because of an inadequate gradient between the building and the pond. Water observed in the sewage pond during previous investigations may be the result of rain, snow melt, or infiltration from the adjacent septic system.

The shallow sand pit is located along the northwestern side of the new TNT washout pond. It was reportedly excavated to provide cover material for the old TNT washout ponds.

The septic tank is located south of the sewage pond; the leach field is reportedly located beneath the pond. From 1948 through 1990, the septic tank and leach field reportedly received waste from the bomb reconditioning building (Building 1245, SWMU 10), Building 1267, and a building to the southwest of the site (Building 1254).

Waste piles identified in fall 1992 (not associated with the sand pit) reportedly contained wood fragments, metal banding, electrical wiring, metal shavings, and old (circa 1948) automobile parts.

5.2 SUMMARY OF CONTAMINATION ASSESSMENT

Potential sources of contamination associated with SWMU 11 include the laundry effluent pond, sewage pond, sand pit, septic tank and leach field, and waste piles. VOCs, SVOCs, and metals in soil and groundwater were identified in environmental samples collected in these areas. Previous investigations defined the septic tank as the primary source of contaminants; the sewage pond was not identified as a potential source of contamination.

5.2.1 Sediment

Sediment samples collected from the laundry effluent pond contained levels of elevated metals and SVOCs. No contaminants were detected in sediment collected from the sewage pond. The sludge sample collected from the septic tank contained elevated levels of metals, SVOCs, and VOCs.

5.2.2 Soil

Two rounds of soil sampling were conducted during the Phase II RFI, the first in spring 1993 and the second in fall 1993. Soil samples were collected from borings drilled north of the septic tank (to 15 feet bgs), in the presumed area of the leach field; and along the sewer discharge pipe (to 10 feet bgs), extending southwest from the septic tank to Building 1245. Soil samples collected in the suspected leach field contained only di-n-butyl phthalate. Sludge was detected at depth in boring SB-32 during round 1; this boring was located in a depression south of the sewage pond. The presence of sludge was not confirmed during round 2 sampling.

Samples collected along the pipeline from the septic tank contained elevated levels of benzene, monochlorobenzene, 1,1,1-trichloroethane (1,1,1-TCA), methylene chloride, toluene, di-n-butyl phthalate, and diethyl phthalate (a suspected laboratory contaminant), at depths of 5 to 10 feet bgs. These results suggest that the pipeline may have leaked.

Soil samples collected in the vicinity of the waste piles appear to have sufficiently defined the extent of metals and total petroleum hydrocarbons (TPHCs) in soil. The samples indicate that horizontal and vertical migration due to runoff and wind erosion has been minimal. Elevated levels of arsenic and lead were detected during the biased sampling performed during round 1; however, the unbiased round 2 grid sampling detected lower concentrations of metals (Rust E&I, 1995). TPHCs were also detected at the waste piles. Lead was detected at 6,700 µg/g in one subsurface soil sample collected from 5 feet bgs during round 2 sampling; however, concentrations were much lower at 10 feet bgs.

Subsurface soil samples collected beneath the laundry effluent pond and sewage pond identified elevated concentrations of SVOCs (bis(2-ethylhexyl)phthalate (10 µg/g) and di-n-octylphthalate (2.7 µg/g)) due to migration from the septic system (Rust E&I, 1995). Although the metals cadmium (102 µg/g), chromium (203 µg/g), lead (440 µg/g), and mercury (0.41 µg/g) were detected in pond sediment, they were not detected in soil below the laundry effluent pond.

To further characterize soil contamination at the Laundry Effluent Pond and Waste Pile Areas, 11 10-foot soil borings were drilled in the suspected leach field, two 10-foot soil borings were drilled adjacent to the area where black sludge was previously encountered, and three sediment samples were collected in the wet area of the sewage pond to evaluate possible contamination. Additionally, one liquid and one sludge sample

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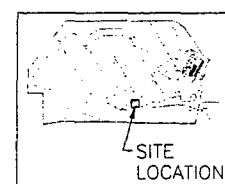
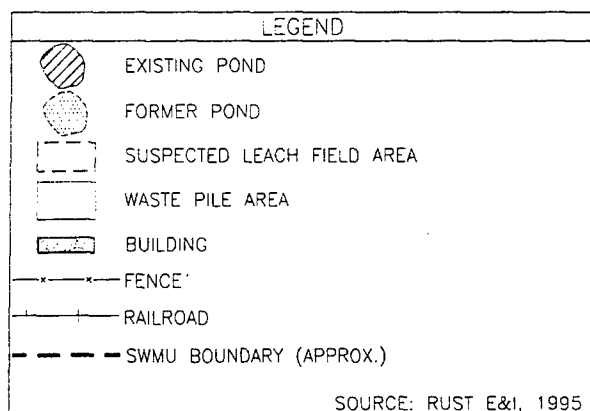
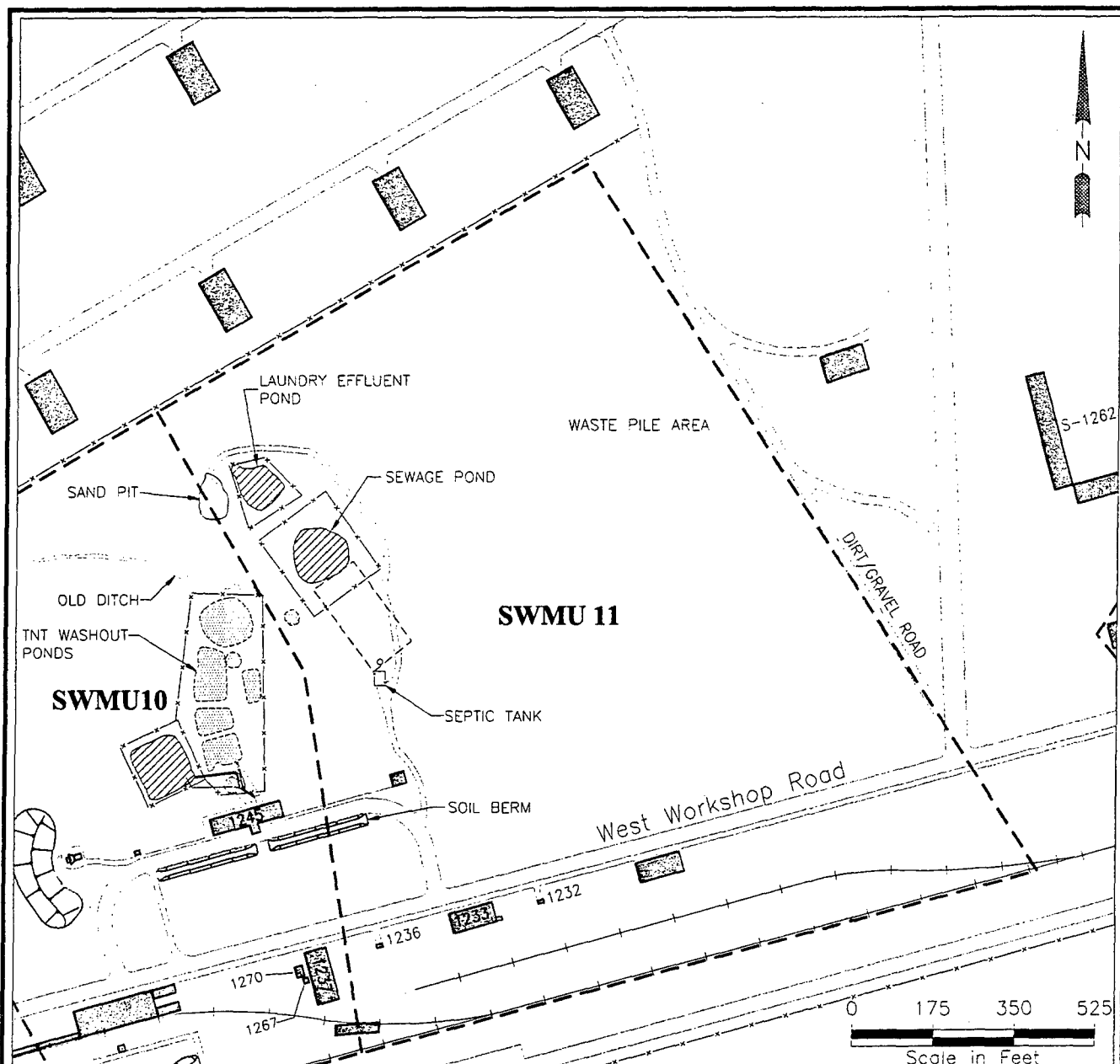


FIGURE 5-1
LAUNDRY EFFLUENT POND
AND WASTE PILE AREAS (SWMU 11)
TOOELE ARMY DEPOT

were collected from the septic tank to compare to the leach field and sewage pond sample results. The *Addendum to DCQAP*, Volume II of the Planning Documents, and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report, provide details of the soil sampling effort and an evaluation of data.

5.2.3 Surface Water

Surface water samples collected from the laundry effluent pond and sewage pond contained elevated concentrations of metals and SVOCs. The water sample collected from the septic tank identified metals, VOCs, SVOCs, and the explosive 1,3,5-TNB.

5.2.4 Groundwater

Groundwater results for the Laundry Effluent Pond and Waste Pile Areas are discussed with those for the TNT Washout Facility (Section 4.1.2.4). Potential contaminant migration from the septic tank to groundwater may explain the presence of VOCs and the low concentrations of SVOCs (below CRDLs) in wells N-3A, N-3I, N-128-88, N-129-88, and N-130-88. These wells are located northwest (downgradient) of the septic tank and associated pipeline.

5.3 SUMMARY OF RA RESULTS

5.3.1 Human Health RA

Table 5-1 summarizes the risks and hazards calculated for SWMU 11. Risks were calculated for three exposure areas – the Laundry Effluent Pond Area, the Waste Pile Area, and the Waste Pile Area hot spot. Results of the human health RA (Rust E&I, 1995) indicate that, under the hypothetical future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at SWMU 11 exceed the target of 1×10^{-6} for both receptors (child and adult). Noncancer HIs also exceed the regulatory target of 1.0 for both receptors. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 11 per the requirements of UAC R315-101-1(b)(4).

The human health RA does not evaluate the future construction worker scenario for cancer risks and noncancer HIs resulting from soil exposure (Rust E&I, 1995). However, the CMS Work Plan evaluates potential exposure to subsurface soil by comparing the maximum concentrations of COPCs, identified using data and methodology presented in the human health RA, to risk-based CAOs for construction workers (developed in Appendix A).

Under the current military land use scenario, which is also the reasonably anticipated future land use, the greatest cancer risk calculated in the human health RA is 1.1×10^{-5} , and the greatest noncancer HI is 0.74 – both of which occur at the Waste Pile Area hot spot. However, these levels do not exceed the State of Utah goals of 1×10^{-4} and

TABLE 5-1

Summary of Human Health RA and
Corrective Measures Recommendations
Laundry Effluent Pond and Waste Pile Areas (SWMU 11)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level (µg/dL) (a)	Recommendations
Laundry Effluent Pond Area				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identified potential cancer risks above 1×10^{-6} or an HI above 1.0. However, active corrective measures are not necessarily required because the risks and hazards calculated for the current land use (also the reasonably anticipated future land use) do not exceed 1×10^{-4} (cancer risk) or 1.0 (HI).
Current Land Use (b)				
Depot personnel	3.2×10^{-7}	0.17	NE (c)	
Future Land Use				
Residential- adult (d)	1.9×10^{-3}	42	NE	
Residential- child (d)	9.0×10^{-4}	58	NE	
Construction worker	NE	NE	NE	
Waste Pile Area				
Current Land Use (b)				
Depot personnel	1.0×10^{-7}	0.011	NE	
Future Land Use				
Residential– adult (d)	1.9×10^{-3}	30	NE	
Residential– child (d)	9.0×10^{-4}	43	NE	
Construction worker	NE	NE	NE	
Waste Pile Area – Hot Spot				
Current Land Use (b)				
Depot personnel	1.1×10^{-5}	0.74	11.12	
Future Land Use				
Residential– adult (d)	2.0×10^{-3}	91	NE	
Residential– child (d)	1.0×10^{-3}	220	29.4	
Construction worker	NE	NE	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter (µg/dL) for 95 percent of the population (should not exceed 10 µg/dL).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Pathway incomplete or not evaluated; see text.
- (d) Human health RA results for a conservative future residential land use scenario, as required under UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMU 11.

1.0, respectively (above which active corrective measures must be evaluated per UAC R315-101-6(e)).

The human health RA did not run models to estimate blood lead levels for the Laundry Effluent Pond and Waste Pile Areas because the EPC of lead in soil (207 µg/g) is below the 400-µg/g screening level set by EPA for CERCLA and RCRA programs. However, lead concentrations are above the screening level at the Waste Pile Area hot spot, and a blood lead concentration of 11.12 µg/dL was calculated for the onsite worker (see Section 5.4). A blood lead concentration of 29.4 µg/dL was calculated for the future child resident.

5.3.2 Ecological RA

Based on the evaluation of COPCs in soil and levels of exposure to ecological receptors, the SWERA (Rust E&I, 1997) concluded that the COPCs detected in soil at SWMU 11 present a potential for unacceptable ecological risk. Specific factors considered in this risk characterization are as follows:

- Risk to passerine birds is 4.4 times the risk estimated for the RSA. The major risk drivers (and percent contribution to estimated risk) are lead (42 percent), iron (25 percent), and copper (17 percent).
- Risk to deer mice is 4.6 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are iron (40 percent), dioxin (29 percent), and RDX (8 percent).
- Risk to plants is 2.4 times the risk estimated for the RSA. The main risk drivers (and percent contribution to estimated risk) are thallium (31 percent) and zinc (30 percent).
- Risk to soil fauna is 5.1 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are chromium (52 percent) and iron (40 percent) in soil.
- The weight-of-evidence (WOE) approach indicates that the risks for all receptors approach that of the RSA; the WOE for plants and soil fauna is greater than that estimated for the RSA.

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 11. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 11.

Based on the above factors, the SWERA (Rust E&I, 1997) concluded that SWMU 11 poses a potential unacceptable risk to ecological receptors. These results are primarily based on sampling conducted at the waste piles. Therefore, it was recommended that the CMS Report consider ecological risks in assessing corrective measures. As part of the corrective measures selection process, the reduction in ecological risk will be evaluated using the procedure presented in Appendix D.

5.4 IDENTIFICATION OF COCs

Tables 5-2 and 5-3 compare the maximum concentration of each COPC to the corresponding quantitative CAOs developed for surface and subsurface soil, respectively. Surface soil COPCs are identified in the human health RA portion of the Phase II RFI Report (Rust E&I, 1995). Subsurface soil COPCs are identified using the data and methodology presented in the human health RA. Based on this evaluation, the COCs for surface soil at SWMU 11 are arsenic, lead, and bis(2-ethylhexyl) phthalate. The COCs for subsurface soil are lead from the Waste Pile Area and antimony from the Laundry Effluent Pond Area. Lead was detected at a concentration sufficient to be a COC in subsurface soil at one soil boring location adjacent to one of the waste piles. Antimony was detected at a concentration sufficient to be a COC in one sample from a depth of 9 feet at a boring location near the sewage pond. Figure 5-2 shows the two COCs identified at the Laundry Effluent Pond Area. Figure 5-3 shows the locations of the waste piles and the CAO exceedances in surface soil at a depth of 0.5 foot bgs – which occurred at four of 30 sample locations for lead and at one location for arsenic. Figure 5-3 also shows the single exceedance of the lead CAO for subsurface soil, adjacent to one of the waste piles.

Antimony was detected in a single sample at a concentration above the subsurface soil CAO; however, because exposure to this isolated location during construction activities (the basis for CAO development) is unlikely, antimony is not considered to be a COC. No COCs were identified in surface water; the identification of COCs in groundwater is discussed in Section 4.5.

The COCs identified at SWMU 11 are evaluated in conjunction with results of the human health RA to determine whether corrective measures need to be evaluated based on criteria specified in State and Federal regulations and existing permit requirements. As stated in the Phase II RFI (Rust E&I, 1995), the human health RA uses the EPC to calculate human health cancer risks and HIs. To further assess the need for corrective measures for identified COCs, the EPCs are compared to CAOs. In the case of surface soil, the comparison is as follows:

SWMU 11, Laundry Effluent Pond and Waste Pile Areas		
COC (Surface Soil)	EPC (µg/g)	CAO (µg/g)
Arsenic	40	32
Bis(2-ethylhexyl) phthalate	110	78
Lead	68.9	1,800

TABLE 5-2

Development of COCs in Surface Soil
Laundry Effluent Pond and Waste Pile Areas (SWMU 11)

COPC (a)	Maximum Concentration (µg/g)	Depot Personnel CAO (b) (µg/g)	Surface Soil COC? (c)
Metals			
Antimony	81	160	No
Arsenic	57	32	Yes
Barium	285	71,000	No
Cadmium	102	220	No
Chromium (d)	203	2,000	No
Copper	500	68,000	No
Lead	14,000	1,800	Yes
Mercury	0.407	440	No
Nickel	33.7	36,000	No
Selenium	1.6	10,000	No
Silver	2.82	7,900	No
Zinc	925	490,000	No
SVOCs			
Bis(2-ethylhexyl) phthalate	110	78	Yes
Di-n-octyl phthalate	2.7	25,000	No

- (a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
- (b) Corrective action objectives developed in Appendix A.
- (c) Contaminants of concern (i.e., COPCs greater than CAOs).
- (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.

TABLE 5-3

Development of COCs in Subsurface Soil
Laundry Effluent Pond and Waste Pile Areas (SWMU 11)

COPC (a)	Maximum Concentration ($\mu\text{g/g}$)	Construction Worker CAO (b) ($\mu\text{g/g}$)	Subsurface Soil COC? (c)
Metals			
Antimony	1,900	470	Yes
Barium	413	110,000	No
Cadmium	49.7	870	No
Chromium (d)	390	23,000	No
Copper	305	64,000	No
Lead	6,700	1,800	Yes
Mercury	1.12	500	No
Nickel	22.9	34,000	No
Silver	1.27	8,400	No
Zinc	3,260	510,000	No
SVOCs			
1,3-Dimethylbenzene	0.92	110,000	No
2-Methylnaphthalene	1.9	63,000	No
Bis(2-ethylhexyl) phthalate	250	1,100	No
Di-n-butyl phthalate	3.7	(e)	No
Diethyl phthalate	4.4	(e)	No
Phenanthrene	7.5	470,000	No
VOCs			
Benzene	0.14	480	No
Monochlorobenzene	0.43	27,000	No
Toluene	0.94	(e)	No
1,1,1-Trichloroethane	0.46	32,000	No

- (a) Contaminants of potential concern identified from data and methodology presented in the Phase II RFI Report (Rust E&I, 1995).
 (b) Corrective action objectives developed in Appendix A.
 (c) Contaminants of concern (i.e., COPCs greater than CAOs).
 (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.
 (e) Calculated CAO exceeds 1 million ppm ($\mu\text{g/g}$).

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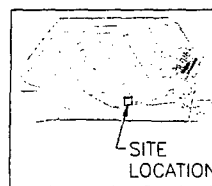
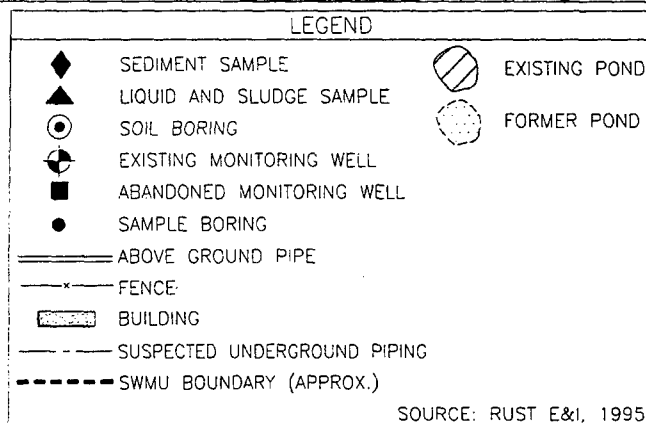
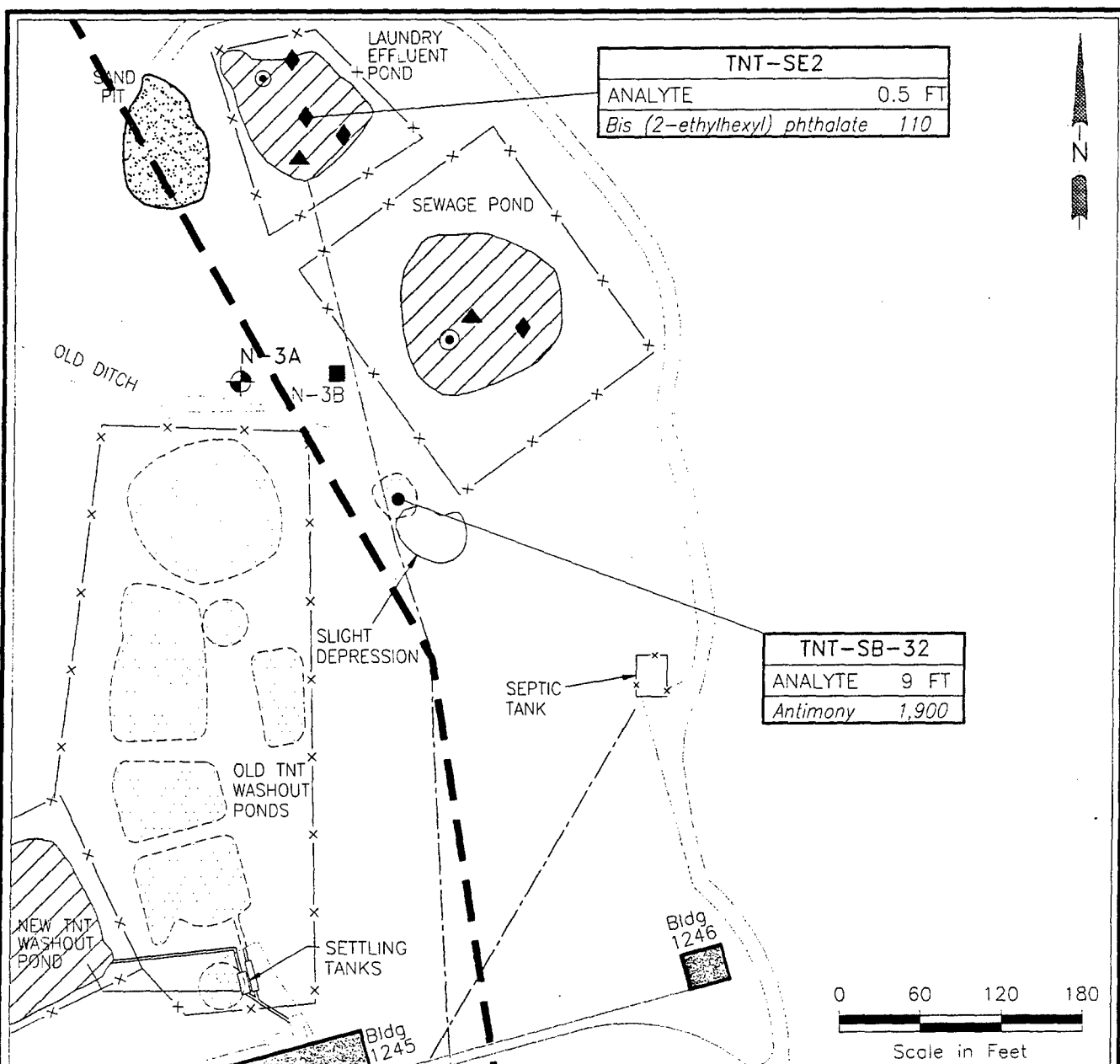


FIGURE 5-2
COC LOCATIONS IN SOIL
LAUNDRY EFFLUENT POND AREA (SWMU 11)
TOOELE ARMY DEPOT

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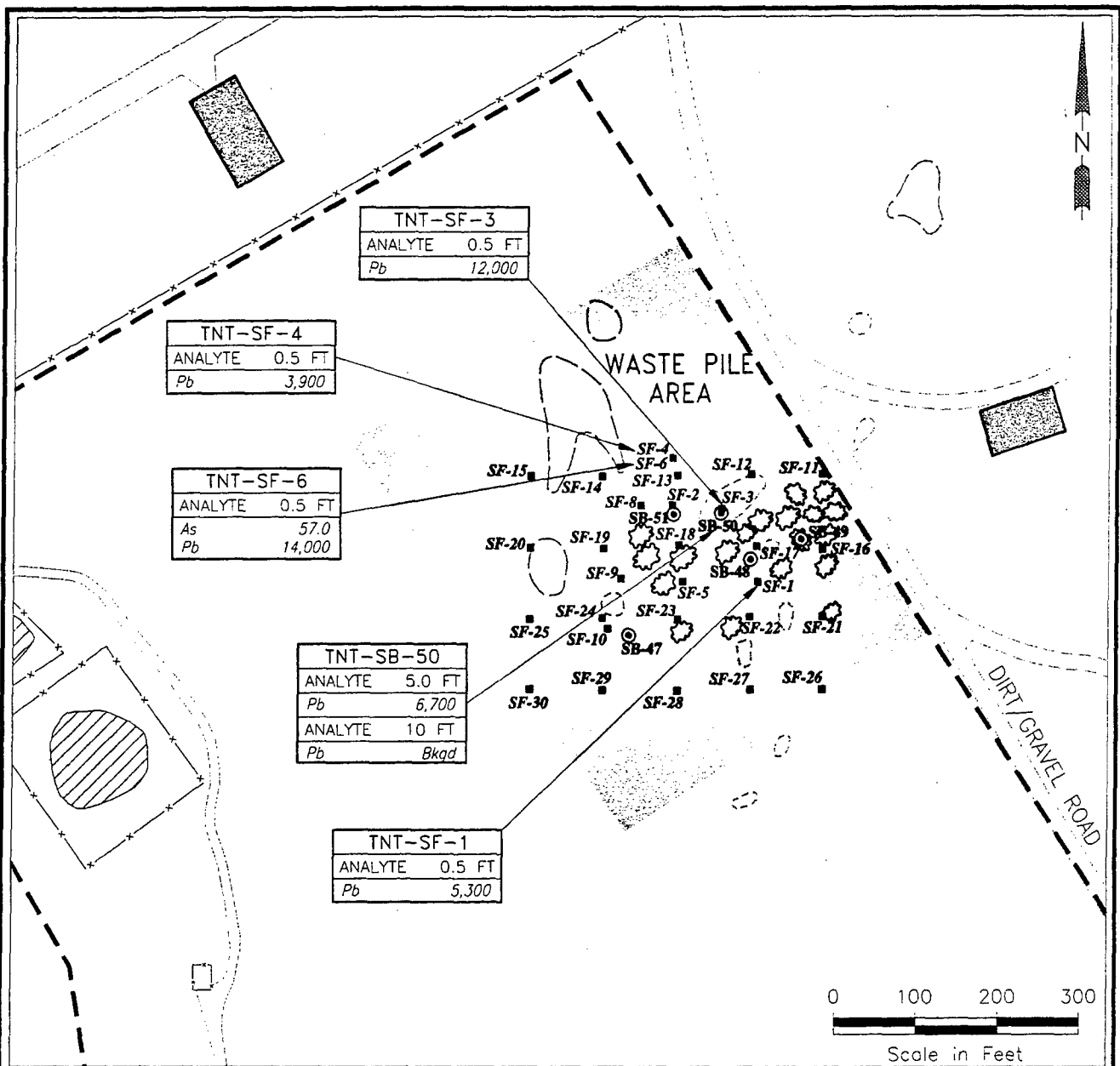


FIGURE 5-3
COC LOCATIONS IN SOIL
WASTE PILE AREA (SWMU 11)
TOOELE ARMY DEPOT



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The arsenic detected in surface soil at the Waste Pile Area is colocated in a sample identified for remedial action based on lead contamination. Although the EPC for lead at the Waste Pile Area as a whole is below the CAO, lead concentrations exceed the CAO within the identified hot spot. Therefore, the remediation of metals-contaminated soil at these locations is evaluated below and will be addressed in the CMS Report. The EPC for bis(2-ethylhexyl) phthalate is equal to the maximum concentration detected and is only slightly above the CAO. In addition, the CAO exceedance was present in only one sample and is not considered to indicate the presence of unacceptable contamination.

5.5 ESTIMATION OF CONTAMINATED VOLUME

Based on a review of the Phase II RFI Report (Rust E&I, 1995) and the COCs identified in Section 5.4, the estimated volume of SWMU 11 (Waste Pile Area) with elevated concentrations of lead is 600 yd³. As shown on Figure 5-4, it is assumed that three separate areas in the Waste Pile Area require evaluation. These three areas surround the COC locations in the north, central, and south portions of the site.

- The north portion has lead and arsenic contamination at the surface (TNT-SF-4 and 6), but no subsurface samples were collected. To allow for the possibility that some subsurface contamination exists, this area includes a larger area with shallow contamination 2 feet deep; and within it, a smaller area of contamination 7.5 feet deep.
- The central portion has lead contamination at the surface (TNT-SF-3) and at 5 feet bgs (TNT-SB-50), but lead is at background levels at 10 feet bgs (TNT-SB-50). This area includes a larger area with shallow contamination 2 feet deep; and within it, a smaller area of contamination 7.5 feet deep (halfway between 5 and 10 feet bgs).
- The south portion has lead contamination at the surface (TNT-SF-1), but no subsurface samples were collected. Because the surface lead levels in the south are not very high, this area includes only shallow contamination 2 feet deep.

5.6 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101, which states that if the cancer risk present at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, the appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the realistic future land use scenario, active corrective measures are required.

To determine which technologies are most appropriate for SWMU 11, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs.

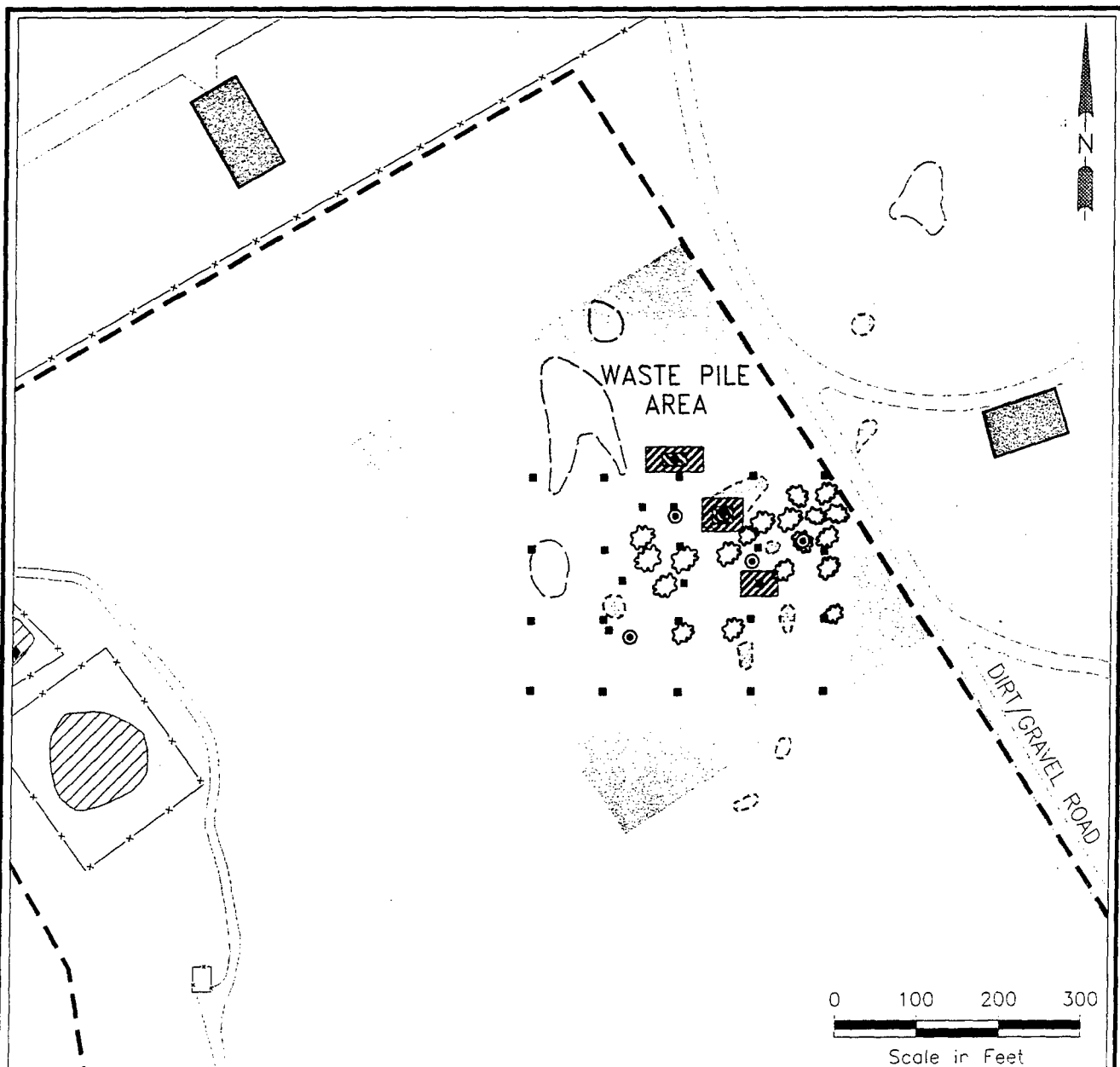
Therefore, based on the above criteria, the following corrective measures technologies are considered to apply to the identified soil COCs:

Corrective Measures Technologies (SWMU 11, Laundry Effluent Pond and Waste Pile Areas)
Land use restrictions Excavation Off-post disposal

The following corrective measures alternative is identified for SWMU 11 for further evaluation in the CMS Report:

SWMU 11	Corrective Measures Alternative
LAUNDRY EFFLUENT POND AND WASTE PILE AREAS	Land use restrictions Impose land use restrictions to prevent residential development Excavation, off-post treatment/disposal, and land use restrictions Remove contaminated soil, conduct off-post treatment/disposal, and impose land use restrictions to prevent residential development

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LEGEND	
	SOIL BORING SAMPLE LOCATION
	SURFACE SOIL SAMPLE LOCATION
	EXISTING POND
	FENCE
	BUILDING
	TREE
	PIT
	WASTE PILE AREA
	WASTE PILE (DEPICTION IS SCHEMATIC)
	EXTENT OF PROPOSED CORRECTIVE ACTION-EXCAVATE 0 TO 2 FEET BGS
	EXTENT OF PROPOSED CORRECTIVE ACTION-EXCAVATE 0 TO 7.5 FEET BGS
	SWMU BOUNDARY (APPROX.)

SOURCE: RUST E&I, 1995

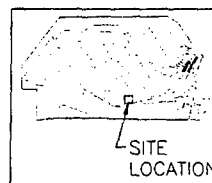


FIGURE 5-4
ESTIMATED EXTENT OF SOIL
CONTAMINATION
WASTE PILE AREA (SWMU 11)
TOOELE ARMY DEPOT



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6.0 SANITARY LANDFILL/PESTICIDE DISPOSAL AREA (SWMU 12/15)

6.1 SWMU BACKGROUND

The Pesticide Disposal Area (SWMU 12) is believed to be located within the Sanitary Landfill (SWMU 15). These SWMUs are discussed together in Section 5.0 because the exact location of SWMU 12 is unknown.

The Sanitary Landfill is located in an arroyo at the southern end of the open revetment area of TEAD, south of SWMU 30 and west of SWMUs 28 and 29, as shown in Figure 6-1. Since 1942, approximately 67 acres of the 100-acre landfill have been used for the disposal of a variety of waste. The waste was buried in trenches and placed in natural depressions, and covered with soil from the surrounding area. The southern portion of SWMU 15 has reportedly been closed for 20 years. The north-central portion has been closed to domestic waste since spring 1994; however, it continued to accept construction debris, asphalt, and asbestos until spring 1996. Based on reported observations by TEAD personnel, it appears that significant water flows no longer occur in the arroyo because of the upstream diversion of surface water.

The landfill reportedly handled conventional sanitary waste (e.g., scrap metal, rubber tires, paper, garbage, and scrap wood), untreated paint sludge, grease and oil, and paper-type filters for separating polychlorinated biphenyls (PCBs) from oil to be reused in electrical transformers. Waste products from metal-plating operations, paint containers, empty paint thinner and stripper containers, battery-acid containers, insecticide and herbicide containers, asbestos-containing materials, and ethylene glycol were also disposed at the landfill during the 1940s, 1950s, and 1960s (EA, 1988). Hazardous waste was not deposited in the landfill after October 1980, when the RCRA Management Plan was implemented.

Previous investigations identified waste in the following areas:

- Central and northeastern side of Incinerator Road – which was used to dispose of general refuse until 1994; the depth of fill material is estimated to be 30 feet.
- Southern portion of the landfill (used prior to 1975).
- Trenches on the western side of Incinerator Road – where asbestos-containing materials were disposed; this area also contained a series of former evaporation ponds used for pesticides disposal.
- Old sewage evaporation basin located just north of the asbestos fill area – where sewage from the Administration Area was channeled prior to 1972.

- Gravel pit near the landfill – where approximately 16 yd³ of liquid boiler residue (black tarry substances) and fuels from Building 637 were disposed.
- Small trench in the northernmost section of the general fill area – where empty 55-gallon drums marked “1,1,1-TCE” were placed.
- West-central portion of the landfill – which was the suspected location of the Pesticide Disposal Area (SWMU 12).
- Two burned areas located east of Incinerator Road – where burned wood debris was noted; rusty nails and bolts were also observed at the easternmost location.

The Pesticide Disposal Area reportedly consisted of a trench where barrels containing small amounts of pesticides were emptied prior to their disposal. This activity is thought to have ceased in 1982 or 1983, though the site was not identified until 1987 (Rust E&I, 1995).

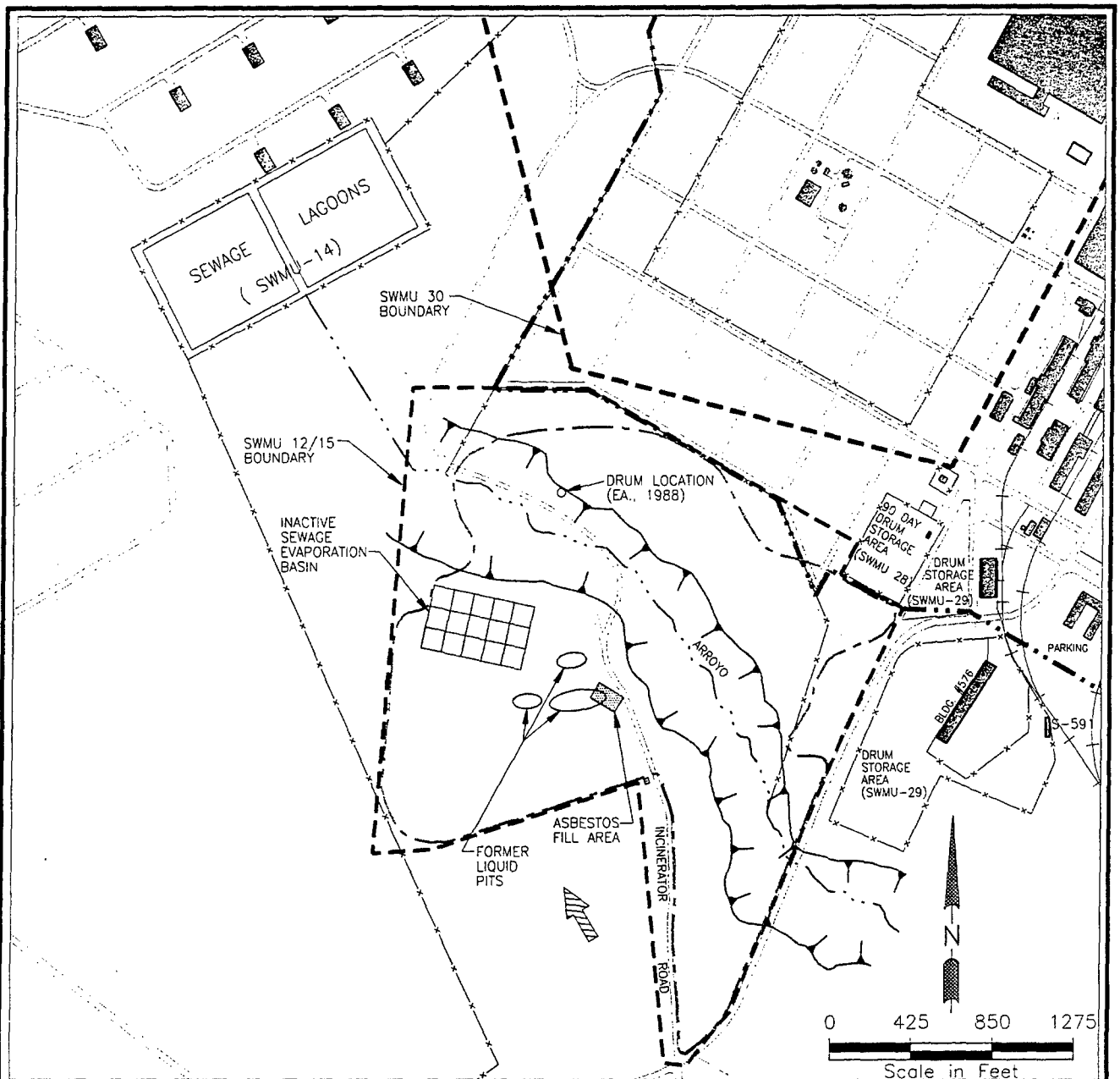
6.2 SUMMARY OF CONTAMINATION ASSESSMENT

6.2.1 Soil

Prior to the Phase II RFI, investigations at SWMU 12/15 focused on groundwater contamination only. During the RFI, soil gas sampling was conducted on a 200- by 200-foot grid spacing to define possible source areas for groundwater and to select locations for surface soil samples (Rust E&I, 1995). Fourteen VOCs – predominantly trichloroethylene (TCE) and 1,1,1-TCA – were identified in soil gas samples collected from the landfill. The maximum concentrations of both TCE and 1,1,1-TCA were detected at two locations in the north-central portion of the landfill. With the exception of these two contaminants, VOCs were detected at low concentrations and did not show any trends that would indicate a significant source area. Surface soil samples – collected from the surface to a depth of 6 inches – were found to contain a variety of contaminants, including metals, VOCs, SVOCs, pesticides, and PCB 1260. Again, TCE was the most commonly detected constituent and was found primarily in the southern portion of the landfill, with concentrations ranging from 0.31 to 2.4 µg/g. SVOCs and pesticides were detected throughout the landfill; no obvious source areas were defined. Elevated concentrations of metals were found throughout the landfill.

Fifteen test pit locations were selected based on soil gas survey results. Test pits were excavated to a depth of 10 feet bgs to provide information on the types of materials disposed in the various portions of the landfill and to determine if contaminants have been released to the surrounding soil. Results indicated the presence of metals, VOCs, SVOCs, pesticides, and PCB 1260. Most of the VOCs, SVOCs, and pesticides were

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LEGEND	
	INTERPRETIVE GROUNDWATER FLOW DIRECTION
	BUILDING
	INTERMITTENT STREAM
	FENCE
	RAILROAD
	NATURAL DEPRESSION
	APPROXIMATE LIMIT OF HISTORIC LANDFILL ACTIVITY
	BASE REALIGNMENT AND CLOSURE (BRAC) PARCEL BOUNDARY
	SWMU BOUNDARY (APPROX.)

SOURCE: RUST E&I, 1995

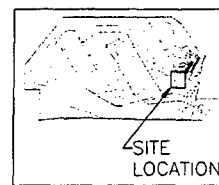


FIGURE 6-1
SANITARY LANDFILL AND PESTICIDE
DISPOSAL AREA (SWMU 12/15)
TOOELE ARMY DEPOT

detected in soil samples collected at the southern end of the landfill. The following materials were encountered during test pit excavation:

- General refuse in the southern portion of SWMU 15.
- Construction rubble and debris in the northeast.
- General refuse in the north-central area.
- Limited disposal, discharge of sewage to evaporation ponds, and possible disposal of pesticides to the west.

6.2.2 Groundwater

Groundwater in the unconfined regional aquifer beneath the Sanitary Landfill flows to the north-northwest and is approximately 280 to 300 feet bgs. Investigations prior to the Phase II RFI identified metals, VOCs, SVOCs, RDX, and pesticides as COPCs for groundwater. The Phase II RFI included metals, VOCs, SVOCs, and pesticides as COPCs, but did not analyze for RDX (Rust E&I, 1995). USACE-Sacramento has conducted additional sampling since completion of the RFI to further evaluate the nature and extent of contamination in groundwater (Geomatrix, 1997).

Based on the results of previous and ongoing sampling, TCE is the predominant COPC in groundwater at the landfill (Figure 6-2); other constituents (pesticides and SVOCs) were detected intermittently and at low levels in the sampled wells. As shown on Figure 6-2, previous groundwater studies indicated that the TCE plume associated with the IWL (SWMU 2) extends almost to the Sanitary Landfill and overlaps with the identified TCE plume at SWMU 12/15.

Additional groundwater investigation activities included installation of one well, redevelopment of four existing wells, and collection of two rounds of groundwater samples from 16 wells. Groundwater sampling was conducted to confirm previous detections of VOCs, SVOCs, pesticides, and metals (see the *Addendum to DCQAP*, Volume II of the Planning Documents; and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report).

The CMS Report will include an assessment of groundwater flow and contaminant transport at the Sanitary Landfill.

6.3 SUMMARY OF RA RESULTS

6.3.1 Human Health RA

Table 6-1 summarizes the risks and hazards calculated for SWMU 12/15. Results of the human health RA (Rust E&I, 1995) indicate that, under the future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at

SWMU 12/15 exceed the target of 1×10^{-6} for the child (7.5×10^{-4}) and adult (1.4×10^{-3}) receptors. Noncancer HIs also exceed the regulatory target of 1.0 for the child (37) and adult (27) receptors. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 12/15 per the requirements of UAC R315-101-1(b)(4).

Under the future construction worker scenario, the soil-based cancer risk is 1.2×10^{-6} . The noncancer HI resulting from soil exposure to the construction worker is 1.6.

Under the current military land use scenario, which is also the reasonably anticipated future land use, the cancer risk calculated in the human health RA is 1.5×10^{-5} , and the noncancer HI is 0.18. These levels are below State of Utah goals of 1×10^{-4} and 1.0, respectively (above which active corrective measures must be evaluated per UAC R315-101-6(e)), and within EPA's target range of 1×10^{-4} to 1×10^{-6} .

No lead modeling was conducted at SWMU 12/15 to estimate blood lead levels. The EPC of lead in soil (127 $\mu\text{g/g}$) does not exceed the 400- $\mu\text{g/g}$ screening level set by EPA for CERCLA and RCRA programs.

6.3.2 Ecological RA

Based on the evaluation of COPCs in soil and levels of exposure to ecological receptors, the SWERA (Rust E&I, 1997) concluded that the COPCs detected in soil at SWMU 12/15 pose a potential for unacceptable ecological risk. Specific factors considered in this risk characterization are as follows:

- Risk to passerine birds is 2.3 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are iron (19 percent), dioxin (16 percent), and copper (16 percent).
- Risks to the deer mouse and jackrabbit are both 1.5 times the risks estimated for the RSA. The primary risk drivers for deer mice (and percent contribution to estimated risk) are iron (35 percent) and copper (16 percent); and for jackrabbits, iron (34 percent) and RDX (14 percent).
- Risk to soil fauna is 13.8 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are chromium (55 percent), copper (20 percent), and iron (16 percent).
- Risk to plants is 13.8 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are PAHs (43 percent), copper (21 percent), and thallium (10 percent).

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at

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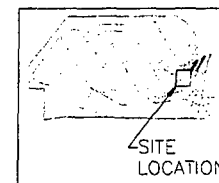
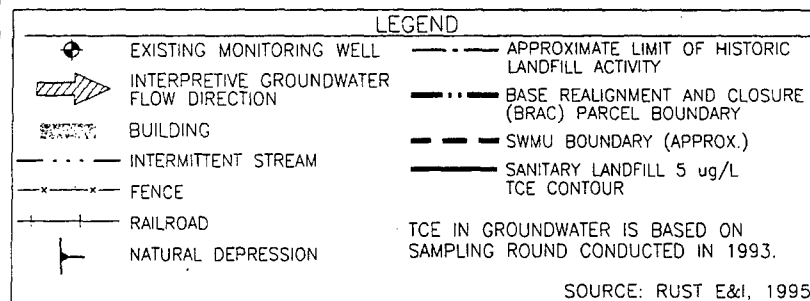
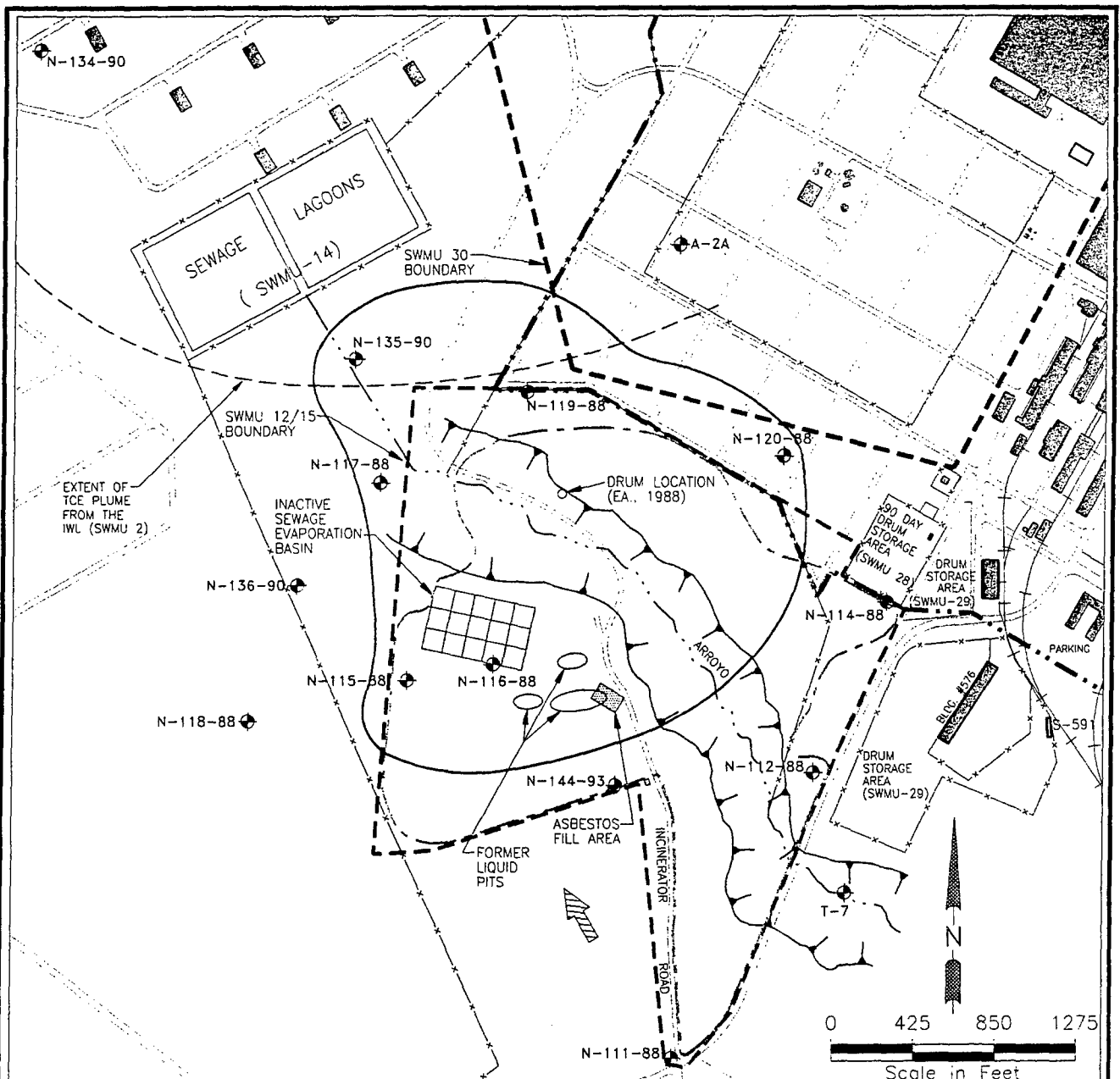


**FIGURE 6-2
TCE PLUME
SANITARY LANDFILL AND PESTICIDE
DISPOSAL AREA (SWMU 12/15)
TOOELE ARMY DEPOT**

TABLE 6-1

Summary of Human Health RA and
Corrective Measures Recommendations
Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level (µg/dL) (a)	Recommendations
Current Land Use (b)				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identified potential cancer risks above 1×10^{-6} or an HI above 1.0. However, active corrective measures are not necessarily required because the risks and hazards calculated for the current land use (also the reasonably anticipated future land use) do not exceed 1×10^{-4} (cancer risk) or 1.0 (HI).
Depot personnel	1.5×10^{-5}	0.18	NE (c)	
Future Land Use				
Residential— adult (d)	1.4×10^{-3}	27	NE	
Residential— child (d)	7.5×10^{-4}	37	NE	
Construction worker	1.2×10^{-6}	1.6	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter (µg/dL) for 95 percent of the population (should not exceed 10 µg/dL).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Pathway incomplete or not evaluated; see text.
- (d) Human health RA results for a conservative future residential land use scenario, as required in UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMUs 12/15.

the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 12/15. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 12/15.

Based on the above factors, the SWERA (Rust E&I, 1997) concluded that SWMU 12/15 pose a potential unacceptable risk to ecological receptors. Therefore, it was recommended that the CMS Report consider ecological risks in assessing corrective measures.

As part of the corrective measures selection process, the reduction in ecological risk will be evaluated using the procedure presented in Appendix D.

6.4 INTERIM CORRECTIVE ACTIONS

Interim corrective actions performed at the Sanitary Landfill include the placement of soil cover over filled material. Past waste management practices consisted of placing the waste in natural depressions and covering the areas with surrounding soil.

6.5 IDENTIFICATION OF COCs

Tables 6-2 and 6-3 compare the maximum concentration of each COPC to the corresponding quantitative CAO developed in Appendix A for surface and subsurface soil, respectively. Based on this comparison, the COCs for surface soil are arsenic, chromium, dieldrin, and carcinogenic PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene). The COCs identified for subsurface soil are arsenic, benzo(a)pyrene, and dibenz(a,h)anthracene. Figure 6-3 shows the locations of these COCs at SWMU 12/15. Based on the qualitative CAOs developed for groundwater – primarily the prevention of further degradation of the environment in accordance with the State of Utah “Principle of Non-Degradation” (UAC R315-101-3) – VOCs are considered to be the COCs at SWMU 12/15.

6.6 APPROXIMATE AREA OF CONTAMINATION

Based on a review of the Phase II RFI (Rust E&I, 1995) and the COCs identified in Section 6.5, the estimated area of SWMU 12/15 that requires corrective measures is 115 acres. This includes two irregularly shaped areas on either side of the arroyo. As shown on Figure 6-4, this area is delineated by the approximate limits of the landfill. For the purpose of the CMS, it is further assumed that groundwater monitoring and recovery wells may be installed outside the boundary of SWMU 12/15.

TABLE 6-2

Development of COCs in Surface Soil
Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)

COPC (a)	Maximum Concentration (µg/g)	Depot Personnel CAO (b) (µg/g)	Surface Soil COC? (c)
Metals			
Antimony	140	160	No
Arsenic	200	32	Yes
Barium	290	71,000	No
Beryllium	1.15	1.5	No
Cadmium	39.8	220	No
Chromium (d)	2,800	2,000	Yes
Copper	1,800	68,000	No
Lead	920	1,800	No
Manganese	665	17,000	No
Mercury	1.2	440	No
Nickel	26.4	36,000	No
Selenium	0.496	10,000	No
Silver	19.6	7,900	No
Vanadium	60.5	1,600	No
Zinc	2,900	490,000	No
PCBs/Pesticides			
PCB 1260	0.937	25	No
Aldrin	0.0332	0.13	No
Alpha-endosulfan	0.00473	7,400	No
Beta-endosulfan	0.0275	7,400	No
Chlordane	0.0854	6.6	No
Dieldrin	0.38	0.14	Yes
Endrin	0.0491	14	No
PP-DDD	0.0117	12	No
PP-DDE	0.106	8.3	No
PP-DDT	0.28	8.3	No
SVOCs			
Acenaphthene	8.4	35,000	No
Acenaphthylene	1.9	17,000	No
Anthracene	9.7	320,000	No
Benzo(a)anthracene	27.0	2.2	Yes

TABLE 6-2 (cont'd)

COPC (a)	Maximum Concentration (µg/g)	Depot Personnel CAO (b) (µg/g)	Surface Soil COC? (c)
Benzo(a)pyrene	10.0	0.22	Yes
Benzo(b)fluoranthene	20.0	2.2	Yes
Benzo(k)fluoranthene	18.0	22	No
Benzo(g,h,i)perylene	22.0	17,000	No
Chrysene	17.0	220	No
Dibenzofuran	1.5	4,900	No
Di-n-butyl phthalate	3.8	120,000	No
Fluoranthene	20	23,000	No
Fluorene	5.4	49,000	No
Indeno(1,2,3-cd)pyrene	42.0	2.2	Yes
2-Methylnaphthalene	0.60	44,000	No
Naphthalene	2.1	44,000	No
Phenanthrene	19	31,000	No
Pyrene	13.8	17,000	No
VOCs			
1,3-Dimethylbenzene	0.78	(e)	No
Ethylbenzene	0.35	120,000	No
Trichloroethylene	2.4	82	No
Trichlorofluoromethane	0.32	140,000	No

- (a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
- (b) Corrective action objectives developed in Appendix A.
- (c) Contaminants of concern (i.e., COPCs greater than CAOs).
- (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.
- (e) Calculated CAO exceeds 1 million ppm (µg/g).

TABLE 6-3

Development of COCs in Subsurface Soil
Sanitary Landfill/Pesticide Disposal Area (SWMU 12/15)

COPC (a)	Maximum Concentration (µg/g)	Construction Worker CAO (b) (µg/g)	Subsurface Soil COC? (c)
Metals			
Antimony	40	470	No
Arsenic	47	32	Yes
Barium	849	110,000	No
Cadmium	32.5	870	No
Chromium	111	23,000	No
Copper	305	64,000	No
Lead	850	1,800	No
Mercury	1.6	500	No
Nickel	66.8	34,000	No
Selenium	320	8,700	No
Zinc	1,390	510,000	No
Pesticides/PCBs			
Alpha - endosulfan	0.0101	9,600	No
Chlordane	0.214	59	No
Dieldrin	0.049	1.3	No
Endrin	0.0135	86	No
Heptachlor	0.00581	4.8	No
Heptachlor epoxide	0.00341	2.4	No
Lindane	0.00248	17	No
Methoxychlor	0.102	8,000	No
PCB - 1260	0.105	25	No
DDD	0.25	90	No
DDE	0.11	64	No
DDT	0.25	64	No
SVOCs			
2-Methylnaphthalene	3.5	63,000	No
4-Methylphenol	6.8	8,000	No
Acenaphthene	19	800,000	No
Acenaphthylene	0.7	400,000	No
Anthracene	10.2	(d)	No
Bis(2-ethylhexyl) phthalate	10	1,100	No
Benzo(a)anthracene	16.6	25	No

TABLE 6-3 (cont'd)

COPC (a)	Maximum Concentration (µg/g)	Construction Worker CAO (b) (µg/g)	Subsurface Soil COC? (c)
Benzo(a)pyrene	8.2	2.5	Yes
Benzo(b)fluoranthene	12.5	25	No
Benzo(g,h,i)perylene	12	400,000	No
Benzo(k)fluoranthene	36.5	250	No
Chrysene	24.3	2,500	No
Dibenz(a,h)anthracene	5.6	2.5	Yes
Dibenzofuran	5.6	6,400	No
Diethyl phthalate	2.3	(d)	No
Dimethyl phthalate	40	(e)	No
Fluoranthene	19.5	530,000	No
Fluorene	15	640,000	No
Indeno(1,2,3-cd)pyrene	8.2	25	No
Naphthalene	8.3	63,000	No
N-Nitrosodiphenylamine	7.6	3,600	No
Pentachlorophenol	6.2	190	No
Phenanthrene	15.8	470,000	No
Phenol	1	950,000	No
Pyrene	16.9	400,000	No
VOCs			
1,2-Dichloroethylene	0.65	140,000	No
1,3-Dimethylbenzene	4.7	110,000	No
Acrylonitrile	10	42	No
Methyl isobutyl ketone	2	(d)	No
Trichlorofluoromethane	6.4	850,000	No
Monochlorobenzene	0.16	27,000	No
Ethylbenzene	2.7	160,000	No
Toluene	3.9	(d)	No
Tetrachloroethylene	1.1	430	No
Trichloroethylene	9.4	1,300	No
Xylene	3.3	640,000	No

(a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).

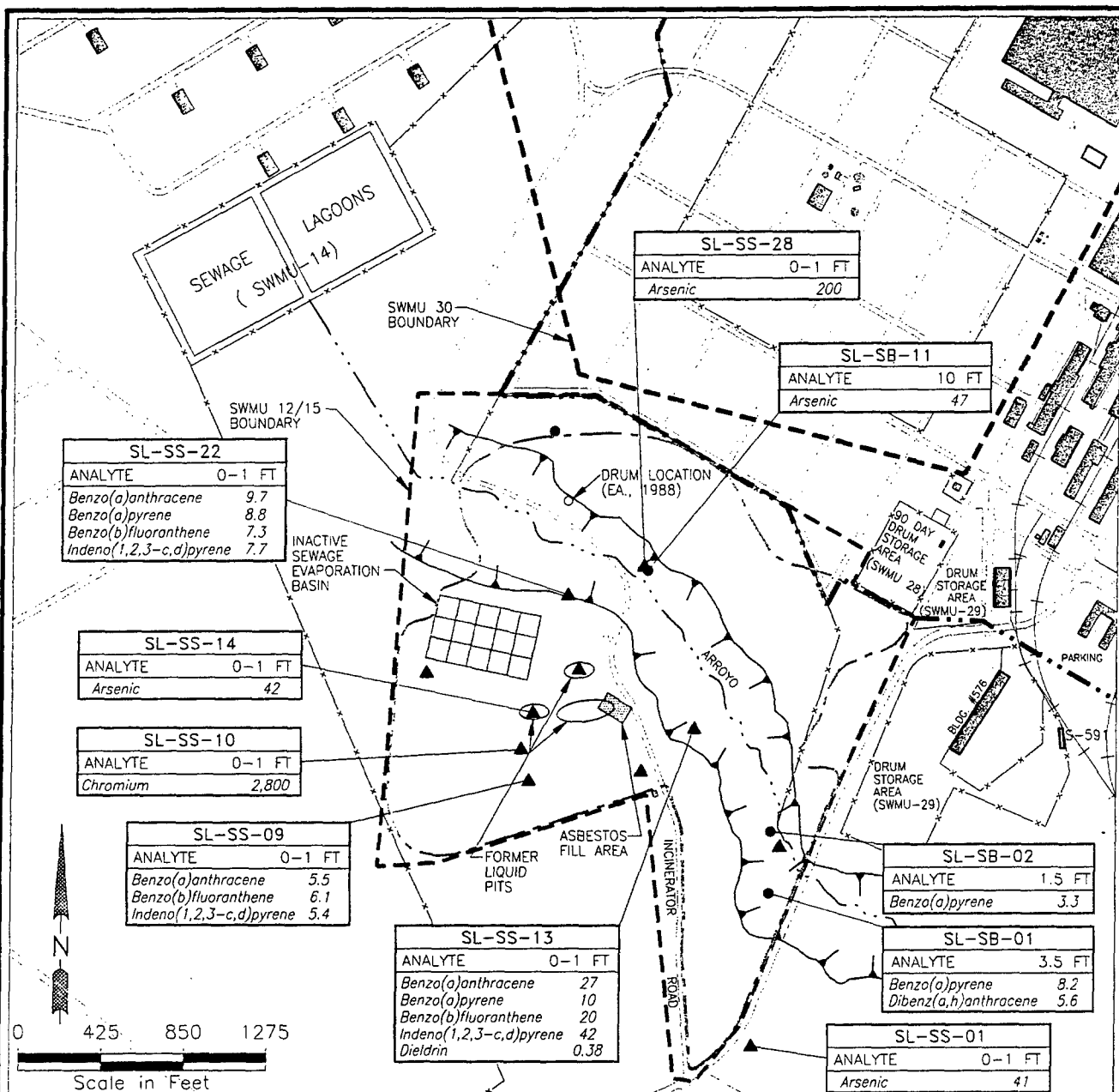
(b) Corrective action objectives developed in Appendix A.

(c) Contaminants of concern (i.e., COPCs greater than CAOs).

(d) Calculated CAO exceeds 1 million ppm (µg/g).

(e) Relevant health effects criteria are unavailable.

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LEGEND

- TEST PIT
- ▲ SURFACE SOIL SAMPLE (0-1 FT)
- ▭ BUILDING
- INTERMITTENT STREAM
- x-x- FENCE
- + + + RAILROAD
- ┐ NATURAL DEPRESSION
- - - APPROXIMATE LIMIT OF HISTORIC LANDFILL ACTIVITY
- · - · - BASE REALIGNMENT AND CLOSURE (BRAC) PARCEL BOUNDARY
- - - SWMU BOUNDARY (APPROX.)

NOTE: CONCENTRATIONS IN ug/g
SOURCE: RUST E&I, 1995

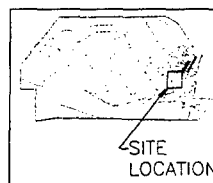
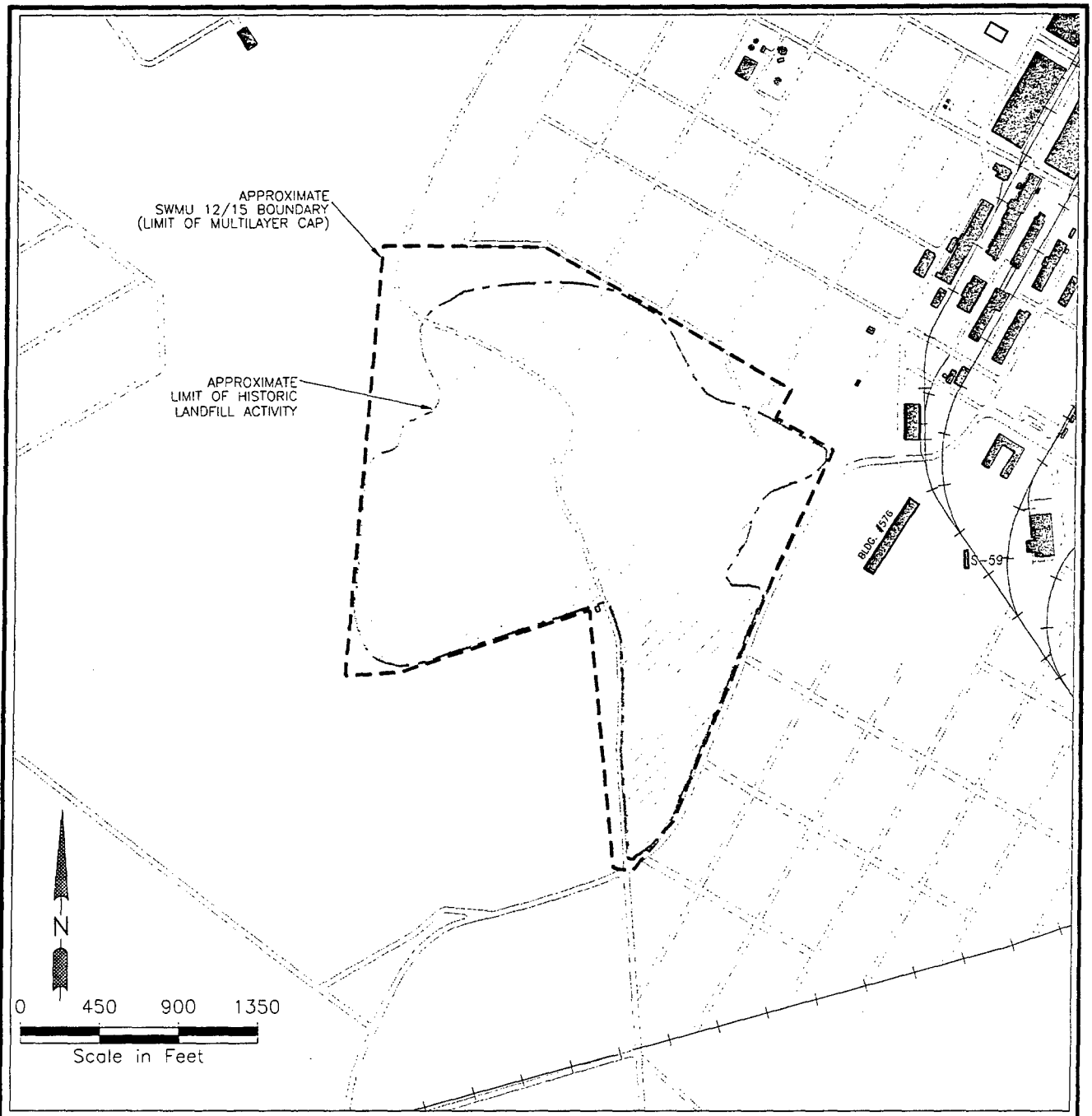


FIGURE 6-3
COC LOCATIONS IN SURFACE AND
SUBSURFACE SOIL
SANITARY LANDFILL AND PESTICIDE
DISPOSAL AREA (SWMU 12/15)
TOOELE ARMY DEPOT

09604\056 File: FIG6-4.dwg Date/Time: February 22, 2000 9:15 a.m. Scale: 1"=0 WASKD Xrefs:



LEGEND

	EXTENT OF PROPOSED CORRECTIVE ACTION
	BUILDING
	INTERMITTENT STREAM
	FENCE
	RAILROAD
	APPROXIMATE LIMIT OF HISTORIC LANDFILL ACTIVITY
	SWMU BOUNDARY (APPROX.)

SOURCE: RUST E&I, 1995

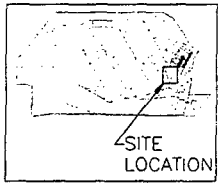


FIGURE 6-4
ESTIMATED EXTENT OF CONTAMINATION
SANITARY LANDFILL AND PESTICIDE
DISPOSAL AREA (SWMU 12/15)
TOOELE ARMY DEPOT

6.7 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101, which states that if the cancer risk at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, the appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the realistic future land use scenario, active corrective measures are required. UAC R315-101-3, the "Principle of Non-degradation," states that active corrective measures are required to prevent further degradation of a resource, including groundwater. In addition, UAC R315-302 (Solid Waste Facility Location Standards, General Facility Requirements, and Closure Requirements) defines the requirements for closure of a landfill and is applicable to SWMU 12/15.

To determine which technologies are most appropriate for SWMU 12/15, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs.

The following corrective measures technologies are considered to apply to the identified COCs in soil and groundwater:

Corrective Measures Technologies (SWMU 12/15, Sanitary Landfill/Pesticide Disposal Area)	
Soil	Land use restrictions
	Soil cap
	Alternative soil cover
Groundwater	Land use restrictions
	Monitoring
	Groundwater monitoring
	Groundwater extraction
	Air stripping

These technologies are based on the estimated HI in the Phase II RFI for the construction worker scenario exceeding the goal of 1.0, the requirement to protect groundwater from further degradation, the State of Utah's landfill closure regulations, and potentially unacceptable ecological risks.

Based on UAC R315-302, a landfill cap meeting the landfill closure specifications is included with each corrective measures alternative. To address all media, COCs, and CAOs, the following corrective measures alternatives, which combine the various technologies, are identified for SWMU 12/15 for further evaluation in the CMS Report:

SWMU 12/15	Corrective Measures Alternatives
SANITARY LANDFILL/ PESTICIDE DISPOSAL AREA	Multilayer landfill cap, groundwater monitoring, and land use restrictions
	Construct multilayer landfill cap in accordance with State of Utah solid waste regulations Monitor identified contaminants in groundwater Impose land use restrictions to prevent residential development
	Evapotranspiration landfill cover, groundwater monitoring, and land use restrictions
	Construct evapotranspiration landfill cover in accordance with State of Utah solid waste regulations Conduct groundwater extraction and treatment using air stripping offsite at the existing IWL extraction and treatment system Impose land use restrictions to prevent residential development
	Evapotranspiration landfill cover, groundwater pump and treat, and land use restrictions
	Construct evapotranspiration landfill cover in accordance with State of Utah solid waste regulations
	Conduct groundwater extraction and treatment using air stripping
	Impose land use restrictions to prevent residential development

7.0 BATTERY SHOP (SWMU 25)

7.1 SWMU BACKGROUND

The Battery Shop (SWMU 25) is located in Building 1252, in the south-central section of TEAD, east of the Laundry Effluent Pond and Waste Pile Areas (SWMU 11). Figure 7-1 shows the layout and location of SWMU 25. The Battery Shop was used for the maintenance and repair of vehicle and forklift batteries from 1980 to 1993. Important site features include two washdown pads (one wooden and one metal) located northeast of Building 1252, a discharge pipe from the building, and a drainage ditch used to collect washdown water from the pads as well as discharge from the shop. The drainage ditch extends to the northeast of the building and terminates approximately 350 feet from the discharge pipe.

Spent battery acid and washdown water were discharged to the ditch throughout site operations. Beginning in 1982, these liquids were neutralized with sodium bicarbonate or sodium hydroxide. The shop floor was washed down daily using sodium bicarbonate, which was discharged to the ditch until 1990, when the drain was sealed and the sump leading to the drain pipe was used to collect washdown wastes. Beginning in 1986, battery acid was containerized for disposal.

7.2 SUMMARY OF CONTAMINATION ASSESSMENT

7.2.1 Soil

Reddish-orange staining – extending 25 feet from the point of pipe discharge to a depth of 5 feet – was observed in soil within the drainage ditch. Slight staining was also observed to a depth of 20 feet in two samples collected adjacent to the discharge area. Sampling results indicate that the metals contamination is primarily restricted to near-surface soil in the narrow drainage area. Arsenic (maximum concentration of 40 µg/g), chromium (112 µg/g), lead (33,251 µg/g), mercury (6.10 µg/g), silver (53 µg/g), and other metals were detected in shallow soil inside the drainage area. Metals concentrations decreased with depth. Outside of the drainage area, arsenic, lead, and thallium were detected. Thallium, at a reported concentration of 1,510 µg/g, was detected in a single soil sample at a location adjacent to the washdown pads during the Phase I investigation. Appendix C presents chemical analysis results for SWMU 25 from the Phase II RFI Report (Rust E&I, 1995).

7.2.2 Groundwater

No groundwater monitoring wells are located at SWMU 25; the closest are located at the TNT Washout Facility (SWMU 10), approximately 1,500 feet downgradient. The depth to groundwater at SWMU 25 is assumed to be approximately 230 feet – the same as measured for SWMU 10.

Although soil borings sampled in the vicinity of the highest reported metals contamination at SWMU 25 revealed elevated levels of chromium, copper, lead, and zinc at a depth of 5 feet bgs, no metals contamination was detected at depths of 10 and 15 feet bgs.

These chemical results support the theory that the high alkalinity of site soil caused lead and other metals from the discharge of acidic wastewater to precipitate in near-surface soil and be immobilized (Rust E&I, 1995). For these reasons, and based on analyses presented in the Phase II RFI Report, the impacts to groundwater (if any) at SWMU 25 are expected to be minimal.

7.3 SUMMARY OF RA RESULTS

7.3.1 Human Health RA

Table 7-1 summarizes the risks and hazards calculated for SWMU 25. Risks were calculated for two exposure areas – the Inside Discharge Area and the Outside Discharge Area. Results of the human health RA (Rust E&I, 1995) indicate that, under the hypothetical future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at SWMU 25 exceed the target of 1×10^{-6} for both the adult and child receptors. Noncancer HIs also exceed the regulatory target of 1.0 for both receptors. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 25 per the requirements of UAC R315-101-1(b)(4).

The human health RA does not evaluate the future construction worker scenario for soil-based cancer risks and noncancer HIs resulting from soil exposure (Rust E&I, 1995). However, the CMS Work Plan evaluates potential exposure to subsurface soil by comparing the maximum concentrations of COPCs, identified using data and methodology presented in the human health RA, to risk-based CAOs for construction workers (developed in Appendix A).

Under the current military land use scenario, which is also the assumed future land use, the greatest cancer risk calculated in the human health RA is 6.7×10^{-6} (Inside Discharge Area), and the greatest noncancer HI is 1.4 (Outside Discharge Area). However, the cancer risk for the Inside Discharge Area is below the State of Utah goal of 1×10^{-4} (above which active corrective measures must be evaluated per UAC R315-101-6(e)) and within EPA's target range of 1×10^{-4} to 1×10^{-6} . The HI for the Outside Discharge Area is slightly above the State of Utah goal of 1.0.

The human health RA ran models to estimate blood lead levels for the Inside Discharge Area because the EPC of lead in soil (1,119 $\mu\text{g/g}$) at SWMU 25 exceeds the 400- $\mu\text{g/g}$ screening level set by EPA for CERCLA and RCRA programs. The calculated onsite worker blood lead level is 6.8 $\mu\text{g/dL}$, and the residential child blood lead level is 8.2 $\mu\text{g/dL}$.

09604\056 File: FIG7-1.dwg Date/Time: February 19, 2000 11:02 a.m. Scale: 1=0 WASKD Xrefs:

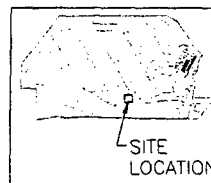
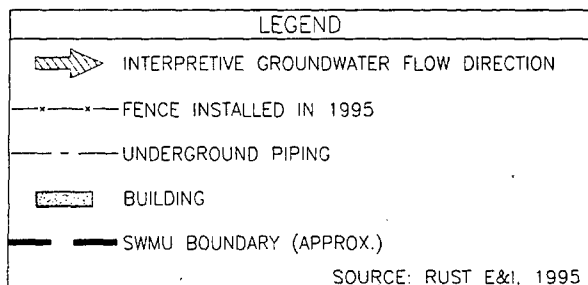
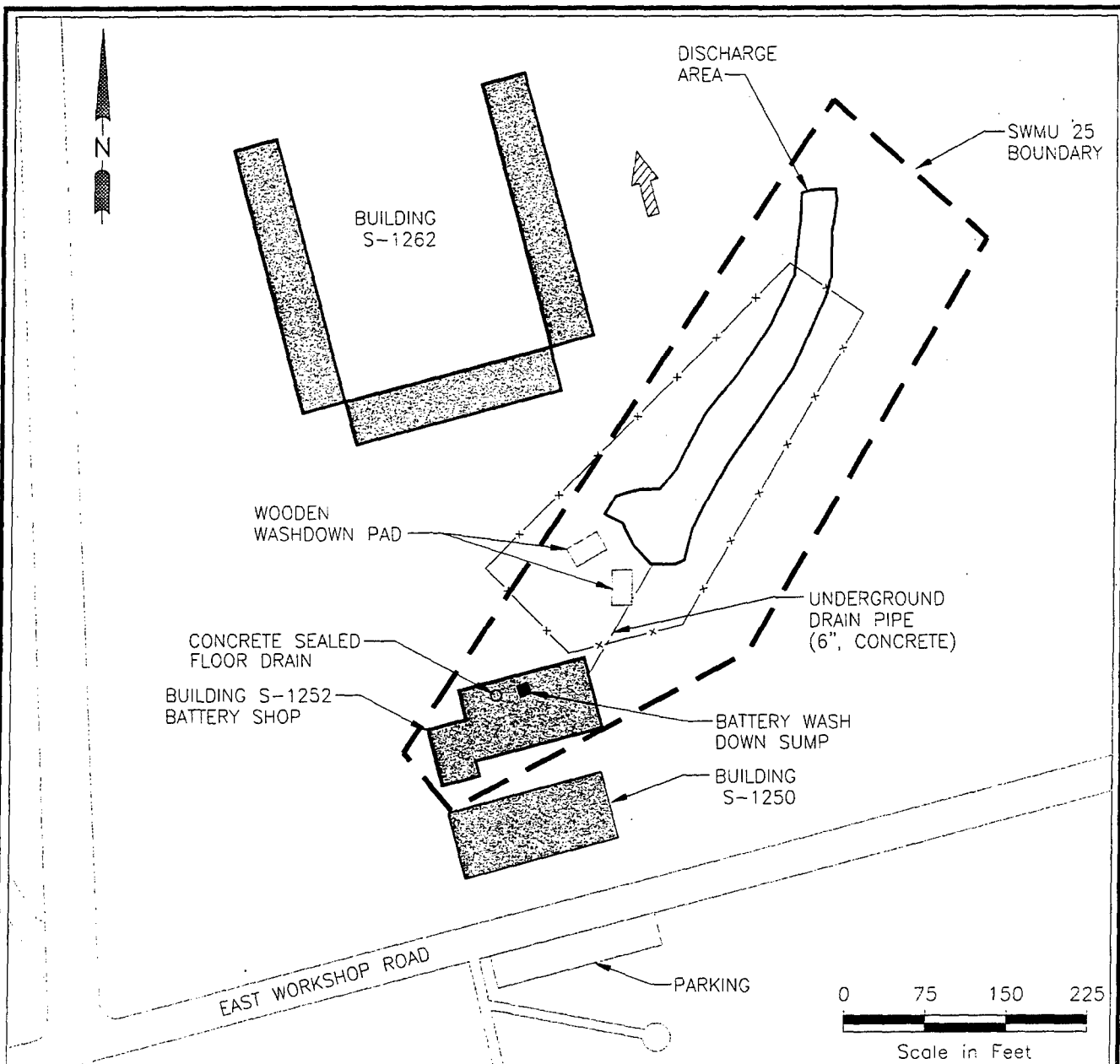


**FIGURE 7-1
BATTERY SHOP (SWMU 25)
TOOELE ARMY DEPOT**

TABLE 7-1

Summary of Human Health RA and
Corrective Measures Recommendations
Battery Shop (SWMU 25)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level (µg/dL) (a)	Recommendations
Inside Discharge Area				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identifies potential cancer risks above 1×10^{-6} or an HI above 1.0. However, active corrective measures are not necessarily required because the risks and hazards calculated for the current land use (also the reasonably anticipated future land use) do not exceed 1×10^{-4} (cancer risk) or 1.0 (HI).
Current Land Use (b)				
Depot personnel	6.7×10^{-6}	0.08	6.8	
Future Land Use				
Residential— adult (c)	5.4×10^{-5}	1.6	NE (d)	
Residential— child (c)	1.1×10^{-4}	9.5	8.2	
Construction worker	NE	NE	NE	
Outside Discharge Area				
Current Land Use (b)				
Depot personnel	5.4×10^{-6}	1.4	NE	
Future Land Use				
Residential— adult (c)	5.5×10^{-5}	6.1	NE	
Residential— child (c)	6.0×10^{-5}	7.5	NE	
Construction worker	NE	NE	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter (µg/dL) for 95 percent of the population (should not exceed 10 µg/dL).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Human health RA results for a conservative future residential land use scenario, as required in UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMU 25.
- (d) Pathway incomplete or not evaluated; see text.

7.3.2 Ecological RA

Based on the evaluation of COPCs in soil and levels of exposure to ecological receptors, the SWERA (Rust E&I, 1997) determined that the COPCs detected in soil at SWMU 25 present a low ecological risk. Specific factors considered in this risk characterization are as follows:

- Risk to passerine birds is 1.7 times the risk estimated for the RSA. Iron contributes 58 percent of the risk.
- No risks to raptors or species of special concern were identified.
- Risk to deer mice is 2.6 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are iron (89 percent) and lead (7 percent).
- Risk to plants equals that estimated for the RSA and is classified as low.
- Risk to soil fauna is 2.8 times the risk estimated for the RSA and is characterized as moderate. The primary risk drivers (and percent contribution to estimated risk) are chromium (58 percent) and iron (39 percent). However, this risk calculation is highly conservative due to the uncertainties associated with the toxicity benchmark values for chromium and iron.
- Because the site is extensively disturbed by human activity and ecological habitat is limited and of low quality, there is insufficient space to support a high diversity of wildlife and plant communities.
- Overall, the WOE assessment for SWMU 25 is similar to or slightly less than that for the RSA.

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 25. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 25.

Based on the limited ecological habitat and lack of highly elevated relative risk for all ecological receptors when compared to RSA conditions, the SWERA (Rust E&I, 1997) concluded that the potential ecological risks associated with SWMU 25 are low. Therefore, it is recommended that no corrective measures be considered to reduce ecological risks.

7.4 INTERIM CORRECTIVE ACTIONS

During the Phase II RFI, the floor drain in Building 1252 was found to have been sealed. In 1995, TEAD fenced the contaminated portion of the drainage area to prevent exposure to on-post workers and grazing cattle. TEAD also instituted a fence inspection program, as required by the State of Utah.

7.5 IDENTIFICATION OF COCs

Tables 7-2 and 7-3 compare the maximum concentration of each COC to the corresponding quantitative CAO developed in Appendix A for surface and subsurface soil, respectively. Surface soil COCs are identified in the human health RA portion of the Phase II RFI Report (Rust E&I, 1995). Subsurface soil COCs are identified using data and methodology presented in the human health RA. Based on this evaluation, arsenic, lead, and thallium are identified as COCs in surface soil at SWMU 25. As shown in Figure 7-2, lead was detected at concentrations well above the CAO at four surface soil locations within the drainage ditch. Thallium was detected at a concentration significantly exceeding the CAO in an isolated location adjacent to the washdown pad.

The COCs identified at SWMU 25 are evaluated with results of the human health RA to determine whether corrective measures need to be evaluated based on criteria specified in the State and Federal regulations and existing permit requirements. As stated in the Phase II RFI Report (Rust E&I, 1995), the human health RA uses the EPC to calculate human health cancer risks and HIs. To further assess the need for corrective measures for the identified COCs, the EPCs are compared to CAOs. The maximum EPCs for surface soil from the Inside and Outside Discharge Areas are compared to CAOs, as presented below:

SWMU 25, Battery Shop		
COC (Surface Soil)	EPC ($\mu\text{g/g}$)	CAO ($\mu\text{g/g}$)
Arsenic	23.3	32
Lead	2,350	1,800
Thallium	274	120

As discussed in Appendix A, the CAO for lead ($1,800 \mu\text{g/g}$) corresponds to a 95th percentile blood lead level of $10 \mu\text{g/dL}$, which is the CDC target level. The EPC for lead is above the CAO, though the corresponding blood lead level is below the CDC target level, which is consistent with results of the Phase II RFI (see Table 7-1). The apparent inconsistency between the identification of thallium as a COC and the results of the human health RA, which did not predict a significant health risk (i.e., HI level above 1.0), is due to the use of two different RA models in the Phase II RFI and the CAO calculations performed in the CMS. The model used for the CAO calculations in Appendix A of this Work Plan integrates the RFI RAs performed for different groups of SWMUs at TEAD, and incorporates updated and more realistic assumptions.

TABLE 7-2

Development of COCs in Surface Soil
Battery Shop (SWMU 25)

COPC (a)	Maximum Concentration ($\mu\text{g/g}$)	Depot Personnel CAO (b) ($\mu\text{g/g}$)	Surface Soil COC? (c)
Metals			
Antimony	94	160	No
Arsenic	43	32	Yes
Cadmium	13.6	220	No
Chromium (d)	112	2,000	No
Cobalt	36	130,000	No
Copper	430	68,000	No
Lead	33,251 (e)	1,800	Yes
Manganese	1,400	17,000	No
Mercury	6.1	440	No
Nickel	22.6	36,000	No
Silver	53	7,900	No
Thallium	1,510	120	Yes
Vanadium	109	1,600	No
Zinc	949	490,000	No

(a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).

(b) Corrective action objectives developed in Appendix A.

(c) Contaminants of concern (i.e., COPCs greater than CAOs).

(d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.

(e) Detected during previous investigations, prior to the Phase II RFI.

TABLE 7-3

Development of COCs in Subsurface Soil
Battery Shop (SWMU 25)

COPC (a)	Maximum Concentration ($\mu\text{g/g}$)	Construction Worker CAO (b) ($\mu\text{g/g}$)	Subsurface Soil COC? (c)
Metals			
Cadmium	1.48	870	No
Chromium (d)	45.9	23,000	No
Copper	137	64,000	No
Lead	520	1,800	No
Mercury	2.3	500	No
Silver	1.02	8,400	No
Zinc	121	510,000	No

- (a) Contaminants of potential concern identified from data and methodology presented in the Phase II RFI (Rust E&I, 1995).
- (b) Corrective action objectives developed in Appendix A.
- (c) Contaminants of concern (i.e., COPCs greater than CAOs).
- (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.

The EPC for arsenic is below the CAO. The elevated arsenic concentrations detected in subsurface soil are likely due to background soil variation and are not considered to be the result of contamination.

Although no groundwater data have been collected at this SWMU, soil sample results indicate that soil contamination is limited to near-surface soil, and impacts to groundwater (if any) are expected to be minimal. Therefore, no COCs are identified for groundwater, and Section 7.7 considers no treatment technologies for groundwater. The qualitative CAO of reducing the potential impact of subsurface soil contamination on groundwater will be addressed through the corrective measures for contaminated soil.

7.6 ESTIMATION OF CONTAMINATED VOLUME

Based on a review of the Phase II RFI (Rust E&I, 1995) and the COCs identified in Section 7.5, the estimated area of SWMU 25 with elevated concentrations of lead and thallium is 8,100 ft². As shown on Figure 7-3, this area is located adjacent to the underground drain pipe, washdown pads, and discharge area; it accounts for approximately 20 percent of SWMU 25. For the purpose of the CMS, it is further assumed that the identified area will be excavated to an average depth of 1 foot bgs. As a result, approximately 300 yd³ of metals-contaminated soil will be generated from excavation activities during corrective measures implementation.

7.7 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

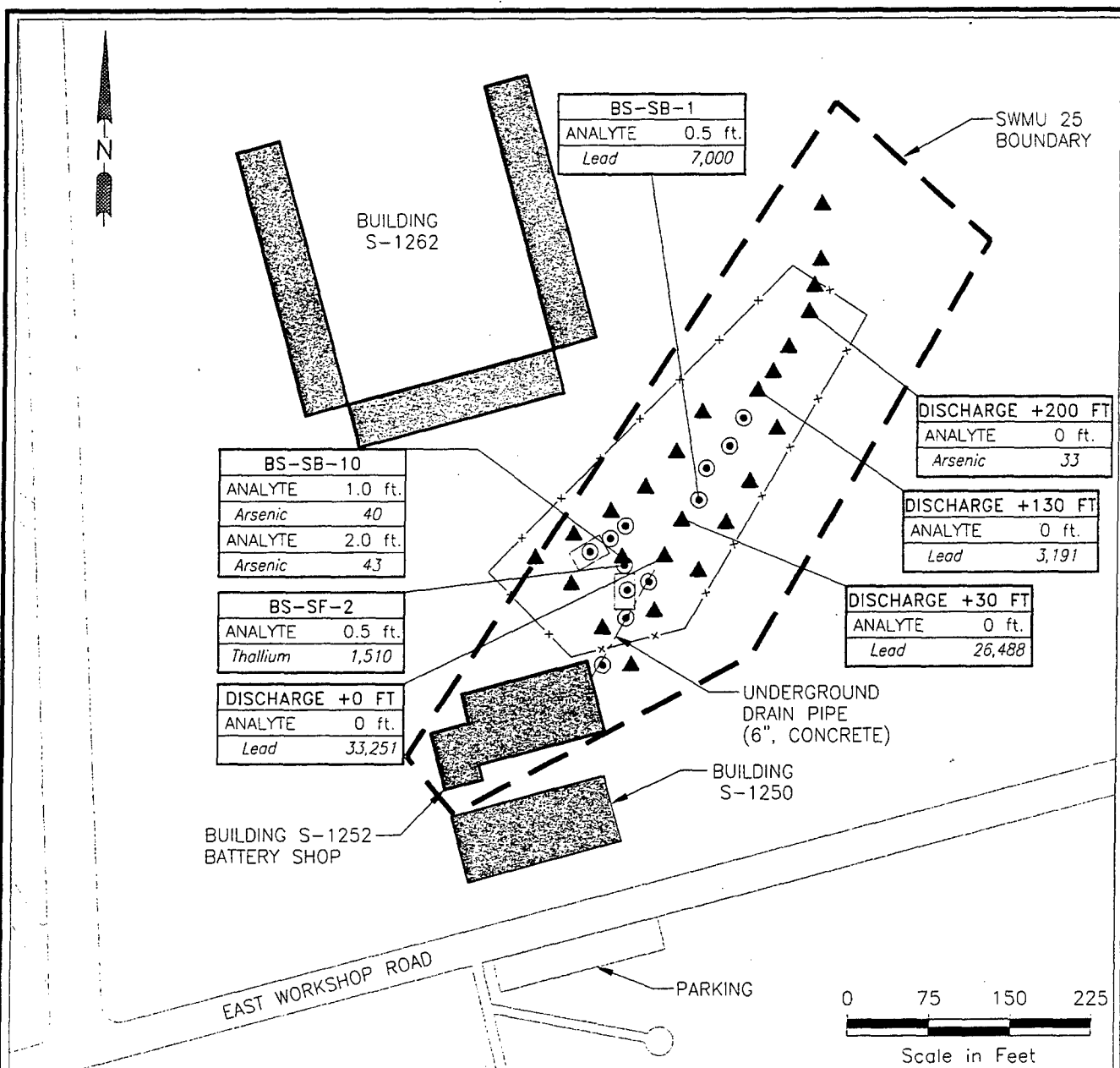
Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101 which states that if the cancer risk present at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the reasonably anticipated future land use scenario, active corrective measures are required. UAC R315-101-3, the "Principle of Non-Degradation," states that active corrective measures are required to prevent further degradation of a resource, including groundwater.

To determine which technologies are most appropriate for SWMU 25, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs.

The human health RA does not indicate a threat to human health based on the EPCs of the identified contaminants. Likewise, no unacceptable impacts to groundwater

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LEGEND	
	SURFACE SOIL SAMPLE
	SOIL BORING
	FENCE INSTALLED IN 1995
	UNDERGROUND PIPING
	BUILDING
	SWMU BOUNDARY (APPROX.)

SOURCE: RUST E&I, 1995

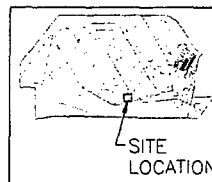


FIGURE 7-2
COC LOCATIONS IN SOIL
BATTERY SHOP (SWMU 25)
TOOELE ARMY DEPOT



DAMES & MOORE
A DAMES & MOORE GROUP COMPANY

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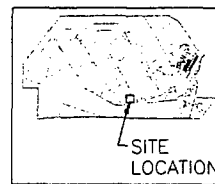
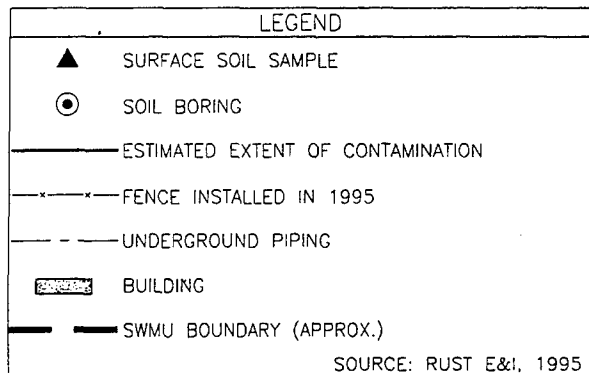
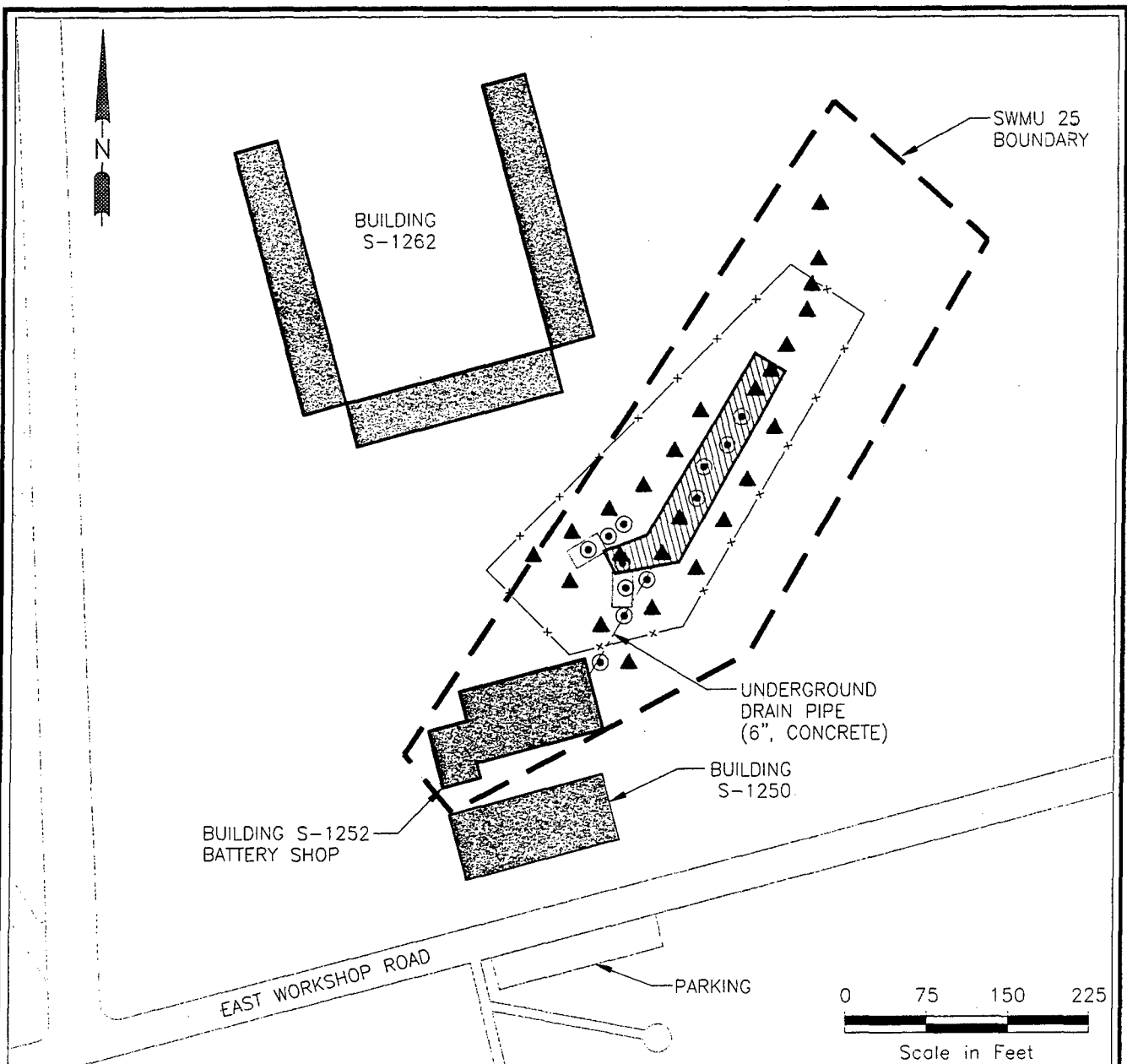


FIGURE 7-3
ESTIMATED EXTENT OF
SOIL CONTAMINATION
BATTERY SHOP (SWMU 25)
TOOELE ARMY DEPOT



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are expected. The SWERA identified low risks to ecological receptors. Lead (present at four locations) and thallium were detected at maximum concentrations above their respective CAOs in surface soil.

Therefore, based on the above criteria, the following corrective measures technologies are considered to apply to the identified COCs in soil:

Corrective Measures Technologies (SWMU 25, Battery Shop)
Land use restrictions Soil cover Excavation Solidification/stabilization Soil washing Off-post treatment/disposal

To address all COCs and CAOs, the following corrective measures alternatives, which combine the various technologies, are identified for SWMU 25 for further evaluation in the CMS Report:

SWMU 25	Corrective Measures Alternatives
BATTERY SHOP	Land use restrictions Impose land use restrictions to prevent residential development Soil cover and land use restrictions Install a soil and vegetative cover over the impacted soil Impose land use restrictions to prevent residential development Excavation, off-post treatment/disposal, and land use restrictions Excavate contaminated soil and treat/ dispose off post Impose land use restrictions to prevent residential development Excavation, solidification/stabilization, and land use restrictions Excavate and stabilize/solidify contaminated soil Impose land use restrictions to prevent residential development Excavation, soil washing, and land use restrictions Excavate and wash contaminated soil, and treat/ dispose treatment residuals off post Impose land use restrictions to prevent residential development

8.0 OLD INDUSTRIAL WASTE LAGOON (SWMU 30)

8.1 SWMU BACKGROUND

The OIWL (SWMU 30) is located northwest of the Maintenance Area. It includes more than 500 acres and encompasses all of the drainage ditches associated with the lagoon. However, only 42 acres is directly affected by site activities. Figure 8-1 shows the layout and location of the OIWL.

SWMU 30 consists of seven former standing liquid areas (referred to as lagoons) and nine ditches. Former standing liquid area 1 on Figure 8-1 is also referred to as the former gravel pit. The majority of the OIWL is designated for continued U.S. Army use; however, a small portion of SWMU 30 – located primarily in the Maintenance Area – is included in the BRAC parcel and is designated for future industrial use.

The lagoon was used for approximately 20 years – from 1945 to 1965 – and received an estimated daily discharge of 125,000 gallons (Weston, 1990). The wastewater discharge to the lagoon contained solvents and heavy metals from degreasing, metal cleaning, stripping, painting, and other maintenance operations.

8.2 SUMMARY OF CONTAMINATION ASSESSMENT

8.2.1 Soil

Analytical results from the Phase II RFI Report indicated the presence of elevated concentrations of metals in surface soil (Rust E&I, 1995). Impacts to subsurface soil were also reported. Appendix C presents chemical analysis results from the Phase II RFI Report.

Barium, cadmium, cobalt, copper, chromium, lead, mercury, nickel, and vanadium were detected in soil. Lead concentrations ranged from 12.4 to 1,000 µg/g in soil samples collected from small surface areas within Ditch A and Lagoons 2, 4, and 5, where cadmium and chromium were also detected.

Toluene, the only VOC detected in soil samples, was reported in 16 samples at a maximum concentration of 0.44 µg/g. Detectable levels of six SVOCs – benzo(a)anthracene, benzyl alcohol, chrysene, di-n-butyl phthalate, fluoranthene, and phenanthrene – were reported in three of the samples, at maximum concentrations of 0.11 µg/g, 0.12 µg/g, 0.096 µg/g, 3.5 µg/g, 0.09 µg/g, and 0.1 µg/g, respectively.

Ten soil borings were drilled in the unremediated, former ditches in the open storage areas of the BRAC parcel to better characterize possible surface and near-surface metals contamination (see the *Addendum to DCQAP*, Volume II of the Planning Documents; and the *Additional Field Investigation Report*, to be submitted as Volume II of the Known Releases SWMUs CMS Report).

8.2.2 Groundwater

The depth to groundwater at the OIWL ranges from 150 to 300 feet bgs, and groundwater flows generally to the northwest. The OIWL overlies the southeastern edge of the TCE plume associated with the IWL (SWMU 2). Because the contaminant plume is being monitored and remediated under the CAP for the IWL, the Phase II RFI included no groundwater investigation for SWMU 30.

8.3 SUMMARY OF RA RESULTS

8.3.1 Human Health RA

Table 8-1 summarizes the risks and hazards calculated for SWMU 30. Results of the human health RA (Rust E&I, 1995) indicate that, under the future residential land use scenario (required to be evaluated per UAC R315-101-5.2(b)(1)), the cancer risks at SWMU 30 exceed the target of 1×10^{-6} for both the adult and child receptors. Noncancer HIs also exceed the regulatory target of 1.0 for both receptors. Elevated cancer risks and hazards result from the inclusion of arsenic, which is present below its background concentration. Because the risk and HI are greater than State of Utah goals (i.e., 1×10^{-6} and 1.0, respectively), the CMS includes SWMU 30 per the requirements of UAC R315-101-1(b)(4).

The human health RA does not evaluate the future construction worker scenario for cancer risks and noncancer HIs resulting from soil exposure (Rust E&I, 1995). However, the CMS Work Plan evaluates potential exposure to subsurface soil by comparing the maximum concentration of COPCs, identified using data and methodology presented in the human health RA, to risk-based CAOs for construction workers (developed in Appendix A).

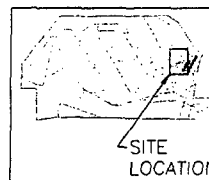
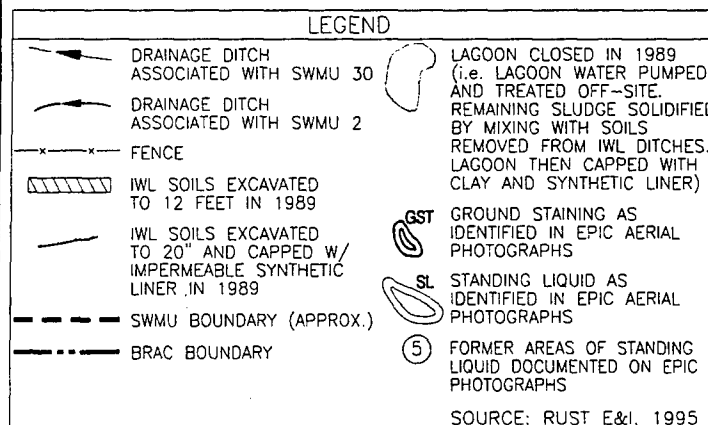
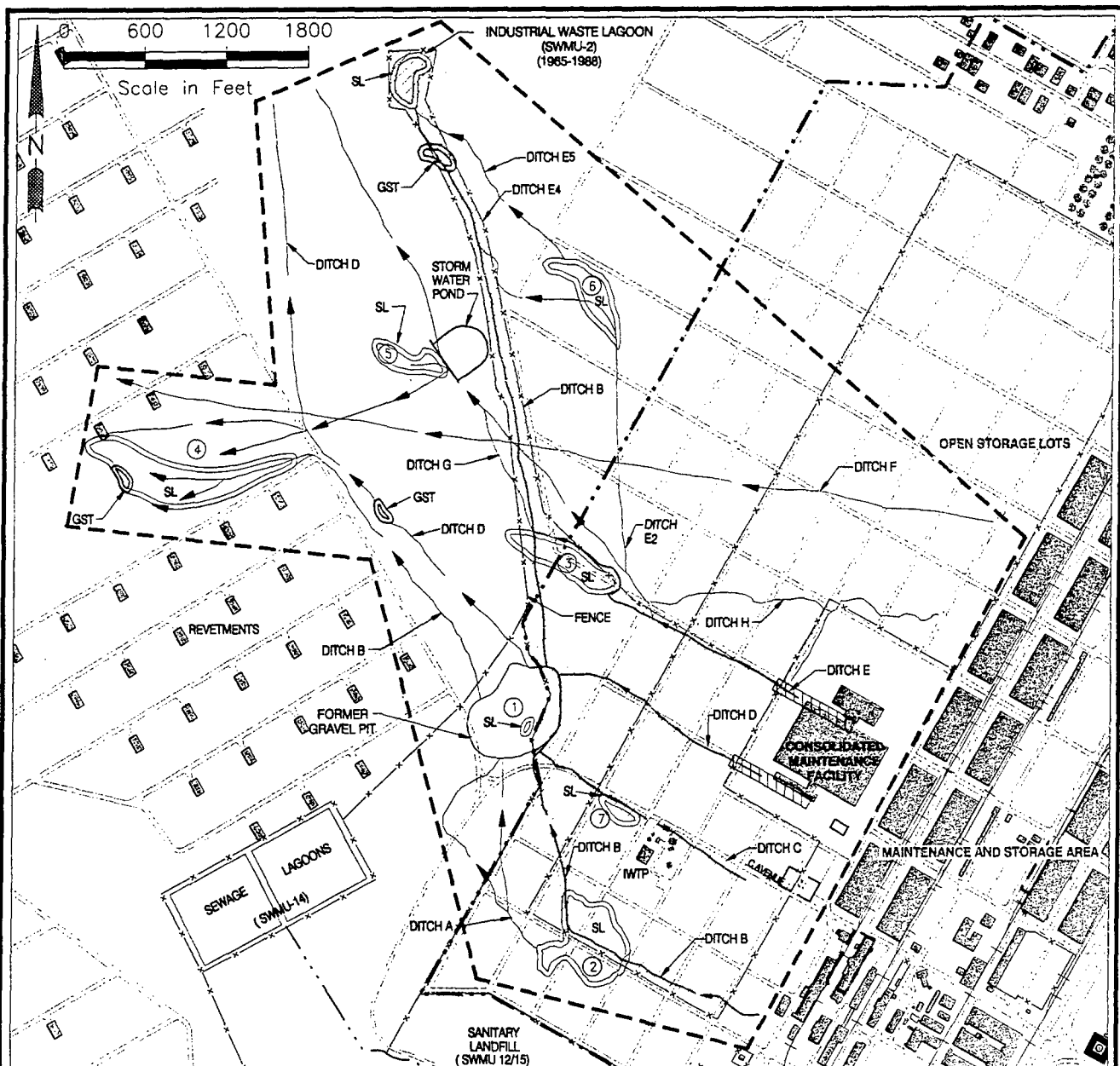
The human health RA (Rust E&I, 1995) evaluates military land use as the current use scenario, and also as the reasonably anticipated future land use. The cancer risk calculated in the human health RA is 9.2×10^{-6} , and the noncancer HI is 5.2×10^{-2} . These levels are below the State of Utah goals of 1×10^{-4} and 1.0, respectively (above which active corrective measures must be evaluated per UAC R315-101-6(e)). In addition, the risk level is within EPA's target range of 1×10^{-4} to 1×10^{-6} , and the HI is below the goal of 1.0.

The human health RA did not run models to estimate blood lead levels because the EPC of lead in soil (129.8 $\mu\text{g/g}$) at SWMU 30 does not exceed the 400- $\mu\text{g/g}$ screening level set by EPA for CERCLA and RCRA programs.

8.3.2 Ecological RA

Based on the evaluation of COPCs in soil and levels of exposure to ecological receptors presented in the SWERA (Rust E&I, 1997), SWMU 30 is unlikely to pose

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NOTES:

1. OLD IWL (SWMU 30) INCLUDES PRE-1965 DITCHES OTHER THAN PORTIONS OF B, C, D, AND E WHICH WERE REMEDIATED IN 1989.
2. IWL (SWMU 2) INCLUDES LAGOON AND CONVEYANCE DITCHES B, C, D, AND E.

FIGURE 8-1
OLD INDUSTRIAL WASTE LAGOON
(SWMU 30)
TOOELE ARMY DEPOT

TABLE 8-1

Summary of Human Health RA and
Corrective Measures Recommendations
Old Industrial Waste Lagoon (SWMU 30)

Land Use/Receptor	Cancer Risk	Hazard Index	Blood Lead Level (µg/dL) (a)	Recommendations
Current Land Use (b)				UAC R315-101-6(d) requires a site management plan because the human health RA conducted for the future residential land use scenario identified potential cancer risks above 1×10^{-6} or an HI above 1.0. However, active corrective measures are not necessarily required because the risks and hazards calculated for the current land use (also the reasonably anticipated future land use) do not exceed 1×10^{-4} (cancer risk) or 1.0 (HI).
Depot personnel	9.2×10^{-6}	5.2×10^{-2}	NE (c)	
Future Land Use				
Residential – adult (d)	5.2×10^{-5}	1.3	NE	
Residential – child (d)	6.0×10^{-5}	5.5	NE	
Construction worker	NE	NE	NE	

SOURCE: Phase II RFI Report (Rust E&I, 1995).

- (a) Blood lead levels are expressed in micrograms per deciliter ($\mu\text{g}/\text{dL}$) for 95 percent of the population (should not exceed $10 \mu\text{g}/\text{dL}$).
- (b) Human health RA results under the actual current – and reasonably anticipated future – land use exposure scenario, as required in UAC R315-101-5.2(b)(2).
- (c) Pathway incomplete or not evaluated; see text.
- (d) Human health RA results for a conservative future residential land use scenario, as required in UAC R315-101-5.2(b)(1). This exposure scenario determines the applicability of risk-based closure and is not considered to be a realistic future use at SWMU 30.

excessive or unacceptable ecological risk. Specific factors considered in this risk characterization are as follows:

- Risk to passerine birds is 1.3 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are iron (28 percent) and chromium (51 percent).
- Risks to raptors and special status receptors are less than the risks estimated for the RSA.
- Risk to the deer mouse is 1.2 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are iron (66 percent) and aluminum (25 percent).
- Risk to plants is 1.1 times the risk estimated for the RSA.
- Risk to soil fauna is 6.3 times the risk estimated for the RSA. The primary risk drivers (and percent contribution to estimated risk) are chromium (91 percent) and iron (6 percent).
- The WOE is high for most receptors, and equals the RSA WOE for plants and soil fauna.

Based on the above factors, the SWERA characterizes ecological risk at SWMU 30 as low for passerine, deer mouse, jackrabbit, and plant receptors (Rust E&I, 1997). However, the risk to soil fauna is characterized as potentially high due to chromium (91 percent of risk) and iron (6 percent of risk). Based on this information, the SWERA concludes that this area is unlikely to pose excessive or unacceptable ecological risks to TEAD receptors and characterizes SWMU 30 as a moderate ecological risk. However, the SWERA indicates that there is a high degree of uncertainty for soil fauna toxicity data, which are the basis for the moderate risk characterization. Specifically, passerine birds, raptors and special status species, mammals, and plants (excluding soil fauna receptors) pose a relative risk up to a factor of 1.3 greater than the RSA. These risk levels are within the low risk characterization used in the SWERA.

The relative risk to soil fauna is 6.3 times the RSA risk and is due primarily to chromium exposure. However, as noted in the SWERA, there is an extensive degree of uncertainty regarding the chromium toxicity benchmark value (TBV) for soil fauna. Specifically, the soil fauna TBV for chromium is derived from a summary of the literature by Suter (1995) and is based on the response of earthworms to chromium applied in the ionic form to soil. Suter indicates a low degree of confidence in the TBV based on limited toxicological data. Further, the comparison of a benchmark value derived from studies using an ionic form of chromium to SWMU soil in which chromium is likely to be bound and unavailable for uptake is another source of conservatism.

In summary, the SWERA (Rust E&I, 1997) concludes the following:

- The OIWL is unlikely to pose excessive or unacceptable ecological risk.
- Ecological risk is characterized as moderate and is based primarily on the chromium risk to soil fauna
- A high degree of uncertainty is associated with the chromium TBV for soil fauna.

Ecological risk and the subsequent risk conclusion are based, in part, on a comparison of the SWMU HI and the RSA HI. Although thallium was not detected at the RSA, the RSA risk considered thallium. This may potentially underestimate the relative ecological risk associated with SWMU 30. To assess the uncertainty associated with thallium, the RSA risk was recalculated without including thallium and used for comparison to the SWMU HI. This reanalysis did not change any conclusions of the ecological RA for SWMU 30.

Thus, based on the above ecological RA summary, it is recommended that no corrective measures be considered to reduce ecological risks at SWMU 30.

8.4 INTERIM CORRECTIVE ACTIONS

In 1989, part of the OIWL was addressed during RCRA remediation of the IWL (SWMU 2). Portions of some of the ditches were closed in 1989 to accommodate construction of the Consolidated Maintenance Facility (Jordan, 1990); these areas were excavated to a minimum depth of 12 feet, a width of 10 feet, and a total length of 650 feet. Confirmation sampling was performed to ensure clean closure. Portions of the ditches that are not within the Maintenance Area were excavated to a depth of 20 inches to remove the primary contamination and then backfilled with clay, a synthetic liner, and fill. The removed materials were used to fill the IWL prior to capping. The Phase II RFI Report did not evaluate the closed portions of the ditches (Rust E&I, 1995). Other portions within the OIWL were paved for roads.

To prevent further disturbance of the OIWL by construction and other activities, TEAD placed signs to alert personnel to potential hazards.

A system of extraction and injection wells is currently in operation at the IWL (SWMU 2) to intercept and treat groundwater prior to its potential off-post migration.

8.5 IDENTIFICATION OF COCs

Tables 8-2 and 8-3 compare the maximum concentration of each COPC to the corresponding quantitative CAO developed in Appendix A for surface and subsurface soil, respectively. Surface soil COPCs are identified in the human health RA portion of the Phase II RFI Report (Rust E&I, 1995). Subsurface soil COPCs are identified using

TABLE 8-2

Development of COCs in Surface Soil
Old Industrial Waste Lagoon (SWMU 30)

COPC (a)	Maximum Concentration (µg/g)	Industrial Worker CAO (b) (µg/g)	Surface Soil COC ? (c)
Metals			
Aluminum	28,300	(d)	No
Arsenic	21.0	32	No
Barium	743	59,000	No
Cadmium	60.9	190	No
Chromium (e)	1,160	1,700	No
Cobalt	14.6	110,000	No
Copper	165	57,000	No
Lead	1,000	1,800	No
Mercury	0.39	370	No
Nickel	21.4	30,000	No
Silver	1.92	6,600	No
Vanadium	41.4	1,300	No
Zinc	1,900	410,000	No
VOCs			
Toluene	0.44	180,000	No

- (a) Contaminants of potential concern identified in the Phase II RFI Report (Rust E&I, 1995).
 (b) Corrective action objectives developed in Appendix A.
 (c) Contaminants of concern (i.e., COPCs greater than CAOs).
 (d) Calculated CAO exceeds 1 million ppm (µg/g).
 (e) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.

TABLE 8-3

Development of COCs in Subsurface Soil
Old Industrial Waste Lagoon (SWMU 30)

COPC (a)	Maximum Concentration (µg/g)	Construction Worker CAO (b) (µg/g)	Subsurface Soil COC? (c)
Metals			
Arsenic	21.6	32	No
Barium	327	110,000	No
Cadmium	18.6	870	No
Chromium (d)	332	23,000	No
Cobalt	7.09	110,000	No
Copper	665	64,000	No
Lead	170	1,800	No
Mercury	0.0609	500	No
Nickel	141	34,000	No
Silver	1.31	8,400	No
Vanadium	101	6,100	No
Zinc	484	510,000	No
SVOCs			
Benzo(a)anthracene	0.11	25	No
Benzyl alcohol	0.12	(e)	No
Chrysene	0.096	2,500	No
Di-n-butyl phthalate	3.5	(f)	No
Fluoranthene	0.09	530,000	No
Phenanthrene	0.1	470,000	No
VOCs			
Toluene	0.41	(e)	No

- (a) Contaminants of potential concern identified from data and methodology presented in the Phase II RFI Report (Rust E&I, 1995).
 (b) Corrective action objectives developed in Appendix A.
 (c) Contaminants of concern (i.e., COPCs greater than CAOs).
 (d) Maximum chromium concentration is conservatively compared to hexavalent chromium CAO.
 (e) Relevant health effects criteria are unavailable.
 (f) Calculated CAO exceeds 1 million ppm (µg/g).

data and methodology presented in the human health RA. Although the human health RA evaluated risks assuming current and future military land use, part of SWMU 30 is within the BRAC parcel. As a result, to provide a more conservative estimate of areas potentially requiring remedial actions, Table 8-2 compares COPCs to CAOs for an industrial worker. Based on this evaluation, no COCs are identified in surface soil. Arsenic was identified as a COPC in the Phase II RFI (Rust E&I, 1995), which used a small data set to develop background levels of metals. Since this study was completed, a comprehensive basewide data set established a background level for arsenic of 32 µg/g (see Appendix A). Comparing these new data with contaminant levels detected at SWMU 30, it was determined that arsenic is below background levels and is neither a COPC nor a COC. Furthermore, no COCs are identified in groundwater because groundwater contamination at SWMU 30 is being addressed through the IWL (SWMU 2) remediation system.

8.6 DEVELOPMENT OF CORRECTIVE MEASURES ALTERNATIVES

Corrective measures alternatives are developed to comply with State and Federal regulations, as well as with the requirements presented in Module VII of TEAD's CAP. The governing regulation for the CMS process is UAC R315-101, which states that if the cancer risk at a site is greater than 1×10^{-6} or the HI is greater than 1.0 under the hypothetical future residential land use scenario, appropriate management measures must be implemented (UAC R315-10-1(b)(4)). Further, UAC R315-101-6(e) states that active corrective measures are required for sites with a calculated cancer risk greater than 1×10^{-4} or an HI greater than 1.0 under the realistic future land use scenario. Because risks and hazards derive from naturally occurring levels of arsenic at SWMU 30, no corrective measures appear to be necessary. However, additional data will be collected and included in the CMS Report evaluation.

To determine which technologies are most appropriate for SWMU 30, the following criteria are considered:

- Results of the human health RA
- Results of the ecological RA
- Results of groundwater sampling and analyses
- Determination of extent and concentration of COCs
- Results of additional data collection.

Therefore, based on the above criteria, the following corrective measures technologies are considered to apply to SWMU 30:

Corrective Measures Technologies (SWMU 30, Old Industrial Waste Lagoon)
Land use restrictions (military property) Deed restrictions (BRAC parcel)

The following corrective measures alternatives are identified for SWMU 30 for further evaluation in the CMS Report:

SWMU 30	Corrective Measures Alternative
OLD INDUSTRIAL WASTE LAGOON	No further action Take no further action at this site Land use/deed restrictions Impose land use/deed restrictions to prevent residential development in the OIWL

9.0 SUMMARY OF CORRECTIVE MEASURES ALTERNATIVES

Table 9-1 summarizes the corrective measures alternatives identified for each of the seven Known Releases SWMUs. The CMS Report will address how the alternatives reduce the exposure to contamination, the concentration of contaminants, or their migration. In addition, the report will evaluate the corrective measures alternatives for the following:

- Technical performance, reliability, implementability, and safety
- Protection of the environment
- Protection of human health
- Institutional requirements and conditions
- Present worth cost.

Based on this evaluation, the CMS Report will select the most appropriate alternative for each SWMU.

TABLE 9-1

Summary of Corrective Measures Alternatives
Known Releases SWMUs

SWMU	Corrective Measures Alternatives
SWMU 3 X-Ray Lagoon	Land use restrictions and well abandonment
SWMU 10 TNT Washout Lagoon	Excavation, composting, groundwater monitoring, and land use restrictions Excavation, composting, groundwater treatment, and land use restrictions Excavation, slurry-phase biological treatment, groundwater monitoring, and land use restrictions Excavation, off-post treatment/disposal, groundwater monitoring, and land use restrictions
SWMU 11 Laundry Effluent Pond and Waste Pile Areas	Land use restrictions Excavation, off-post treatment/disposal, and land use restrictions
SWMU 12/15 Sanitary Landfill/Pesticide Disposal Area	Multilayer landfill cap, groundwater monitoring, and land use restrictions Evapotranspiration landfill cover, groundwater monitoring, and land use restrictions Evapotranspiration landfill cover, groundwater pump and treat, and land use restrictions
SWMU 25 Battery Shop	Land use restrictions Soil and vegetative cover and land use restrictions Excavation, off-post treatment/disposal, and land use restrictions Excavation, solidification/stabilization, and land use restrictions Excavation, soil washing, and land use restrictions
SWMU 30 Old Industrial Waste Lagoon	No further action Land use/deed restrictions

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APPENDIX A

Identification and Development of Corrective Action Objectives

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IDENTIFICATION AND DEVELOPMENT OF CORRECTIVE ACTION OBJECTIVES

A.1 INTRODUCTION

As discussed in Section 1.0 of the Corrective Measures Study (CMS) Work Plan, the results of the human health risk assessment (RA) of the Known Releases Solid Waste Management Units (SWMUs) at Tooele Army Depot (TEAD; formerly the North Area) indicate that corrective measures must be evaluated for seven of the nine Known Releases SWMUs. The Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report (Rust E&I, 1995) presents the human health RA results.

The first step in evaluating corrective measures is to develop corrective action objectives (CAOs), which consist of medium- and chemical-specific goals for protecting human health and the environment. The CAOs are used to focus the development of corrective measures alternatives on technologies that may achieve appropriate target levels, thereby limiting the number of alternatives analyzed.

CAOs can be specific and numerical (i.e., quantitative) or general and descriptive (i.e., qualitative). They are achieved by reducing exposure (e.g., installing a soil cover or limiting access) or by reducing contaminant levels (e.g., active remediation; USEPA, 1988). CAOs are used to evaluate which samples/areas within a site may require corrective measures and which corrective measures alternative best protects human health and the environment.

The CAOs for the Known Releases SWMUs, developed in Section A.7, are based on land use and potential receptor assumptions (Section A.2), exposure assessment and methodology (Section A.3), results of the human health RA (Section A.4), toxicity evaluation (Section A.5), and evaluation of background soil chemistry (Section A.6). They were developed in accordance with the State of Utah Administrative Code (UAC) R315-101 (including the "Principle of Non-Degradation"), U.S. Environmental Protection Agency (EPA) guidance (USEPA, 1991a), and the human health RA performed for the Known Releases SWMUs (Rust E&I, 1995).

Note that the development of quantitative CAOs for the CMS Work Plan is based on methodologies used in the human health RA (Rust E&I, 1995), which were modified as follows:

- To be consistent with CAOs developed for other groups of SWMUs at TEAD despite different methodologies used in the respective human health RAs.
- To ensure technical accuracy based on the most up-to-date EPA guidance.
- To develop specific land use exposure scenarios to produce a consistent set of CAOs that can be applied to all SWMUs at TEAD.

- To support eventual conversion of the CAOs to actual cleanup levels.

Accordingly, the majority of this appendix explains modifications to specific methodologies used in the human health RA for the Known Releases SWMUs (Rust E&I, 1995).

A.2 LAND USE AND POTENTIALLY EXPOSED RECEPTORS

To focus on developing practicable and cost-effective corrective measures alternatives and to streamline the environmental cleanup process, EPA guidance (Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.7-04) and U.S. Army policy (Radkiewicz, 1995) direct that CAOs should reflect the anticipated land use.

In 1993, the Base Realignment and Closure (BRAC) Program made a recommendation to realign TEAD. This action was accepted by Congress and the President and became law under provisions of the Defense Closure and Realignment Act of 1990. As discussed in the *TEAD Conversion and Reuse Plan* (Tooele County Economic Development Corporation, 1995), the planned realignment includes continued use of the majority of the installation as a military facility, focusing on conventional ammunition storage.

Two small portions of the eastern area of TEAD have been transferred under the BRAC Program. The Industrial Area (1,200 acres) is slated for manufacturing, warehouse, industrial, and light industrial uses. The Administration Area (500 acres) is slated for residential land use, with supporting commercial and recreational land uses. Except for a small portion of the Old Industrial Waste Lagoon (OIWL; SWMU 30) that is located in the Industrial Area, all of the Known Releases SWMUs are located in the areas that will continue to be used for military purposes.

The human health RA (Rust E&I, 1995) assumes that at all SWMUs Depot personnel and off-post residents are potentially exposed receptors for the current land use; and that on-post residents and Depot personnel, are potentially exposed receptors for the future land use. Exposure to the construction worker was only evaluated at SWMUs 12 and 15, and 10 and 11. Although future onsite residential land use is quantitatively evaluated as an additional hypothetical exposure scenario (per State of Utah regulatory requirements), the Reuse Plan does not support this land use at the Known Releases SWMUs.

Therefore, based on the Reuse Plan and EPA and Army guidance that CAOs should reflect actual anticipated land use, the assumed land uses for the Known Releases SWMUs are:

- Continued military use for the non-BRAC sites (i.e., all SWMUs except for a small portion of SWMU 30), with Depot personnel (i.e., civilians employed at TEAD) the most likely receptors.

- Industrial/commercial land use for the BRAC site (i.e., a small portion of SWMU 30).

Construction workers may be exposed to subsurface soil at all of the SWMUs. According to the Reuse Plan, none of the Known Releases SWMUs are located near areas proposed for residential, recreational, or other land uses. If land use changes in the future, the SWMUs will be reevaluated.

A.3 EXPOSURE ASSESSMENT AND METHODOLOGY FOR DEVELOPMENT OF CAOs

A.3.1 QUALITATIVE CAOs

A.3.1.1 Groundwater. There is no current exposure to contaminated groundwater at the Known Releases SWMUs, nor is future exposure likely based on the future land use scenarios discussed in Section A.2. Several deep upgradient supply wells (WW-01, WW-02, WW-03, and WW-04) are the current water source for TEAD. The water from these wells is tested regularly for bacteria, inorganics and metals nitrates, radionuclides, volatile organic compounds (VOCs), and pesticides, and has not been found to be contaminated (Rust E&I, 1995).

Under nonresidential land use – particularly the continued military future land use scenario, in which the U.S. Army determines the specific use of the property – it is reasonable to assume that no groundwater well will be installed within the limited volume of contaminated groundwater and be used for domestic purposes. Under future industrial land use, it is likely that the current City of Tooele water supply would be used. The future exposure of off-post residents to contaminated groundwater from the Known Releases SWMUs is unlikely because of the natural processes of degradation, dilution, and dispersion. These processes limit the extent of contaminants in groundwater and reduce their concentrations as demonstrated by the fate and transport modeling performed in the human health RA (Rust E&I, 1995). The distances of the Known Releases SWMUs from the downgradient facility boundary accentuate these processes.

No chemical-specific quantitative CAOs are calculated for contaminants in groundwater because of the lack of reasonable exposure routes to this medium. However, qualitative CAOs do exist for contaminated groundwater, as listed below:

- To prevent further degradation of a valuable resource (i.e., contamination shall not increase beyond existing levels in the alluvial aquifer in the vicinity of TEAD (which is a viable drinking water source), per the State of Utah's "Principle of Non-Degradation"(UAC R315-101-3)).
- To further restrict and prevent possible exposure to contaminated groundwater (e.g., by institutional controls).

- To protect public health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

A.3.1.2 Soil. Under both the continued military and commercial/industrial land use scenarios, contact with soil contaminants will occur from both surface and subsurface soil. Section A.3.2 describes the methodology and exposure pathways for developing quantitative CAOs based on these potential exposures. The qualitative CAOs for soil are:

- To protect groundwater from further degradation (i.e., levels of contamination shall not increase beyond existing levels, per the State of Utah's "Principle of Non-Degradation" (UAC R315-101-3)).
- To protect human health and the environment in accordance with regulatory requirements (i.e., the general objective of all corrective measures).

A.3.2 QUANTITATIVE CAOs

Quantitative CAOs are acceptable residual contaminant concentrations. As discussed in Section A.3.1.1, no quantitative CAOs are calculated for groundwater.

The following components of the human health RA methodology are used to determine CAOs for soil:

- Intake by assumed exposure pathways.
- Chemical-specific toxicity data in the form of health effects criteria (see Section A.5).
- Assumed target cancer risk level and noncancer hazard quotient (HQ).

The target risk level and HQ are general health effects levels deemed acceptable for exposure to individual carcinogenic and noncarcinogenic contaminants, respectively. The general equation for chemical intake used in the human health RA is:

$$Intake(mg/kg-day) = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT} \quad (Eq\ A-1)$$

where:

<i>C</i>	=	chemical concentration
<i>IR</i>	=	intake rate
<i>EF</i>	=	exposure frequency
<i>ED</i>	=	exposure duration
<i>CF</i>	=	conversion factor (to attain proper units)
<i>BW</i>	=	body weight

AT = averaging time for cancer or noncancer effects.

This equation is algebraically combined with the general expressions for cancer risk and noncancer health effects, respectively:

$$Risk = Intake \times SF \quad (Eq\ A-2)$$

$$HQ = Intake/RfD \quad (Eq\ A-3)$$

where:

$Risk$ = target risk level (1×10^{-6} , or one in 1 million excess cancer cases due to exposure to a chemical, given the assumed exposure pathway).

SF = slope factor, or health effects criterion for cancer effects.

HQ = target HQ (1.0, implying that intake should not exceed the RfD).

RfD = reference dose, or health effects criterion for noncancer effects.

Assumed values for risk and HQ and chemical-specific SFs or RfDs are used to solve for the concentration term, or the pathway-specific CAO.

For the continued military land use scenario at the Known Releases SWMUs, construction workers are used in addition to Depot personnel to characterize potential exposure to contaminated soil. Both industrial and construction workers are used for the industrial land use scenario. Depot personnel and industrial worker exposure is limited to surface soil, while construction workers may also be exposed to subsurface soil.

The two exposure pathways evaluated for developing quantitative CAOs are inadvertent ingestion of soil and dermal absorption of contaminants following direct contact with soil. Inhalation of contaminants in particulates is also evaluated, but – because at negligible contribution and high uncertainty – this pathway is not included in the calculation of quantitative CAOs. Section A.7 evaluates the influence of this pathway.

Tables A-1 to A-4 quantitatively summarize each of these pathways. The exposure pathway equations and variable values are generally the same as those in the human health RA (Rust E&I, 1995); *exceptions are described in more detail below*. In addition, the human health RAs performed by other contractors for other groups of SWMUs at TEAD were reviewed for applicable equations and variable values (Montgomery Watson, 1997; Rust E&I, 1997a; SAIC, 1997). Each of these RAs has undergone regulatory review.

The primary differences among the methodologies used in the CMS Work Plan to develop quantitative CAOs and those of the human health RA for the Known Releases SWMUs (Rust E&I, 1995) are as follows:

TABLE A-1
Summary of Quantitative CAO Calculations--
Exposure via Ingestion of Chemicals in Soil

CAO EQUATIONS:

$$CAO = \frac{\text{Risk} \times BW \times AT_c}{SF \times IR \times CF \times FI \times EF \times ED} \quad (\text{carcinogens})$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times CF \times FI \times EF \times ED} \quad (\text{noncarcinogens})$$

Supporting Equations:

$$\text{Intake} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$\text{Risk} = \text{Intake} \times SF$$

$$HQ = \text{Intake}/RfD$$

where:

CAO = Corrective Action Objective (CS, µg/g)

Risk = Target risk level (unitless)

HQ = Target hazard quotient (unitless)

Intake = Average daily intake (mg/kg-day)

SF = Slope factor (mg/kg-day)⁻¹

RfD = Reference dose (mg/kg-day)

CS = Exposure point chemical concentration in soil (µg/g)

IR = Ingestion rate (mg soil/day)

CF = Conversion factor (10⁻⁶ g/µg)

FI = Fraction ingested at site (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged, in days)

FUTURE LAND USE - POTENTIALLY EXPOSED POPULATIONS

A. Depot Personnel

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10 ⁻⁶	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	50 mg/day	Standard default for commercial/industrial workers (USEPA, 1991b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	208 days/year	4 days/week for 52 weeks/year (current schedule at TEAD; Rust E&I, 1995)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE A-1 (cont'd)
Summary of Quantitative CAO Calculations--
Exposure via Ingestion of Chemicals in Soil

B. Industrial Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	50 mg/day	Standard default for commercial/industrial workers (USEPA, 1991b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

C. Construction Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	480 mg/day	High intake estimate (USEPA, 1991b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	30 days/year	Professional judgement (Rust E&I, 1995)
ED	5 years	Professional judgement (Rust E&I, 1995)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	1,825 days	ED x 365 days/year (USEPA, 1989a)

REDUCED EQUATIONS

1. Carcinogenic Intake:

$$\begin{aligned} \text{CAO} &= 6.88/\text{SF} \text{ (depot personnel)} \\ \text{CAO} &= 5.72/\text{SF} \text{ (industrial workers)} \\ \text{CAO} &= 24.8/\text{SF} \text{ (construction workers)} \end{aligned}$$

2. Noncarcinogenic Intake:

$$\begin{aligned} \text{CAO} &= \text{RfD} \times 2.46 \times 10^6 \text{ (depot personnel)} \\ \text{CAO} &= \text{RfD} \times 2.04 \times 10^6 \text{ (industrial workers)} \\ \text{CAO} &= \text{RfD} \times 1.77 \times 10^6 \text{ (construction workers)} \end{aligned}$$

TABLE A-2
Summary of Quantitative CAO Calculations--
Exposure via Dermal Absorption of Chemicals in Soil

CAO EQUATIONS:

$$CAO = \frac{Risk \times BW \times AT_c}{SF_d \times SA \times AF \times ABS \times CF \times FI \times EF \times ED} \quad (\text{carcinogens})$$

$$CAO = \frac{HQ \times RfD_d \times BW \times AT_{nc}}{SA \times AF \times ABS \times CF \times FI \times EF \times ED} \quad (\text{noncarcinogens})$$

Supporting Equations:

$$\text{Absorbed dose} = \frac{CS \times SA \times AF \times ABS \times CF \times FI \times EF \times ED}{BW \times AT}$$

$$Risk = \text{Absorbed dose} \times SF_d$$

$$HQ = \text{Absorbed dose}/RfD_d$$

where:

CAO = Corrective Action Objective (CS, $\mu\text{g/g}$)

Risk = Target risk level (unitless)

HQ = Target hazard quotient (unitless)

Absorbed dose = (mg/kg-day)

SF_d = Slope factor, modified for absorption (mg/kg-day)⁻¹

RfD_d = Reference dose, modified for absorption (mg/kg-day)

CS = Exposure point chemical concentration in soil ($\mu\text{g/g}$)

SA = Exposed skin surface area (cm^2)

AF = Soil-to-skin adherence factor ($\text{mg}/\text{cm}^2\text{-event}$)

ABS = Adult skin absorption factor (unitless)

CF = Conversion factor ($10^{-6} \text{ g}/\mu\text{g}$)

FI = Fraction contacted at site (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged, in days)

FUTURE LAND USE - POTENTIALLY EXPOSED POPULATIONS

A. Depot Personnel

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	5,000 cm^2	Standard default for commercial/industrial workers (USEPA, 1992a)
AF	1	Standard upper-end default value (USEPA, 1992a)
ABS	0.001 inorganics 0.01 organics	USEPA Region IV recommendations and TEAD RAs (USEPA, 1995c; Rust E&I, 1995; 1997b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	208 days/year	4 days/week for 52 weeks/year (current schedule at TEAD; Rust E&I, 1995)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE A-2 (cont'd)
Summary of Quantitative CAO Calculations--
Exposure via Dermal Absorption of Chemicals in Soil

B. Industrial Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10 ⁻⁶	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	5,000 cm ²	Standard default for commercial/industrial workers (USEPA, 1992a)
AF	1	Standard upper-end default value (USEPA, 1992a)
ABS	0.001 inorganics 0.01 organics	USEPA Region IV recommendations and TEAD RAs (USEPA, 1995c; Rust E&I, 1995; 1997b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

C. Construction Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10 ⁻⁶	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
SA	5,000 cm ²	Standard default for commercial/industrial workers (USEPA, 1992a)
AF	1	Standard upper-end default value (USEPA, 1992a)
ABS	0.001 inorganics 0.01 organics	USEPA Region IV recommendations and TEAD RAs (USEPA, 1995c; Rust E&I, 1995; 1997b)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
EF	30 days/year	Professional judgement (Rust E&I, 1995)
ED	5 years	Professional judgement (Rust E&I, 1995)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	1,825 days	ED x 365 days/year (USEPA, 1989a)

REDUCED EQUATIONS

1. Carcinogenic Intake:

$$\begin{aligned} \text{CAO} &= 6.88 \times 10^{-2} / (\text{SF}_d \times \text{ABS}) \text{ (depot personnel)} \\ \text{CAO} &= 5.72 \times 10^{-2} / (\text{SF}_d \times \text{ABS}) \text{ (industrial workers)} \\ \text{CAO} &= 2.38 / (\text{SF}_d \times \text{ABS}) \text{ (construction workers)} \end{aligned}$$

2. Noncarcinogenic Intake:

$$\begin{aligned} \text{CAO} &= (\text{RfD}_d \times 2.46 \times 10^4) / \text{ABS} \text{ (depot personnel)} \\ \text{CAO} &= (\text{RfD}_d \times 2.04 \times 10^4) / \text{ABS} \text{ (industrial workers)} \\ \text{CAO} &= (\text{RfD}_d \times 1.70 \times 10^5) / \text{ABS} \text{ (construction workers)} \end{aligned}$$

TABLE A-3

Summary of Quantitative Soil CAO Calculations--
Exposure via Inhalation of Chemicals in Particulates

CAO EQUATIONS:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times FI \times ET \times EF \times ED \times (1/PEF)} \quad (\text{carcinogens})$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times FI \times ET \times EF \times ED \times (1/PEF)} \quad (\text{noncarcinogens})$$

Supporting Equations:

$$Intake = \frac{CS \times IR \times FI \times ET \times EF \times ED \times (1/PEF)}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CS, $\mu\text{g/g}$)

Risk = Target risk level (unitless)

HQ = Target hazard quotient (unitless)

Intake = Average daily intake (mg/kg-day)

SF = Slope factor (mg/kg-day^{-1})

RfD = Reference dose (mg/kg-day)

CS = Exposure point chemical concentration in soil ($\mu\text{g/g}$)

IR = Inhalation rate (m^3/hour)

FI = Fraction inhaled from site (unitless)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

PEF = Particulate emission factor (m^3/kg)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged, in days)

FUTURE LAND USE - POTENTIALLY EXPOSED POPULATIONS

A. Depot Personnel

Variable	Value	Rationale/Source
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	$1.3 \text{ m}^3/\text{hour}$	Recommended average value for adult outside workers (USEPA, 1997)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	10 hours/day	Current schedule at TEAD (Rust E&I, 1995)
EF	208 days/year	4 days/week for 52 weeks/year (current schedule at TEAD; Rust E&I, 1995)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
PEF	$4.63 \times 10^9 \text{ m}^3/\text{kg}$	Standard default value for typical site (USEPA, 1991a)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT_c	25,550 days	70-year lifetime (70 years $\times$ 365 days/year; USEPA, 1991b)
AT_{nc}	9,125 days	ED $\times$ 365 days/year (USEPA, 1991b)

TABLE A-3 (cont'd)
Summary of Quantitative Soil CAO Calculations--
Exposure via Inhalation of Chemicals in Particulates

B. Industrial Worker

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m ³ /hour	Recommended average value for adult outside workers (USEPA, 1997)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	8 hours/day	Standard work day (USEPA, 1991b)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
PEF	4.63×10^9 m ³ /kg	Standard default value for typical site (USEPA, 1991a)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{ac}	9,125 days	ED x 365 days/year (USEPA, 1991b)

C. Construction Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m ³ /hour	Recommended average value for adult outside workers (USEPA, 1997)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	8 hours/day	Standard work day (USEPA, 1991b)
EF	30 days/year	Professional judgement (Rust E&I, 1995)
ED	5 years	Professional judgement (Rust E&I, 1995)
PEF	4.63×10^9 m ³ /kg	Standard default value for typical site (USEPA, 1991a)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{ac}	1,825 days	ED x 365 days/year (USEPA, 1991b)

REDUCED EQUATIONS

1. Carcinogenic Intake:

$$\begin{aligned} \text{CAO} &= 1.22 \times 10^5 / \text{SF} \text{ (depot personnel)} \\ \text{CAO} &= 1.27 \times 10^5 / \text{SF} \text{ (industrial workers)} \\ \text{CAO} &= 5.29 \times 10^6 / \text{SF} \text{ (construction workers)} \end{aligned}$$

2. Noncarcinogenic Intake:

$$\begin{aligned} \text{CAO} &= \text{RfD} \times 4.37 \times 10^{10} \text{ (depot personnel)} \\ \text{CAO} &= \text{RfD} \times 4.54 \times 10^{10} \text{ (industrial workers)} \\ \text{CAO} &= \text{RfD} \times 3.79 \times 10^{11} \text{ (construction workers)} \end{aligned}$$

TABLE A-4

Summary of Quantitative Air CAO Calculations--
Exposure via Inhalation of Chemicals in Particulates

CAO Equations:

$$CAO = \frac{Risk \times BW \times AT_c}{SF \times IR \times DF \times FI \times ET \times EF \times ED} \quad (\text{carcinogens})$$

$$CAO = \frac{HQ \times RfD \times BW \times AT_{nc}}{IR \times DF \times FI \times ET \times EF \times ED} \quad (\text{noncarcinogens})$$

Supporting Equations:

$$Intake = \frac{CA \times IR \times DF \times FI \times ET \times EF \times ED}{BW \times AT}$$

$$Risk = Intake \times SF$$

$$HQ = Intake/RfD$$

where:

CAO = Corrective Action Objective (CA, mg/m³)

Risk = Target risk level (unitless)

HQ = Target hazard quotient (unitless)

Intake = Average daily intake (mg/kg-day)

SF = Slope factor (mg/kg-day)⁻¹

RfD = Reference dose (mg/kg-day)

CA = Exposure point chemical concentration in air (mg/m³)

IR = Inhalation rate (m³/hour)

DF = Deposition fraction (unitless)

FI = Fraction inhaled from site (unitless)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged, in days)

FUTURE LAND USE - POTENTIALLY EXPOSED POPULATIONS

A. Depot Personnel

Variable	Value	Rationale/Source
Risk	10 ⁻⁶	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m ³ /hour	Recommended value for adult outside workers (USEPA, 1997)
DF	1.0 for volatiles 0.3 for particulates	Professional judgement (Rust E&I, 1995)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	10 hours/day	Current schedule at TEAD (Rust E&I, 1995)
EF	208 days/year	4 days/week for 52 weeks/year (current schedule at TEAD; Rust E&I, 1995)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

TABLE A-4 (cont'd)
Summary of Quantitative Air CAO Calculations--
Exposure via Inhalation of Chemicals in Particulates

B. Industrial Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m ³ /hour	Recommended value for adult outside workers (USEPA, 1997)
DF	1.0 for volatiles 0.3 for particulates	Professional judgement (Rust E&I, 1995)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	8 hours/day	Standard work day (USEPA, 1991b)
EF	250 days/year	Standard default for commercial/industrial workers (USEPA, 1991b)
ED	25 years	95th percentile for employment at one location (USEPA, 1991b)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	9,125 days	ED x 365 days/year (USEPA, 1991b)

C. Construction Workers

<u>Variable</u>	<u>Value</u>	<u>Rationale/Source</u>
Risk	10^{-6}	Conservative point of departure (NCP; USEPA, 1991a)
HQ	1	Standard default (USEPA, 1991a)
IR	1.3 m ³ /hour	Recommended value for adult outside workers (USEPA, 1997)
DF	1.0 for volatiles 0.3 for particulates	Professional judgement (Rust E&I, 1995)
FI	1	Standard default for commercial/industrial workers (USEPA, 1989a)
ET	8 hours/day	Standard work day (USEPA, 1991b)
EF	30 days/year	Professional judgement (Rust E&I, 1995)
ED	5 years	Professional judgement (Rust E&I, 1995)
BW	70 kg	Adult average weight (USEPA, 1989a)
AT _c	25,550 days	70-year lifetime (70 years x 365 days/year; USEPA, 1991b)
AT _{nc}	1,825 days	ED x 365 days/year (USEPA, 1989a)

REDUCED EQUATIONS

1. Carcinogenic Intake:

$$\begin{aligned} \text{CAO} &= 2.65 \times 10^{-5} / (\text{SF} \times \text{DF}) \text{ (depot personnel)} \\ \text{CAO} &= 2.75 \times 10^{-5} / (\text{SF} \times \text{DF}) \text{ (industrial workers)} \\ \text{CAO} &= 1.15 \times 10^{-3} / (\text{SF} \times \text{DF}) \text{ (construction workers)} \end{aligned}$$

2. Noncarcinogenic Intake:

$$\begin{aligned} \text{CAO} &= (\text{RfD} \times 9.45) / \text{DF} \text{ (depot personnel)} \\ \text{CAO} &= (\text{RfD} \times 9.83) / \text{DF} \text{ (industrial workers)} \\ \text{CAO} &= (\text{RfD} \times 8.19 \times 10^1) / \text{DF} \text{ (construction workers)} \end{aligned}$$

- The CMS Work Plan assumes 5,000 square centimeters (cm²) as the surface area (SA) of exposed skin for Depot personnel, industrial workers, and construction workers exposed to soil (see Table A-2). The human health RA (Rust E&I, 1995) assumed 4,590 cm² for the Depot personnel and 2,000 cm² for the construction worker. The 5,000-cm² value is EPA's recommended default value for adults based on exposure to 25 percent of mean total body SA (USEPA, 1992a). EPA guidance recommends using mean skin SA values, because they are directly proportional to body weight (for which an average value is used; USEPA, 1989a). The 4,590 cm² value is based on exposed skin SA of head, arms and hands.
- In accordance with EPA guidance (USEPA, 1989a) and the human health RA for the Group B SWMUs (SAIC, 1997a), the CMS Work Plan assumes 1,825 days as the averaging time (AT) for noncarcinogens for the construction worker. This guidance presents AT as the period over which exposure occurs, defined as ED × 365 days/year (days/yr). The human health RA for the Known Releases SWMUs assumed 30 days (Rust E&I, 1995).
- The human health RA for the Known Releases SWMUs (Rust E&I, 1995) does not include an industrial exposure scenario. The exposure variables assumed for the industrial receptor are standard EPA default values (USEPA, 1991b; 1992a).
- Table A-3 presents the quantitative summary for the CAO calculation for soil based on exposure via inhalation of contaminated particulates. The human health RA (Rust E&I, 1995) used an emission and dispersion model to estimate particulate concentrations.

The approach used for developing CAOs for soil simplifies the exposure pathway by using a generic particulate emission factor (PEF) based on long-term dust emission and dispersion modeling results performed by EPA (USEPA, 1991a). This approach was also used in the human health RA performed for another group of SWMUs at TEAD (SAIC, 1997).

In addition, Table A-4 presents the quantitative summary for CAOs for air based on dust inhalation. These CAOs can be compared to estimated contaminant concentrations in air from the modeling performed in the human health RA (i.e., the exposure point concentrations(see Section A.7)).

- The value used for variable inhalation rate (IR) in the inhalation of particulates pathway for all receptors is 1.3 cubic meters per hour (m³/hr) – EPA's recommended average value for adults working outside (USEPA, 1997). The human health RA used 0.8 m³/hr.

- For the development of CAOs at the non-BRAC SWMUs, it should be noted that the military land use conservatively assumes that a receptor is exposed to contaminants at a particular SWMU for an entire working career. Under continued military land use, it is likely that the actual exposure would be significantly less. However, the maximum exposure scenario is used because of the uncertainty of the particular exposure variable values selected.

A.4 RESULTS OF HUMAN HEALTH RA

As previously discussed, according to UAC R315-101-1(b)4, a site requires further evaluation if a human health RA performed in accordance with the Risk Rule shows a cancer risk greater than 1×10^{-6} or a noncancer hazard index (HI) for multiple contaminants and multiple exposure pathways greater than 1.0 based on a residential exposure scenario. For the Known Releases SWMUs, the human health RA (Rust E&I, 1995) determined that SWMUs 3, 10, 11, 12/15, 25, and 30 meet these criteria and require further evaluation in the form of a CMS.

The human health RA identified contaminants of potential concern (COPCs) for the Known Releases SWMUs. COPCs are those analytes that are detected at levels greater than established background concentrations and that meet quality assurance/quality control (QA/QC) requirements. (Although the human health RA identified COPCs for groundwater, quantitative CAOs are not developed for this medium, because exposure is discounted (see Section A.3.1.1).) COPCs were selected for subsurface soil at those SWMUs at which construction worker exposure was not evaluated in the human health RA (Rust E&I, 1995).

Quantitative CAOs are calculated for all identified COPCs in surface soil and subsurface soil for all SWMUs. CAOs are not developed for inorganic analytes that are essential human nutrients, but are toxic only at extremely high doses and for which health effects criteria do not exist (i.e., calcium, magnesium, potassium, and sodium).

A.5 TOXICITY EVALUATION

For the development of quantitative CAOs based on exposure to chemicals, the following health effects criteria are of principal importance:

- RfDs for oral exposure – estimates of acceptable daily intake for chronic and subchronic exposure that will not produce deleterious noncancer effects. EPA defines subchronic exposure as periods of less than 7 years (USEPA, 1989a). Therefore, subchronic RfDs apply to construction workers, while chronic RfDs apply to Depot personnel and industrial workers.

- Reference concentrations (RfCs) for inhalation exposure – estimates of acceptable concentrations for chronic and subchronic exposure that will not produce deleterious noncancer effects. These values are converted to inhalation RfDs by multiplying the RfC by the reference IR value of 20 m³/day and dividing by the reference BW of 70 kilograms. Subchronic inhalation RfDs apply to the construction worker only, as discussed for RfDs for oral exposure.
- SFs for oral exposure – plausible upper bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a).
- SFs for the inhalation route – plausible upper bound estimates of the probability of an individual developing cancer as a result of lifetime exposure to a potential carcinogen (USEPA, 1989a). Inhalation SFs are calculated from inhalation unit risk values in a similar manner as described above for inhalation RfDs.

The primary source of chemical-specific health effects criteria is EPA's Integrated Risk Information System (IRIS) database (USEPA, 1998a). IRIS is a computer-housed catalog of EPA health effects criteria and information. Data in IRIS are reviewed and updated monthly. If health effects criteria are not available in IRIS, EPA recommends use of the Office of Research and Development's Health Effects Assessment Summary Tables (HEAST; USEPA, 1995a) as a secondary data source. The Superfund Technical Support Center (STSC) is used for additional health effects criteria not provided in IRIS or HEAST (Rust E&I, 1995). STSC develops provisional RfDs and SFs on a site-specific basis for those contaminants with adequate toxicological data, but for which no approved values exist in IRIS or HEAST.

The human health RA (Rust E&I, 1995) presented the health effects criteria for COPCs that exhibit adverse health effects; Tables 1, 2, and 3 in Attachment 1, which are excerpted from the human health RA, list these criteria. These same health effects criteria are used to develop CAOs, with some exceptions. Sections A.5.1 through A.5.4 discuss the differences between health effects criteria used in the CMS Work Plan to develop quantitative CAOs and those used in the human health RA (Rust E&I, 1995). The pathway-specific tables in Attachment 1 list the actual health effects criteria used to develop CAOs.

A.5.1 MODIFICATION TO DERMAL EXPOSURE ROUTE

Health effects criteria are available only for the oral and inhalation routes, and most of these criteria are based on the administered rather than the absorbed dose (i.e., the amount of chemical at a human exchange boundary, such as skin, that is available for absorption – but not the amount actually absorbed into the blood). As presented in Table A-2, the equation for dermal contact exposures defines absorbed dose rather than intake. Thus, the administered dose health effects criteria must be converted to absorbed dose criteria in accordance with EPA methodology (USEPA, 1989a; 1992a).

This adjustment is made using oral absorption efficiency data (i.e., data on gastrointestinal absorption) from the species on which the oral health effects criteria are based. The administered dose oral health effects criterion is multiplied (for RfDs) or divided (for SFs) by the gastrointestinal absorption factor to derive the absorbed dose criterion. This conversion was not made in the Known Releases human health RA (Rust E&I, 1995), but was made in the human health RAs for other groups of SWMUs at TEAD (Montgomery Watson, 1997; SAIC, 1997; and Rust E&I, 1997a). Because of inconsistencies among gastrointestinal absorption data sources used by these other human health RAs for the absorbed dose criteria, the CMS Work Plan uses only one reference for developing CAOs (Oak Ridge National Laboratory (ORNL), 1995). A gastrointestinal absorption of 100 percent is assumed for COPCs not included in this source. Tables 5, 9, and 13 in Attachment 1 present dermal absorption pathways and the ORNL gastrointestinal absorption data used to develop CAOs.

Mercury is the only exception to using data from the ORNL source. As a contaminant at TEAD, mercury is expected to be present as an inorganic complex such as a salt, rather than in its elemental form. Thus, the 15 percent absorption value for inorganic mercury from another TEAD human health RA (Montgomery Watson, 1997) is used rather than the value for elemental mercury listed by ORNL.

A.5.2 MODIFICATION TO HUMAN HEALTH RA HEALTH EFFECTS CRITERIA

For development of CAOs, the CMS Work Plan incorporates the following modifications to health effects criteria used in the human health RA (Rust E&I, 1995):

- Arsenic – Since completion of the human health RA, the IRIS oral SF for arsenic has changed from 1.8 to 1.5 per milligram per kilogram per day ((mg/kg-day)⁻¹). The new SF is used to develop quantitative CAOs.
- Iron – The CMS Work Plan uses an RfD of 0.3 mg/kg-day from STSC (USEPA, 1998b). The human health RA (Rust E&I, 1995) used no health effects criteria for iron.
- Chlordane – Since completion of the human health RA (Rust E&I, 1995) the IRIS oral SF and oral chronic RfD have changed from 1.3 (mg/kg-day)⁻¹ and 6×10⁻⁵ mg/kg-day to 0.35 (mg/kg-day)⁻¹ and 5×10⁻⁴ mg/kg-day, respectively. The new IRIS values are used herein (USEPA, 1998a).
- 1,3-Dichlorobenzene – The CMS Work Plan uses an RfD of 9×10⁻⁴ mg/kg-day from STSC (USEPA, 1998b). The human health RA (Rust E&I, 1995) used no health effects criteria for 1,3-dichlorobenzene.
- Dieldrin – An oral SF of 16 (from IRIS), rather than 1.6 as used in the human health RA, is used to develop quantitative CAOs for dieldrin.

- DNT – The IRIS oral SF of $0.68 \text{ (mg/kg-day)}^{-1}$ is used for both the 2,4- and 2,6-DNT isomers, because the study upon which the SF is based used a mixture of the two isomers. The human health RA applied this SF only to 2,6-DNT.
- Manganese – Since completion of the human health RA, the IRIS oral RfD has changed from 0.14 milligram per kilogram per day (mg/kg-day) for food exposures (assumed to be applicable to soil ingestion). IRIS now recommends that a modifying factor of three be applied for nondietary exposures after subtracting dietary intake. The CMS Work Plan uses the resulting RfD of 2.4×10^{-2} to develop CAOs.
- 2-Methylnaphthalene – The human health RA (Rust E&I, 1995) used no health effects criteria for 2-methylnaphthalene. An RfD of 4×10^{-2} mg/kg-day is used herein, based on information provided by STSC (USEPA, 1998b).
- 1,1,1-Trichloroethane – The CMS Work Plan uses an RfD of 2×10^{-2} mg/kg-day from STSC (USEPA, 1998b). The human health RA (Rust E&I, 1995) used no health effects criterion for 1,1,1-trichloroethane.
- 1,3,5-Trinitrobenzene – Since completion of the human health RA (Rust E&I, 1995), the IRIS oral RfD has changed from 5×10^{-5} to 3×10^{-2} mg/kg-day. The new IRIS value is used herein (USEPA, 1998a).

A.5.3 NONCANCER EFFECTS ASSOCIATED WITH LEAD

The evaluation of the potential for noncancer effects associated with exposure to lead is different from that of other chemicals for two reasons:

- Although many studies have evaluated the effects of low level exposure to lead, EPA study groups have not reached a consensus on a threshold level for lead exposure. It appears that some of lead's effects, particularly those associated with certain blood enzymes and neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold. As a result, no RfD is established for lead, even though adverse effects are well known.
- Lead in the environment originates from a variety of sources, including air pollution, diet, water pipes, soil, and paints. Because exposure is rarely limited to one pathway, the hazards associated with lead cannot be fully evaluated without considering other environmental contributors.

To adjust for these factors, EPA developed the integrated exposure uptake/biokinetic model (IEUBK), which combines the various exposure pathways to calculate blood lead levels in a given population of children.

Over the last few years, researchers at EPA and other institutions have developed biokinetic lead models to estimate blood lead levels in adult populations. The evolving nature of the state-of-the-art regarding lead uptake by adults in a nonresidential setting is apparent in the variety of blood lead models and approaches used at TEAD over the last several years.

The California EPA (CAEPA) Department of Toxic Substances Control (DTSC) has developed a model for evaluating exposure to lead, referred to as the DTSC lead RA spreadsheet or "Pbspread" (CAEPA, 1996). This model, which was designed following EPA's IEUBK model, is used to calculate blood lead concentrations or acceptable levels in environmental media, given certain exposure assumptions. Unlike the IEUBK model, which is used to assess blood lead levels in children only, the Pbspread model can be used to calculate blood lead levels or acceptable lead levels in soil for adult receptors. The Group A human health RA (Montgomery Watson, 1997) used a previous version of this model to assess nonresidential exposure to lead at TEAD.

The Known Releases and Operable Units human health RAs used another model, developed by Bowers *et al.* (1994), to assess nonresidential exposure to lead. The Bowers model was also adapted by EPA Region 8 at the California Gulch National Priority List (NPL) site (USEPA, 1995d).

A recent methodology developed by EPA's Technical Review Workgroup (TRW; USEPA, 1996) for adult lead risk assessment is conceptually similar to the Bowers model and California Gulch lead assessments. It is used herein, and in the Group B and Group C human health RAs, as an interim approach to develop acceptable lead concentrations in soil at TEAD sites where – based on the most likely future land use – the receptors are limited to adults.

The basis of the TRW approach is to relate soil lead intake to blood lead concentrations in women of child-bearing age. The TRW report introduces the term "risk-based remediation goal" (RBRG). The basic algorithms used in the methodology to calculate an RBRG, the default parameter values from the model, and selected parameter values and justification for their selection are listed below in support of a nonresidential adult RBRG (or CAO) for lead (USEPA, 1996):

$$RBRG = PbS = \frac{(PbB_{adult, central, goal} - PbB_{adult, 0}) \times AT}{(BKSF \times IR_s \times AF_s \times EF_s)} \quad (Eq\ A-4)$$

In this form, the algorithm can be used to calculate an RBRG where it represents the average soil lead concentration (PbS) that would be expected to result in a specified adult blood lead concentration ($PbB_{adult, central, goal}$) and corresponding 95th percentile fetal blood lead concentration ($PbB_{fetal, 0.95, goal}$). Another necessary algorithm from the TRW report (USEPA, 1996) is:

$$PbB_{adult, central, goal} = \frac{PbB_{fetal, 0.95, goal}}{GSD^{1.645} \times R_{fetal/maternal}} \quad (\text{Eq A-5})$$

This equation describes the relationship between the blood lead concentration in adult women and the corresponding 95th percentile fetal blood lead concentration ($PbB_{fetal, 0.95}$), assuming that $PbB_{adult, central}$ reflects the geometric mean of a lognormal distribution of blood lead concentrations in women of child-bearing age.

For Equations A-4 and A-5:

$PbB_{adult, central, goal}$ = goal for central estimate of blood lead concentration (micrograms per deciliter ($\mu\text{g/dL}$)) in adults (i.e., women of child-bearing age) exposed to the site. The goal is intended to ensure that $PbB_{fetal, 0.95, goal}$ does not exceed 10 $\mu\text{g/dL}$ (USEPA, 1995b).

$PbB_{fetal, 0.95, goal}$ = goal for the 95th percentile blood lead concentration ($\mu\text{g/dL}$) among fetuses born to women exposed to the specified site soil concentration. This is interpreted to mean that there is a 95 percent likelihood that a fetus, in a woman who experiences such exposures, would have a blood lead concentration no greater than $PbB_{fetal, 0.95, goal}$ (i.e., for the approach described herein, the likelihood of a blood lead concentration greater than 10 $\mu\text{g/dL}$ is less than 5 percent).

GSD = estimated value of the individual geometric standard deviation (dimensionless); the GSD among adults (i.e., women of child-bearing age) exposed to similar onsite lead concentrations, but with nonuniform response (i.e., varying intake and biokinetics) to site lead and nonuniform offsite lead exposures. The exponent 1.645 is the value of the standard normal deviation used to calculate the 95th percentile from a lognormal distribution.

$R_{fetal/maternal}$ = constant of proportionality between fetal blood lead concentration at birth and maternal blood lead concentration (dimensionless).

$PbB_{adult, 0}$ = typical blood lead concentration ($\mu\text{g/dL}$) in adults (i.e., women of child-bearing age) not exposed to the site.

AT = averaging time; the total period during which soil contact may occur; 365 days/yr for continuing long-term exposures.

$BKSF$	=	biokinetic slope factor (quasi-steady state) relating increase in typical adult blood lead concentration to average daily lead uptake ($\mu\text{g/dL}$ blood lead increase per $\mu\text{g/day}$ lead uptake).
IR_s	=	intake rate of soil, including both outdoor soil and indoor soil-derived dust (grams per day (g/day)).
AF_s	=	absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless).
EF_s	=	exposure frequency for contact with assessed soil or dust derived in part from soil (days of exposure during the averaging period); may be taken as days/yr for continuing, long-term exposures.

Equations A-4 and A-5 are based on six assumptions detailed in the TRW report (USEPA, 1996) and summarized below:

- Blood lead concentration for adults is estimated by summing background blood lead concentration and expected site-related contribution.
- $BKSF$ is used to estimate the site-related increase in blood lead concentration.
- Lead uptake is related to soil lead levels using standard RA exposure variables.
- Primarily indoor exposure is used for default parameter values for occupational exposure to adults.
- A lognormal model is used to estimate interindividual variability in blood lead concentrations.
- Expected fetal blood lead concentrations are proportional to maternal blood lead concentrations.

The primary basis for Equation A-4 is that:

- Fetuses and neonates are a highly sensitive population with respect to the adverse effects of lead on development.
- $10 \mu\text{g/dL}$ is considered to be a blood lead level of concern from the standpoint of protecting the health of sensitive populations (USEPA, 1995b; 1996).

The following parameter values are selected for the lead CAO calculation:

Parameter Values for Lead CAO Calculation		
$PbB_{\text{fetal, 0.95, goal}}$	10 $\mu\text{g/dL}$	Default
GSD	1.8	Selected from default range based on expected homogeneity of population
$R_{\text{fetal/maternal}}$	0.9	Default
$PbB_{\text{adult, 0}}$	1.7 $\mu\text{g/dL}$	Selected from default range based on a study of blood lead concentrations from 728 non-Hispanic white women
AT	365 days/yr	Default
BKSF	0.4 $\mu\text{g/dL per } \mu\text{g/day}$	Default
IR_s	0.05 g/day	Default
AF_s	0.12	Default
EF_s	219 days/yr	Default

Using these values and the algorithms presented above, the final RBRG is 1,754 micrograms per gram ($\mu\text{g/g}$), which – when rounded to two significant figures – is 1,800 $\mu\text{g/g}$. This value is based primarily on default assumptions from the TRW report (USEPA, 1996) and is used as the CAO for lead in soil for all three receptor populations evaluated – the Depot worker, the industrial worker, and the construction worker.

The exposures for the Depot worker and the industrial worker are similar enough to the exposure defined by the default parameter values assumed for the lead model so as to eliminate the need to distinguish between them. Although exposure for the construction worker is considerably less than for the other receptors (thereby suggesting a greater CAO value), the TRW report clearly states that the model is not appropriate for exposure frequencies of less than 90 days because the basis for using the BKSF approach implies quasi-steady state for blood lead (USEPA, 1996). The report further states that constant lead intake over approximately 90 days is required to achieve a blood lead concentration that is sufficiently close to quasi-steady state. The construction worker scenario used to develop CAOs includes an assumption of 30 days/yr for EF. Therefore, the TRW methodology is not appropriate for this exposure scenario. It is assumed that a lead CAO for soil of 1,800 $\mu\text{g/g}$ is protective for construction worker exposures.

A.5.4 MODIFICATION TO APPROACH TO HANDLING CARCINOGENIC PAHs

The various RAs performed at TEAD have used two approaches for handling carcinogenic polycyclic aromatic hydrocarbons (PAH_cs). Both appear to be acceptable based on current guidance (USEPA, 1993).

- The first approach calls for adjusting the SF of each individual PAH_c using the estimated order of potential potency compared to benzo(a)pyrene (BaP), calculating the risks separately for each PAH_c, and summing the risks.

- The second approach calls for adjusting the soil chemical data using the same estimated order of potential potency values for each PAH_c, summing the adjusted data to produce a BaP equivalency concentration, and calculating the risk using the BaP SF.

Each of these approaches produces the exact same risk given the same data. The RAs for Groups B and C used the individual PAH_c approach, while the RAs for the Known Releases, Group A, and Operable Units used the BaP equivalency approach.

However, when comparing data to CAOs, these two approaches do not necessarily produce identical results. The BaP equivalency approach is, theoretically, slightly more conservative. Rather than using 10^{-6} as an individual target risk, as is done for all other contaminants, it assumes a more restrictive risk of 10^{-6} for a *combination* of seven PAH_cs. Additivity of risk is usually accounted for within the framework of risk-based cleanup values or CAOs by using a conservative "point of departure" risk estimate of 10^{-6} , with the understanding that even if several carcinogenic contaminants are present, the overall standards are still protective. It is unnecessary to assume a greater level of protectiveness for PAH_cs compared to other contaminants.

PAH_c data from the two SWMUs at TEAD with the greatest PAH contamination were used to test the actual difference between the two approaches as applied to CAOs. SWMU 37 (Group A) has two samples that exceed at least one individual PAH_c CAO (SS-37-003 and SB-37-002). These same two samples exceed the BaP PRG when converted to BaP equivalency. SWMU 12/15 (Known Releases) has four samples that exceed at least one individual PAH_c CAO (SL-SS-5, SL-SS-9, SL-SS-13, and SL-SS-22). These same samples exceed the BaP CAO when converted to BaP equivalency. In other words, either approach to handling PAH_cs leads to the exact same conclusion at the two SWMUs of interest.

The individual PAH_c approach is used herein rather than the BaP equivalency approach, which was used in the Known Releases RFI (Rust E&I, 1995). The effort required to manipulate TEAD soil data is not warranted based on the minimal differences in results and the sufficient protectiveness of the individual PAH_c approach. The two examples discussed above (SWMU 37 and SWMU 12/15) indicate that there is no difference in the conclusions drawn from the two approaches.

Two advantages of the individual PAH_c approach are noted below:

- It allows determination of which specific PAH_cs may require cleanup at a particular site.
- It allows immediate comparison of future sampling to CAOs without performing an intermediate BaP equivalency calculation for each data point.

The equivalency approach is, theoretically, slightly more conservative – but only in unusual cases at extremely low concentrations, very near the CAOs. EPA approved the rationale for this modification to how PAHs are handled (Henningson, 1997).

A.6 EVALUATION OF BACKGROUND SOIL CHEMISTRY

Extensive background soil sampling has been conducted for the various environmental studies at TEAD. Background concentrations can have a significant effect on the determination of quantitative CAOs.

Not all chemicals detected at hazardous waste sites originate from site-related activities; for example, the presence of metals is often due to natural geologic materials. Similarly, anthropogenic activities unrelated to a site frequently contribute certain organic chemicals (e.g., polycyclic aromatic hydrocarbons (PAHs) or pesticides derived from urban or agricultural sources). If site sample concentrations for a specific compound are similar to or lower than background concentrations, and the chemical is not associated with activities at the site, there is no need to consider potential corrective measures with respect to that compound.

A.6.1 BACKGROUND SAMPLE IDENTIFICATION

As part of the various RI and RFI activities at TEAD, background samples were collected from locations presumed, on the basis of historical information, to be free of contamination and to be unaffected by known anthropogenic activities. These samples were analyzed for metals. All locations were identified as background in the approved work plans, thus representing nonsite conditions.

Soil samples were collected at multiple depths. At most locations, a surface soil sample (with a starting depth 0 feet below ground surface (bgs)) and a subsurface soil sample (usually starting at 2 or 3 feet bgs) were collected. At location SB-BK-006, samples were collected from 10 feet bgs or deeper. Table A-5 provides a complete list of soil background samples, sampling depths, and soil types.

Background soil samples were also collected from several soil mapping units. Although the geology of the soil is different in these units, the chemistry is generally not statistically different. According to an evaluation of soil chemistry, 14 of the 17 analytes tested belong to the same soil population at a 95 percent significance level. Only calcium, arsenic, and chromium populations appeared to be statistically different at the 95 percent significance level. Because the majority of metals are within the same statistical population, background comparison criteria are calculated by combining the background sample results from the different soil types. Attachment 2 evaluates the chemical concentration difference by soil type.

TABLE A-5
Background Soil Samples

<u>Sample ID</u>	<u>Starting Depth (ft bgs)</u>	<u>Comments</u>	<u>Soil Type</u>
SB-BK-001	0		Hiko Peak
SB-BK-001	3		Hiko Peak
SB-BK-002	0		Berent
SB-BK-002	2		Berent
SB-BK-003	0		Medburn
SB-BK-003	2		Medburn
SB-BK-004	0	Duplicate sample included in average.	Hiko Peak
SB-BK-004	3		Hiko Peak
SB-BK-005	0		Medburn
SB-BK-005	3		Medburn
SB-BK-006	10	Not representative of shallow soils.	
SB-BK-006	15	Not representative of shallow soils.	
SB-BK-006	30	Not representative of shallow soils.	
SB-BK-006	45	Not representative of shallow soils.	
SB-BK-006	60	Not representative of shallow soils.	
SB-BK-006	70	Not representative of shallow soils.	
SB-BK-006	100	Not representative of shallow soils.	
SB-BK-007A	0		Berent
SB-BK-007B	3		Berent
SB-BK-008A	0		Berent
SB-BK-008B	3		Berent
SB-BK-009A	0		Abela
SB-BK-009B	3		Abela
SB-BK-010A	0		Abela
SB-BK-010B	3		Abela
SB-BK-011A	0		Berent
SB-BK-011B	3		Berent
SB-BK-012A	0		Berent
SB-BK-012B	3		Berent
SB-BK-013A	0		Medburn
SB-BK-013B	3		Medburn
SB-BK-014A	0		Medburn
SB-BK-014B	3		Medburn
SB-BK-015A	0		Medburn
SB-BK-015B	3		Medburn
SB-BK-016A	0		Abela
SB-BK-016B	2	Duplicate sample included in average.	Abela
SB-BK-007	0		Abela
SB-BK-008	0		Abela
SB-BK-017A	0		Abela
SB-BK-017B	2		Abela
SB-BK-018A	0		Abela
SB-BK-018B	2		Abela
SB-BK-019A	0	Duplicate sample included in average.	Abela
SB-BK-019B	5		Abela
SB-BK-019C	7.5		Abela
SB-BK-020A	0		Abela
SB-BK-020B	5		Abela
SB-BK-020C	7.5		Abela
SB-BK-021A	0.08		Abela
SB-BK-021B	5		Abela
SB-BK-021C	7.5		Abela
SB-BK-022A	0.08		Abela
SB-BK-022B	5		Abela
SB-BK-022C	7.5		Abela
BKS-92-01	0		Medburn
BKB-92-01	3		Medburn
BKS-92-02	0		Medburn
BKB-92-02	2		Medburn
BKS-92-03	0	Excluded due to suspected surface contamination.	Hiko Peak
BKB-92-03	3	Excluded due to suspected surface contamination.	Hiko Peak
BKS-92-04	0		Berent
BKB-92-04	3		Berent
BKS-93-05	0.5		Berent
BKB-93-05	3.5		Berent

Prior to statistical evaluation, the background data were reviewed for evidence that analytical results should be excluded from the data set. An entire sample was excluded from consideration as representative of background if the RI or RFI for which it was collected presented evidence that it deviated sufficiently from other background samples. Two samples (BKS-92-03 and BKB-92-03) were excluded because of possible surface contamination (Rust E&I, 1995). In addition, all samples collected at depths of 5 feet bgs or greater were excluded from background calculations; the survey data for TEAD suggest that soil at these levels is qualitatively different than shallower soil. Furthermore, the background calculations are primarily for use in comparing shallow soil data.

Analytical data were additionally reviewed for laboratory or data qualifiers to indicate that a sample analysis was rejected, unusable, or artificially high as a result of dilution effects. Data with an Installation Restoration Data Management Information System (IRDMIS) flagging code of "K" – indicating interference or high background in the analysis – were dropped from the data set. Also deleted were data with unusually high detection limits because of differences in analytical procedure; inclusion of the high detection limits as nondetects could result in artificially elevated statistical criteria.

Replicate samples – often labeled "duplicate" – were collected at several locations (see Table A-5). The results for each analyte were averaged for each replicate sample and included as a single data value. Prior to evaluating the distribution of data, the nondetects were treated as described in EPA guidance (i.e., for an analyte with at least one detection in at least one sample, one-half the detection limit was used for each nondetect).

A.6.2 STATISTICAL APPROACH

Probability distributions are used to describe metals concentrations in geological samples, which vary randomly within a specific distribution range. As few as 10 to 25 samples are statistically analyzed to estimate chemical concentrations across the overall geographic area within specified confidence levels. The statistical approach applied herein complies with EPA guidance for establishing background in groundwater at environmental sites, which can be used to establish background levels in other media such as soil (USEPA, 1989b; 1992b). The addendum to the guidance document (USEPA, 1992b) provides the more robust treatment of statistics for background data calculations. In accordance with this guidance, background comparison values may be equated with either the 95 percent upper tolerance limit (UTL) or the maximum observed background concentration. (The UTL is a numerical value at which there is 95 percent certainty that 95 percent of the measured values of a parameter are less than the value.)

Site-specific metals that are present at concentrations less than the 95 percent UTL are likely to represent natural conditions, while those that exceed the UTL may represent the effects of site activities or other nonbackground effects. Although not statistically defined, the maximum background value adopted as the background comparison criterion under certain statistical conditions may also be used as a measure of whether site constituents exceed anticipated background.

The probability distribution of concentrations is determined for analytes with at least 50 percent detection frequency. The normality of the distribution is tested using the Shapiro-Wilk method, which applies to data sets with 50 or fewer cases (USEPA, 1992b). The data are first tested for lognormal distribution (i.e., mathematically transformed by calculating the natural logarithms and then generating the Shapiro-Wilk statistic), as recommended in the guidance document. When the Shapiro-Wilk statistic is less than listed critical values (depending on the number of samples in the test population), the normality of the data is rejected. If the data are not shown to be lognormal, they are tested for a normal distribution by calculating the Shapiro-Wilk statistic on the nontransformed data. Once the normality or lognormality of the data is established, the UTL evaluation proceeds.

Tolerance limits are calculated for normally and lognormally distributed data according to standard techniques, and the mean and standard deviations of the concentrations of each analyte are determined. If the data distribution is lognormal, the mean and standard deviations of the transformed data are determined. The UTL is calculated as (USEPA, 1989b):

$$UTL = \bar{x} + ks \quad (\text{Eq A-6})$$

where:

- $\bar{x}$ = arithmetic mean of the concentration data (or transformed data).
- k = tolerance factor for estimating the 95 percent confidence limit of the 95th percentile of a normal distribution.
- s = standard deviation for the background concentration data (or transformed data).

The k value, which depends on the number of background samples, is presented in the guidance document (USEPA, 1989b). For a lognormal distribution, all of the data are transformed by calculating the natural logarithm. The logarithmic values are used in calculating a mean and a standard deviation. The UTL is calculated as described above, but using the mean and standard deviation for the lognormal data. The final value used in comparing the 95 percent UTL to site data, however, is determined by calculating the antilog (or exponential) of the logarithmic UTL.

When the Shapiro-Wilk test fails for the transformed and untransformed data, the data are neither normally nor lognormally distributed, and calculation of UTL is not applicable. This may occur when a large proportion of the data is nondetects. Calculating a UTL is also not applicable for data sets with less than 50 percent detections. In these cases, the maximum detected background concentration or the maximum detection limit is selected.

Table A-6 summarizes the detection frequency of all metals; the results of the Shapiro-Wilk test; and the 95 percent UTL, where appropriate; and the background comparison criteria.

A.6.3 BACKGROUND CONCENTRATIONS AS QUANTITATIVE CAOs

Background concentrations are used as quantitative CAOs when they exceed risk-based quantitative CAOs. The National Contingency Plan (NCP) preamble (55 *Federal Register*, 8717) states that preliminary remediation goals (PRGs; i.e., the CERCLA equivalent to quantitative CAOs) may be revised based on "technical factors," which may include background levels of contaminants.

Ideally, it is desirable to prevent any unacceptable risks posed by exposure to environmental conditions. Unfortunately, however, if lifetime exposure is assumed, some chemicals present risks greater than 1×10^{-6} or HIs greater than 1.0, even at natural concentrations. Studies of risk perception (Slovic *et al.*, 1990; Plough and Krimsky, 1990) conclude that people are willing to accept risks that they feel are beyond anyone's control (e.g., those caused by earthquakes or general air pollution) or are within their control (e.g., driving a car). Highly toxic compounds, such as arsenic and beryllium in natural concentrations in soil, fall into the former category, but site-related contamination does not.

This risk perception generality, the NCP guidance, and the practical impossibility of reducing exposure or remediating background concentrations to lower risks to acceptable levels lead to the use of certain background concentrations as quantitative CAOs. Therefore, if a calculated CAO is less than background, the background concentration is used as the CAO. For the Known Releases SWMUs, arsenic and beryllium are the only analytes for which background-based quantitative CAOs for soil are used.

A.7 QUANTITATIVE CAOs

Quantitative CAOs are calculated based on the exposure methodology, contaminants, health effects criteria, and background data presented in Sections A.3, A.4, A.5, and A.6, respectively. As discussed in Section A.6.3, background concentrations for soil at TEAD are used to replace health-based CAOs when they exceed the health-based values. Table A-7 presents the quantitative soil CAOs for each receptor group evaluated for comparison with site data. These values represent the concentrations at which a target risk level of 1×10^{-6} or a target HQ of 1.0 for individual COPCs is achieved by exposure via the incidental ingestion of soil and the dermal absorption of contaminants in soil pathways.

With the exception of arsenic, beryllium, lead, and polychlorinated biphenyls (PCBs), the quantitative CAOs in Table A-7 follow this risk-based approach. The arsenic and beryllium CAOs (32 mg/g and 1.5 µg/g, respectively) are based on background concentrations, as discussed in Section A.6.4. The lead CAO is based on modeled results of blood lead concentrations, as discussed in Section A.5.3. The CAO for PCBs is based

TABLE A-6
Background Soil Comparison Criteria (µg/g)
Tooele Army Depot

<u>Analyte</u>	<u>Detection Frequency</u>	<u>Distribution</u>	<u>Maximum Detection</u>	<u>95% UTL</u>	<u>Comparison Criterion</u>
Aluminum	100	Lognormal	32,000	34,861	34,900
Antimony	6	N/A	1.45		1.45
Arsenic	94	Neither	32		32
Barium	100	Lognormal	270	291	291
Beryllium	64	Neither	1.53		1.53
Cadmium	23	N/A	1.33		1.33
Calcium	100	Neither	220,000		220,000
Chromium	98	Normal	23.9	23.0	23
Cobalt	88	Neither	9.63		9.63
Copper	100	Lognormal	41.2	39.9	39.9
Iron	100	Lognormal	26,000	27,348	27,300
Lead	95	Lognormal	85	96.7	96.7
Magnesium	100	Lognormal	18,000	17,039	17,000
Manganese	100	Lognormal	2,160	1,029	1,030
Mercury	14	N/A	0.11		0.11
Nickel	89	Neither	26.5		26.5
Potassium	100	Lognormal	8,200	10,987	11,000
Selenium	2	N/A	0.198		0.198
Silver	20	N/A	7.75		7.75
Sodium	100	Neither	3,000		3,000
Thallium	40	N/A	54.4		54.4
Vanadium	100	Lognormal	28	33.8	33.8
Zinc	100	Lognormal	142	137	137

TABLE A-7

Quantitative Soil CAOs for Known Releases SWMUs at TEAD

Surface Soil (µg/g) (a)			Total Soil (µg/g) (a)	
COPCs	Depot Personnel	Industrial	COPCs	Construction
<u>Metals:</u>			<u>Metals:</u>	
Aluminum	(b)	(b)	Aluminum	(b)
Antimony	160	140	Antimony	470
Arsenic	32 (c)	32 (c)	Arsenic	32 (c)
Barium	71,000	59,000	Barium	110,000
Beryllium	1.5 (c)	1.5 (c)	Beryllium	2.8
Cadmium	220	190	Cadmium	870
Chromium (+3)	120,000	97,000	Chromium (+3)	580,000
Chromium (+6)	2,000	1,700	Chromium (+6)	23,000
Cobalt	130,000	110,000	Cobalt	110,000
Copper	68,000	57,000	Copper	64,000
Iron	440,000	370,000	Iron	500,000
Lead	1,800 (d)	1,800 (d)	Lead	1,800 (d)
Manganese	17,000	14,000	Manganese	34,000
Mercury	440	370	Mercury	500
Nickel	36,000	30,000	Nickel	34,000
Selenium	10,000	8,300	Selenium	8,700
Silver	7,900	6,600	Silver	8,400
Thallium	120	98	Thallium	1,300
Vanadium	1,600	1,300	Vanadium	6,100
Zinc	490,000	410,000	Zinc	510,000
<u>Volatiles:</u>			<u>Volatiles:</u>	
Acetone	110,000	93,000	Acetone	(b)
Benzene	120	97	Acrylonitrile	42
1,3-Dimethylbenzene	(b)	(b)	Benzene	480
Ethylbenzene	120,000	100,000	Chlorobenzene	27,000
Tetrachloroethene	66	55	1,2-Dichloroethene	140,000
Trichloroethene	82	68	1,3-Dimethylbenzene	110,000
Trichlorofluoromethane	140,000	110,000	Ethylbenzene	160,000
Toluene	220,000	180,000	Methyl isobutyl ketone	(b)
Xylenes	(b)	(b)	Tetrachloroethene	430
<u>Semivolatiles:</u>			1,1,1-Trichloroethane	32,000
Acenaphthene	35,000	29,000	Trichloroethene	1,300
Acenaphthylene	17,000	15,000	Trichlorofluoromethane	850,000
Anthracene	320,000	260,000	Toluene	(b)
Benzo(a)anthracene	2.2	1.9	Xylenes	640,000
Benzo(a)pyrene	0.22	0.19	<u>Semivolatiles:</u>	
Benzo(b)fluoranthene	2.2	1.9	Acenaphthene	800,000
Benzo(k)fluoranthene	22	19	Acenaphthylene	400,000
Benzo(g,h,i)perylene	17,000	15,000	Anthracene	(b)
Bis(2-ethylhexyl) phthalate	78	65	Benzo(a)anthracene	25
Butyl benzyl phthalate	190,000	150,000	Benzo(a)pyrene	2.5
Chrysene	220	190	Benzo(b)fluoranthene	25
Dibenz(a,h)anthracene	0.22	0.19	Benzo(k)fluoranthene	250
Dibenzofuran	4,900	4,100	Benzyl alcohol	(b)
1,2-Dichlorobenzene	110,000	92,000	Benzo(g,h,i)perylene	400,000
1,3-Dichlorobenzene	1,100	920	Bis(2-ethylhexyl) phthalate	1,100
1,4-Dichlorobenzene	140	110	Butyl benzyl phthalate	(b)
Diethyl phthalate	930,000	770,000	Chrysene	2,500
Di-n-butyl phthalate	120,000	100,000	Dibenz(a,h)anthracene	2.5
Di-n-octyl phthalate	25,000	20,000	Dibenzofuran	6,400
Fluoranthene	23,000	19,000	1,2-Dichlorobenzene	140,000
Fluorene	49,000	41,000	1,3-Dichlorobenzene	1,400
Indeno(1,2,3-cd)pyrene	2.2	1.9	1,4-Dichlorobenzene	930
2-Methylnaphthalene	44,000	36,000	Diethyl phthalate	(b)
Naphthalene	44,000	36,000	Dimethyl phthalate	-
Phenanthrene	31,000	26,000	Di-n-butyl phthalate	(b)
Phenol	700,000	580,000	Di-n-octyl phthalate	32,000
Pyrene	17,000	15,000	Fluoranthene	530,000

TABLE A-7 (cont'd)

Quantitative Soil CAOs for Known Releases SWMUs at TEAD

Surface Soil (µg/g) (a)			Total Soil (µg/g) (a)	
COPCs	Depot Personnel	Industrial	COPCs	Construction
<u>Explosives:</u>			Fluorene	640,000
2,4-Dinitrotoluene	4.6	3.9	Indeno(1,2,3-cd)pyrene	25
2,6-Dinitrotoluene	4.6	3.9	2-Methylnaphthalene	63,000
HMX	16,000	13,000	4-Methylphenol	8,000
Nitrobenzene	600	500	Naphthalene	63,000
RDX	31	26	N-Nitrosodiphenylamine	3,600
1,3,5-Trinitrobenzene	29,000	24,000	Pentachlorophenol	190
2,4,6-Trinitrotoluene	86	72	Phenanthrene	470,000
			Phenol	950,000
			Pyrene	400,000
<u>Pesticide/PCBs:</u>			<u>Explosives:</u>	
Aldrin	0.13	0.11	2,4-Dinitrotoluene	33
Chlordane	6.6	5.5	2,6-Dinitrotoluene	33
Dieldrin	0.14	0.12	HMX	52,000
DDD	12	10	Nitrobenzene	8,000
DDE	8.3	6.9	RDX	200
DDT	8.3	6.9	1,3,5-Trinitrobenzene	46,000
Endosulfan	7,400	6,100	2,4,6-Trinitrotoluene	710
Endrin	14	12		
Heptachlor	0.64	0.53	<u>Pesticide/PCBs:</u>	
Heptachlor epoxide	0.32	0.26	Aldrin	1.2
Isodrin	—	—	Chlordane	59
PCBs	25 (e)	25 (e)	Dieldrin	1.3
			DDD	90
<u>Anions</u>			DDE	64
Nitrate	(b)	(b)	DDT	64
Nitrite	200,000	170,000	Endosulfan	9,600
			Endrin	86
			Heptachlor	4.8
			Heptachlor epoxide	2.4
			Isodrin	—
			Lindane	17
			Methoxychlor	8,000
			PCBs	25 (e)
			<u>Anions</u>	
			Nitrate	(b)
			Nitrite	170,000

(a) - Includes all COPCs for all SWMUs identified in human health RA (Rust E&I, 1995). CAOs for Industrial workers only apply to COPCs from BRAC SWMUs.

Target risk for CAOs assumed to be 1×10^{-6} , target HQ of 1.0.

(b) - No CAO listed because the calculated CAO is greater than one million parts per million (µg/g).

(c) - CAO is based on background concentration.

(d) - CAO is based on the results of blood lead modeling (see text for details).

(e) - CAO is based on the Toxic Substances Control Act, "PCB Spill Cleanup Policy," (40 CFR 761, Subpart G).

COPCs in bold are identified in subsurface soil but not in surface soil.

— Indicates that the relevant health effects criteria are unavailable.

on the concentration presented in the Toxic Substances Control Act "PCB Spill Cleanup Policy" for nonresidential land uses (40 CFR 761, Subpart G).

Tables 4 through 17 in Attachment 1 present pathway- and medium-specific CAO based on a target risk level of 1×10^{-6} and a target HQ of 1.0. These tables also list the CAOs for target cancer risk levels of 1×10^{-5} and 1×10^{-4} for comparison. It should be noted that, in the absence of regulatory criteria, EPA recommends use of the 1×10^{-6} cancer risk level as a starting point for analysis of remedial alternatives. This reflects EPA's preference for managing risks at the more protective end of the risk range (USEPA, 1991a; NCP preamble, 55 *Federal Register*, 8718-9). This same EPA guidance presents some flexibility in target risk levels. ("Preliminary and final remediation goals, i.e., target risk levels, however, may vary from the point of departure depending upon site-specific circumstances.")

Tables 7, 11, and 15 of Attachment 1 summarize CAOs for individual pathways, assuming a chemical-specific target risk of 1×10^{-6} and a target HQ of 1.0 for each pathway, and resulting CAOs, assuming exposure via both pathways (i.e., the column headed "Combination" in the summary tables). Note that the combination CAO is less than either individual pathway CAO because it is based on a *total* target risk and target HQ of 1×10^{-6} and 1.0, respectively, posed to a receptor via both pathways. Pathway-specific CAOs are algebraically combined using a relationship of the reciprocal of the sum of the reciprocal of the pathway-specific CAOs. Attachment 3 explains the derivation of this relationship.

A.7.1 INHALATION OF PARTICULATES EXPOSURE PATHWAY

Table A-7 does not include the exposure pathway of inhalation of particulates because of the following:

- High uncertainty associated with relating SWMU-specific soil concentrations to exposure using emissions and dispersion modeling.
- Low relative effect of the inhalation pathway on the total CAO for soil.

Instead, two approaches are used to evaluate the particulate inhalation pathway. First, air CAOs are calculated (see Table A-8 and Attachment 1) and compared with estimated contaminant concentrations in air from the model used in the human health RA (i.e., the exposure point concentrations). Second, soil CAOs are calculated for the particulate inhalation pathway using the PEF approach discussed in Section A.3.2 to determine if this pathway is a significant component of total exposure to soil.

With the exception of hexavalent chromium, the modeled SWMU-specific exposure point concentrations in air for all COPCs presented in the human health RA are less than their respective air CAOs. Furthermore, with the exception of hexavalent chromium and arsenic, the air CAOs are at least 100 times greater than the SWMU-specific exposure point concentrations, demonstrating that the inhalation pathway has a minor effect on total

TABLE A-8

Quantitative Air CAOs for Known Releases SWMUs at TEAD

COPCs	Air (mg/m ³) (a)		
	Depot Personnel	Industrial	Construction
<u>Metals:</u>			
Aluminum	4.40E-02	4.59E-02	3.82E-01
Antimony	--	--	--
Arsenic	5.90E-06	6.11E-06	2.55E-04
Barium	3.10E-03	3.28E-03	2.73E-01
Beryllium	1.00E-05	1.09E-05	4.55E-04
Cadmium	1.40E-05	1.46E-05	6.07E-04
Chromium (+3)	--	--	--
Chromium (+6)	2.10E-06	2.18E-06	9.10E-05
Cobalt	1.80E-04	1.87E-04	1.56E-03
Copper	--	--	--
Iron	--	--	--
Lead	--	--	--
Manganese	4.50E-04	4.68E-04	3.90E-03
Mercury	2.70E-03	2.81E-03	2.34E-02
Nickel	1.05E-04	1.09E-04	4.55E-03
Selenium	--	--	--
Silver	9.13E-05	9.50E-05	7.92E-04
Thallium	--	--	--
Vanadium	--	--	--
Zinc	--	--	--
<u>Volatiles:</u>			
Acetone	--	--	--
Acrylonitrile	(b)	(b)	4.78E-03
Benzene	9.12E-04	9.49E-04	3.95E-02
Chlorobenzene	(b)	(b)	4.09E-01
1,2-Dichloroethene	(b)	(b)	--
1,3-Dimethylbenzene	--	--	--
Ethylbenzene	2.70E+00	2.81E+00	2.37E+01
Methyl isobutyl ketone	(b)	(b)	1.64E+01
Tetrachloroethene	1.30E-02	1.36E-02	5.73E-01
1,1,1-Trichloroethane	(b)	(b)	2.37E+01
Trichloroethene	4.41E-03	4.59E-03	1.91E-01
Trichlorofluoromethane	1.89E+00	1.97E+00	1.64E+02
Toluene	1.08E+00	1.12E+00	2.37E+01
Xylenes	--	--	--
<u>Semivolatiles:</u>			
Acenaphthene	--	--	--
Acenaphthylene	--	--	--
Anthracene	--	--	--
Benzo(a)anthracene	1.45E-04	1.50E-04	6.26E-03
Benzo(a)pyrene	1.45E-05	1.50E-05	6.26E-04
Benzo(b)fluoranthene	1.45E-04	1.50E-04	6.26E-03
Benzo(k)fluoranthene	1.45E-03	1.50E-03	6.26E-02
Benzo(g,h,i)perylene	--	--	--
Benzyl alcohol	(b)	(b)	--
Bis(2-ethylhexyl) phthalate	6.30E-03	6.55E-03	2.73E-01
Butyl benzyl phthalate	--	--	--
Chrysene	1.45E-02	1.50E-02	6.26E-01
Dibenz(a,h)anthracene	1.45E-05	1.50E-05	6.26E-04
Dibenzofuran	--	--	--
1,2-Dichlorobenzene	1.26E+00	1.31E+00	1.09E+02
1,3-Dichlorobenzene	--	--	--
1,4-Dichlorobenzene	7.20E+00	7.49E+00	1.94E+02
Diethyl phthalate	--	--	--
Dimethyl phthalate	(b)	(b)	--
Di-n-butyl phthalate	--	--	--

TABLE A-8 (cont'd)

Quantitative Air CAOs for Known Releases SWMUs at TEAD

COPCs	Air (mg/m ³) (a)		
	Depot Personnel	Industrial	Construction
Di-n-octyl phthalate	--	--	--
Fluoranthene	--	--	--
Fluorene	--	--	--
Indeno(1,2,3-cd)pyrene	1.45E-04	1.50E-04	6.26E-03
2-Methylnaphthalene	--	--	--
4-Methylphenol	(b)	(b)	--
Naphthalene	3.78E-03	3.93E-03	3.28E-02
N-Nitrosodiphenylamine	(b)	(b)	--
Pentachlorophenol	(b)	(b)	--
Phenanthrene	--	--	--
Phenol	--	--	--
Pyrene	--	--	--
<u>Explosives:</u>			
2,4-Dinitrotoluene	--	--	--
2,6-Dinitrotoluene	--	--	--
HMX	--	--	--
Nitrobenzene	1.89E-02	1.97E-02	1.64E+00
RDX	--	--	--
1,3,5-Trinitrobenzene	--	--	--
2,4,6-Trinitrotoluene	--	--	--
<u>Pesticide/PCBs:</u>			
Aldrin	5.19E-06	5.40E-06	2.25E-04
Chlordane	6.78E-05	7.06E-05	2.94E-03
Dieldrin	5.51E-06	5.73E-06	2.39E-04
DDD	3.67E-04	3.82E-04	1.59E-02
DDE	2.59E-04	2.70E-04	1.12E-02
DDT	2.60E-04	2.70E-04	1.12E-02
Endosulfan	--	--	--
Endrin	--	--	--
Heptachlor	1.96E-05	2.04E-05	8.49E-04
Heptachlor epoxide	9.69E-06	1.01E-05	4.20E-04
Isodrin	--	--	--
Lindane	(b)	(b)	--
Methoxychlor	(b)	(b)	--
PCBs	--	--	--
<u>Anions:</u>			
Nitrate	2.62E+01	2.73E+01	4.37E+02
Nitrite	1.64E+00	1.70E+00	2.73E+01

(a) - COPC list includes those identified as surface soil and subsurface soil in human health RA (Rust E&I, 1995).

(b) - COPC identified only in subsurface soil and receptor is only exposed to surface soil; therefore no CAO is calculated.

COPCs in **bold** are identified in surface soil but not in subsurface soil.

'--' Indicates that the relevant health effects criteria are unavailable.

exposure and, correspondingly, on the total CAO. The greatest arsenic exposure concentration in air is at SWMU 12/15, and it is 12 times less than the CAO for air. However, the arsenic CAO is based on background – not risk – so a small exposure component from dust inhalation would have no effect on the CAO. The greatest chromium exposure point concentration in air is also at SWMU 12/15, and it is approximately two times greater than the air CAO for Depot personnel.

For those COPCs with toxicity data for both the oral and inhalation exposure routes, Table 17 in Attachment 1 presents a ratio of the soil CAO for the Depot personnel receptor if inhalation of particulates is included to the soil CAO based only on ingestion and dermal absorption for those COPCs with toxicity data for both the oral and inhalation routes. This ratio demonstrates that the contribution from the inhalation pathway is negligible for all organic COPCs. For inorganics, inhalation is a negligible pathway for the total CAO for arsenic, beryllium, and mercury and a minor contributor for aluminum, barium, cobalt, and manganese. Although the contribution to total exposure from the inhalation pathway for cobalt (i.e., 35 percent) may be a significant portion of the total, the maximum detected concentration of cobalt in Known Releases samples (14.6 µg/g) is three to four orders of magnitude less than the CAO, causing the inhalation of cobalt to be irrelevant. Table 17 demonstrates that the inhalation of particulates pathway is not an important contributor to the soil CAO based on total exposure; the exclusion of this pathway in the soil CAO is further justified because of the uncertainty associated with modeling concentrations of particulates in air. Although the same analysis was not performed for the construction worker, the same arguments hold.

Soil CAOs for COPCs that are carcinogenic via inhalation, but not via ingestion (i.e., hexavalent chromium, cadmium, and nickel), cannot be based on both exposure routes because of the different toxic effects. For chromium and nickel, inhalation-based CAOs are greater than, but on the same order as, CAOs based on noncancer effects via ingestion and dermal absorption, indicating that the inhalation pathway need not be included in the soil CAO calculation. For cadmium, the inhalation pathway is even less significant, because the inhalation-based CAO is 50 times greater than the CAO based on exposure by the other two pathways.

A.7.2 ADDITIVE RISK

Chemical-specific CAOs are based on a target risk level of 1×10^{-6} for carcinogens and a target HQ of 1.0 for noncarcinogens. Consequently, even if a site is cleaned up to CAO levels, the total additive risk based on exposure to residual levels of contamination may be greater than these targets, if there are multiple carcinogenic or noncarcinogenic contaminants.

For carcinogenic contaminants, EPA believes that setting a 10^{-6} risk level for individual chemicals will lead to additive risks from multiple chemicals within the acceptable risk range of 10^{-4} to 10^{-6} (USEPA, 1996b). Therefore, additivity with respect to carcinogens is generally of minimal concern unless there are many COPCs. (For the

Known Releases sites, SWMU 10 has the highest number of carcinogenic COPCs (i.e., five); if the exposure point concentrations of these five contaminants were at the CAO level, the resulting risk would be 5×10^{-6} .)

Additive risk for noncarcinogens is more complex because of the theory that thresholds exist for noncancer effects. However, effects are additive only if two or more contaminants act on the same target organ or system.

An evaluation of noncarcinogenic COPCs at the Known Releases sites revealed that the CAOs are sufficiently protective to account for additive risk. For each noncarcinogenic COPC, the ratio of the maximum concentration to the CAO was calculated (i.e., the HQ) and summed. Single contaminant maximum concentrations exceeded their CAOs (i.e., are noncarcinogenic COCs) from the surface and subsurface soil at SWMU 10, subsurface soil at SWMU 11, and surface soil at SWMU 25. Additionally, the summed ratios exceeded 1.0 from the surface soil of SWMU 11 and SWMU 30. The additivity of each these SWMUs is discussed in detail below.

At SWMU 10, in both surface and subsurface soil, 2,4,6-TNT is the only noncarcinogenic contaminant detected at a maximum concentration that exceeds its CAO. However, 2,4,6-TNT also has carcinogenic effects that result in a more stringent CAO. Assuming that the greatest residual concentration following site cleanup for 2,4,6-TNT is the carcinogenic CAO, the resulting HI would be less than 1.0 for all contaminants in surface or subsurface soil. Therefore, the CAOs are sufficiently protective at SWMU 10 to account for additive risk.

The principal contributors to the HI from exposure to surface soil at SWMU 11 are antimony, arsenic, cadmium, chromium, and silver. Only two of these metals (arsenic and silver) affect the same target organ—skin. However, the sum of the arsenic and silver HQs is only 0.1, far less than the target of 1.0. Therefore, the CAOs are sufficiently protective at SWMU 11 surface soil to account for additive risk.

The maximum antimony concentration in subsurface soil at SWMU 11 exceeds its CAO. Because none of the other contributors to the HI with an HQ greater than 0.01 affect the same target organ as antimony (blood), the antimony CAO is sufficiently protective to account for additive risk.

At SWMU 25, thallium exceeds its CAO based on exposure to surface soil. The toxic effect for thallium is the reduction of two enzymes measured in the blood. The only other contributor to the HI with HQs greater than 0.01 (i.e., antimony, arsenic, cadmium, chromium, manganese, mercury, and vanadium) that affects blood is antimony; however, the antimony RfD is based on glucose and cholesterol effects to blood that are unrelated to the reduced enzyme levels from thallium exposure. Therefore, the CAOs at SWMU 25 are sufficiently protective to account for additive risk.

The principal contributors to the HI (i.e., those analytes with an HQ greater than 0.01) for exposure to surface soil at SWMU 30 are aluminum, arsenic, barium, cadmium, chromium, and vanadium. Because none of these metals act on the same target organ, the CAOs are sufficiently protective to account for additive effects.

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ATTACHMENT 1

**Supporting Data for Development of
Corrective Action Objectives**

TABLE 1
Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects

Chemical	Oral				Inhalation			
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
Explosives								
HMX	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
RDX	1.10E-01	C	Carcinomas/liver/ mouse	IRIS	ND	ND	ND	IRIS/HEAST
Nitrobenzene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
1,3,5-Trinitrobenzene	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
2,4,6-Trinitrobenzene	3.0E-02**	C	Urinary bladder papilloma and carcinoma in rats	IRIS	ND	ND	ND	IRIS/HEAST
Semi-Volatile Organic Compounds								
Acenaphthylene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Acenaphthene	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Anthracene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Benzo(a)anthracene	ND**	B2	ND	IRIS	ND**	B2	ND	IRIS/HEAST
Benzo(a)pyrene	7.3E+00	B2	Carcinomas/stomach/ mice	IRIS	6.1E+00	B2	ND	HEAST
Benzo(b)fluoranthene	ND**	B2	ND	IRIS	ND**	B2	ND	IRIS/HEAST
Benzo(g,h,i)perylene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Benzo(k)fluoranthene	ND**	B2	ND	IRIS	ND**	ND	ND	IRIS/HEAST
Benzyl alcohol	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Bis(2-ethylhexyl) phthalate	1.4E-02	B2	Carcinomas/liver/mouse	IRIS	1.4E-02	B2	Carcinomas/liver/mouse	SHRTSC
Butylbenzyl phthalate	ND	C	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST

Attachment 1

TABLE 1 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects (continued)

Chemical	Oral				Inhalation			
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
Chrysene	ND ^a	B2	ND	IRIS	ND ^a	B2	ND	IRIS/HEAST
1,3-Dichlorobenzene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
1,4-Dichlorobenzene	2.4E-02	B2	Tumors/liver/mouse	HEAST	ND	B2	ND	IRIS/HEAST
2,4-Dinitrotoluene	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
2,6-Dinitrotoluene	6.8E-01 ^a	B2	Carcinomas/liver/rat	IRIS	ND	ND	ND	IRIS/HEAST
3,5-Dinitroaniline	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Di-n-butyl phthalate	ND	D	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Di-n-octyl phthalate	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Dibenzo(a,h)anthracene	ND ^a	B2	ND	IRIS	ND ^a	B2	ND	IRIS/HEAST
Dibenzofuran	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Diethyl phthalate	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Dimethyl phthalate	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Endrin	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Fluoranthene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Fluorene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Indeno(1,2,3-cd)pyrene	ND ^a	B2	ND	IRIS	ND ^a	B2	ND	IRIS/HEAST
2-Methylnaphthalene	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
4-Methylphenol	ND	C	ND	IRIS/HEAST	ND	C	ND	IRIS/HEAST
N-nitrosodiphenylamine	4.9E-03 ^a	B2	Transitional cell/bladder/rat	IRIS	ND	B2	ND	IRIS/HEAST
Naphthalene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST

TABLE 1 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects (continued)

Chemical	Oral			Inhalation				
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
Pentachlorophenol	1.2E-01	B2	Carcinomas/liver/mouse	IRIS	ND	B2	ND	IRIS/HEAST
Phenanthrene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Phenol	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Pyrene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
PCB 1260	7.7E+00	B2	Carcinomas/liver/rat	IRIS	ND	B2	ND	IRIS/HEAST
TPH	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Volatile Organic Compounds								
Acetone	ND	D	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Acrylonitrile	5.4E-01 ¹⁰	B1	Carcinomas/multiple/rat	IRIS	2.4E-01	B1	Respiratory cancer/lungs/humans	IRIS
Benzene	2.9E-02 ¹¹	A	Leukemia/NA/human	IRIS	2.9E-02	A	Leukemia/bone marrow/humans	IRIS
Chlorobenzene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
1,2-Dichlorobenzene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
1,2-Dichloroethene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
1,3-Dimethylbenzene	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Ethylbenzene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Methylene chloride	7.5E-03	B2	Carcinomas/liver/mouse	IRIS	1.60E-03	B2	Adenomas & carcinomas/liver/mouse	IRIS
Methyl isobutyl ketone	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Tetrachloroethene	5.2E-02	C/B2	NA/liver/NA	SHRTSC	2.0E-03	C/B2	ND/liver/ND	SHRTSC
Toluene	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST

TABLE 1 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects (continued)

Chemical	Oral				Inhalation			
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
1,1,1-Trichloroethane	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Trichloroethylene	1.1E-02	B2	NA/liver/NA	SHRTSC	6.0E-03	B2	ND/liver/ND	SHRTSC
Trichlorofluoromethane	ND	ND	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Xylene (total)	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
<i>Perilicides</i>								
Aldrin	1.7E+01	B2	Carcinomas/liver/mouse	IRIS	1.7E+01	B2	Same as oral study	IRIS
Alpha-endosulfan	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Beta-endosulfan	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Chlordane	1.3E+00	B2	Carcinomas/liver/mouse	IRIS	1.3E+00	B2	Same as oral study	IRIS
Dieldrin	1.6E+00	B2	Carcinomas/liver/mouse	IRIS	1.6E+01	B2	Same as oral study	IRIS
Endrin	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Heptachlor	4.5E+00	B2	Carcinomas/liver/mouse	IRIS	4.5E+00	B2	Same as oral study	IRIS
Heptachlor epoxide	9.1E+00	B2	Carcinomas/liver/mouse	IRIS	9.1E+00	B2	Same as oral study	IRIS
Isoodrin	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Lindane/gamma BHC	1.3E+00	B2/C	Liver tumors in mice	HEAST	ND	B2/C	ND	IRIS/HEAST
Methoxychlor	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
p,p'-DDD	2.4E-01	B2	Carcinomas/liver/mouse	IRIS	2.4E-01 ^a	B2	ND	IRIS/HEAST
p,p'-DDE	3.4E-01	B2	Carcinomas/liver/mouse	IRIS	3.4E-01 ^a	B2	ND	IRIS/HEAST
p,p'-DDT	3.4E-01	B2	Carcinomas/liver/mouse	IRIS	3.4E-01	B2	Same as oral study	IRIS

TABLE 1 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects (continued)

Chemical	Oral				Inhalation			
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
<i>Metals</i>								
Aluminum	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Antimony	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Arsenic	1.8E+00***	A	Carcinomas/skin/human	IRIS	1.5E+01	A	Lung cancer in humans	IRIS
Barium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Beryllium	4.3E+00**	B2	Unspecified/rats	IRIS	8.4E+00	B2	Cancer/lungs/humans	IRIS
Cadmium	ND	B1	ND	IRIS/HEAST	6.30E+00	B1	Cancer/lungs/humans	IRIS
Calcium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Chromium	ND	A	ND	IRIS/HEAST	4.20E+01**	A	Cancer/lungs/humans	IRIS
Cobalt	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Copper	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Iron	ND	ND	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Lead	ND	B2	ND	IRIS/HEAST	ND	B2	ND	IRIS/HEAST
Magnesium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Manganese	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Mercury	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Nickel	ND	A	ND	IRIS/HEAST	8.4E-01**	A	Tumors/Respiratory/ Human	IRIS
Potassium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Selenium	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Silver	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST

TABLE 1 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Carcinogenic Effects (continued)

Chemical	Oral				Inhalation			
	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source	Slope Factor (mg/kg/day) ⁻¹	Weight of Evidence	Cancer Type/Target Organ/Species	Source
Sodium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Thallium	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST
Vanadium	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Zinc	ND	D	ND	IRIS/HEAST	ND	D	ND	IRIS/HEAST

Notes: --ND indicates No Data. SHRTSC indicates Superfund Health Risk Technical Support Center. Value provided is provisional. Inhalation slope factors calculated from published inhalation unit risk value (i.e., SF=Unit Risk ($\mu\text{g}/\text{m}^3$)⁻¹ x $1\text{E}+03$ $\mu\text{g}/\text{mg}$ x 70kg). The source hierarchy for obtaining toxicity values is as follows: (1) primary source = IRIS; (2) secondary source = HEAST; (3) when values were unavailable in IRIS or HEAST = SHRTSC; (4) "IRIS/HEAST" (under source column in table) indicates that both sources were consulted but lacked toxicity values.

*The oral slope factor for this chemical was used to evaluate carcinogenic effects from dermal exposure.

*TEFs were used to adjust the exposure point concentration. The adjusted concentrations are then summed to a value representing carcinogenic PAHs as a group. Risk is then determined by multiplying by the toxicity value for benzo(a)pyrene. The inhalation slope factor for B(a)P was published in HEAST for 1992 but has been subsequently withdrawn.

*Values for 2,4,7,8-dinitrotoluene mixture used in lieu of data for 2,6-dinitrotoluene.

*Value for DDT used as surrogate for DDE. Oral value was used for DDD.

*Oral slope factor calculated from proposed unit risk.

*Values for chromium (VI).

*Value for nickel refinery dust.

Source: Table 4-6 of human health RA (Rust, 1995)

TABLE 2

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects

Chemical	Oral				Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Explosives										
HMX	5.00E-02	low	Hepatic lesions	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
RDX	3.00E-03**	high	Inflammation of prostate	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Nitrobenzene	5.00E-04	low	Hematologic, adrenal, renal, and hepatic lesions	10,000/1	IRIS	6.00E-04	ND	Same as oral study	10,000/ND	HEAST- Table II
1,3,5-Trinitrobenzene	5.00E-03**	low	Increase in spleen weight	10,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
2,4,6-Trinitrobenzene	5.00E-04	medium	Liver effects	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Semi-Volatile Organic Compounds										
Acenaphthylene	3.0E-02***	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Acenaphthene	6.00E-02	low	Hepatotoxicity	3,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Anthracene	3.00E-01**	low	No observed effects	3,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Benzo(a)anthracene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(a)pyrene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(b)fluoranthene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(c,h,i)perylene	3.0E-02***	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(k)fluoranthene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzyl alcohol	3.00E-01	ND	Fore stomach epithelial hyperplasia	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Bis(2-ethylhexyl) phthalate	2.00E-02	medium	Liver weight gain	1,000/1	IRIS	5.7E-02**	ND	ND	ND	SHRTSC
Butylbenzyl phthalate	2.00E-01	low	Liver weight gain	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST

TABLE 2 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral				Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Chrysene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
1,3-Dichlorobenzene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
1,4-Dichlorobenzene	2.00E-01 ¹⁰	mod. to low	Nephropathy	1000/1	SHRTSC	2.30E-01	medium	Liver weight gain	100/1	IRIS
2,4-Dinitrotoluene	2.00E-03 ¹⁰	high	Neurotoxicity	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
2,6-Dinitrotoluene	1.00E-03 ¹⁰	ND	Increased mortality	3,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
3,5-Dinitroaniline	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Di-n-butyl phthalate	1.00E-01	low	Increased mortality	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Di-n-octyl phthalate	2.00E-02	ND	Increased liver and kidney weight	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Dibenzo(a,h) anthracene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Dibenzofuran	4.0E-03	low	Decrease in absolute organ weight and body length; kidney effects	3,000/1	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
Diethyl phthalate	8.00E-01 ¹⁰	low	Altered organ weight	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Dimethyl phthalate	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Endrin ketone	3.0E-04 ¹⁰	ND	ND	ND	IRIS	ND	ND	ND	ND	IRIS/HEAST
Fluoranthene	4.00E-02	low	Nephropathy	3,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Fluorene	4.00E-02 ¹⁰	low	Decrease in RBC	3,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Indeno(1,2,3-cd) pyrene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
2-Methylnaphthalene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
4-Methylphenol	5.00E-03 ¹⁰	ND	Maternal death	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST

TABLE 2 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral				Inhalation					
	RfD, (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
N-nitrosodi- phenylamine	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Naphthalene	4.0E-02**	ND	Decreased body weight	1,000	SHRTSC	1.2E-04**	low	Nasal lesions	3000/1	SHRTSC
Pentachlorophenol	3.00E-02	medium	Liver and kidney pathology	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Phenanthrene	3.0E-02***	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Phenol	6.00E-01**	low	Decrease in fetal body weight	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Pyrene	3.00E-02**	low	Kidney effects	3,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
PCB 1260	2.0E-03***	ND	Immune system toxicity	300/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
TPH	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Volatile Organic Compounds										
Acetone	1.00E-01	low	Increased liver and kidney weights	1000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Acrylonitrile	1.0E-03**	ND	Decreased sperm counts and semiferous tubule degeneration	1,000	HEAST	5.70E-04	medium	Epithelium hyperplasia of the respiratory tract	1,000/1	IRIS
Benzene	3.0E-04**	medium	Hematological and immunological effects	3000/1	SHRTSC	1.7E-03	low	Hematological effects	1,000/1	SHRTSC
Chlorobenzene	2.00E-02	medium	Histopathologic changes in liver	1,000/1	IRIS	5.0E-03	ND	Liver and kidney effects	10,000	HEAST- Table II
1,2-Dichlorobenzene	9.00E-02**	low	No effects observed	1,000/1	IRIS	4.0E-02	ND	Decreased body weight gain	1,000	HEAST- Table II
1,2-Dichloroethene	9.00E-03	ND	Liver lesions	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST

TABLE 2 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral				Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
1,3-Dimethylbenzene	2.00E+00 ⁰⁰	ND	Hypersensitivity	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Ethylbenzene	1.00E-01	low	Liver and kidney toxicity	1,000/1	IRIS	2.9E-01	low	Developmental toxicity	300/1	IRIS
Methylene chloride	6.00E-02	medium	Liver toxicity	100/1	IRIS	8.60E-01	ND	Liver toxicity	100/1	HEAST
Methyl isobutyl ketone	8.00E-02	ND	Leukemia, increased urinary protein, increased liver and kidney weight	3,000	HEAST	2.2E-02	ND	Increase in liver weights and kidney effects	100/1	HEAST- Table II
Tetrachloroethene	1.00E-02	medium	Hepatotoxicity, weight gain	1,000/1	IRIS	1.2E-01	medium	Hepatotoxicity; nephrotoxicity	300/1	SHRTSC
Toluene	2.00E-01	medium	Changes in liver and kidney weight	1,000/1	IRIS	1.10E-01	medium	Neurologic effects	300/1	IRIS
1,1,1-Trichloroethane	ND	ND	ND	ND	IRIS/HEAST	2.9E-01	ND	Hepatotoxicity	1,000	SHRTSC
Trichloroethylene	6.0E-03	low	Increased liver and kidney weights	3000/1	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
Trichlorofluoro methane	3.00E-01 ⁰⁰	medium	Survival and histopathology	1,000/1	IRIS	2.00E-01	ND	Increased kidney and lung inflammation	10,000/1	HEAST- Table II
Xylene (total)	2.00E+00 ⁰⁰	medium	Hypersensitivity, decrease in body weight, increase in mortality	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
<i>Pesticides</i>										
Aldrin	3.00E-05	medium	Liver toxicity	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Alpha-endosulfen	6.00E-03 ⁰⁰	ND	Decreased body weight gain	100	HEAST	ND	ND	ND	ND	IRIS/HEAST
Beta-endosulfen	6.00E-03 ⁰⁰	ND	Decreased body weight gain	100	HEAST	ND	ND	ND	ND	IRIS/HEAST
Chlordane	6.00E-05	low	Liver hypertrophy	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST

TABLE 2 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral				Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Dieldrin	5.00E-05	medium	Liver lesions	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Endrin	3.00E-04	medium	Liver lesions	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Hepachlor	5.00E-04	low	Liver weight gain	300/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Hepachlor epoxide	1.30E-05	low	Increased liver to body weight ratio	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Iodrin	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Lindane/gamma BHC	3.00E-04	medium	Liver and kidney toxicity	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Methoxychlor	5.00E-05**	low	Increase in fetal mortality	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDD	3.00E-05**	low	Body weight depression	10,000/1	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDE	7.00E-04	low	Mild liver lesions	10,000/1	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDT	5.00E-04	medium	Liver lesions	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Mefluthrin	1.0E+00**	low	Developmental neurotoxicity	100	SHRTSC	1.4E-03	medium	Cognitive and psychomotor impairment	300	SHRTSC
Azinphos	4.00E-04**	low	Longevity, blood glucose	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Azinphos	3.00E-04**	medium	Hyperpigmentation	3/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Berthos	7.00E-02**	medium	Increase in blood pressure	3/1	IRIS	1.00E-04	ND	ND	ND	HEAST- Table II
Beryllium	5.0E-03**	low	None observed	100/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Cadmium (food)	1.00E-03**	high	Significant proteinuria	10/1	IRIS	ND	ND	ND	ND	IRIS/HEAST

TABLE 2 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral				Inhalation					
	RD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Cadmium (water)	5.00E-04 ^{aa}	high	Significant proteinuria	10/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Calcium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Chromium ^{VI}	5.00E-03 ^{aa}	low	No effects reported	500/1	IRIS	1.1E-06 ^{aa}	low	ND	100/ND	SHRTSC
Cobalt	6.0E-02 ^{aa}	low	Polycythemia in renally compromised patients	ND	SHRTSC	5.7E-06	ND	Respiratory effects	100/ND	SHRTSC
Copper	3.7E-02 ^{aa}	ND	Gastrointestinal irritation	ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Iron	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Lead	ND	ND	Neurological symptoms	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Magnesium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Manganese (feed)	1.4E-01 ^{aa}	medium	CNS effects	1/1	IRIS	1.40E-05	medium	CNS effects	1,000/1	IRIS
Manganese (water)	5.0E-03 ^{aa}	medium	CNS effects	1/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Mercury	3.00E-04 ^{aa}	ND	Kidney effects	1,000/1	HEAST	8.60E-05	ND	Neurotoxicity	30	HEAST
Nickel	2.00E-02 ^{aa}	medium	Decrease in body and organ weight	300/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Potassium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Selenium	5.00E-03 ^{aa}	high	Clinical selenium	3/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Silver	5.00E-03 ^{aa}	low	Argyria	3/1	IRIS	2.9E-06	low	Ocular argyria	1000/1	SHRTSC
Sodium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Thallium (w/fate)	8.0E-05	low	No observed effects	3000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Vanadium	7.00E-03 ^{aa}	ND	No observed effects	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST

Chemicals of Potential Concern: Toxicity Values for Potential Non-Carcinogenic Effects (continued)

Chemical	Oral					Inhalation				
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Zinc	3.00E-01 ¹⁴	medium	Decrease in erythrocyte	3/1	IRIS	ND	ND	ND	ND	IRIS/HEAST

¹⁴ U.S. Environmental Protection Agency, Health Assessment Center. Values provided are provisional. The source hierarchy for obtaining toxicity values is as follows: (1) primary studies; (2) peer-reviewed literature; (3) Health Assessment Center files; (4) Health Assessment Center files; (5) Health Assessment Center files; (6) Health Assessment Center files; (7) Health Assessment Center files; (8) Health Assessment Center files; (9) Health Assessment Center files; (10) Health Assessment Center files. Values provided are provisional. The source hierarchy for obtaining toxicity values is as follows: (1) primary studies; (2) peer-reviewed literature; (3) Health Assessment Center files; (4) Health Assessment Center files; (5) Health Assessment Center files; (6) Health Assessment Center files; (7) Health Assessment Center files; (8) Health Assessment Center files; (9) Health Assessment Center files; (10) Health Assessment Center files.

Notes: -ND indicates No Data. SHRTSC indicates Superfund Health Risk Technical Support Center. Values provided in provisional. The source hierarchy for obtaining toxicity values is as follows: (1) primary source = IRIS; (2) secondary source = HEAST; (3) when values were unavailable in IRIS or HEAST = SHRTSC; (4) "IRIS/HEAST" (under source column in table) indicates that both sources were consulted but lacked toxicity values.

¹The oral RfD for this chemical was used to evaluate non-carcinogenic effects from dermal exposures.

²Value for pyrene used as surrogate.

³No chronic inhalation RfD has been derived for this chemical. Provisional subchronic value was used.

⁴Value for endrin used for endrin ketone.

⁵Value for PCB 1254 used as surrogate for PCB 1260.

⁶Values for endosulfan used in lieu of data specific for alpha- and beta-endosulfan.

⁷Values for chromium (VI).

⁸Oral RfD was calculated from the drinking water standard (1.3 mg/L) published in HEAST.

Source: Table 4-7 of human health RA (Rust, 1995)

TABLE 3

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects

Chemical	Subchronic Oral				Subchronic Inhalation					
	RM (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RM (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
<i>Explores</i>										
HMX	5.00E-02 ⁴⁰	low	Hepatic lesions	1,000/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
RDX	3.00E-03	high	Inflammation of prostate	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Nitrobenzene	5.00E-03	ND	Hematologic and hepatic lesions	1,000/1	HEAST	6.0E-03	ND	Hematological effects; lesions of adrenals, liver, kidney	1000/ND	HEAST- Table II
1,3,5-Trinitrobenzene	5.00E-04	ND	Increase in spleen weight	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
2,4,6-Trinitrobenzene	5.00E-04	ND	Liver effects	1,000/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
<i>Semi-Volatile Organic Compounds</i>										
Acenaphthylene	3.0E-01 ⁴⁰	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Acenaphthene	6.00E-01	ND	Hepatotoxicity	300/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Anthracene	3.00E+00	ND	No observed effects	300/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(a)anthracene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(a)pyrene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(b)fluoranthene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(g,h,i)perylene	3.0E-01 ⁴⁰	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzo(k)fluoranthene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Benzyl alcohol	1.00E+00	ND	Decreased weight	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Bis(2-ethylhexyl) phthalate	2.00E-02 ⁴⁰	medium	Liver weight gain	1,000/1	IRIS	5.7E-02	low	Increased incidence of litters with gross retardations	100/ND	SHRTSC

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral					Subchronic Inhalation			
	RM (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RM (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor
Butylbenzyl phthalate	2.00E+00	low	Liver weight gain	100/1	HEAST	ND	ND	ND	IRIS/HEAST
Chrysene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
1,3-Dichlorobenzene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
1,4-Dichlorobenzene	2.0E-01 ⁴⁰	medium to low	Nephropathy	1000/1	SHRTSC	7.1E-01	ND	Liver weight gain	30/ND HEAST
2,4-Dinitrotoluene	2.00E-03	High	Neurotoxicity	100/1	HEAST	ND	ND	ND	IRIS/HEAST
2,6-Dinitrotoluene	1.00E-02	ND	Increased mortality	300/1	HEAST	ND	ND	ND	IRIS/HEAST
3,5-Dinitroanisole	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Di-n-butyl phthalate	1.00E+00	low	Increased mortality	100/1	HEAST	ND	ND	ND	IRIS/HEAST
Di-n-octyl phthalate	2.00E-02	ND	Increased liver and kidney weight	1,000/1	HEAST	ND	ND	ND	IRIS/HEAST
Dibenz(a,h) anthracene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST
Dibenzofuran	4.0E-03 ⁴⁰	ND	ND	ND	SHRTSC	ND	ND	ND	IRIS/HEAST
Diethyl phthalate	9.00E+00	low	Altered organ weight	100/1	HEAST	ND	ND	ND	IRIS/HEAST
Dimethyl phthalate	1.00E+01	ND	Kidney effects	100/1	HEAST	ND	ND	ND	IRIS/HEAST
Endrin ketone	3.0E-04 ⁴⁰	ND	ND	ND	IRIS	ND	ND	ND	IRIS/HEAST
Fluoranthene	4.00E-01	low	Nephropathy, liver, weight changes	300/1	HEAST	ND	ND	ND	IRIS/HEAST
Fluorene	4.00E-01	low	Decrease in RBC	300/1	HEAST	ND	ND	ND	IRIS/HEAST
Indeno(1,2,3-cd) pyrene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	IRIS/HEAST

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral				Subchronic Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
2-Methylnaphthalene	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
4-Methylphenol	5.00E-03	ND	Maternal death	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
N-nitrosodiphenylamine	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Naphthalene	4.0E-02	ND	Decreased body weight	ND	SHRTSC	1.2E-04	low	Nasal lesions	3000/1	SHRTSC
Pentachlorophenol	3.00E-02	ND	Reproductive	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Phenanthrene	3.0E-02**	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Phenol	6.00E-01	low	Decrease in fetal body weight	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Pyrene	3.00E-01	ND	Kidney effects	300/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
PCB 1260	5.00E-05**	ND	Immune system toxicity	100/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
TPH	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Volatile Organic Compounds										
Acetone	1.0E+00	ND	Increased liver weight	100/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Acrylonitrile	1.00E-02	ND	Decreased sperm count	100/ND	HEAST	5.70E-04**	medium	Respiratory tract effects	1,000/1	IRIS
Benzene	3.0E-04**	medium	Hematological and immunological effects	3000/1	SHRTSC	1.7E-02	low	Depressed hematopoietals	100/ND	SHRTSC
Chlorobenzene	2.00E-02**	medium	Histiopathologic changes in liver	1,000/1	IRIS	5.0E-03**	ND	Liver and kidney effects	10,000/ND	HEAST-Table II
1,2-Dichlorobenzene	9.00E-02**	low	No effects observed	1,000/1	IRIS	4.0E-01	ND	ND	ND	HEAST-Table II

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral					Subchronic Inhalation				
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
1,2-Dichloroethane (mixed isomers)	9.00E-03	ND	Liver lesions	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
1,3-Dimethylbenzene	7.0E-02	low	Neurotoxicity	1,000/3	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
Ethylbenzene	1.00E-01	low	Liver and kidney toxicity	1,000/1	SHRTSC	2.9E-01	low	Developmental toxicity	300/1	SHRTSC
Methylene chloride	6.00E-02	medium	Liver toxicity	100/1	HEAST	8.60E-01	ND	Liver toxicity	100/1	HEAST
Methyl isobutyl ketone	8.00E-01	ND	Liver and kidney effects	300/ND	HEAST	2.0E-01	ND	Increase in liver and kidney weight	100/ND	HEAST- Table II
Tetrachloroethene	1.00E-01	medium	Hepatotoxicity, weight gain	100/1	HEAST	1.2E-01**	medium	Hepatotoxicity; nephrotoxicity	300/1	SHRTSC
Toluene	2.00E+00	medium	Changes in liver and kidney weight	100/1	HEAST	2.9E-01	medium	Neurologic effects	300/1	SHRTSC
1,1,1-Trichloroethane	ND	ND	ND	ND	IRIS/HEAST	2.9E-01**	ND	ND	ND	IRIS/HEAST
Trichloroethylene	6.0E-03**	ND	ND	ND	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
Trichlorofluore methane	7.00E-01	ND	Increased mortality	1,000/1	HEAST	2.00E+00	ND	Kidney and lung effects	1,000/1	HEAST- Table II
Xylene (total)	4.0E-01	low	CNS Toxicity	1,000/1	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
<i>Pesticides</i>										
Aldrin	3.00E-05	medium	Liver toxicity	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Alpha-endosulfan**	6.00E-03	ND	Decreased body weight	3/1	HEAST, Suppl. I	ND	ND	ND	ND	IRIS/HEAST
Beta-endosulfan**	6.00E-03	ND	Decreased body weight	3/1	HEAST, Suppl. I	ND	ND	ND	ND	IRIS/HEAST
Chlordane	6.00E-05	low	Liver hypertrophy	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Dieldrin	5.00E-05	medium	Liver lesions	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral				Subchronic Inhalation					
	RD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Calcium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Chromium ^{VI}	2.00E-02	ND	No effects reported	100/I	HEAST	1.1E-06	low	Diffuse nasal symptoms	100/ND	SHRTSC
Cobalt	6.0E-02 ^W	ND	ND	ND	SHRTSC	5.7E-06 ^W	ND	ND	ND	SHRTSC
Copper	3.7E-02 ^W	ND	Gastrointestinal irritation	ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Iron	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Lead	ND	ND	Neurological symptoms	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Magnesium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Manganese (food)	1.4E-01	ND	CNS effects	1/I	HEAST	1.40E-05 ^W	medium	CNS effects	1,000/I	IRIS
Manganese (water)	5.00E-03	ND	CNS effects	1/I	HEAST	ND	ND	ND	ND	IRIS/HEAST
Mercury	3.00E-04	ND	Kidney effects	1,000/I	HEAST	8.60E-05	NA	Neurotoxicity	ND	HEAST
Nickel	2.00E-02	medium	Decrease in body and organ weight	300/I	HEAST	ND	ND	ND	ND	IRIS/HEAST
Potassium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Selenium	5.00E-03	high	Clinical tetraosis	3/I	HEAST	ND	ND	ND	ND	IRIS/HEAST
Silver	5.00E-03	low	Argyria	3/I	HEAST	2.9E-06 ^W	ND	ND	ND	SHRTSC
Sodium	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Thallium (sulfate)	8.0E-04	ND	Liver effects; alopecia	300/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Vanadium	7.00E-03	ND	No observed effects	100/I	HEAST	ND	ND	ND	ND	IRIS/HEAST

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral				Subchronic Inhalation					
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Endrin	3.00E-04	medium	Neurotoxicity and liver lesions	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Heptachlor	5.00E-04	low	Liver weight gain	300/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Heptachlor epoxide	1.30E-03	low	Liver and body weight gain	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Isodrin	ND	ND	ND	ND	IRIS/HEAST	ND	ND	ND	ND	IRIS/HEAST
Lindane/gamma BHC	3.00E-03	medium	Liver and kidney toxicity	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Methoxychlor	5.00E-03	low	Increase in fetal mortality	1,000/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDD	3.00E-03**	ND	ND	ND	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDE	7.00E-04**	ND	ND	ND	SHRTSC	ND	ND	ND	ND	IRIS/HEAST
p,p'-DDT	5.00E-04	medium	Liver lesions	100/1	HEAST	ND	ND	ND	ND	IRIS/HEAST
Metals										
Aluminum	1.0E+00**	ND	ND	ND	SHRTSC	1.4E-03**	ND	ND	ND	SHRTSC
Arsimony	4.00E-04	ND	Increased mortality, altered blood chemistry	1,000/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Arsenic	3.00E-04	ND	Kidneys and hyperpigmentation	3/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Barium	7.00E-02	medium	Increase in blood pressure	3/1	HEAST	1.0E-03	ND	ND	ND	HEAST- Table II
Beryllium	5.3E-03	ND	None observed	100/ND	HEAST	ND	ND	ND	ND	IRIS/HEAST
Cadmium (food)	1.00E-03**	high	Human studies	10/1	IRIS	ND	ND	ND	ND	IRIS/HEAST
Cadmium (water)	5.00E-04**	high	Significant proteinuria	10/1	IRIS	ND	ND	ND	ND	IRIS/HEAST

TABLE 3 (cont'd)

Chemicals of Potential Concern: Toxicity Values for Potential Subchronic Effects (continued)

Chemical	Subchronic Oral					Subchronic Inhalation				
	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source	RfD (mg/kg/day)	Confidence Level	Critical Effect	Uncertainty Modifying Factor	Source
Zinc	3.00E-01 ¹⁴	medium	Decrease in erythrocyte	3/1	HEAST	ND	ND	ND	ND	IRIS/HEAST

Notes.—ND indicates No Data. SHRTSC indicates Superfund Health Risk Technical Support Center. Value provided is provisional. The source hierarchy for obtaining toxicity values is as follows: (1) primary source = IRIS; (2) secondary source = HEAST; (3) when values were unavailable in IRIS or HEAST = SHRTSC; (4) "IRIS/HEAST" (under source column in table) indicates that both sources were consulted but lacked toxicity values.

¹Chronic values used as the subchronic criteria. Subchronic values for pyrene used as subchronic surrogate criteria for acenaphthylene, benzof(g,h,i)pyrene, and phenanthrene.

²Subchronic value for PCB 1254 used as surrogate for subchronic values for PCB 1260.

³Values for endosulfan used in lieu of data specific for alpha- and beta-endosulfan.

⁴Values for chromium (VI).

⁵The oral RfD does not supply the minimum daily requirement of the elements in children. Therefore, subchronic exposure to child was not evaluated.

⁶Value for endrin used as surrogate for endrin ketone.

⁷Subchronic RfD was calculated from the subchronic drinking water standard published in HEAST.

Source: Table 4-8 of human health RA (Rust, 1995)

TABLE 4
Corrective Action Objectives (CAOs)
Soil Ingestion--Depot Personnel

SE	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at
			1E-06	1E-05	1E-04	Target HQ = 1.0
		<u>Metals:</u>				
	1.0E+00	Aluminum	--	--	--	2.46E+06
	4.0E-04	Antimony	--	--	--	9.83E+02
1.5E+00	3.0E-04	Arsenic	4.59E+00	4.59E+01	4.59E+02	7.37E+02
	7.0E-02	Barium	--	--	--	1.72E+05
4.3E+00	5.0E-03	Beryllium	1.60E+00	1.60E+01	1.60E+02	1.23E+04
	1.0E-03	Cadmium	--	--	--	2.46E+03
	1.0E+00	Chromium (+3)	--	--	--	2.46E+06
	5.0E-03	Chromium (+6)	--	--	--	1.23E+04
	6.0E-02	Cobalt	--	--	--	1.47E+05
	3.7E-02	Copper	--	--	--	9.11E+04
	3.0E-01	Iron	--	--	--	7.37E+05
		Lead	--	--	--	--
	2.4E-02	Manganese	--	--	--	5.90E+04
	3.0E-04	Mercury	--	--	--	7.37E+02
	2.0E-02	Nickel	--	--	--	4.91E+04
	5.0E-03	Selenium	--	--	--	1.23E+04
	5.0E-03	Silver	--	--	--	1.23E+04
	8.0E-05	Thallium	--	--	--	1.97E+02
	7.0E-03	Vanadium	--	--	--	1.72E+04
	3.0E-01	Zinc	--	--	--	7.37E+05
		<u>Volatiles:</u>				
	1.0E-01	Acetone	--	--	--	2.46E+05
2.9E-02	3.0E-04	Benzene	2.37E+02	2.37E+03	2.37E+04	7.37E+02
	2.0E+00	1,3-Dimethylbenzene	--	--	--	4.91E+06
	1.0E-01	Ethylbenzene	--	--	--	2.46E+05
5.2E-02	1.0E-02	Tetrachloroethene	1.32E+02	1.32E+03	1.32E+04	2.46E+04
1.1E-02	6.0E-03	Trichloroethene	6.25E+02	6.25E+03	6.25E+04	1.47E+04
	3.0E-01	Trichlorofluoromethane	--	--	--	7.37E+05
	2.0E-01	Toluene	--	--	--	4.91E+05
	2.0E+00	Xylenes	--	--	--	4.91E+06
		<u>Semivolatiles:</u>				
	6.0E-02	Acenaphthene	--	--	--	1.47E+05
	3.0E-02	Acenaphthylene	--	--	--	7.37E+04
	3.0E-01	Anthracene	--	--	--	7.37E+05
7.3E-01		Benzo(a)anthracene	9.42E+00	9.42E+01	9.42E+02	--
7.3E+00		Benzo(a)pyrene	9.42E-01	9.42E+00	9.42E+01	--
7.3E-01		Benzo(b)fluoranthene	9.42E+00	9.42E+01	9.42E+02	--
7.3E-02		Benzo(k)fluoranthene	9.42E+01	9.42E+02	9.42E+03	--
	3.0E-02	Benzo(g,h,i)perylene	--	--	--	7.37E+04
1.4E-02	2.0E-02	Bis(2-ethylhexyl) phthalate	4.91E+02	4.91E+03	4.91E+04	4.91E+04
	2.0E-01	Butyl benzyl phthalate	--	--	--	4.91E+05
7.3E-03		Chrysene	9.42E+02	9.42E+03	9.42E+04	--
7.3E+00		Dibenz(a,h)anthracene	9.42E-01	9.42E+00	9.42E+01	--
	4.0E-03	Dibenzofuran	--	--	--	9.83E+03
	9.0E-02	1,2-Dichlorobenzene	--	--	--	2.21E+05
	9.0E-04	1,3-Dichlorobenzene	--	--	--	2.21E+03
2.4E-02	2.0E-01	1,4-Dichlorobenzene	2.87E+02	2.87E+03	2.87E+04	4.91E+05
	8.0E-01	Diethyl phthalate	--	--	--	1.97E+06
	1.0E-01	Di-n-butyl phthalate	--	--	--	2.46E+05
	2.0E-02	Di-n-octyl phthalate	--	--	--	4.91E+04
	4.0E-02	Fluoranthene	--	--	--	9.83E+04
	4.0E-02	Fluorene	--	--	--	9.83E+04
7.3E-01		Indeno(1,2,3-cd)pyrene	9.42E+00	9.42E+01	9.42E+02	--
	4.0E-02	2-Methylnaphthalene	--	--	--	9.83E+04
	4.0E-02	Naphthalene	--	--	--	9.83E+04
	3.0E-02	Phenanthrene	--	--	--	7.37E+04

TABLE 4 (cont'd)
Corrective Action Objectives (CAOs)
Soil Ingestion—Depot Personnel

SF	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
	6.0E-01	Phenol	--	--	--	1.47E+06
	3.0E-02	Pyrene	--	--	--	7.37E+04
		<u>Explosives:</u>				
	1.0E-04	1,3-Dinitrobenzene	--	--	--	2.46E+02
6.8E-01	2.0E-03	2,4-Dinitrotoluene	1.01E+01	1.01E+02	1.01E+03	4.91E+03
6.8E-01	1.0E-03	2,6-Dinitrotoluene	1.01E+01	1.01E+02	1.01E+03	2.46E+03
	5.0E-02	HMX	--	--	--	1.23E+05
	5.0E-04	Nitrobenzene	--	--	--	1.23E+03
	1.0E-02	2-Nitrotoluene	--	--	--	2.46E+04
1.1E-01	3.0E-03	RDX	6.25E+01	6.25E+02	6.25E+03	7.37E+03
	1.0E-02	Tetryl	--	--	--	2.46E+04
	3.0E-02	1,3,5-Trinitrobenzene	--	--	--	7.37E+04
3.0E-02	5.0E-04	2,4,6-Trinitrotoluene	2.29E+02	2.29E+03	2.29E+04	1.23E+03
		<u>Pesticide/PCBs:</u>				
1.7E+01	3.0E-05	Aldrin	4.05E-01	4.05E+00	4.05E+01	7.37E+01
3.5E-01	5.0E-04	Chlordane	1.97E+01	1.97E+02	1.97E+03	1.23E+03
1.6E+01	5.0E-05	Dieldrin	4.30E-01	4.30E+00	4.30E+01	1.23E+02
2.4E-01	3.0E-03	DDD	2.87E+01	2.87E+02	2.87E+03	7.37E+03
3.4E-01	7.0E-04	DDE	2.02E+01	2.02E+02	2.02E+03	1.72E+03
3.4E-01	5.0E-04	DDT	2.02E+01	2.02E+02	2.02E+03	1.23E+03
	6.0E-03	Endosulfan	--	--	--	1.47E+04
	3.0E-04	Endrin	--	--	--	7.37E+02
4.5E+00	5.0E-04	Heptachlor	1.53E+00	1.53E+01	1.53E+02	1.23E+03
9.1E+00	1.3E-05	Heptachlor epoxide	7.56E-01	7.56E+00	7.56E+01	3.19E+01
		Isodrin	--	--	--	--
7.7E+00	2.0E-05	PCBs	8.93E-01	8.93E+00	8.93E+01	4.91E+01
		<u>Anions:</u>				
	1.6E+00	Nitrate	--	--	--	3.93E+06
	1.0E-01	Nitrite	--	--	--	2.46E+05

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BW _a	kg	70
ATNC	days	9125
ATC	days	25550
IR _a	mg/day	50
CF	kg/mg	1E-06
FI	none	1
EF	days/yr	208
ED _a	yrs	25
HI	none	1

TABLE 5
Corrective Action Objectives (CAOs)
Soil Dermal Absorption--Depot Personnel

SF	RfD	Dermal		G-I	Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) for Hazard Index = 1.0
		SF	RfD	Abs. (a)	ABS		1E-06	1E-05	1E-04	
Metals:										
1.5E+00	1.0E+00		1.0E-01	1.0E-01	0.001	Aluminum	--	--	--	2.46E+06
	4.0E-04		8.0E-06	2.0E-02	0.001	Antimony	--	--	--	1.97E+02
	3.0E-04	3.7E+00	1.2E-04	4.1E-01	0.001	Arsenic	1.88E+01	1.88E+02	1.88E+03	3.02E+03
4.3E+00	7.0E-02		4.9E-03	7.0E-02	0.001	Barium	--	--	--	1.20E+05
	5.0E-03	4.3E+02	5.0E-05	1.0E-02	0.001	Beryllium	1.60E-01	1.60E+00	1.60E+01	1.23E+03
	1.0E-03		1.0E-05	1.0E-02	0.001	Cadmium	--	--	--	2.46E+02
	1.0E+00		5.0E-03	5.0E-03	0.001	Chromium (+3)	--	--	--	1.23E+05
	5.0E-03		1.0E-04	2.0E-02	0.001	Chromium (+6)	--	--	--	2.46E+03
	6.0E-02		4.8E-02	8.0E-01	0.001	Cobalt	--	--	--	1.18E+06
	3.7E-02		1.1E-02	3.0E-01	0.001	Copper	--	--	--	2.73E+05
	3.0E-01		4.5E-02	1.5E-01	0.001	Iron	--	--	--	1.11E+06
				1.5E-01	0.001	Lead	--	--	--	--
	2.4E-02		9.6E-04	4.0E-02	0.001	Manganese	--	--	--	2.36E+04
	3.0E-04		4.5E-05	1.5E-01	0.001	Mercury	--	--	--	1.11E+03
	2.0E-02		5.4E-03	2.7E-01	0.001	Nickel	--	--	--	1.33E+05
	5.0E-03		2.2E-03	4.4E-01	0.001	Selenium	--	--	--	5.40E+04
	5.0E-03		9.0E-04	1.8E-01	0.001	Silver	--	--	--	2.21E+04
	8.0E-05		1.2E-05	1.5E-01	0.001	Thallium	--	--	--	2.95E+02
	7.0E-03		7.0E-05	1.0E-02	0.001	Vanadium	--	--	--	1.72E+03
	3.0E-01		6.0E-02	2.0E-01	0.001	Zinc	--	--	--	1.47E+06
Volatiles:										
2.9E-02	1.0E-01		8.3E-02	8.3E-01	0.01	Acetone	--	--	--	2.04E+05
	3.0E-04	3.0E-02	2.9E-04	9.7E-01	0.01	Benzene	2.30E+02	2.30E+03	2.30E+04	7.15E+02
	2.0E+00		1.8E+00	9.2E-01	0.01	1,3-Dimethylbenzene	--	--	--	4.52E+06
	1.0E-01		9.7E-02	9.7E-01	0.01	Ethylbenzene	--	--	--	2.38E+05
5.2E-02	1.0E-02	5.2E-02	1.0E-02	1.0E+00	0.01	Tetrachloroethene	1.32E+02	1.32E+03	1.32E+04	2.46E+04
1.1E-02	6.0E-03	7.3E-02	9.0E-04	1.5E-01	0.01	Trichloroethene	9.38E+01	9.38E+02	9.38E+03	2.21E+03
	3.0E-01		6.9E-02	2.3E-01	0.01	Trichlorofluoromethane	--	--	--	1.70E+05
	2.0E-01		1.6E-01	8.0E-01	0.01	Toluene	--	--	--	3.93E+05
	2.0E+00		1.8E+00	9.2E-01	0.01	Xylenes	--	--	--	4.52E+06
Semivolatiles:										
	6.0E-02		1.9E-02	3.1E-01	0.01	Acenaphthene	--	--	--	4.57E+04
	3.0E-02		9.3E-03	3.1E-01	0.01	Acenaphthylene	--	--	--	2.28E+04
	3.0E-01		2.3E-01	7.6E-01	0.01	Anthracene	--	--	--	5.60E+05
7.3E-01		2.4E+00		3.1E-01	0.01	Benzo(a)anthracene	2.92E+00	2.92E+01	2.92E+02	--
7.3E+00		2.4E+01		3.1E-01	0.01	Benzo(a)pyrene	2.92E-01	2.92E+00	2.92E+01	--
7.3E-01		2.4E+00		3.1E-01	0.01	Benzo(b)fluoranthene	2.92E+00	2.92E+01	2.92E+02	--
7.3E-02		2.4E-01		3.1E-01	0.01	Benzo(k)fluoranthene	2.92E+01	2.92E+02	2.92E+03	--
	3.0E-02		9.3E-03	3.1E-01	0.01	Benzo(g,h,i)perylene	--	--	--	2.28E+04
1.4E-02	2.0E-02	7.4E-02	3.8E-03	1.9E-01	0.01	Bis(2-ethylhexyl) phthalate	9.34E+01	9.34E+02	9.34E+03	9.34E+03
	2.0E-01		1.2E-01	6.1E-01	0.01	Butyl benzyl phthalate	--	--	--	3.00E+05
7.3E-03		2.4E-02		3.1E-01	0.01	Chrysene	2.92E+02	2.92E+03	2.92E+04	--
7.3E+00		2.4E+01		3.1E-01	0.01	Dibenz(a,h)anthracene	2.92E-01	2.92E+00	2.92E+01	--
	4.0E-03		4.0E-03	1.0E+00	0.01	Dibenzofuran	--	--	--	9.83E+03
	9.0E-02		9.0E-02	1.0E+00	0.01	1,2-Dichlorobenzene	--	--	--	2.21E+05
	9.0E-04		9.0E-04	1.0E+00	0.01	1,3-Dichlorobenzene	--	--	--	2.21E+03
2.4E-02	2.0E-01	2.7E-02	1.8E-01	9.0E-01	0.01	1,4-Dichlorobenzene	2.58E+02	2.58E+03	2.58E+04	4.42E+05
	8.0E-01		7.2E-01	9.0E-01	0.01	Diethyl phthalate	--	--	--	1.77E+06
	1.0E-01		1.0E-01	1.0E+00	0.01	Di-n-butyl phthalate	--	--	--	2.46E+05
	2.0E-02		2.0E-02	1.0E+00	0.01	Di-n-octyl phthalate	--	--	--	4.91E+04
	4.0E-02		1.2E-02	3.1E-01	0.01	Fluoranthene	--	--	--	3.05E+04
	4.0E-02		4.0E-02	1.0E+00	0.01	Fluorene	--	--	--	9.83E+04
7.3E-01		2.4E+00		3.1E-01	0.01	Indeno(1,2,3-cd)pyrene	2.92E+00	2.92E+01	2.92E+02	--
	4.0E-02		3.2E-02	8.0E-01	0.01	2-Methylnaphthalene	--	--	--	7.86E+04
	4.0E-02		3.2E-02	8.0E-01	0.01	Naphthalene	--	--	--	7.86E+04
	3.0E-02		2.2E-02	7.3E-01	0.01	Phenanthrene	--	--	--	5.38E+04

TABLE 5 (cont'd)
Corrective Action Objectives (CAOs)
Soil Dermal Absorption--Depot Personnel

SF	Dermal		Dermal		G-I	Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) for Hazard Index = 1.0
	Rfd	SF	RfD	Abs. (a)	ABS	1E-06		1E-05	1E-04		
	6.0E-01		5.4E-01	9.0E-01	0.01	Phenol	--	--	--	1.33E+06	
	3.0E-02		9.3E-03	3.1E-01	0.01	Pyrene	--	--	--	2.28E+04	
						<u>Explosives:</u>					
	1.0E-04		6.5E-05	6.5E-01	0.01	1,3-Dinitrobenzene	--	--	--	1.60E+02	
6.8E-01	2.0E-03	8.0E-01	1.7E-03	8.5E-01	0.01	2,4-Dinitrotoluene	8.60E+00	8.60E+01	8.60E+02	4.18E+03	
6.8E-01	1.0E-03	8.0E-01	8.5E-04	8.5E-01	0.01	2,6-Dinitrotoluene	8.60E+00	8.60E+01	8.60E+02	2.09E+03	
	5.0E-02		7.5E-03	1.5E-01	0.01	HMX	--	--	--	1.84E+04	
	5.0E-04		4.9E-04	9.7E-01	0.01	Nitrobenzene	--	--	--	1.19E+03	
	1.0E-02		1.0E-02	1.0E+00	0.01	2-Nitrotoluene	--	--	--	2.46E+04	
1.1E-01	3.0E-03	1.1E-01	3.0E-03	1.0E+00	0.01	RDX	6.25E+01	6.25E+02	6.25E+03	7.37E+03	
	1.0E-02		5.0E-03	5.0E-01	0.01	Tetryl	--	--	--	1.23E+04	
	3.0E-02		2.0E-02	6.5E-01	0.01	1,3,5-Trinitrobenzene	--	--	--	4.79E+04	
3.0E-02	5.0E-04	5.0E-02	3.0E-04	6.0E-01	0.01	2,4,6-Trinitrotoluene	1.38E+02	1.38E+03	1.38E+04	7.37E+02	
						<u>Pesticide/PCBs:</u>					
1.7E+01	3.0E-05	3.4E+01	1.5E-05	5.0E-01	0.01	Aldrin	2.02E-01	2.02E+00	2.02E+01	3.69E+01	
3.5E-01	5.0E-04	7.0E-01	2.5E-04	5.0E-01	0.01	Chlordane	9.83E+00	9.83E+01	9.83E+02	6.14E+02	
1.6E+01	5.0E-05	3.2E+01	2.5E-05	5.0E-01	0.01	Dieldrin	2.15E-01	2.15E+00	2.15E+01	6.14E+01	
2.4E-01	3.0E-03	3.4E-01	2.1E-03	7.0E-01	0.01	DDD	2.01E+01	2.01E+02	2.01E+03	5.16E+03	
3.4E-01	7.0E-04	4.9E-01	4.9E-04	7.0E-01	0.01	DDE	1.42E+01	1.42E+02	1.42E+03	1.20E+03	
3.4E-01	5.0E-04	4.9E-01	3.5E-04	7.0E-01	0.01	DDT	1.42E+01	1.42E+02	1.42E+03	8.60E+02	
	6.0E-03		6.0E-03	1.0E+00	0.01	Endosulfan	--	--	--	1.47E+04	
	3.0E-04		6.0E-06	2.0E-02	0.01	Endrin	--	--	--	1.47E+01	
4.5E+00	5.0E-04	6.3E+00	3.6E-04	7.2E-01	0.01	Heptachlor	1.10E+00	1.10E+01	1.10E+02	8.84E+02	
9.1E+00	1.3E-05	1.3E+01	9.4E-06	7.2E-01	0.01	Heptachlor epoxide	5.44E-01	5.44E+00	5.44E+01	2.30E+01	
				1.0E+00	0.01	Isodrin	--	--	--	--	
7.7E+00	2.0E-05	8.6E+00	1.8E-05	9.0E-01	0.01	PCBs	8.04E-01	8.04E+00	8.04E+01	4.42E+01	
						<u>Anions:</u>					
	1.6E+00		8.0E-01	5.0E-01	0.001	Nitrate	--	--	--	1.97E+07	
	1.0E-01		5.0E-02	5.0E-01	0.001	Nitrite	--	--	--	1.23E+06	

-- Indicates that the relevant health effects criteria are unavailable.

(a) - Gastrointestinal absorption data from ORNL (1995). GI absorption assumed to be 100% when data are unavailable.

Variable	Units	Value
Risk	none	1E-06
BWa	kg	70
ATNC	days	9125
ATC	days	25550
AF	mg/cm ²	1
CF	kg/mg	1E-06
SA	cm ²	5000
EV	events/day	1
EF	days/yr	208
EDa	hrs	25
HI	none	1

TABLE 6
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation—Depot Personnel

SF	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ=1.0
				1E-06	1E-05	1E-04	
			<u>Metals:</u>				
1.5E+01	1.4E-03	0.3	Aluminum	--	--	--	4.41E-02
		0.3	Antimony	--	--	--	--
		0.3	Arsenic	5.88E-06	5.88E-05	5.88E-04	--
	1.0E-04	0.3	Barium	--	--	--	3.15E-03
8.4E+00		0.3	Beryllium	1.05E-05	1.05E-04	1.05E-03	--
6.3E+00		0.3	Cadmium	1.40E-05	1.40E-04	1.40E-03	--
		0.3	Chromium (+3)	--	--	--	--
4.2E+01	1.1E-06	0.3	Chromium (+6)	2.10E-06	2.10E-05	2.10E-04	3.46E-05
	5.7E-06	0.3	Cobalt	--	--	--	1.80E-04
		0.3	Copper	--	--	--	--
		0.3	Iron	--	--	--	--
		0.3	Lead	--	--	--	--
	1.4E-05	0.3	Manganese	--	--	--	4.50E-04
	8.6E-05	0.3	Mercury	--	--	--	2.70E-03
8.4E-01		0.3	Nickel	1.05E-04	1.05E-03	1.05E-02	--
		0.3	Selenium	--	--	--	--
	2.9E-06	0.3	Silver	--	--	--	9.13E-05
		0.3	Thallium	--	--	--	--
		0.3	Vanadium	--	--	--	--
		0.3	Zinc	--	--	--	--
			<u>Volatiles:</u>				
2.9E-02		1.0	Acetone	--	--	--	--
		1.0	Benzene	9.12E-04	9.12E-03	9.12E-02	--
		1.0	1,3-Dimethylbenzene	--	--	--	--
	2.9E-01	1.0	Ethylbenzene	--	--	--	2.70E+00
2.0E-03	1.2E-01	1.0	Tetrachloroethene	1.30E-02	1.30E-01	1.30E+00	1.13E+00
6.0E-03		1.0	Trichloroethene	4.41E-03	4.41E-02	4.41E-01	--
	2.0E-01	1.0	Trichlorofluoromethane	--	--	--	1.89E+00
	1.1E-01	1.0	Toluene	--	--	--	1.08E+00
		1.0	Xylenes	--	--	--	--
			<u>Semivolatiles:</u>				
		0.3	Acenaphthene	--	--	--	--
		0.3	Acenaphthalene	--	--	--	--
		0.3	Anthracene	--	--	--	--
6.1E-01		0.3	Benzo(a)anthracene	1.45E-04	1.45E-03	1.45E-02	--
6.1E+00		0.3	Benzo(a)pyrene	1.45E-05	1.45E-04	1.45E-03	--
6.1E-01		0.3	Benzo(b)fluoranthene	1.45E-04	1.45E-03	1.45E-02	--
6.1E-02		0.3	Benzo(k)fluoranthene	1.45E-03	1.45E-02	1.45E-01	--
		0.3	Benzo(g,h,i)perylene	--	--	--	--
1.4E-02	5.7E-02	0.3	Bis(2-ethylhexyl) phthalate	6.30E-03	6.30E-02	6.30E-01	1.80E+00
		0.3	Butyl benzyl phthalate	--	--	--	--
6.1E-03		0.3	Chrysene	1.45E-02	1.45E-01	1.45E+00	--
6.1E+00		0.3	Dibenzo(a,h)anthracene	1.45E-05	1.45E-04	1.45E-03	--
		0.3	Dibenzofuran	--	--	--	--
	4.0E-02	0.3	1,2-Dichlorobenzene	--	--	--	1.26E+00
		0.3	1,3-Dichlorobenzene	--	--	--	--
	2.3E-01	0.3	1,4-Dichlorobenzene	--	--	--	7.20E+00
		0.3	Diethyl phthalate	--	--	--	--
		0.3	Di-n-butyl phthalate	--	--	--	--
		0.3	Di-n-octyl phthalate	--	--	--	--
		0.3	Fluoranthene	--	--	--	--
		0.3	Fluorene	--	--	--	--
6.1E-01		0.3	Indeno(1,2,3-cd)pyrene	1.45E-04	1.45E-03	1.45E-02	--

TABLE 6 (cont'd)
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation--Depot Personnel

SF	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ = 1.0
				1E-06	1E-05	1E-04	
		0.3	2-Methylnaphthalene	--	--	--	--
	1.2E-04	0.3	Naphthalene	--	--	--	3.78E-03
		0.3	Phenanthrene	--	--	--	--
		0.3	Phenol	--	--	--	--
		0.3	Pyrene	--	--	--	--
			<u>Explosives:</u>				
		0.3	2,4-Dinitrotoluene	--	--	--	--
		0.3	2,6-Dinitrotoluene	--	--	--	--
		0.3	HMX	--	--	--	--
	6.0E-04	0.3	Nitrobenzene	--	--	--	1.89E-02
		0.3	RDX	--	--	--	--
		0.3	1,3,5-Trinitrobenzene	--	--	--	--
		0.3	2,4,6-Trinitrotoluene	--	--	--	--
			<u>Pesticides/PCBs:</u>				
1.7E+01		0.3	Aldrin	5.19E-06	5.19E-05	5.19E-04	--
3.5E-01		0.3	Chlordane	2.52E-04	2.52E-03	2.52E-02	--
1.6E+01		0.3	Dieldrin	5.51E-06	5.51E-05	5.51E-04	--
2.4E-01		0.3	DDD	3.67E-04	3.67E-03	3.67E-02	--
3.4E-01		0.3	DDE	2.59E-04	2.59E-03	2.59E-02	--
3.4E-01		0.3	DDT	2.60E-04	2.60E-03	2.60E-02	--
		0.3	Endosulfan	--	--	--	--
		0.3	Endrin	--	--	--	--
4.5E+00		0.3	Heptachlor	1.96E-05	1.96E-04	1.96E-03	--
9.1E+00		0.3	Heptachlor epoxide	9.69E-06	9.69E-05	9.69E-04	--
		0.3	Isodrin	--	--	--	--
		0.3	PCBs	--	--	--	--
			<u>Anions:</u>				
	1.6E+00	0.3	Nitrate	--	--	--	5.04E+01
	1.0E-01	0.3	Nitrite	--	--	--	3.15E+00

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	9125
ATC	days	25550
ET	hrs/day	1.0E+01
EF	days/yr	208
ED	yrs	25
HI	none	1
BW	kg	70
IR	m ³ /hour	1.3

TABLE 7

CAOs for Known Releases SWMUs at TEAD--Surface Soil (µg/g)
Future Land Use--Depot Personnel

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
<u>Metals:</u>			
Aluminum	2.46E+06	2.46E+06	(b)
Antimony	9.83E+02	1.97E+02	1.64E+02
Arsenic	4.59E+00	1.88E+01	3.69E+00
Barium	1.72E+05	1.20E+05	7.08E+04
Beryllium	1.60E+00	1.60E-01	1.45E-01
Cadmium	2.46E+03	2.46E+02	2.23E+02
Chromium (+3)	2.46E+06	1.23E+05	1.17E+05
Chromium (+6)	1.23E+04	2.46E+03	2.05E+03
Cobalt	1.47E+05	1.18E+06	1.31E+05
Copper	9.11E+04	2.73E+05	6.84E+04
Iron	7.37E+05	1.11E+06	4.42E+05
Lead	--	--	--
Manganese	5.90E+04	2.36E+04	1.68E+04
Mercury	7.37E+02	1.11E+03	4.42E+02
Nickel	4.91E+04	1.33E+05	3.59E+04
Selenium	1.23E+04	5.40E+04	1.00E+04
Silver	1.23E+04	2.21E+04	7.90E+03
Thallium	1.97E+02	2.95E+02	1.18E+02
Vanadium	1.72E+04	1.72E+03	1.56E+03
Zinc	7.37E+05	1.47E+06	4.91E+05
<u>Volatiles:</u>			
Acetone	2.46E+05	2.04E+05	1.11E+05
Benzene	2.37E+02	2.30E+02	1.17E+02
1,3-Dimethylbenzene	4.91E+06	4.52E+06	(b)
Ethylbenzene	2.46E+05	2.38E+05	1.21E+05
Tetrachloroethene	1.32E+02	1.32E+02	6.61E+01
Trichloroethene	6.25E+02	9.38E+01	8.16E+01
Trichlorofluoromethane	7.37E+05	1.70E+05	1.38E+05
Toluene	4.91E+05	3.93E+05	2.18E+05
Xylenes	4.91E+06	4.52E+06	(b)
<u>Semivolatiles:</u>			
Acenaphthene	1.47E+05	4.57E+04	3.49E+04
Acenaphthylene	7.37E+04	2.28E+04	1.74E+04
Anthracene	7.37E+05	5.60E+05	3.18E+05
Benzo(a)anthracene	9.42E+00	2.92E+00	2.23E+00
Benzo(a)pyrene	9.42E-01	2.92E-01	2.23E-01
Benzo(b)fluoranthene	9.42E+00	2.92E+00	2.23E+00
Benzo(k)fluoranthene	9.42E+01	2.92E+01	2.23E+01
Benzo(g,h,i)perylene	7.37E+04	2.28E+04	1.74E+04
Bis(2-ethylhexyl) phthalate	4.91E+02	9.34E+01	7.85E+01
Butyl benzyl phthalate	4.91E+05	3.00E+05	1.86E+05
Chrysene	9.42E+02	2.92E+02	2.23E+02
Dibenz(a,h)anthracene	9.42E-01	2.92E-01	2.23E-01
Dibenzofuran	9.83E+03	9.83E+03	4.91E+03
1,2-Dichlorobenzene	2.21E+05	2.21E+05	1.11E+05
1,3-Dichlorobenzene	2.21E+03	2.21E+03	1.11E+03
1,4-Dichlorobenzene	2.87E+02	2.58E+02	1.36E+02
Diethyl phthalate	1.97E+06	1.77E+06	9.31E+05
Di-n-butyl phthalate	2.46E+05	2.46E+05	1.23E+05
Di-n-octyl phthalate	4.91E+04	4.91E+04	2.46E+04

TABLE 7 (cont'd)

**CAOs for Known Releases SWMUs at TEAD--Surface Soil (µg/g)
Future Land Use--Depot Personnel**

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
Fluoranthene	9.83E+04	3.05E+04	2.33E+04
Fluorene	9.83E+04	9.83E+04	4.91E+04
Indeno(1,2,3-cd)pyrene	9.42E+00	2.92E+00	2.23E+00
2-Methylnaphthalene	9.83E+04	7.86E+04	4.37E+04
Naphthalene	9.83E+04	7.86E+04	4.37E+04
Phenanthrene	7.37E+04	5.38E+04	3.11E+04
Phenol	1.47E+06	1.33E+06	6.98E+05
Pyrene	7.37E+04	2.28E+04	1.74E+04
<u>Explosives:</u>			
1,3-Dinitrobenzene	2.46E+02	1.60E+02	9.68E+01
2,4-Dinitrotoluene	1.01E+01	8.60E+00	4.65E+00
2,6-Dinitrotoluene	1.01E+01	8.60E+00	4.65E+00
HMX	1.23E+05	1.84E+04	1.60E+04
Nitrobenzene	1.23E+03	1.19E+03	6.05E+02
2-Nitrotoluene	2.46E+04	2.46E+04	1.23E+04
RDX	6.25E+01	6.25E+01	3.13E+01
Tetryl	2.46E+04	1.23E+04	8.19E+03
1,3,5-Trinitrobenzene	7.37E+04	4.79E+04	2.90E+04
2,4,6-Trinitrotoluene	2.29E+02	1.38E+02	8.60E+01
<u>Pesticide/PCBs:</u>			
Aldrin	4.05E-01	2.02E-01	1.35E-01
Chlordane	1.97E+01	9.83E+00	6.55E+00
Dieldrin	4.30E-01	2.15E-01	1.43E-01
DDD	2.87E+01	2.01E+01	1.18E+01
DDE	2.02E+01	1.42E+01	8.33E+00
DDT	2.02E+01	1.42E+01	8.33E+00
Endosulfan	1.47E+04	1.47E+04	7.37E+03
Endrin	7.37E+02	1.47E+01	1.45E+01
Heptachlor	1.53E+00	1.10E+00	6.40E-01
Heptachlor epoxide	7.56E-01	5.44E-01	3.16E-01
Isodrin	-	-	-
PCBs	8.93E-01	8.04E-01	4.23E-01
<u>Anions</u>			
Nitrate	3.93E+06	1.97E+07	(b)
Nitrite	2.46E+05	1.23E+06	2.05E+05

'-' Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on $1/[(1/\text{Ingestion CAO}) + (1/\text{Dermal CAO})]$, see Attachment 3 for derivation.

(b) - No CAO listed because the calculated CAO is greater than one million parts per million (µg/g).

TABLE 8
Corrective Action Objectives (CAOs)
Soil Ingestion—Future Industrial Worker

SF	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ=1.0
			1E-06	1E-05	1E-04	
		<u>Metals:</u>				
	1.0E+00	Aluminum	--	--	--	2.04E+06
	4.0E-04	Antimony	--	--	--	8.18E+02
1.5E+00	3.0E-04	Arsenic	3.82E+00	3.82E+01	3.82E+02	6.13E+02
	7.0E-02	Barium	--	--	--	1.43E+05
4.3E+00	5.0E-03	Beryllium	1.33E+00	1.33E+01	1.33E+02	1.02E+04
	1.0E-03	Cadmium	--	--	--	2.04E+03
	1.0E+00	Chromium (+3)	--	--	--	2.04E+06
	5.0E-03	Chromium (+6)	--	--	--	1.02E+04
	6.0E-02	Cobalt	--	--	--	1.23E+05
	3.7E-02	Copper	--	--	--	7.58E+04
	3.0E-01	Iron	--	--	--	6.13E+05
		Lead	--	--	--	--
	2.4E-02	Manganese	--	--	--	4.91E+04
	3.0E-04	Mercury	--	--	--	6.13E+02
	2.0E-02	Nickel	--	--	--	4.09E+04
	5.0E-03	Selenium	--	--	--	1.02E+04
	5.0E-03	Silver	--	--	--	1.02E+04
	8.0E-05	Thallium	--	--	--	1.64E+02
	7.0E-03	Vanadium	--	--	--	1.43E+04
	3.0E-01	Zinc	--	--	--	6.13E+05
		<u>Volatiles:</u>				
	1.0E-01	Acetone	--	--	--	2.04E+05
2.9E-02	3.0E-04	Benzene	1.97E+02	1.97E+03	1.97E+04	6.13E+02
	2.0E+00	1,3-Dimethylbenzene	--	--	--	4.09E+06
	1.0E-01	Ethylbenzene	--	--	--	2.04E+05
5.2E-02	1.0E-02	Tetrachloroethene	1.10E+02	1.10E+03	1.10E+04	2.04E+04
1.1E-02	6.0E-03	Trichloroethene	5.20E+02	5.20E+03	5.20E+04	1.23E+04
	3.0E-01	Trichlorofluoromethane	--	--	--	6.13E+05
	2.0E-01	Toluene	--	--	--	4.09E+05
	2.0E+00	Xylenes	--	--	--	4.09E+06
		<u>Semivolatiles:</u>				
	6.0E-02	Acenaphthene	--	--	--	1.23E+05
	3.0E-02	Acenaphthylene	--	--	--	6.13E+04
	3.0E-01	Anthracene	--	--	--	6.13E+05
7.3E-01		Benzo(a)anthracene	7.84E+00	7.84E+01	7.84E+02	--
7.3E+00		Benzo(a)pyrene	7.84E-01	7.84E+00	7.84E+01	--
7.3E-01		Benzo(b)fluoranthene	7.84E+00	7.84E+01	7.84E+02	--
7.3E-02		Benzo(k)fluoranthene	7.84E+01	7.84E+02	7.84E+03	--
	3.0E-02	Benzo(g,h,i)perylene	--	--	--	6.13E+04
1.4E-02	2.0E-02	Bis(2-ethylhexyl) phthalate	4.09E+02	4.09E+03	4.09E+04	4.09E+04
	2.0E-01	Butyl benzyl phthalate	--	--	--	4.09E+05
7.3E-03		Chrysene	7.84E+02	7.84E+03	7.84E+04	--
7.3E+00		Dibenz(a,h)anthracene	7.84E-01	7.84E+00	7.84E+01	--
	4.0E-03	Dibenzofuran	--	--	--	8.18E+03
	9.0E-02	1,2-Dichlorobenzene	--	--	--	1.84E+05
	9.0E-04	1,3-Dichlorobenzene	--	--	--	1.84E+03
2.4E-02	2.0E-01	1,4-Dichlorobenzene	2.38E+02	2.38E+03	2.38E+04	4.09E+05
	8.0E-01	Diethyl phthalate	--	--	--	1.64E+06
	1.0E-01	Di-n-butyl phthalate	--	--	--	2.04E+05
	2.0E-02	Di-n-octyl phthalate	--	--	--	4.09E+04
	4.0E-02	Fluoranthene	--	--	--	8.18E+04
	4.0E-02	Fluorene	--	--	--	8.18E+04
7.3E-01		Indeno(1,2,3-cd)pyrene	7.84E+00	7.84E+01	7.84E+02	--

TABLE 8 (cont'd)
Corrective Action Objectives (CAOs)
Soil Ingestion--Future Industrial Worker

SE	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ=1.0
			1E-06	1E-05	1E-04	
	4.0E-02	2-Methylnaphthalene	--	--	--	8.18E+04
	4.0E-02	Naphthalene	--	--	--	8.18E+04
	3.0E-02	Phenanthrene	--	--	--	6.13E+04
	6.0E-01	Phenol	--	--	--	1.23E+06
	3.0E-02	Pyrene	--	--	--	6.13E+04
		<u>Explosives:</u>				
6.8E-01	2.0E-03	2,4-Dinitrotoluene	8.42E+00	8.42E+01	8.42E+02	4.09E+03
6.8E-01	1.0E-03	2,6-Dinitrotoluene	8.42E+00	8.42E+01	8.42E+02	2.04E+03
	5.0E-02	HMX	--	--	--	1.02E+05
	5.0E-04	Nitrobenzene	--	--	--	1.02E+03
1.1E-01	3.0E-03	RDX	5.20E+01	5.20E+02	5.20E+03	6.13E+03
	3.0E-02	1,3,5-Trinitrobenzene	--	--	--	6.13E+04
3.0E-02	5.0E-04	2,4,6-Trinitrotoluene	1.91E+02	1.91E+03	1.91E+04	1.02E+03
		<u>Pesticide/PCBs:</u>				
1.7E+01	3.0E-05	Aldrin	3.37E-01	3.37E+00	3.37E+01	6.13E+01
3.5E-01	5.0E-04	Chlordane	1.64E+01	1.64E+02	1.64E+03	1.02E+03
1.6E+01	5.0E-05	Dieldrin	3.58E-01	3.58E+00	3.58E+01	1.02E+02
2.4E-01	3.0E-03	DDD	2.38E+01	2.38E+02	2.38E+03	6.13E+03
3.4E-01	7.0E-04	DDE	1.68E+01	1.68E+02	1.68E+03	1.43E+03
3.4E-01	5.0E-04	DDT	1.68E+01	1.68E+02	1.68E+03	1.02E+03
	6.0E-03	Endosulfan	--	--	--	1.23E+04
	3.0E-04	Endrin	--	--	--	6.13E+02
4.5E+00	5.0E-04	Heptachlor	1.27E+00	1.27E+01	1.27E+02	1.02E+03
9.1E+00	1.3E-05	Heptachlor epoxide	6.29E-01	6.29E+00	6.29E+01	2.66E+01
		Isodrin	--	--	--	--
7.7E+00	2.0E-05	PCBs	7.43E-01	7.43E+00	7.43E+01	4.09E+01
		<u>Anions:</u>				
	1.6E+00	Nitrate	--	--	--	3.27E+06
	1.0E-01	Nitrite	--	--	--	2.04E+05

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BW _a	kg	70
ATNC	days	9125
ATC	days	25550
IR _a	mg/day	50
CF	kg/mg	1E-06
FI	none	1
EF	days/yr	250
ED _a	yr	25
HI	none	1

TABLE 9
Corrective Action Objectives (CAOs)
Soil Dermal Absorption—Future Industrial Worker

SF	Rfd	Dermal	Dermal	G-I	Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at
		SF	RD	Abs.	ABS		1E-06	1E-05	1E-04	Target HQ = 1.0
<u>Metals:</u>										
1.50E+00	1.0E+00	3.7E+00	1.0E-01	1.0E-01	0.001	Aluminum	--	--	--	2.04E+06
	4.0E-04		8.0E-06	2.0E-02	0.001	Antimony	--	--	--	1.64E+02
	3.0E-04		1.2E-04	4.1E-01	0.001	Arsenic	1.56E+01	1.56E+02	1.56E+03	2.51E+03
4.30E+00	7.0E-02	4.3E+02	4.9E-03	7.0E-02	0.001	Barium	--	--	--	1.00E+05
	5.0E-03		5.0E-05	1.0E-02	0.001	Beryllium	1.33E-01	1.33E+00	1.33E+01	1.02E+03
	1.0E-03		1.0E-05	1.0E-02	0.001	Cadmium	--	--	--	2.04E+02
	1.0E+00		5.0E-03	5.0E-03	0.001	Chromium (+3)	--	--	--	1.02E+05
	5.0E-03		1.0E-04	2.0E-02	0.001	Chromium (+6)	--	--	--	2.04E+03
	6.0E-02		4.8E-02	8.0E-01	0.001	Cobalt	--	--	--	9.81E+05
	3.7E-02		1.1E-02	3.0E-01	0.001	Copper	--	--	--	2.27E+05
	3.0E-01		4.5E-02	1.5E-01	0.001	Iron	--	--	--	9.20E+05
				1.5E-01	0.001	Lead	--	--	--	--
	2.4E-02		9.6E-04	4.0E-02	0.001	Manganese	--	--	--	1.96E+04
	3.0E-04		4.5E-05	1.5E-01	0.001	Mercury	--	--	--	9.20E+02
	2.0E-02		5.4E-03	2.7E-01	0.001	Nickel	--	--	--	1.10E+05
5.0E-03	2.2E-03	4.4E-01	0.001	Selenium	--	--	--	4.50E+04		
5.0E-03	9.0E-04	1.8E-01	0.001	Silver	--	--	--	1.84E+04		
8.0E-05	1.2E-05	1.5E-01	0.001	Thallium	--	--	--	2.45E+02		
7.0E-03	7.0E-05	1.0E-02	0.001	Vanadium	--	--	--	1.43E+03		
3.0E-01	6.0E-02	2.0E-01	0.001	Zinc	--	--	--	1.23E+06		
<u>Volatiles:</u>										
2.90E-02	1.0E-01	3.0E-02	8.3E-02	8.3E-01	0.01	Acetone	--	--	--	1.70E+05
	3.0E-04		2.9E-04	9.7E-01	0.01	Benzene	1.91E+02	1.91E+03	1.91E+04	5.95E+02
	2.0E+00		1.8E+00	9.2E-01	0.01	1,3-Dimethylbenzene	--	--	--	3.76E+06
5.20E-02	1.0E-01	5.2E-02	9.7E-02	9.7E-01	0.01	Ethylbenzene	--	--	--	1.98E+05
	1.0E-02		1.0E-02	1.0E+00	0.01	Tetrachloroethene	1.10E+02	1.10E+03	1.10E+04	2.04E+04
1.10E-02	6.0E-03	7.3E-02	9.0E-04	1.5E-01	0.01	Trichloroethene	7.80E+01	7.80E+02	7.80E+03	1.84E+03
	3.0E-01		6.9E-02	2.3E-01	0.01	Trichlorofluoromethane	--	--	--	1.41E+05
	2.0E-01		1.6E-01	8.0E-01	0.01	Toluene	--	--	--	3.27E+05
	2.0E+00		1.8E+00	9.2E-01	0.01	Xylenes	--	--	--	3.76E+06
	6.0E-02		1.9E-02	3.1E-01	0.01	Acenaphthene	--	--	--	3.80E+04
	3.0E-02		9.3E-03	3.1E-01	0.01	Acenaphthylene	--	--	--	1.90E+04
	3.0E-01		2.3E-01	7.6E-01	0.01	Anthracene	--	--	--	4.66E+05
7.30E-01	2.4E+00		3.1E-01	3.1E-01	0.01	Benzo(a)anthracene	2.43E+00	2.43E+01	2.43E+02	--
7.30E+00	2.4E+01		3.1E-01	3.1E-01	0.01	Benzo(a)pyrene	2.43E-01	2.43E+00	2.43E+01	--
7.30E-01	2.4E+00		3.1E-01	3.1E-01	0.01	Benzo(b)fluoranthene	2.43E+00	2.43E+01	2.43E+02	--
7.30E-02	2.4E-01		3.1E-01	3.1E-01	0.01	Benzo(k)fluoranthene	2.43E+01	2.43E+02	2.43E+03	--
1.40E-02	3.0E-02	7.4E-02	9.3E-03	3.1E-01	0.01	Benzo(g,h,i)perylene	--	--	--	1.90E+04
	2.0E-02		3.8E-03	1.9E-01	0.01	Bis(2-ethylhexyl) phthalate	7.77E+01	7.77E+02	7.77E+03	7.77E+03
	2.0E-01		1.2E-01	6.1E-01	0.01	Butyl benzyl phthalate	--	--	--	2.49E+05
7.30E-03	2.4E-02		3.1E-01	3.1E-01	0.01	Chrysene	2.43E+02	2.43E+03	2.43E+04	--
7.30E+00	2.4E+01		3.1E-01	3.1E-01	0.01	Dibenz(a,h)anthracene	2.43E-01	2.43E+00	2.43E+01	--
2.40E-02	4.0E-03	2.7E-02	4.0E-03	1.0E+00	0.01	Dibenzofuran	--	--	--	8.18E+03
	9.0E-02		9.0E-02	1.0E+00	0.01	1,2-Dichlorobenzene	--	--	--	1.84E+05
	9.0E-04		9.0E-04	1.0E+00	0.01	1,3-Dichlorobenzene	--	--	--	1.84E+03
	2.0E-01		1.8E-01	9.0E-01	0.01	1,4-Dichlorobenzene	2.15E+02	2.15E+03	2.15E+04	3.68E+05
	8.0E-01		7.2E-01	9.0E-01	0.01	Diethyl phthalate	--	--	--	1.47E+06
	1.0E-01		1.0E-01	1.0E+00	0.01	Di-n-butyl phthalate	--	--	--	2.04E+05
	2.0E-02		2.0E-02	1.0E+00	0.01	Di-n-octyl phthalate	--	--	--	4.09E+04
	4.0E-02		1.2E-02	3.1E-01	0.01	Fluoranthene	--	--	--	2.53E+04
7.30E-01	2.4E+00		4.0E-02	1.0E+00	0.01	Fluorene	--	--	--	8.18E+04
	4.0E-02		3.1E-01	3.1E-01	0.01	Indeno(1,2,3-cd)pyrene	2.43E+00	2.43E+01	2.43E+02	--
	4.0E-02		3.2E-02	8.0E-01	0.01	2-Methylnaphthalene	--	--	--	6.54E+04

TABLE 9 (cont'd)
Corrective Action Objectives (CAOs)
Soil Dermal Absorption—Future Industrial Worker

SF	RfD	Dermal		G-I		Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
		SF	RfD	Abs.	ABS			1E-06	1E-05	1E-04	
	4.0E-02		3.2E-02	8.0E-01	0.01		Naphthalene	--	--	--	6.54E+04
	3.0E-02		2.2E-02	7.3E-01	0.01		Phenanthrene	--	--	--	4.48E+04
	6.0E-01		5.4E-01	9.0E-01	0.01		Phenol	--	--	--	1.10E+06
	3.0E-02		9.3E-03	3.1E-01	0.01		Pyrene	--	--	--	1.90E+04
<u>Explosives:</u>											
6.80E-01	2.0E-03	8.0E-01	1.7E-03	8.5E-01	0.01		2,4-Dinitrotoluene	7.15E+00	7.15E+01	7.15E+02	3.47E+03
6.80E-01	1.0E-03	8.0E-01	8.5E-04	8.5E-01	0.01		2,6-Dinitrotoluene	7.15E+00	7.15E+01	7.15E+02	1.74E+03
	5.0E-02		7.5E-03	1.5E-01	0.01		HMX	--	--	--	1.53E+04
	5.0E-04		4.9E-04	9.7E-01	0.01		Nitrobenzene	--	--	--	9.91E+02
1.10E-01	3.0E-03	1.1E-01	3.0E-03	1.0E+00	0.01		RDX	5.20E+01	5.20E+02	5.20E+03	6.13E+03
	3.0E-02		2.0E-02	6.5E-01	0.01		1,3,5-Trinitrobenzene	--	--	--	3.99E+04
3.00E-02	5.0E-04	5.0E-02	3.0E-04	6.0E-01	0.01		2,4,6-Trinitrotoluene	1.14E+02	1.14E+03	1.14E+04	6.13E+02
<u>Pesticide/PCBs:</u>											
1.70E+01	3.0E-05	3.4E+01	1.5E-05	5.0E-01	0.01		Aldrin	1.68E-01	1.68E+00	1.68E+01	3.07E+01
3.50E-01	5.0E-04	7.0E-01	2.5E-04	5.0E-01	0.01		Chlordane	8.18E+00	8.18E+01	8.18E+02	5.11E+02
1.60E+01	5.0E-05	3.2E+01	2.5E-05	5.0E-01	0.01		Dieldrin	1.79E-01	1.79E+00	1.79E+01	5.11E+01
2.40E-01	3.0E-03	3.4E-01	2.1E-03	7.0E-01	0.01		DDD	1.67E+01	1.67E+02	1.67E+03	4.29E+03
3.40E-01	7.0E-04	4.9E-01	4.9E-04	7.0E-01	0.01		DDE	1.18E+01	1.18E+02	1.18E+03	1.00E+03
3.40E-01	5.0E-04	4.9E-01	3.5E-04	7.0E-01	0.01		DDT	1.18E+01	1.18E+02	1.18E+03	7.15E+02
	6.0E-03		6.0E-03	1.0E+00	0.01		Endosulfan	--	--	--	1.23E+04
	3.0E-04		6.0E-06	2.0E-02	0.01		Endrin	--	--	--	1.23E+01
4.50E+00	5.0E-04	6.3E+00	3.6E-04	7.2E-01	0.01		Heptachlor	9.16E-01	9.16E+00	9.16E+01	7.36E+02
9.10E+00	1.3E-05	1.3E+01	9.4E-06	7.2E-01	0.01		Heptachlor epoxide	4.53E-01	4.53E+00	4.53E+01	1.91E+01
				1.0E+00	0.01		Isodrin	--	--	--	--
7.70E+00	2.0E-05	8.6E+00	1.8E-05	9.0E-01	0.01		PCBs	6.69E-01	6.69E+00	6.69E+01	3.68E+01
<u>Anions:</u>											
	1.6E+00		8.0E-01	5.0E-01	0.001		Nitrate	--	--	--	1.64E+07
	1.0E-01		5.0E-02	5.0E-01	0.001		Nitrite	--	--	--	1.02E+06

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
BW	kg	70
ATNC	days	9125
ATC	days	25550
AF	mg/cm ²	1
CF	kg/mg	1E-06
SA	cm ²	5000
EV	events/day	1
EF	days/yr	250
ED	hrs	25
HI	none	1

TABLE 10
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation—Future Industrial Worker

SF	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ=1.0
				1E-06	1E-05	1E-04	
			<u>Metals:</u>				
1.5E+01	1.4E-03	0.3	Aluminum	--	--	--	4.59E-02
		0.3	Antimony	--	--	--	--
		0.3	Arsenic	6.11E-06	6.11E-05	6.11E-04	--
	1.0E-04	0.3	Barium	--	--	--	3.28E-03
8.4E+00		0.3	Beryllium	1.09E-05	1.09E-04	1.09E-03	--
6.3E+00		0.3	Cadmium	1.46E-05	1.46E-04	1.46E-03	--
		0.3	Chromium (+3)	--	--	--	--
4.2E+01	1.1E-06	0.3	Chromium (+6)	2.18E-06	2.18E-05	2.18E-04	3.60E-05
	5.7E-06	0.3	Cobalt	--	--	--	1.87E-04
		0.3	Copper	--	--	--	--
		0.3	Iron	--	--	--	--
		0.3	Lead	--	--	--	--
	1.4E-05	0.3	Manganese	--	--	--	4.68E-04
	8.6E-05	0.3	Mercury	--	--	--	2.81E-03
8.4E-01		0.3	Nickel	1.09E-04	1.09E-03	1.09E-02	--
		0.3	Selenium	--	--	--	--
	2.9E-06	0.3	Silver	--	--	--	9.50E-05
		0.3	Thallium	--	--	--	--
		0.3	Vanadium	--	--	--	--
		0.3	Zinc	--	--	--	--
			<u>Volatiles:</u>				
2.9E-02		1.0	Acetone	--	--	--	--
		1.0	Benzene	9.49E-04	9.49E-03	9.49E-02	--
		1.0	1,3-Dimethylbenzene	--	--	--	--
	2.9E-01	1.0	Ethylbenzene	--	--	--	2.81E+00
2.0E-03	1.2E-01	1.0	Tetrachloroethene	1.36E-02	1.36E-01	1.36E+00	1.18E+00
6.0E-03		1.0	Trichloroethene	4.59E-03	4.59E-02	4.59E-01	--
	2.0E-01	1.0	Trichlorofluoromethane	--	--	--	1.97E+00
	1.1E-01	1.0	Toluene	--	--	--	1.12E+00
		1.0	Xylenes	--	--	--	--
			<u>Semivolatiles:</u>				
		0.3	Acenaphthene	--	--	--	--
		0.3	Acenaphthalene	--	--	--	--
		0.3	Anthracene	--	--	--	--
6.1E-01		0.3	Benzo(a)anthracene	1.50E-04	1.50E-03	1.50E-02	--
6.1E+00		0.3	Benzo(a)pyrene	1.50E-05	1.50E-04	1.50E-03	--
6.1E-01		0.3	Benzo(b)fluoranthene	1.50E-04	1.50E-03	1.50E-02	--
6.1E-02		0.3	Benzo(k)fluoranthene	1.50E-03	1.50E-02	1.50E-01	--
		0.3	Benzo(g,h,i)perylene	--	--	--	--
1.4E-02	5.7E-02	0.3	Bis(2-ethylhexyl) phthalate	6.55E-03	6.55E-02	6.55E-01	1.87E+00
		0.3	Butyl benzyl phthalate	--	--	--	--
6.1E-03		0.3	Chrysene	1.50E-02	1.50E-01	1.50E+00	--
6.1E+00		0.3	Dibenzo(a,h)anthracene	1.50E-05	1.50E-04	1.50E-03	--
		0.3	Dibenzofuran	--	--	--	--
	4.0E-02	0.3	1,2-Dichlorobenzene	--	--	--	1.31E+00
		0.3	1,3-Dichlorobenzene	--	--	--	--
	2.3E-01	0.3	1,4-Dichlorobenzene	--	--	--	7.49E+00
		0.3	Diethyl phthalate	--	--	--	--
		0.3	Di-n-butyl phthalate	--	--	--	--
		0.3	Di-n-octyl phthalate	--	--	--	--
		0.3	Fluoranthene	--	--	--	--
		0.3	Fluorene	--	--	--	--

TABLE 10 (cont'd)
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation--Future Industrial Worker

SF	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ = 1.0
				1E-06	1E-05	1E-04	
6.1E-01	1.2E-04	0.3	Indeno(1,2,3-cd)pyrene	1.50E-04	1.50E-03	1.50E-02	--
		0.3	2-Methylnaphthalene	--	--	--	--
		0.3	Naphthalene	--	--	--	3.93E-03
		0.3	Phenanthrene	--	--	--	--
		0.3	Phenol	--	--	--	--
		0.3	Pyrene	--	--	--	--
6.0E-04	6.0E-04	<u>Explosives:</u>					
		0.3	2,4-Dinitrotoluene	--	--	--	--
		0.3	2,6-Dinitrotoluene	--	--	--	--
		0.3	HMX	--	--	--	--
		0.3	Nitrobenzene	--	--	--	1.97E-02
		0.3	RDX	--	--	--	--
1.7E+01	3.4E-01	0.3	1,3,5-Trinitrobenzene	--	--	--	--
		0.3	2,4,6-Trinitrotoluene	--	--	--	--
		<u>Pesticides/PCBs:</u>					
		0.3	Aldrin	5.40E-06	5.40E-05	5.40E-04	--
		0.3	Chlordane	2.62E-04	2.62E-03	2.62E-02	--
		0.3	Dieldrin	5.73E-06	5.73E-05	5.73E-04	--
3.4E-01	3.4E-01	0.3	DDD	3.82E-04	3.82E-03	3.82E-02	--
		0.3	DDE	2.70E-04	2.70E-03	2.70E-02	--
		0.3	DDT	2.70E-04	2.70E-03	2.70E-02	--
		0.3	Endosulfan	--	--	--	--
		0.3	Endrin	--	--	--	--
		0.3	Heptachlor	2.04E-05	2.04E-04	2.04E-03	--
9.1E+00	9.1E+00	0.3	Heptachlor epoxide	1.01E-05	1.01E-04	1.01E-03	--
		0.3	Isodrin	--	--	--	--
		0.3	PCBs	--	--	--	--
		<u>Anions:</u>					
		0.3	Nitrate	--	--	--	5.24E+01
		0.3	Nitrite	--	--	--	3.28E+00

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	9125
ATC	days	25550
ET	hrs/day	8
EF	days/yr	250
ED	yrs	25
HI	none	1
BW	kg	70
IR	m ³ /hour	1.3

TABLE 11

CAOs for Known Releases SWMUs at TEAD--Surface Soil (µg/g)
Future Land Use--Industrial Worker

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
<u>Metals:</u>			
Aluminum	2.04E+06	2.04E+06	(b)
Antimony	8.18E+02	1.64E+02	1.36E+02
Arsenic	3.82E+00	1.56E+01	3.07E+00
Barium	1.43E+05	1.00E+05	5.89E+04
Beryllium	1.33E+00	1.33E-01	1.21E-01
Cadmium	2.04E+03	2.04E+02	1.86E+02
Chromium (+3)	2.04E+06	1.02E+05	9.73E+04
Chromium (+6)	1.02E+04	2.04E+03	1.70E+03
Cobalt	1.23E+05	9.81E+05	1.09E+05
Copper	7.58E+04	2.27E+05	5.69E+04
Iron	6.13E+05	9.20E+05	3.68E+05
Lead	--	--	--
Manganese	4.91E+04	1.96E+04	1.40E+04
Mercury	6.13E+02	9.20E+02	3.68E+02
Nickel	4.09E+04	1.10E+05	2.98E+04
Selenium	1.02E+04	4.50E+04	8.33E+03
Silver	1.02E+04	1.84E+04	6.57E+03
Thallium	1.64E+02	2.45E+02	9.81E+01
Vanadium	1.43E+04	1.43E+03	1.30E+03
Zinc	6.13E+05	1.23E+06	4.09E+05
<u>Volatiles:</u>			
Acetone	2.04E+05	1.70E+05	9.27E+04
Benzene	1.97E+02	1.91E+02	9.72E+01
1,3-Dimethylbenzene	4.09E+06	3.76E+06	(b)
Ethylbenzene	2.04E+05	1.98E+05	1.01E+05
Tetrachloroethene	1.10E+02	1.10E+02	5.50E+01
Trichloroethene	5.20E+02	7.80E+01	6.79E+01
Trichlorofluoromethane	6.13E+05	1.41E+05	1.15E+05
Toluene	4.09E+05	3.27E+05	1.82E+05
Xylenes	4.09E+06	3.76E+06	(b)
<u>Semivolatiles:</u>			
Acenaphthene	1.23E+05	3.80E+04	2.90E+04
Acenaphthylene	6.13E+04	1.90E+04	1.45E+04
Anthracene	6.13E+05	4.66E+05	2.65E+05
Benzo(a)anthracene	7.84E+00	2.43E+00	1.86E+00
Benzo(a)pyrene	7.84E-01	2.43E-01	1.86E-01
Benzo(b)fluoranthene	7.84E+00	2.43E+00	1.86E+00
Benzo(k)fluoranthene	7.84E+01	2.43E+01	1.86E+01
Benzo(g,h,i)perylene	6.13E+04	1.90E+04	1.45E+04
Bis(2-ethylhexyl) phthalate	4.09E+02	7.77E+01	6.53E+01
Butyl benzyl phthalate	4.09E+05	2.49E+05	1.55E+05
Chrysene	7.84E+02	2.43E+02	1.86E+02
Dibenz(a,h)anthracene	7.84E-01	2.43E-01	1.86E-01
Dibenzofuran	8.18E+03	8.18E+03	4.09E+03
1,2-Dichlorobenzene	1.84E+05	1.84E+05	9.20E+04
1,3-Dichlorobenzene	1.84E+03	1.84E+03	9.20E+02
1,4-Dichlorobenzene	2.38E+02	2.15E+02	1.13E+02
Diethyl phthalate	1.64E+06	1.47E+06	7.75E+05

TABLE 11 (cont'd)

CAOs for Known Releases SWMUs at TEAD--Surface Soil (µg/g)
Future Land Use--Industrial Worker

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
Di-n-butyl phthalate	2.04E+05	2.04E+05	1.02E+05
Di-n-octyl phthalate	4.09E+04	4.09E+04	2.04E+04
Fluoranthene	8.18E+04	2.53E+04	1.93E+04
Fluorene	8.18E+04	8.18E+04	4.09E+04
Indeno(1,2,3-cd)pyrene	7.84E+00	2.43E+00	1.86E+00
2-Methylnaphthalene	8.18E+04	6.54E+04	3.63E+04
Naphthalene	8.18E+04	6.54E+04	3.63E+04
Phenanthrene	6.13E+04	4.48E+04	2.59E+04
Phenol	1.23E+06	1.10E+06	5.81E+05
Pyrene	6.13E+04	1.90E+04	1.45E+04
<u>Explosives:</u>			
2,4-Dinitrotoluene	8.42E+00	7.15E+00	3.87E+00
2,6-Dinitrotoluene	8.42E+00	7.15E+00	3.87E+00
HMX	1.02E+05	1.53E+04	1.33E+04
Nitrobenzene	1.02E+03	9.91E+02	5.03E+02
RDX	5.20E+01	5.20E+01	2.60E+01
1,3,5-Trinitrobenzene	6.13E+04	3.99E+04	2.42E+04
2,4,6-Trinitrotoluene	1.91E+02	1.14E+02	7.15E+01
<u>Pesticide/PCBs:</u>			
Aldrin	3.37E-01	1.68E-01	1.12E-01
Chlordane	1.64E+01	8.18E+00	5.45E+00
Dieldrin	3.58E-01	1.79E-01	1.19E-01
DDD	2.38E+01	1.67E+01	9.82E+00
DDE	1.68E+01	1.18E+01	6.93E+00
DDT	1.68E+01	1.18E+01	6.93E+00
Endosulfan	1.23E+04	1.23E+04	6.13E+03
Endrin	6.13E+02	1.23E+01	1.20E+01
Heptachlor	1.27E+00	9.16E-01	5.32E-01
Heptachlor epoxide	6.29E-01	4.53E-01	2.63E-01
Isodrin	--	--	--
PCBs	7.43E-01	6.69E-01	3.52E-01
<u>Anions</u>			
Nitrate	3.27E+06	1.64E+07	(b)
Nitrite	2.04E+05	1.02E+06	1.70E+05

-- Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on $1/[(1/\text{Ingestion CAO}) + (1/\text{Dermal CAO})]$, see Attachment 3 for derivation.

(b) - No CAO listed because the calculated CAO is greater than one million parts per million (µg/g).

TABLE 12
Corrective Action Objectives (CAOs)
Soil Ingestion--Construction Worker

SF	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
		<i>Metals:</i>				
	1.0E+00	Aluminum	--	--	--	1.77E+06
	4.0E-04	Antimony	--	--	--	7.10E+02
1.5E+00	3.0E-04	Arsenic	1.66E+01	1.66E+02	1.66E+03	5.32E+02
	7.0E-02	Barium	--	--	--	1.24E+05
4.3E+00	5.0E-03	Beryllium	5.78E+00	5.78E+01	5.78E+02	8.87E+03
	1.0E-03	Cadmium	--	--	--	1.77E+03
	1.0E+00	Chromium (+3)	--	--	--	1.77E+06
	2.0E-02	Chromium (+6)	--	--	--	3.55E+04
	6.0E-02	Cobalt	--	--	--	1.06E+05
	3.7E-02	Copper	--	--	--	6.58E+04
	3.0E-01	Iron	--	--	--	5.32E+05
		Lead	--	--	--	--
	2.4E-02	Manganese	--	--	--	4.26E+04
	3.0E-04	Mercury	--	--	--	5.32E+02
	2.0E-02	Nickel	--	--	--	3.55E+04
	5.0E-03	Selenium	--	--	--	8.87E+03
	5.0E-03	Silver	--	--	--	8.87E+03
	8.0E-04	Thallium	--	--	--	1.42E+03
	7.0E-03	Vanadium	--	--	--	1.24E+04
	3.0E-01	Zinc	--	--	--	5.32E+05
		<i>Volatiles:</i>				
	1.0E+00	Acetone	--	--	--	1.77E+06
5.4E-01	1.0E-02	Acrylonitrile	4.60E+01	4.60E+02	4.60E+03	1.77E+04
2.9E-02	3.0E-04	Benzene	8.57E+02	8.57E+03	8.57E+04	5.32E+02
	2.0E-02	Chlorobenzene	--	--	--	3.55E+04
	9.0E-02	1,2-Dichloroethene	--	--	--	1.60E+05
	7.0E-02	1,3-Dimethylbenzene	--	--	--	1.24E+05
	1.0E-01	Ethylbenzene	--	--	--	1.77E+05
	8.0E-01	Methyl isobutyl ketone	--	--	--	1.42E+06
5.2E-02	1.0E-01	Tetrachloroethene	4.78E+02	4.78E+03	4.78E+04	1.77E+05
	2.0E-02	1,1,1-Trichloroethane	--	--	--	3.55E+04
1.1E-02	6.0E-03	Trichloroethene	2.26E+03	2.26E+04	2.26E+05	1.06E+04
	7.0E-01	Trichlorofluoromethane	--	--	--	1.24E+06
	2.0E+00	Toluene	--	--	--	3.55E+06
4.0E-01		Xylenes	--	--	--	7.10E+05
		<i>Semivolatiles:</i>				
	6.0E-01	Acenaphthene	--	--	--	1.06E+06
	3.0E-01	Acenaphthylene	--	--	--	5.32E+05
	3.0E+00	Anthracene	--	--	--	5.32E+06
7.3E-01		Benzo(a)anthracene	3.40E+01	3.40E+02	3.40E+03	--
7.3E+00		Benzo(a)pyrene	3.40E+00	3.40E+01	3.40E+02	--
7.3E-01		Benzo(b)fluoranthene	3.40E+01	3.40E+02	3.40E+03	--
7.3E-02		Benzo(k)fluoranthene	3.40E+02	3.40E+03	3.40E+04	--
	3.0E-01	Benzo(g,h,i)perylene	--	--	--	5.32E+05
	1.0E+00	Benzyl alcohol	--	--	--	1.77E+06
1.4E-02	2.0E-02	Bis(2-ethylhexyl) phthalate	1.77E+03	1.77E+04	1.77E+05	3.55E+04
	2.0E+00	Butyl benzyl phthalate	--	--	--	3.55E+06
7.3E-03		Chrysene	3.40E+03	3.40E+04	3.40E+05	--
7.3E+00		Dibenz(a,h)anthracene	3.40E+00	3.40E+01	3.40E+02	--
	4.0E-03	Dibenzofuran	--	--	--	7.10E+03
	9.0E-02	1,2-Dichlorobenzene	--	--	--	1.60E+05
	9.0E-04	1,3-Dichlorobenzene	--	--	--	1.60E+03
2.4E-02	2.0E-01	1,4-Dichlorobenzene	1.04E+03	1.04E+04	1.04E+05	3.55E+05
	8.0E+00	Diethyl phthalate	--	--	--	1.42E+07
		Dimethyl phthalate	--	--	--	--
	1.0E+00	Di-n-butyl phthalate	--	--	--	1.77E+06
	2.0E-02	Di-n-octyl phthalate	--	--	--	3.55E+04
	4.0E-01	Fluoranthene	--	--	--	7.10E+05

TABLE 12 (cont'd)
Corrective Action Objectives (CAOs)
Soil Ingestion--Construction Worker

SF	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
7.3E-01	4.0E-01	Fluorene	--	--	--	7.10E+05
		Indeno(1,2,3-cd)pyrene	3.40E+01	3.40E+02	3.40E+03	--
	4.0E-02	2-Methylnaphthalene	--	--	--	7.10E+04
	5.0E-03	4-Methylphenol	--	--	--	8.87E+03
4.9E-03	4.0E-02	Naphthalene	--	--	--	7.10E+04
		N-Nitrosodiphenylamine	5.07E+03	5.07E+04	5.07E+05	--
	1.2E-01	Pentachlorophenol	2.07E+02	2.07E+03	2.07E+04	5.32E+04
	3.0E-01	Phenanthrene	--	--	--	5.32E+05
1.2E-01	6.0E-01	Phenol	--	--	--	1.06E+06
	3.0E-01	Pyrene	--	--	--	5.32E+05
		Explosives:				
	6.8E-01	2,4-Dinitrotoluene	3.65E+01	3.65E+02	3.65E+03	3.55E+03
6.8E-01	1.0E-02	2,6-Dinitrotoluene	3.65E+01	3.65E+02	3.65E+03	1.77E+04
	5.0E-02	HMX	--	--	--	8.87E+04
	5.0E-03	Nitrobenzene	--	--	--	8.87E+03
	1.1E-01	RDX	2.26E+02	2.26E+03	2.26E+04	5.32E+03
3.0E-02	3.0E-02	1,3,5-Trinitrobenzene	--	--	--	5.32E+04
	5.0E-04	2,4,6-Trinitrotoluene	8.28E+02	8.28E+03	8.28E+04	8.87E+02
		Pesticide/PCBs:				
	1.7E+01	Aldrin	1.46E+00	1.46E+01	1.46E+02	5.32E+01
3.5E-01	5.0E-04	Chlordane	7.10E+01	7.10E+02	7.10E+03	8.87E+02
	1.6E+01	Dieldrin	1.55E+00	1.55E+01	1.55E+02	8.87E+01
	2.4E-01	DDD	1.04E+02	1.04E+03	1.04E+04	5.32E+03
	3.4E-01	DDE	7.31E+01	7.31E+02	7.31E+03	1.24E+03
3.4E-01	5.0E-04	DDT	7.31E+01	7.31E+02	7.31E+03	8.87E+02
	6.0E-03	Endosulfan	--	--	--	1.06E+04
	3.0E-04	Endrin	--	--	--	5.32E+02
	4.5E+00	Heptachlor	5.52E+00	5.52E+01	5.52E+02	8.87E+02
9.1E+00	1.3E-05	Heptachlor epoxide	2.73E+00	2.73E+01	2.73E+02	2.31E+01
		Isodrin	--	--	--	--
	1.3E+00	Lindane	1.91E+01	1.91E+02	1.91E+03	5.32E+03
	5.0E-03	Methoxychlor	--	--	--	8.87E+03
7.7E+00	5.0E-05	PCBs	3.23E+00	3.23E+01	3.23E+02	8.87E+01
		Anions:				
	1.6E+00	Nitrate				2.84E+06
	1.0E-01	Nitrite				1.77E+05

-- Indicates that the relevant health effects criteria are unavailable.
COPCs in bold are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
BW	kg	70
ATNC	days	1825
ATC	days	25550
IR	mg/day	480
CF	kg/mg	1E-06
FI	none	1
EF	days/yr	30
ED	hrs	5
HI	none	1

TABLE 13
Corrective Action Objectives (CAOs)
Soil Dermal Absorption--Construction Worker

SF	RID	Dermal	Dermal	G-I	Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at
		SF	RID	Abs.	ABS		1E-06	1E-05	1E-04	Target HQ = 1.0
Metals:										
1.5E+00	1.0E+00		1.0E-01	1.0E-01	0.001	Aluminum	-	-	-	1.70E+07
	4.0E-04		8.0E-06	2.0E-02	0.001	Antimony	-	-	-	1.36E+03
	3.0E-04	3.7E+00	1.2E-04	4.1E-01	0.001	Arsenic	6.52E+02	6.52E+03	6.52E+04	2.10E+04
4.3E+00	7.0E-02		4.9E-03	7.0E-02	0.001	Barium	-	-	-	8.35E+05
	5.0E-03	4.3E+02	5.0E-05	1.0E-02	0.001	Beryllium	5.55E+00	5.55E+01	5.55E+02	8.52E+03
	1.0E-03		1.0E-05	1.0E-02	0.001	Cadmium	-	-	-	1.70E+03
	1.0E+00		5.0E-03	5.0E-03	0.001	Chromium (+3)	-	-	-	8.52E+05
	2.0E-02		4.0E-04	2.0E-02	0.001	Chromium (+6)	-	-	-	6.81E+04
	6.0E-02		4.8E-02	8.0E-01	0.001	Cobalt	-	-	-	8.18E+06
	3.7E-02		1.1E-02	3.0E-01	0.001	Copper	-	-	-	1.90E+06
	3.0E-01		4.5E-02	1.5E-01	0.001	Iron	-	-	-	7.67E+06
				1.5E-01	0.001	Lead	-	-	-	-
	2.4E-02		9.6E-04	4.0E-02	0.001	Manganese	-	-	-	1.64E+05
	3.0E-04		4.5E-05	1.5E-01	0.001	Mercury	-	-	-	7.67E+03
	2.0E-02		5.4E-03	2.7E-01	0.001	Nickel	-	-	-	9.20E+05
	5.0E-03		2.2E-03	4.4E-01	0.001	Selenium	-	-	-	3.75E+05
	5.0E-03		9.0E-04	1.8E-01	0.001	Silver	-	-	-	1.53E+05
	8.0E-04		1.2E-04	1.5E-01	0.001	Thallium	-	-	-	2.04E+04
	7.0E-03		7.0E-05	1.0E-02	0.001	Vanadium	-	-	-	1.19E+04
	3.0E-01		6.0E-02	2.0E-01	0.001	Zinc	-	-	-	1.02E+07
Volatiles:										
5.4E-01	1.0E+00		8.3E-01	8.3E-01	0.01	Acetone	-	-	-	1.41E+07
	1.0E-02	5.4E-01	1.0E-02	1.0E+00	0.01	Acrylonitrile	4.42E+02	4.42E+03	4.42E+04	1.70E+05
	3.0E-04	3.0E-02	2.9E-04	9.7E-01	0.01	Benzene	7.98E+03	7.98E+04	7.98E+05	4.96E+03
2.9E-02	2.0E-02		6.2E-03	3.1E-01	0.01	Chlorobenzene	-	-	-	1.06E+05
	9.0E-02		9.0E-02	1.0E+00	0.01	1,2-Dichloroethene	-	-	-	1.53E+06
	7.0E-02		6.4E-02	9.2E-01	0.01	1,3-Dimethylbenzene	-	-	-	1.10E+06
	1.0E-01		9.7E-02	9.7E-01	0.01	Ethylbenzene	-	-	-	1.65E+06
	8.0E-01		6.4E-01	8.0E-01	0.01	Methyl isobutyl ketone	-	-	-	1.09E+07
	5.2E-02	1.0E-01	5.2E-02	1.0E+00	0.01	Tetrachloroethene	4.59E+03	4.59E+04	4.59E+05	1.70E+06
	2.0E-02		1.8E-02	9.0E-01	0.01	1,1,1-Trichloroethane	-	-	-	3.07E+05
	1.1E-02	6.0E-03	7.3E-02	9.0E-04	1.5E-01	Trichloroethene	3.25E+03	3.25E+04	3.25E+05	1.53E+04
	7.0E-01		1.6E-01	2.3E-01	0.01	Trichlorofluoromethane	-	-	-	2.74E+06
	2.0E+00		1.6E+00	8.0E-01	0.01	Toluene	-	-	-	2.73E+07
4.0E-01		3.7E-01	9.2E-01	0.01	Xylenes	-	-	-	6.27E+06	
Semi-volatiles:										
	6.0E-01		1.9E-01	3.1E-01	0.01	Acenaphthene	-	-	-	3.17E+06
	3.0E-01		9.3E-02	3.1E-01	0.01	Acenaphthylene	-	-	-	1.58E+06
	3.0E+00		2.3E+00	7.6E-01	0.01	Anthracene	-	-	-	3.88E+07
7.3E-01		2.4E+00		3.1E-01	0.01	Benzo(a)anthracene	1.01E+02	1.01E+03	1.01E+04	-
7.3E+00		2.4E+01		3.1E-01	0.01	Benzo(a)pyrene	1.01E+01	1.01E+02	1.01E+03	-
7.3E-01		2.4E+00		3.1E-01	0.01	Benzo(b)fluoranthene	1.01E+02	1.01E+03	1.01E+04	-
7.3E-02		2.4E-01		3.1E-01	0.01	Benzo(k)fluoranthene	1.01E+03	1.01E+04	1.01E+05	-
	3.0E-01		9.3E-02	3.1E-01	0.01	Benzo(g,h,i)perylene	-	-	-	1.58E+06
	1.0E+00		6.6E-01	6.6E-01	0.01	Benzyl alcohol	-	-	-	1.12E+07
	1.4E-02	2.0E-02	7.4E-02	3.8E-03	1.9E-01	Bis(2-ethylhexyl) phthalate	3.24E+03	3.24E+04	3.24E+05	6.47E+04
	2.0E+00		1.2E+00	6.1E-01	0.01	Butyl benzyl phthalate	-	-	-	2.08E+07
	7.3E-03		2.4E-02		3.1E-01	Chrysene	1.01E+04	1.01E+05	1.01E+06	-
	7.3E+00		2.4E+01		3.1E-01	Dibenz(a,h)anthracene	1.01E+01	1.01E+02	1.01E+03	-
	4.0E-03		4.0E-03	1.0E+00	0.01	Dibenzofuran	-	-	-	6.81E+04
	9.0E-02		9.0E-02	1.0E+00	0.01	1,2-Dichlorobenzene	-	-	-	1.53E+06
	9.0E-04		9.0E-04	1.0E+00	0.01	1,3-Dichlorobenzene	-	-	-	1.53E+04
	2.4E-02	2.0E-01	2.7E-02	1.8E-01	9.0E-01	1,4-Dichlorobenzene	8.94E+03	8.94E+04	8.94E+05	3.07E+06
	8.0E+00		7.2E+00	9.0E-01	0.01	Diethyl phthalate	-	-	-	1.23E+08
				9.0E-01	0.01	Dimethyl phthalate	-	-	-	-
	1.0E+00		1.0E+00	1.0E+00	0.01	Di-n-butyl phthalate	-	-	-	1.70E+07
2.0E-02		2.0E-02	1.0E+00	0.01	Di-n-octyl phthalate	-	-	-	3.41E+05	
	4.0E-01		1.2E-01	3.1E-01	0.01	Fluoranthene	-	-	-	2.11E+06
	4.0E-01		4.0E-01	1.0E+00	0.01	Fluorene	-	-	-	6.81E+06
	7.3E-01		2.4E+00		3.1E-01	Indeno(1,2,3-cd)pyrene	1.01E+02	1.01E+03	1.01E+04	-

TABLE 13 (cont'd)
Corrective Action Objectives (CAOs)
Soil Dermal Absorption—Construction Worker

SF	Rfd	Dermal		G-I	Der.	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
		SF	RfD				1E-06	1E-05	1E-04	
	4.0E-02		3.2E-02	8.0E-01	0.01	2-Methylnaphthalene	—	—	—	5.45E+05
	5.0E-03		5.0E-03	1.0E+00	0.01	4-Methylphenol	—	—	—	8.52E+04
	4.0E-02		3.2E-02	8.0E-01	0.01	Naphthalene	—	—	—	5.45E+05
4.9E-03		2.0E-02		2.5E-01	0.01	N-Nitrosodiphenylamine	1.22E+04	1.22E+05	1.22E+06	—
1.2E-01	3.0E-02	1.2E-01	3.0E-02	1.0E+00	0.01	Pentachlorophenol	1.99E+03	1.99E+04	1.99E+05	5.11E+05
	3.0E-01		2.2E-01	7.3E-01	0.01	Phenanthrene	—	—	—	3.73E+06
	6.0E-01		5.4E-01	9.0E-01	0.01	Phenol	—	—	—	9.20E+06
	3.0E-01		9.3E-02	3.1E-01	0.01	Pyrene	—	—	—	1.58E+06
Explosives:										
6.8E-01	2.0E-03	8.0E-01	1.7E-03	8.5E-01	0.01	2,4-Dinitrotoluene	2.98E+02	2.98E+03	2.98E+04	2.90E+04
6.8E-01	1.0E-02	8.0E-01	8.5E-03	8.5E-01	0.01	2,6-Dinitrotoluene	2.98E+02	2.98E+03	2.98E+04	1.45E+05
	5.0E-02		7.5E-03	1.5E-01	0.01	HMX	—	—	—	1.28E+05
	5.0E-03		4.9E-03	9.7E-01	0.01	Nitrobenzene	—	—	—	8.26E+04
1.1E-01	3.0E-03	1.1E-01	3.0E-03	1.0E+00	0.01	RDX	2.17E+03	2.17E+04	2.17E+05	5.11E+04
	3.0E-02		2.0E-02	6.5E-01	0.01	1,3,5-Trinitrobenzene	—	—	—	3.32E+05
3.0E-02	5.0E-04	5.0E-02	3.0E-04	6.0E-01	0.01	2,4,6-Trinitrotoluene	4.77E+03	4.77E+04	4.77E+05	5.11E+03
Pesticide/PCBs:										
1.7E+01	3.0E-05	3.4E+01	1.5E-05	5.0E-01	0.01	Aldrin	7.01E+00	7.01E+01	7.01E+02	2.56E+02
3.5E-01	5.0E-04	7.0E-01	2.5E-04	5.0E-01	0.01	Chlordane	3.41E+02	3.41E+03	3.41E+04	4.26E+03
1.6E+01	5.0E-05	3.2E+01	2.5E-05	5.0E-01	0.01	Dieldrin	7.45E+00	7.45E+01	7.45E+02	4.26E+02
2.4E-01	3.0E-03	3.4E-01	2.1E-03	7.0E-01	0.01	DDD	6.96E+02	6.96E+03	6.96E+04	3.58E+04
3.4E-01	7.0E-04	4.9E-01	4.9E-04	7.0E-01	0.01	DDE	4.91E+02	4.91E+03	4.91E+04	8.35E+03
3.4E-01	5.0E-04	4.9E-01	3.5E-04	7.0E-01	0.01	DDT	4.91E+02	4.91E+03	4.91E+04	5.96E+03
	6.0E-03		6.0E-03	1.0E+00	0.01	Endosulfan	—	—	—	1.02E+05
	3.0E-04		6.0E-06	2.0E-02	0.01	Endrin	—	—	—	1.02E+02
4.5E+00	5.0E-04	6.3E+00	3.6E-04	7.2E-01	0.01	Heptachlor	3.82E+01	3.82E+02	3.82E+03	6.13E+03
9.1E+00	1.3E-05	1.3E+01	9.4E-06	7.2E-01	0.01	Heptachlor epoxide	1.89E+01	1.89E+02	1.89E+03	1.59E+02
			1.0E+00		0.01	Isodrin	—	—	—	—
1.3E+00	3.0E-03	1.3E+00	2.9E-03	9.7E-01	0.01	Lindane	1.78E+02	1.78E+03	1.78E+04	4.96E+04
	5.0E-03		5.0E-03	1.0E+00	0.01	Methoxychlor	—	—	—	8.52E+04
7.7E+00	5.0E-05	8.6E+00	4.5E-05	9.0E-01	0.01	PCBs	2.79E+01	2.79E+02	2.79E+03	7.67E+02
Anions:										
	1.6E+00		8.0E-01	5.0E-01	0.001	Nitrate	—	—	—	1.36E+08
	1.0E-01		5.0E-02	5.0E-01	0.001	Nitrite	—	—	—	8.52E+06

— Indicates that the relevant health effects criteria are unavailable.
COPCs in bold are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
BW _a	kg	70
ATNC	days	1825
ATC	days	25550
AF	mg/cm ²	1
CF	kg/mg	1E-06
SA	cm ²	5000
EV	events/day	1
EF	days/yr	30
ED _a	hrs	5
HI	none	1

TABLE 14
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation--Construction Worker

SE	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ = 1.0
				1E-06	1E-05	1E-04	
			<i>Metals:</i>				
	1.4E-03	0.3	Aluminum	--	--	--	3.82E-01
		0.3	Antimony	--	--	--	--
1.50E+01		0.3	Arsenic	2.55E-04	2.55E-03	2.55E-02	--
	1.0E-03	0.3	Barium	--	--	--	2.73E-01
8.40E+00		0.3	Beryllium	4.55E-04	4.55E-03	4.55E-02	--
6.30E+00		0.3	Cadmium	6.07E-04	6.07E-03	6.07E-02	--
		0.3	Chromium (+3)	--	--	--	--
4.20E+01	1.1E-06	0.3	Chromium (+6)	9.10E-05	9.10E-04	9.10E-03	3.00E-04
	5.7E-06	0.3	Cobalt	--	--	--	1.56E-03
		0.3	Copper	--	--	--	--
		0.3	Iron	--	--	--	--
		0.3	Lead	--	--	--	--
	1.4E-05	0.3	Manganese	--	--	--	3.90E-03
	8.6E-05	0.3	Mercury	--	--	--	2.34E-02
8.40E-01		0.3	Nickel	4.55E-03	4.55E-02	4.55E-01	--
		0.3	Selenium	--	--	--	--
	2.9E-06	0.3	Silver	--	--	--	7.92E-04
		0.3	Thallium	--	--	--	--
		0.3	Vanadium	--	--	--	--
		0.3	Zinc	--	--	--	--
			<i>Volatiles:</i>				
		1.0	Acetone	--	--	--	--
2.40E-01	5.7E-04	1.0	Acrylonitrile	4.78E-03	4.78E-02	4.78E-01	4.67E-02
2.90E-02	1.7E-02	1.0	Benzene	3.95E-02	3.95E-01	3.95E+00	1.39E+00
	5.0E-03	1.0	Chlorobenzene	--	--	--	4.09E-01
		1.0	1,2-Dichloroethene	--	--	--	--
		1.0	1,3-Dimethylbenzene	--	--	--	--
	2.9E-01	1.0	Ethylbenzene	--	--	--	2.37E+01
	2.0E-01	1.0	Methyl isobutyl ketone	--	--	--	1.64E+01
2.0E-03	1.2E-01	1.0	Tetrachloroethene	5.73E-01	5.73E+00	5.73E+01	9.83E+00
	2.9E-01	1.0	1,1,1-Trichloroethane	--	--	--	2.37E+01
6.0E-03		1.0	Trichloroethene	1.91E-01	1.91E+00	1.91E+01	--
	2.0E+00	1.0	Trichlorofluoromethane	--	--	--	1.64E+02
	2.9E-01	1.0	Toluene	--	--	--	2.37E+01
		1.0	Xylenes	--	--	--	--
			<i>Semivolatiles:</i>				
		0.3	Acenaphthene	--	--	--	--
		0.3	Acenaphthylene	--	--	--	--
		0.3	Anthracene	--	--	--	--
6.10E-01		0.3	Benzo(a)anthracene	6.26E-03	6.26E-02	6.26E-01	--
6.10E+00		0.3	Benzo(a)pyrene	6.26E-04	6.26E-03	6.26E-02	--
6.10E-01		0.3	Benzo(b)fluoranthene	6.26E-03	6.26E-02	6.26E-01	--
6.10E-02		0.3	Benzo(k)fluoranthene	6.26E-02	6.26E-01	6.26E+00	--
		0.3	Benzo(g,h,i)perylene	--	--	--	--
		0.3	Benzyl alcohol	--	--	--	--
1.40E-02	5.7E-02	0.3	Bis(2-ethylhexyl) phthalate	2.73E-01	2.73E+00	2.73E+01	1.56E+01
		0.3	Butyl benzyl phthalate	--	--	--	--
6.10E-03		0.3	Chrysene	6.26E-01	6.26E+00	6.26E+01	--
6.10E+00		0.3	Dibenz(a,h)anthracene	6.26E-04	6.26E-03	6.26E-02	--
		0.3	Dibenzofuran	--	--	--	--
	4.0E-01	0.3	1,2-Dichlorobenzene	--	--	--	1.09E+02
		0.3	1,3-Dichlorobenzene	--	--	--	--
	7.1E-01	0.3	1,4-Dichlorobenzene	--	--	--	1.94E+02
		0.3	Diethyl phthalate	--	--	--	--
		0.3	Dimethyl phthalate	--	--	--	--
		0.3	Di-n-butyl phthalate	--	--	--	--
		0.3	Di-n-octyl phthalate	--	--	--	--
		0.3	Fluoranthene	--	--	--	--

TABLE 14 (cont'd)
Corrective Action Objectives (CAOs) for Air
Particulate Inhalation—Construction Worker

SF	Rfd	DF	Analyte	CAOs (mg/m ³) at Target Risk Levels			CAOs (mg/m ³) at Target HQ = 1.0
				1E-06	1E-05	1E-04	
6.10E-01			0.3 Fluorene	--	--	--	--
			0.3 Indeno(1,2,3-cd)pyrene	6.26E-03	6.26E-02	6.26E-01	--
			0.3 2-Methylnaphthalene	--	--	--	--
			0.3 4-Methylphenol	--	--	--	--
1.2E-04			0.3 Naphthalene	--	--	--	3.28E-02
			0.3 N-Nitrosodiphenylamine	--	--	--	--
			0.3 Pentachlorophenol	--	--	--	--
			0.3 Phenanthrene	--	--	--	--
			0.3 Phenol	--	--	--	--
			0.3 Pyrene	--	--	--	--
			<u>Explosives:</u>				
6.0E-03			0.3 2,4-Dinitrotoluene	--	--	--	--
			0.3 2,6-Dinitrotoluene	--	--	--	--
			0.3 HMX	--	--	--	--
			0.3 Nitrobenzene	--	--	--	1.64E+00
			0.3 RDX	--	--	--	--
			0.3 1,3,5-Trinitrobenzene	--	--	--	--
			0.3 2,4,6-Trinitrotoluene	--	--	--	--
1.70E+01 3.50E-01 1.60E+01 2.40E-01 3.40E-01 3.40E-01 4.50E+00 9.10E+00			<u>Pesticide/PCBs:</u>				
			0.3 Aldrin	2.25E-04	2.25E-03	2.25E-02	--
			0.3 Chlordane	1.09E-02	1.09E-01	1.09E+00	--
			0.3 Dieldrin	2.39E-04	2.39E-03	2.39E-02	--
			0.3 DDD	1.59E-02	1.59E-01	1.59E+00	--
			0.3 DDE	1.12E-02	1.12E-01	1.12E+00	--
			0.3 DDT	1.12E-02	1.12E-01	1.12E+00	--
			0.3 Endosulfan	--	--	--	--
			0.3 Endrin	--	--	--	--
			0.3 Heptachlor	8.49E-04	8.49E-03	8.49E-02	--
			0.3 Heptachlor epoxide	4.20E-04	4.20E-03	4.20E-02	--
			0.3 Isodrin	--	--	--	--
			0.3 Lindane	--	--	--	--
			0.3 Methoxychlor	--	--	--	--
			0.3 PCBs	--	--	--	--
1.6E+00 1.0E-01			<u>Anions:</u>				
			0.3 Nitrate	--	--	--	4.37E+02
			0.3 Nitrite	--	--	--	2.73E+01

-- Indicates that the relevant health effects criteria are unavailable.

COPCs in bold are identified in subsurface soil but not in surface soil.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	1825
ATC	days	25550
ET	hrs/day	8
EF	days/yr	30
ED	hrs	5
HI	none	1
BW	kg	70
IR	m ³ /hour	1.3

TABLE 15

CAOs for Known Releases SWMUs at TEAD—Total Soil (µg/g)
Future Land Use—Construction Worker

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
<i>Metals:</i>			(b)
Aluminum	1.77E+06	1.70E+07	4.67E+02
Antimony	7.10E+02	1.36E+03	1.61E+01
Arsenic	1.66E+01	6.52E+02	1.08E+05
Barium	1.24E+05	8.35E+05	2.83E+00
Beryllium	5.78E+00	5.55E+00	8.69E+02
Cadmium	1.77E+03	1.70E+03	5.75E+05
Chromium (+3)	1.77E+06	8.52E+05	2.33E+04
Chromium (+6)	3.55E+04	6.81E+04	1.05E+05
Cobalt	1.06E+05	8.18E+06	6.36E+04
Copper	6.58E+04	1.90E+06	4.98E+05
Iron	5.32E+05	7.67E+06	—
Lead	—	—	—
Manganese	4.26E+04	1.64E+05	3.38E+04
Mercury	5.32E+02	7.67E+03	4.98E+02
Nickel	3.55E+04	9.20E+05	3.42E+04
Selenium	8.87E+03	3.75E+05	8.67E+03
Silver	8.87E+03	1.53E+05	8.39E+03
Thallium	1.42E+03	2.04E+04	1.33E+03
Vanadium	1.24E+04	1.19E+04	6.08E+03
Zinc	5.32E+05	1.02E+07	5.06E+05
<i>Volatiles:</i>			(b)
Acetone	1.77E+06	1.41E+07	4.17E+01
Acrylonitrile	4.60E+01	4.42E+02	4.81E+02
Benzene	5.32E+02	4.96E+03	2.66E+04
Chlorobenzene	3.55E+04	1.06E+05	1.45E+05
1,2-Dichloroethene	1.60E+05	1.53E+06	1.12E+05
1,3-Dimethylbenzene	1.24E+05	1.10E+06	1.60E+05
Ethylbenzene	1.77E+05	1.65E+06	(b)
Methyl isobutyl ketone	1.42E+06	1.09E+07	4.33E+02
Tetrachloroethene	4.78E+02	4.59E+03	3.18E+04
1,1,1-Trichloroethane	3.55E+04	3.07E+05	1.33E+03
Trichloroethene	2.26E+03	3.25E+03	8.55E+05
Trichlorofluoromethane	1.24E+06	2.74E+06	(b)
Toluene	3.55E+06	2.73E+07	6.38E+05
Xylenes	7.10E+05	6.27E+06	(b)
<i>Semivolatiles:</i>			(b)
Acenaphthene	1.06E+06	3.17E+06	7.97E+05
Acenaphthylene	5.32E+05	1.58E+06	3.98E+05
Anthracene	5.32E+06	3.88E+07	(b)
Benzo(a)anthracene	3.40E+01	1.01E+02	2.55E+01
Benzo(a)pyrene	3.40E+00	1.01E+01	2.55E+00
Benzo(b)fluoranthene	3.40E+01	1.01E+02	2.55E+01
Benzo(k)fluoranthene	3.40E+02	1.01E+03	2.55E+02
Benzo(g,h,i)perylene	5.32E+05	1.58E+06	3.98E+05
Benzyl alcohol	1.77E+06	1.12E+07	(b)
Bis(2-ethylhexyl) phthalate	1.77E+03	3.24E+03	1.15E+03
Butyl benzyl phthalate	3.55E+06	2.08E+07	(b)
Chrysene	3.40E+03	1.01E+04	2.55E+03
Dibenz(a,h)anthracene	3.40E+00	1.01E+01	2.55E+00
Dibenzofuran	7.10E+03	6.81E+04	6.43E+03
1,2-Dichlorobenzene	1.60E+05	1.53E+06	1.45E+05
1,3-Dichlorobenzene	1.60E+03	1.53E+04	1.45E+03
1,4-Dichlorobenzene	1.04E+03	8.94E+03	9.28E+02
Diethyl phthalate	1.42E+07	1.23E+08	(b)

Attachment 1

TABLE 15 (cont'd)

CAOs for Known Releases SWMUs at TEAD--Total Soil (µg/g)
Future Land Use--Construction Worker

	<u>Ingestion</u>	<u>Dermal</u>	<u>Combination (a)</u>
Dimethyl phthalate	--	--	--
Di-n-butyl phthalate	1.77E+06	1.70E+07	(b)
Di-n-octyl phthalate	3.55E+04	3.41E+05	3.21E+04
Fluoranthene	7.10E+05	2.11E+06	5.31E+05
Fluorene	7.10E+05	6.81E+06	6.43E+05
Indeno(1,2,3-cd)pyrene	3.40E+01	1.01E+02	2.55E+01
2-Methylnaphthalene	7.10E+04	5.45E+05	6.28E+04
4-Methylphenol	8.87E+03	8.52E+04	8.03E+03
Naphthalene	7.10E+04	5.45E+05	6.28E+04
N-Nitrosodiphenylamine	5.07E+03	1.22E+04	3.58E+03
Pentachlorophenol	2.07E+02	1.99E+03	1.87E+02
Phenanthrene	5.32E+05	3.73E+06	4.66E+05
Phenol	1.06E+06	9.20E+06	9.54E+05
Pyrene	5.32E+05	1.58E+06	3.98E+05
<u>Explosives:</u>			
2,4-Dinitrotoluene	3.65E+01	2.98E+02	3.25E+01
2,6-Dinitrotoluene	3.65E+01	2.98E+02	3.25E+01
HMX	8.87E+04	1.28E+05	5.24E+04
Nitrobenzene	8.87E+03	8.26E+04	8.01E+03
RDX	2.26E+02	2.17E+03	2.05E+02
1,3,5-Trinitrobenzene	5.32E+04	3.32E+05	4.59E+04
2,4,6-Trinitrotoluene	8.28E+02	4.77E+03	7.06E+02
<u>Pesticide/PCBs:</u>			
Aldrin	1.46E+00	7.01E+00	1.21E+00
Chlordane	7.10E+01	3.41E+02	5.87E+01
Dieldrin	1.55E+00	7.45E+00	1.28E+00
DDD	1.04E+02	6.96E+02	9.01E+01
DDE	7.31E+01	4.91E+02	6.36E+01
DDT	7.31E+01	4.91E+02	6.36E+01
Endosulfan	1.06E+04	1.02E+05	9.64E+03
Endrin	5.32E+02	1.02E+02	8.57E+01
Heptachlor	5.52E+00	3.82E+01	4.82E+00
Heptachlor epoxide	2.73E+00	1.89E+01	2.38E+00
Isodrin	--	--	--
Lindane	1.91E+01	1.78E+02	1.73E+01
Methoxychlor	8.87E+03	8.52E+04	8.03E+03
PCBs	3.23E+00	2.79E+01	2.89E+00
<u>Anions:</u>			
Nitrate	2.84E+06	1.36E+08	(b)
Nitrite	1.77E+05	8.52E+06	1.74E+05

-- Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on $1/[1/(\text{Ingestion CAO}) + 1/(\text{Dermal CAO})]$, see Attachment 3 for derivation, and apply to all depths of soil.

(b) - No CAO listed because the calculated CAO is greater than one million parts per million (µg/g). COPCs in bold are identified in subsurface soil but not in surface soil.

TABLE 16
Corrective Action Objectives (CAOs) for Soil
Particulate Inhalation--Depot Personnel

SF	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ = 1.0
			1E-06	1E-05	1E-04	
		<i>Metals:</i>				
	1.4E-03	Aluminum	--	--	--	6.12E+07
		Antimony	--	--	--	--
1.5E+01		Arsenic	8.17E+03	8.17E+04	8.17E+05	--
	1.0E-04	Barium	--	--	--	4.37E+06
8.4E+00		Beryllium	1.46E+04	1.46E+05	1.46E+06	--
6.3E+00		Cadmium	1.94E+04	1.94E+05	1.94E+06	--
		Chromium (+3)	--	--	--	--
4.2E+01	1.1E-06	Chromium (+6)	2.92E+03	2.92E+04	2.92E+05	4.81E+04
	5.7E-06	Cobalt	--	--	--	2.49E+05
		Copper	--	--	--	--
		Iron	--	--	--	--
		Lead	--	--	--	--
	1.4E-05	Manganese	--	--	--	6.25E+05
	8.6E-05	Mercury	--	--	--	3.75E+06
8.4E-01		Nickel	1.46E+05	1.46E+06	1.46E+07	--
		Selenium	--	--	--	--
	2.9E-06	Silver	--	--	--	1.27E+05
		Thallium	--	--	--	--
		Vanadium	--	--	--	--
		Zinc	--	--	--	--
		<i>Volatiles:</i>				
		Acetone	--	--	--	--
2.9E-02		Benzene	4.22E+06	4.22E+07	4.22E+08	--
		1,3-Dimethylbenzene	--	--	--	--
	2.9E-01	Ethylbenzene	--	--	--	1.25E+10
2.0E-03	1.2E-01	Tetrachloroethene	6.03E+07	6.03E+08	6.03E+09	5.25E+09
6.0E-03		Trichloroethene	2.04E+07	2.04E+08	2.04E+09	--
	2.0E-01	Trichlorofluoromethane	--	--	--	8.75E+09
	1.1E-01	Toluene	--	--	--	5.00E+09
		Xylenes	--	--	--	--
		<i>Semivolatiles:</i>				
		Acenaphthene	--	--	--	--
		Acenaphthalene	--	--	--	--
		Anthracene	--	--	--	--
6.1E-01		Benzo(a)anthracene	2.01E+05	2.01E+06	2.01E+07	--
6.1E+00		Benzo(a)pyrene	2.01E+04	2.01E+05	2.01E+06	--
6.1E-01		Benzo(b)fluoranthene	2.01E+05	2.01E+06	2.01E+07	--
6.1E-02		Benzo(k)fluoranthene	2.01E+06	2.01E+07	2.01E+08	--
		Benzo(g,h,i)perylene	--	--	--	--
1.4E-02	5.7E-02	Bis(2-ethylhexyl) phthalate	8.75E+06	8.75E+07	8.75E+08	2.49E+09
		Butyl benzyl phthalate	--	--	--	--
6.1E-03		Chrysene	2.01E+07	2.01E+08	2.01E+09	--
6.1E+00		Dibenzo(a,h)anthracene	2.01E+04	2.01E+05	2.01E+06	--
		Dibenzofuran	--	--	--	--
	4.0E-02	1,2-Dichlorobenzene	--	--	--	1.75E+09
		1,3-Dichlorobenzene	--	--	--	--
	2.3E-01	1,4-Dichlorobenzene	--	--	--	1.00E+10
		Diethyl phthalate	--	--	--	--
		Di-n-butyl phthalate	--	--	--	--
		Di-n-octyl phthalate	--	--	--	--
		Fluoranthene	--	--	--	--
		Fluorene	--	--	--	--
6.1E-01		Indeno(1,2,3-cd)pyrene	2.01E+05	2.01E+06	2.01E+07	--

TABLE 16 (cont'd)
Corrective Action Objectives (CAOs) for Soil
Particulate Inhalation--Depot Personnel

SE	Rfd	Analyte	CAOs (µg/g) at Target Risk Levels			CAOs (µg/g) at Target HQ=1.0
			1E-06	1E-05	1E-04	
		2-Methylnaphthalene	--	--	--	--
	1.2E-04	Naphthalene	--	--	--	5.25E+06
		Phenanthrene	--	--	--	--
		Phenol	--	--	--	--
		Pyrene	--	--	--	--
		<u>Explosives:</u>				
		2,4-Dinitrotoluene	--	--	--	--
		2,6-Dinitrotoluene	--	--	--	--
		HMX	--	--	--	--
	6.0E-04	Nitrobenzene	--	--	--	2.62E+07
		2-Nitrotoluene	--	--	--	--
		RDX	--	--	--	--
		1,3,5-Trinitrobenzene	--	--	--	--
		2,4,6-Trinitrotoluene	--	--	--	--
		<u>Pesticides/PCBs:</u>				
1.7E+01		Aldrin	7.21E+03	7.21E+04	7.21E+05	--
3.5E-01		Chlordane	3.50E+05	3.50E+06	3.50E+07	--
1.6E+01		Dieldrin	7.66E+03	7.66E+04	7.66E+05	--
2.4E-01		DDD	5.10E+05	5.10E+06	5.10E+07	--
3.4E-01		DDE	3.60E+05	3.60E+06	3.60E+07	--
3.4E-01		DDT	3.61E+05	3.61E+06	3.61E+07	--
		Endosulfan	--	--	--	--
		Endrin	--	--	--	--
4.5E+00		Heptachlor	2.72E+04	2.72E+05	2.72E+06	--
9.1E+00		Heptachlor epoxide	1.35E+04	1.35E+05	1.35E+06	--
		Isodrin	--	--	--	--
		PCBs	--	--	--	--
		<u>Anions:</u>				
1.6E+00		Nitrate	--	--	--	7.00E+10
1.0E-01		Nitrite	--	--	--	4.37E+09

-- Indicates that the relevant health effects criteria are unavailable.

Variable	Units	Value
Risk	none	1E-06
ATNC	days	9125
ATC	days	25550
ET	hours/day	10
EF	days/yr	208
ED	yrs	25
HI	none	1
BW	kg	70
IR	m ³ /hour	1.3
PEF	m ³ /kg	4.63E+09

TABLE 17
Contribution of Inhalation Exposure Route to
CAOs for Known Releases SWMUs at TEAD--Surface Soil (µg/g)
Future Land Use--Depot Personnel

<u>Analyte</u>	<u>Ingestion</u>	<u>Dermal</u>	<u>Comb. (a)</u>	<u>Inhalation</u>	<u>Comb. with Inhalation (a)</u>	<u>Inhal. Comb. /Comb. (b)</u>
<u>Metals:</u>						
Aluminum	2.46E+06	2.46E+06	1.23E+06	6.12E+07	1.20E+06	0.980
Antimony	9.83E+02	1.97E+02	1.64E+02	--	(c)	(c)
Arsenic	4.59E+00	1.88E+01	3.69E+00	8.17E+03	3.69E+00	1.000
Barium	1.72E+05	1.20E+05	7.08E+04	4.37E+06	6.97E+04	0.984
Beryllium	1.60E+00	1.60E-01	1.45E-01	1.46E+04	1.45E-01	1.000
Cadmium	2.46E+03	2.46E+02	2.23E+02	1.94E+04	(d)	(d)
Chromium (+3)	2.46E+06	1.23E+05	1.17E+05	--	(c)	(c)
Chromium (+6)	1.23E+04	2.46E+03	2.05E+03	2.92E+03	(d)	(d)
Cobalt	1.47E+05	1.18E+06	1.31E+05	2.49E+05	8.59E+04	0.656
Copper	9.11E+04	2.73E+05	6.84E+04	--	(c)	(c)
Iron	7.37E+05	1.11E+06	4.42E+05	--	(c)	(c)
Lead	--	--	--	--	(c)	(c)
Manganese	5.90E+04	2.36E+04	1.68E+04	6.25E+05	1.64E+04	0.974
Mercury	7.37E+02	1.11E+03	4.42E+02	3.75E+06	4.42E+02	1.000
Nickel	4.91E+04	1.33E+05	3.59E+04	1.46E+05	(d)	(d)
Selenium	1.23E+04	5.40E+04	1.00E+04	--	(c)	(c)
Silver	1.23E+04	2.21E+04	7.90E+03	1.27E+05	(c)	(c)
Thallium	1.97E+02	2.95E+02	1.18E+02	--	(c)	(c)
Vanadium	1.72E+04	1.72E+03	1.56E+03	--	(c)	(c)
Zinc	7.37E+05	1.47E+06	4.91E+05	--	(c)	(c)
<u>Volatiles:</u>						
Acetone	2.46E+05	2.04E+05	1.11E+05	--	(c)	(c)
Benzene	2.37E+02	2.30E+02	1.17E+02	4.22E+06	1.17E+02	1.000
1,3-Dimethylbenzene	4.91E+06	4.52E+06	2.35E+06	--	(c)	(c)
Ethylbenzene	2.46E+05	2.38E+05	1.21E+05	1.25E+10	1.21E+05	1.000
Tetrachloroethene	1.32E+02	1.32E+02	6.61E+01	6.03E+07	6.61E+01	1.000
Trichloroethene	6.25E+02	9.38E+01	8.16E+01	2.04E+07	8.16E+01	1.000
Trichlorofluoromethane	7.37E+05	1.70E+05	1.38E+05	8.75E+09	1.38E+05	1.000
Toluene	4.91E+05	3.93E+05	2.18E+05	5.00E+09	2.18E+05	1.000
Xylenes	4.91E+06	4.52E+06	2.35E+06	--	(c)	(c)
<u>Semivolatiles:</u>						
Acenaphthene	1.47E+05	4.57E+04	3.49E+04	--	(c)	(c)
Acenaphthylene	7.37E+04	2.28E+04	1.74E+04	--	(c)	(c)
Anthracene	7.37E+05	5.60E+05	3.18E+05	--	(c)	(c)
Benzo(a)anthracene	9.42E+00	2.92E+00	2.23E+00	2.01E+05	2.23E+00	1.000
Benzo(a)pyrene	9.42E-01	2.92E-01	2.23E-01	2.01E+04	2.23E-01	1.000
Benzo(b)fluoranthene	9.42E+00	2.92E+00	2.23E+00	2.01E+05	2.23E+00	1.000
Benzo(k)fluoranthene	9.42E+01	2.92E+01	2.23E+01	2.01E+06	2.23E+01	1.000
Benzo(g,h,i)perylene	7.37E+04	2.28E+04	1.74E+04	--	(c)	(c)
Bis(2-ethylhexyl) phthalate	4.91E+02	9.34E+01	7.85E+01	8.75E+06	7.84E+01	1.000
Butyl benzyl phthalate	4.91E+05	3.00E+05	1.86E+05	--	(c)	(c)
Chrysene	9.42E+02	2.92E+02	2.23E+02	2.01E+07	2.23E+02	1.000
Dibenz(a,h)anthracene	9.42E-01	2.92E-01	2.23E-01	2.01E+04	2.23E-01	1.000
Dibenzofuran	9.83E+03	9.83E+03	4.91E+03	--	(c)	(c)
1,2-Dichlorobenzene	2.21E+05	2.21E+05	1.11E+05	1.75E+09	1.11E+05	1.000
1,3-Dichlorobenzene	2.21E+03	2.21E+03	1.11E+03	--	(c)	(c)
1,4-Dichlorobenzene	2.87E+02	2.58E+02	1.36E+02	1.00E+10	1.36E+02	1.000
Diethyl phthalate	1.97E+06	1.77E+06	9.31E+05	--	(c)	(c)
Di-n-butyl phthalate	--	--	--	--	(c)	(c)
Di-n-octyl phthalate	2.46E+05	2.46E+05	1.23E+05	--	(c)	(c)
Fluoranthene	9.83E+04	3.05E+04	2.33E+04	--	(c)	(c)
Fluorene	9.83E+04	9.83E+04	4.91E+04	--	(c)	(c)

TABLE 17 (cont'd)
Contribution of Inhalation Exposure Route to
CAOs for Known Releases SWMUs at TEAD—Surface Soil μ g/g)
Future Land Use—Depot Personnel

<u>Analyte</u>	<u>Ingestion</u>	<u>Dermal</u>	<u>Comb. (a)</u>	<u>Inhalation</u>	<u>Comb. with Inhalation (a)</u>	<u>Inhal. Comb. /Comb. (b)</u>
Indeno(1,2,3-cd)pyrene	9.42E+00	2.92E+00	2.23E+00	2.01E+05	2.23E+00	1.000
2-Methylnaphthalene	9.83E+04	7.86E+04	4.37E+04	--	(c)	(c)
Naphthalene	9.83E+04	7.86E+04	4.37E+04	5.25E+06	4.33E+04	0.992
Phenanthrene	7.37E+04	5.38E+04	3.11E+04	--	(c)	(c)
Phenol	1.47E+06	1.33E+06	6.98E+05	--	(c)	(c)
Pyrene	7.37E+04	2.28E+04	1.74E+04	--	(c)	(c)
<u>Explosives:</u>						
1,3-Dinitrobenzene	2.46E+02	1.60E+02	9.68E+01	--	(c)	(c)
2,4-Dinitrotoluene	1.01E+01	8.60E+00	4.65E+00	--	(c)	(c)
2,6-Dinitrotoluene	1.01E+01	8.60E+00	4.65E+00	--	(c)	(c)
HMX	1.23E+05	1.84E+04	1.60E+04	--	(c)	(c)
Nitrobenzene	1.23E+03	1.19E+03	6.05E+02	2.62E+07	6.05E+02	1.000
2-Nitrotoluene	2.46E+04	2.46E+04	1.23E+04	--	(c)	(c)
RDX	6.25E+01	6.25E+01	3.13E+01	--	(c)	(c)
Tetryl	2.46E+04	1.23E+04	8.19E+03	--	(c)	(c)
1,3,5-Trinitrobenzene	1.23E+02	7.98E+01	4.84E+01	--	(c)	(c)
2,4,6-Trinitrotoluene	2.29E+02	1.38E+02	8.60E+01	--	(c)	(c)
<u>Pesticide/PCBs:</u>						
Aldrin	4.05E-01	2.02E-01	1.35E-01	7.21E+03	1.35E-01	1.000
Chlordane	1.97E+01	9.83E+00	6.55E+00	3.50E+05	6.55E+00	1.000
Dieldrin	4.30E-01	2.15E-01	1.43E-01	7.66E+03	1.43E-01	1.000
DDD	2.87E+01	2.01E+01	1.18E+01	5.10E+05	1.18E+01	1.000
DDE	2.02E+01	1.42E+01	8.33E+00	3.60E+05	8.33E+00	1.000
DDT	2.02E+01	1.42E+01	8.33E+00	3.61E+05	8.33E+00	1.000
Endosulfan	1.47E+04	1.47E+04	7.37E+03	--	(c)	(c)
Endrin	7.37E+02	1.47E+01	1.45E+01	--	(c)	(c)
Heptachlor	1.53E+00	1.10E+00	6.40E-01	2.72E+04	6.40E-01	1.000
Heptachlor epoxide	7.56E-01	5.44E-01	3.16E-01	1.35E+04	3.16E-01	1.000
Isodrin	--	--	--	--	(c)	(c)
PCBs	8.93E-01	8.04E-01	4.23E-01	--	(c)	(c)
<u>Anions</u>						
Nitrate	3.93E+06	1.97E+07	3.28E+06	7.00E+10	(c)	(c)
Nitrite	2.46E+05	1.23E+06	2.05E+05	4.37E+09	(c)	(c)

-- Indicates that the relevant health effects criteria are unavailable.

(a) - Values are based on 1/E(1/CAO), see Attachment 3 for derivation.

(b) - Ratio of combination CAO with inhalation pathway to combination CAO without inhalation.

(c) - Inhalation-based CAO calculation cannot be performed due to lack of health effects criteria.

(d) - Inhalation-based CAOs cannot be combined with other exposure routes because the inhalation values are based on carcinogenic effects, while the other routes are based on noncarcinogenic effects.

ATTACHMENT 2

Evaluation of TEAD Soil Chemistry

EVALUATION OF TEAD SOIL CHEMISTRY

The soil classification scheme used by the U.S. Soil Conservation Service (SCS) relies on differences in physical properties and origin for identifying soil mapping units. SCS does not use chemical variations as a discriminator, yet chemical concentration variations are of primary importance in the evaluation of background.

The background soil at TEAD was sampled from several soil mapping units. For the evaluation of soil chemistry, these samples were separated on the basis of soil type and evaluated for variations in chemical concentrations.

Surface soil mapping units reflect the differences in geologic materials and processes from which the soils originated, as noted below:

- Soils on the east side of TEAD are in the Abela Series, the Doyce Series, and Medburn Series.
 - The Abela is described as alluvial fans derived from limestone and quartzite.
 - The Doyce forms alluvial fans, but consists of mixed materials.
 - The Medburn is predominantly derived from sedimentary rocks in the form of alluvium and lacustrine sediments.
- In the western and central portions of TEAD, soils are within the Berent-Hiko Peak Complex, or the Medburn series.
 - The Berent consists of eolian sands.
 - The Hiko Peak is alluvium derived from mixed rock types, including lacustrine sediments.
 - The Medburn Saline consists of lacustrine sediments.

As with any mapping procedure, enclaves of a variety of soils may occur within a mapping unit. However, these five units define the predominant soils at TEAD (SCS, 1991).

The soil series define two identifiable groups in the east or west. The eastern soils are dominated by alluvium formed from limestone and quartzite; the western soils are generally derived from lacustrine (Lake Bonneville) materials and form terraces or fan terraces. The background soil samples were generally collected from these soil types in the extreme east or west of TEAD (Montgomery Watson, 1997). As a consequence, soil samples were sorted by location and identified as either "east" or "west." Table 1 presents

TABLE 1
Background Soil Samples and Soil Type

Sample ID	Starting Depth (ft bgs)	Comments	Soil Type
SB-BK-001	0		Hiko Peak
SB-BK-001	3		Hiko Peak
SB-BK-002	0		Berent
SB-BK-002	2		Berent
SB-BK-003	0		Medburn
SB-BK-003	2		Medburn
SB-BK-004	0	Duplicate sample included in average.	Hiko Peak
SB-BK-004	3		Hiko Peak
SB-BK-005	0		Medburn
SB-BK-005	3		Medburn
SB-BK-006	10	Not representative of shallow soils.	
SB-BK-006	15	Not representative of shallow soils.	
SB-BK-006	30	Not representative of shallow soils.	
SB-BK-006	45	Not representative of shallow soils.	
SB-BK-006	60	Not representative of shallow soils.	
SB-BK-006	70	Not representative of shallow soils.	
SB-BK-006	100	Not representative of shallow soils.	
SB-BK-007A	0		Berent
SB-BK-007B	3		Berent
SB-BK-008A	0		Berent
SB-BK-008B	3		Berent
SB-BK-009A	0		Abela
SB-BK-009B	3		Abela
SB-BK-010A	0		Abela
SB-BK-010B	3		Abela
SB-BK-011A	0		Berent
SB-BK-011B	3		Berent
SB-BK-012A	0		Berent
SB-BK-012B	3		Berent
SB-BK-013A	0		Medburn
SB-BK-013B	3		Medburn
SB-BK-014A	0		Medburn
SB-BK-014B	3		Medburn
SB-BK-015A	0		Medburn
SB-BK-015B	3		Medburn
SB-BK-016A	0		Abela
SB-BK-016B	2	Duplicate sample included in average.	Abela
SB-BK-007	0		Abela
SB-BK-008	0		Abela
SB-BK-017A	0		Abela
SB-BK-017B	2		Abela
SB-BK-018A	0		Abela
SB-BK-018B	2		Abela
SB-BK-019A	0	Duplicate sample included in average.	Abela
SB-BK-019B	5		Abela
SB-BK-019C	7.5		Abela
SB-BK-020A	0		Abela
SB-BK-020B	5		Abela
SB-BK-020C	7.5		Abela
SB-BK-021A	0.08		Abela
SB-BK-021B	5		Abela
SB-BK-021C	7.5		Abela
SB-BK-022A	0.08		Abela
SB-BK-022B	5		Abela
SB-BK-022C	7.5		Abela
BKS-92-01	0		Medburn
BKB-92-01	3		Medburn
BKS-92-02	0		Medburn
BKB-92-02	2		Medburn
BKS-92-03	0	Excluded due to suspected surface contamination.	Hiko Peak
BKB-92-03	3	Excluded due to suspected surface contamination.	Hiko Peak
BKS-92-04	0		Berent
BKB-92-04	3		Berent
BKS-93-05	0.5		Berent
BKB-93-05	3.5		Berent

the soil type for each background sample. The soil type for each background location was taken directly from the background soil sample location map presented in Montgomery Watson (1997) and SAIC (1997). These figures include the soil mapping units described above. Samples collected in Abela and Medburn soils are classified as east; and Hiko Peak, Berent, and Medburn Saline soils are classified as west. Of the 56 background soils, 34 were classified as east and 22 as west. Grouping the samples by specific soil type (Abela, Berent, Hiko Peak, Medburn) would result in too few samples per type for meaningful statistical evaluation.

In preparation for testing between east and west populations, the chemical distributions within each population were tested by analyte for their lognormal or normal distribution. The data were first reviewed for data qualifiers, detection limits, and presence of duplicates, as described for the entire data set in Appendix A, Section A.6. The distribution was evaluated using the Shapiro-Wilk test.

- If there were less than 50 percent detections of an analyte within each group, a distribution test was not performed.
- If the data for any given analyte had the same type of distribution in east and west, the F-test for differences in variance was applied.
- If the data for a specified analyte were normal (or lognormal) for both east and west sample populations, and the F-test indicated that the variances were similar, the Student's t-test was considered applicable to testing differences in the mean.
- If the data distribution for the east and west populations did not conform to the same distribution, failed to match any distribution, or failed the F-test of variances, nonparametric methods for comparing two populations applied. The Mann-Whitney U test was selected as the nonparametric alternative to the Student's t-test. (The Mann-Whitney U test is recommended for comparison of two ordered data sets with unequal variance. (Sokal and Rohlf, 1981; Gad and Weil, 1991)). It is essentially identical to the t-test for independent samples, except that it relies on rank sums rather than means and can be applied to non-normal data. Table 2 summarizes the test results. The statistical tests used in the evaluation were according to standard statistical methodologies described in Sokal and Rohlf (1981) and Gilbert (1987).

For each metal analyzed in the background samples with greater than 50 percent detections, a test of differences was performed by using either the Student's t-test or the Mann-Whitney U test. Those analytes with fewer than 50 percent detections were not considered due to the low percentage of measurable quantities.

Table 2 summarizes the results of the population distribution tests. Based on these results, the following analyte populations were the same at 95 percent significance for the

TABLE 2

Soil Chemistry Differences: East versus West

	Detection Frequency		Distribution		F-test Result	t-test Result	U-test Result	EAST vs. WEST
	EAST	WEST	EAST	WEST				
Aluminum	100	100	Lognormal	Lognormal	Pass	Pass		Same
Antimony	9	0	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	94	94	Neither	Lognormal			Fail	Differ
Barium	100	100	Lognormal	Lognormal	Fail		Pass	Same
Beryllium	71	55	Neither	Neither			Pass	Same
Cadmium	35	5	N/A	N/A	N/A	N/A	N/A	N/A
Calcium	100	100	Neither	Neither			Fail	Differ
Chromium	100	95	Lognormal	Lognormal	Fail		Fail	Differ
Cobalt	91	82	Neither	Normal			Pass	Same
Copper	100	100	Lognormal	Lognormal	Pass	Pass		Same
Iron	100	100	Lognormal	Lognormal	Fail		Pass	Same
Lead	97	91	Lognormal	Lognormal	Pass	Pass		Same
Magnesium	100	100	Lognormal	Lognormal	Pass	Pass		Same
Manganese	100	100	Neither	Neither			Pass	Same
Mercury	21	5	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	94	82	Normal	Neither			Pass	Same
Potassium	100	100	Lognormal	Lognormal	Pass	Pass		Same
Selenium	0	6	N/A	N/A	N/A	N/A	N/A	N/A
Silver	18	23	N/A	N/A	N/A	N/A	N/A	N/A
Sodium	100	100	Neither	Neither			Pass	Same
Thallium	38	44	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	100	100	Lognormal	Lognormal	Pass	Pass		Same
Zinc	100	100	Lognormal	Lognormal	Pass	Pass		Same

east and west – aluminum, barium, beryllium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc. Those analytes that showed a statistical difference in population distribution at 95 percent were arsenic, chromium, and calcium.

In summary, the testing of east and west soil chemistry for differences in population distribution suggested that – for the majority of chemicals (20 out of 23) – the soils cannot be distinguished. Furthermore, the acceptance of the null hypothesis for each metal analyte is not made with 100 percent confidence (i.e., an “expected” 5 percent failure rate); a metal is assumed to incorrectly fail the test 5 percent of the time, even if there is no difference between the metals distributions from east to west. Certainly, if differences are more common than similarities, the soils could be separated into two background concentrations by geographic area.

This alternative consideration of having two background concentrations for different portions of TEAD is less tenable because of the preponderance of metals with distributions that test as the same, and because the criteria could be illogically met simply by moving soil from one portion of TEAD to another, if the background concentrations become cleanup levels. Therefore, for each analyte, a single background comparison criterion is calculated using all of the soil data.

ATTACHMENT 3

Derivation of Relationship for Combining Pathway- Specific Corrective Action Objectives

DERIVATION OF RELATIONSHIP FOR COMBINING PATHWAY-SPECIFIC CORRECTIVE ACTION OBJECTIVES

The general equation for pathway-specific risk for a single chemical is:

$$Risk = \frac{C \cdot Sf}{I} \quad (Eq 1)$$

where the slope factor (Sf) is determined from chemical-specific toxicity tests, and total intake is a function of the contaminant concentration at the site (C) and the combined pathway-specific exposure variable (I).

The total risk at a site for one chemical is the sum of the pathway-specific risks:

$$Total\ risk = Risk\ (ingestion) + Risk\ (dermal\ absorption) + Risk\ (inhalation) \quad (Eq 2)$$

In many cases, the risk associated with the inhalation pathway is insignificant, but for purposes of this derivation the less general case is retained.

The CAO for a specific contaminant is the concentration at the site that is equivalent to the case of risk equals 1×10^{-6} . In this case, the C term is called the CAO.

A mathematical expression of risk for the CAO concentration in soil is:

$$Risk = \frac{CAO \cdot Sf_1}{I_1} + \frac{CAO \cdot Sf_2}{I_2} + \frac{CAO \cdot Sf_3}{I_3} \quad (Eq 3)$$

where the CAO is the site-specific concentration needed to create a total risk of exactly 1×10^{-6} . Factoring out the CAO term, the same equation is written as:

$$Risk = CAO \cdot \left(\frac{Sf_1}{I_1} + \frac{Sf_2}{I_2} + \frac{Sf_3}{I_3} \right) \quad (Eq 4)$$

Solving this equation for the CAO:

$$CAO = \frac{Risk}{\left(\frac{Sf_1}{I_1} + \frac{Sf_2}{I_2} + \frac{Sf_3}{I_3} \right)} \quad (Eq 5)$$

Dividing both the numerator and denominator by risk yields:

$$CAO = \frac{1}{\frac{1}{Risk} \cdot \left(\frac{Sf_1}{I_1} + \frac{Sf_2}{I_2} + \frac{Sf_3}{I_3} \right)} \quad (\text{Eq 6})$$

Factoring risk into each term of the denominator results in the following expression:

$$CAO = \frac{1}{\left(\frac{Sf_1}{Risk \cdot I_1} + \frac{Sf_2}{Risk \cdot I_2} + \frac{Sf_3}{Risk \cdot I_3} \right)} \quad (\text{Eq 7})$$

Note that for this expression to be true, risk must be equal to 1×10^{-6} .

Referring to Equation 1, the terms in the denominator are familiar as the reciprocal of:

$$C_i = \frac{Sf_i}{Risk \cdot I_i} \quad (\text{Eq 8})$$

where C_i is the concentration for a specific analyte via a particular pathway evaluated for a risk of 1×10^{-6} . Finally, this may be substituted into Equation 7 and yields the result:

$$CAO = \frac{1}{\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)} = \frac{1}{\sum \frac{1}{C_n}} \quad (\text{Eq 9})$$

Thus, the CAO for a specific contaminant is equal to the reciprocal of the sum of the reciprocals of the pathway-specific concentrations equal to a risk of 1×10^{-6} .

For noncarcinogenic chemicals, the derivation is analogous but not identical. The general expression for the hazard quotient (HQ) is defined as:

$$HQ = \frac{C}{RfD \cdot I} \quad (\text{Eq 10})$$

where the RfD is determined from chemical-specific toxicity tests, and total intake is a function of the combined pathway-specific exposure variable (I) and the contaminant concentration at the site.

The total HQ for a single chemical at a site is the sum of the pathway-specific HQs:

$$\text{Total HQ} = \text{HQ (ingestion)} + \text{HQ (dermal absorption)} + \text{HQ (inhalation)} \quad (\text{Eq 11})$$

The CAO for a noncarcinogenic chemical is the concentration at the site that is equivalent to the case of HQ equals 1.0. The C term is the same as the CAO, but is factored into each pathway:

$$\text{HQ} = \frac{\text{CAO}}{\text{RfD}_1 \cdot I_1} + \frac{\text{CAO}}{\text{RfD}_2 \cdot I_2} + \frac{\text{CAO}}{\text{RfD}_3 \cdot I_3} \quad (\text{Eq 12})$$

where CAO is the site-specific concentration needed to create a total HQ of exactly 1.0. Factoring out the CAO term, the equation becomes:

$$\text{HQ} = \text{CAO} \cdot \frac{1}{\text{RfD}_1 \cdot I_1} + \frac{1}{\text{RfD}_2 \cdot I_2} + \frac{1}{\text{RfD}_3 \cdot I_3} \quad (\text{Eq 13})$$

Solving for the CAO, the equation is rewritten as:

$$\text{CAO} = \frac{\text{HQ}}{\left(\frac{1}{\text{RfD}_1 \cdot I_1} + \frac{1}{\text{RfD}_2 \cdot I_2} + \frac{1}{\text{RfD}_3 \cdot I_3} \right)} \quad (\text{Eq 14})$$

Dividing both the numerator and denominator by HQ results in the form:

$$\text{CAO} = \frac{1}{\frac{1}{\text{HQ}} \left(\frac{1}{\text{RfD}_1 \cdot I_1} + \frac{1}{\text{RfD}_2 \cdot I_2} + \frac{1}{\text{RfD}_3 \cdot I_3} \right)} \quad (\text{Eq 15})$$

Factoring the HQ into the denominator, the expression becomes:

$$\text{CAO} = \frac{1}{\left(\frac{1}{\text{HQ} \cdot \text{RfD}_1 \cdot I_1} + \frac{1}{\text{HQ} \cdot \text{RfD}_2 \cdot I_2} + \frac{1}{\text{HQ} \cdot \text{RfD}_3 \cdot I_3} \right)} \quad (\text{Eq 16})$$

Recall that for this equation to be true, HQ is assumed to equal 1.0. The terms in the denominator are familiar as the C term from Equation 10. The final substitution becomes:

$$\text{CAO} = \frac{1}{\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)} = \frac{1}{\sum \frac{1}{C_n}} \quad (\text{Eq 17})$$

Thus, for both carcinogenic and noncarcinogenic chemicals, the CAO is the sum of one over the sum of the reciprocals of the pathway-specific concentrations.

To verify this derivation, the supporting equations from the summary of CAO tables (A-1 and A-2) can be used. For example, the combined CAO for antimony for Depot personnel is 164 micrograms per gram ($\mu\text{g/g}$; Table 8, Attachment 1). When placed in the intake and HQ supporting equations for soil ingestion (Table A-1), this concentration produces an HQ of 0.167. The same concentration in the dermal absorption supporting equations (Table A-2) corresponds to an HQ of 0.834. The sum of these two pathway-specific HQs is 1.00, demonstrating that 164 $\mu\text{g/g}$ is the antimony concentration in soil that represents an acceptable HQ.

APPENDIX B

Identification and Screening of Treatment Technologies and Management Measures

IDENTIFICATION AND SCREENING OF TREATMENT TECHNOLOGIES AND MANAGEMENT MEASURES

B.1 INTRODUCTION

Appendix B identifies potentially applicable treatment technologies and management measures for the following COCs in soil and groundwater at the seven Known Releases SWMUs, as discussed in Sections 3.0 to 7.0:

- Soil
 - Metals (SWMUs 12/15 and 25)
 - Explosives (SWMU 10)
 - SVOCs (SWMU 12/15)
 - Pesticides (SWMU 12/15).
- Groundwater
 - Explosives (SWMU 10)
 - VOCs (SWMU 12/15).

In addition, to ensure that the future land use remains military (non-BRAC) or industrial (BRAC) and to meet the requirements of UAC R315-101-6(e), Appendix B presents and evaluates management measures for the SWMUs for which no COCs are identified under the assumed future land use scenario (SWMUs 3 and 30).

Each identified treatment technology or management measure is evaluated by comparing it to standard initial screening criteria, including site characteristics, waste (or COC) characteristics, and technology limitations, as described below:

- Site characteristics include specific site conditions that may limit or impede the applicability of the technology, such as the presence of buried utilities in the vicinity of proposed remediation, accessibility (for equipment), and continued site activity during the implementation of corrective measures.
- Waste characteristics refer to the ability of the technology to treat or contain specific contaminants (i.e., COCs). This screening also discusses the anticipated fate of COCs in the environment, including their persistence and mobility.
- Technology limitations consider reliability and performance record.

Although a wide range of treatment technologies are commercially available, Appendix B focuses only on those that are proven and potentially applicable to the

SWMUs under consideration. Technologies are screened on the basis of their applicability and effectiveness. Sections 3.0 through 7.0 assemble the technologies that pass the initial screening into corrective measures alternatives for each SWMU.

B.2 CORRECTIVE MEASURES TECHNOLOGIES FOR SOIL

Corrective measures for soil may be driven by potential risks to both human and ecological receptors and by the potential effects of soil contaminants on groundwater. As discussed in Appendix A, the primary exposure pathways associated with surface soil include inadvertent ingestion and dermal absorption following direct contact. Potential effects on other media (i.e., surface water and sediment) as a result of soil erosion during storms are also considered. The COCs for soil at the Known Releases SWMUs include metals, explosives, SVOCs, and pesticides.

The technologies considered are screened according to the three criteria outlined in Section B.1. They are evaluated based on their ability to meet both the quantitative and qualitative CAOs for soil, as listed below:

- To achieve acceptable residual contaminant concentrations (developed in Appendix A).
- To protect the environment from further degradation, in accordance with the "Principle of Non-Degradation," UAC R315-101-3.
- To protect human health and the environment.

Sections B.2.1 through B.2.11 describe potentially applicable treatment technologies and management measures to address the identified risks from contaminated soil at the Known Releases SWMUs.

Based on the screening of potentially applicable treatment technologies, some are eliminated from further consideration. Table B-1 summarizes the potentially applicable technologies identified and assessed in this screening process, including the advantages and disadvantages of each, and notes whether they are retained for further consideration in developing site-wide corrective measures alternatives. Ancillary activities – such as monitoring, backfilling, grading, and revegetation – will be incorporated into the corrective measures alternatives as appropriate. However, these activities are not considered as separate technologies for the purpose of the screening process.

B.2.1 Institutional Controls

Institutional controls are used to limit human activities at or near a contaminated site. These mechanisms may include short- or long-term restrictions on property use.

B.2.1.1 Land Use Restrictions. Land use restrictions limit the future use of a site that remains under Army control. These restrictions may be used to prevent future residential use of the property. Land use restrictions will be incorporated into Tooele Army Depot's Installation Master Plan. The Real Property Planning Board has authority over land use at the base and is responsible for developing, enforcing, and modifying the Master Plan. The authority of the board is derived from the responsible major Army command (i.e., Industrial Operations Command). The overall purpose of the Master Plan is to describe and analyze existing facilities, conditions, and future requirements, as well as to provide guidelines for orderly growth and development of the installation. The Master Plan consolidates interrelated programs and information into a framework for determining installation requirements associated with current and future assigned missions and activities. Specifically, the Master Plan is the mechanism for ensuring that installation projects are sited to meet operational, safety, and environmental requirements.

The Installation Master Plan consists of two principal categories of component plans – primary and secondary. The primary components include the Existing Conditions Plan, Land Use Plan, Utilities Plan, Transportation Plan, and Future Development Plan. The secondary components range from installation design guidelines to environmental protection plans. Unlike primary component plans – which are required in all Army Master Plans – each installation determines the number, type, and extent of secondary plans to be included in its Master Plan.

Environmental protection (site management) plans will be written and used to identify land use restrictions, as well as maintenance and monitoring requirements for other institutional controls (e.g., fencing) that may be implemented. These plans will also include legal descriptions and maps identifying the location of each site where land use restrictions or other institutional controls will be applied, and will be attached as secondary components to the Master Plan.

In addition to site management, conditions will be added to the Post Closure Permit for those sites under the RCRA corrective action program to document restrictions as well as monitoring, maintenance, and inspection requirements.

Army actions that could occur and will be affected by land use restrictions or other institutional controls are Outgrants (Leases); Divesting Title (Sale or Transfer); Transfer of Jurisdiction Between Agencies; New Construction; Maintenance or Modification to Existing Facilities; and Licenses, Permits, or Easements for Use.

In all cases, procedures are in place to ensure that an environmental evaluation is conducted prior to executing the action and that all constraints or limitations are identified and documented. Although mechanisms for conducting such evaluations vary depending on the action, the result is that the proponent of the action must comply with all applicable restrictions or limitations.

Because Army regulations direct that all revisions to the plan be evaluated with regard to potential effects on human health and the environment, unauthorized future use

(i.e., residential) of non-BRAC Known Releases SWMUs would require the resolution of conflicts between identified risks and hazards and proposed changes in land use.

If any of the non-BRAC SWMUs are realigned as part of the BRAC program, restrictions would be included in the deed at the time of property transfer or lease to limit potential future use of the area. The need for remediation will depend on the future planned use at the site; residential use will require an evaluation of remedial action.

Land use restrictions are retained for further consideration because they are applicable to the non-BRAC SWMUs and identified COCs, and have been shown at other sites to effectively prevent exposure and minimize risk.

B.2.1.2 Deed Restrictions. Deed restrictions limit the future use of a site that is no longer under Army control. These restrictions prevent the completion of exposure pathways that may cause a potential human health risk. Zoning regulations are one form of deed restrictions; they are commonly used to control property development and to ensure continued nonresidential land use. As stated above, a legally binding deed notice accompanies any transfer of property from the Army to another owner (TEAD, 1997).

Because deed restrictions are applicable to a portion of SWMU 30 and identified COCs, and have been shown to effectively prevent exposure and minimize risk, they are retained for further consideration.

B.2.1.3 Fencing. This institutional control involves enclosing individual or contiguous areas within a secured fence with a locking gate. Fencing reduces human health risks by limiting exposure to contaminants in soil. Fencing is applicable to all contaminant classes. It is viable in little-used portions of a site that contain contaminants that are not likely to become airborne particles (e.g., areas that have an overlying gravel layer) and that do not affect other environmental media.

Fencing is applicable to all COCs identified at the Known Releases SWMUs and is proven effective in preventing exposure and minimizing risk. In addition, fencing can be used to protect the integrity of a cap or soil cover used to contain contaminants. Several restricted areas of TEAD are already fenced. Although site characteristics may preclude the use of fencing in active areas of specific SWMUs, this institutional control is considered appropriate to the Known Releases SWMUs and is retained for further consideration.

B.2.2 Natural Attenuation

Natural attenuation involves the use of natural processes to reduce contaminant concentrations to environmentally acceptable levels. Active processes for natural attenuation include, but are not limited to (U.S. Army Science Board, 1995):

- Biological processes (aerobic and anaerobic biodegradation, plant and animal uptake).

- Physical processes (advection, dispersion, diffusion, volatilization, dilution, and sorption/desorption).
- Chemical processes (ion exchange, complexation, and abiotic transformation).

Natural attenuation differs from "no further action" in that data analyses and contaminant migration modeling and monitoring are conducted to verify that the attenuation processes are actively reducing contaminant concentrations. According to UAC R315-101-6(c)(1) – "no further action" cannot be evaluated for sites (such as the Known Releases SWMUs evaluated in the CMS) that have a risk level greater than 1×10^{-6} or an HI greater than 1.0 under the hypothetical future residential land use scenario.

According to U.S. Environmental Protection Agency (EPA) guidance, three specific types of "evidence" must be substantiated to confirm that natural attenuation is occurring (USEPA, 1997):

- Historical soil chemistry data must demonstrate a clear and meaningful trend of decreasing contaminant mass or concentration over time.
- Data must be presented to demonstrate the types of natural attenuation active at the site, and the rate at which such processes are expected to reduce contaminant concentrations to required levels.
- Microcosm studies must be performed to demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the COCs.

The feasibility of natural attenuation depends on:

- The type and concentrations of contaminants
- Likelihood and frequency of human exposure to the area
- Depth to groundwater below the affected area
- Concentration of contaminants (if any) in the underlying aquifer
- Time required for natural degradation to occur.

Factors that affect the rate of natural attenuation include soil moisture, organic matter, porosity, oxygen content, pH, and the presence of bacterial populations in soil. Because many of these factors at TEAD are not favorable for biological processes, it may require a considerable amount of time to achieve CAOs for the organic COCs identified in surface soil at the Known Releases SWMUs – explosives, SVOCs, and pesticides – this technology is not retained for further consideration.

B.2.3 Capping/Soil Covers

Capping involves covering an area of contaminated soil to reduce exposure to human or ecological receptors. Capping also prevents the release of contaminants as fugitive dust to the atmosphere, mitigates continued erosion of contaminated soil, and reduces the migration of contaminants to groundwater by limiting the infiltration of precipitation.

Typical cap construction materials include asphalt, concrete, compacted soil, clay, geosynthetic membranes, or a combination of these materials. Composite caps typically include a drainage layer to channel infiltrating precipitation away from the waste. The design may also contain perimeter drains to keep the area around the cap dry.

Stabilized soil covers involve the placement of appropriate materials (e.g., compacted soil, gravel, synthetic erosion control mats, and geotextiles) over contaminated surface soil to reduce exposure to human or ecological receptors. Covers are graded to enhance stormwater runoff and then stabilized through revegetation. Soil covers may also include measures for erosion control, slope stabilization, and safe management of runoff water (e.g., earth dikes, lined ditches, and stone check dams). Modeling may be required to demonstrate that soil contamination at the Known Releases SWMUs will have no future effects on groundwater.

The landfill at SWMU 12/15 is bisected by an arroyo. Based on reported observations by TEAD personnel, it appears that significant water flow no longer occurs in the arroyo, due to the upstream diversion of surface water. Nevertheless, because of the potential for occasional water flow in the arroyo, the landfill soil cover or cap must be designed to accommodate possible surface water flow through the arroyo. Factors affecting the design of the landfill cap or soil cover include: the suitability of local soils for use in the proposed simple soil cover and Geosynthetic cap; the effectiveness and reliability of the proposed covers in arid climates; and the feasibility and relative cost of covering the channel areas within the arroyo.

Possible solutions addressing the arroyo include extending the simple soil cover or Geosynthetic cap over the channel, or construction of an engineered channel. The engineered channel would be constructed by making the channel a uniform width and paving with asphalt or a soil cement cover. Paving the arroyo could provide vehicle access to the interior of the landfill for inspection and maintenance. These options will be evaluated further in the CMS Report.

To evaluate the relative performance of the proposed landfill cover and cap designs for SWMU 12/15, a water balance analysis is performed as part of the CMS Report. The analysis is conducted using the Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model includes a simulation of baseline conditions and simulations for each of the proposed landfill designs. The performance of each design is compared against the modeled baseline condition. The relative

performance of each proposed type of cap is one additional factor in the selection process.

Both soil covers and composite caps are easily implemented and are cost effective. The labor, equipment, and materials required for their construction are readily available.

Nonrigid caps constructed of soil/clay, or synthetic membranes are considered most appropriate for SWMUs 12/15 and 25 (where COCs are identified in soil) because of the anticipated future use of these areas.

As a proven technology applicable to the identified sites and COCs, capping and soil covers are retained for further consideration. Capping at the Sanitary Landfill (SWMUs 12/15) will comply with State of Utah landfill closure requirements.

B.2.4 Excavation

The removal of contaminated soil eliminates exposure to Depot personnel and potential migration of contaminants from source areas to groundwater. Excavation is viable in areas with limited subsurface obstacles, such as buried structures, utilities, and building foundations. The disadvantages of this technology include the handling of potentially hazardous materials and disruptions to ongoing installation activities. Excavation is an established technology applicable to all COCs and is retained for further consideration on an area-specific basis for SWMUs 10 and 25. Because of the volume of material present at the Sanitary Landfill, excavation is not considered applicable for SWMUs 12/15.

B.2.5 Biological Treatment

The biological treatment of organic contaminants in soil involves their biotransformation to less toxic end products or their mineralization to carbon dioxide and water. Several different biological processes and technologies have been used to treat contaminated soil, including landfarming, composting, bioventing, and slurry-phase reactors. Of the organic COCs identified in soil at the Known Releases SWMUs, biological treatment is most applicable to explosives. This treatment includes the ex situ aerobic methods of biotransformation by windrow composting and slurry phase treatment using a bioreactor. Soil with higher fractions of fines (such as identified at the Known Releases SWMUs) may facilitate faster remediation because of the large surface area available for microbial activity.

Recent research has also identified an ex situ anaerobic bioremediation method for the biotransformation of explosives in soil; the applicability of this method for use at the Known Releases SWMUs will be determined as more information is obtained from upcoming pilot studies.

Biological treatment is considered applicable only for explosives-contaminated soil at the TNT Washout Facility (SWMU 10). However, the dewatering of soil slurry may be encumbered by the high fraction of fines in the contaminated media. Other parameters that affect biological activity in contaminated soil include soil pH, moisture content, and the presence of toxic or inhibitory concentrations of metals and organics. Soil pH can be optimized through the addition of agricultural limestone or ferrous sulfate. (With a slurry system, a buffer solution can be used to ensure that the optimal pH is maintained in the treatment reactor.) Soil moisture can be optimized by drip irrigation, and high concentrations of toxic or inhibitory compounds can be diluted by soil bulking. If biological treatment is recommended for implementation, a bench-scale treatability study using soil from SWMU 10 may be conducted to further assess these and other limitations.

B.2.5.1 Aerobic Treatment. Two methods of aerobic treatment are considered as treatment technologies for soil at SWMU 10 – composting and slurry phase biological treatment.

- Composting uses indigenous microorganisms to degrade the organic material present in contaminated soil under controlled conditions. Bulking agents – such as cow manure, vegetable waste, or wood chips – are added to enhance the porosity of the mixture as well as to provide a readily available carbon source to support the microorganism population. Several parameters – including temperature, oxygen content, moisture content, pH, and the availability of inorganic nutrients in the compost – must be controlled to optimize treatment.

Field-scale pilot studies at other U.S. Army installations demonstrate that composting reduces explosives concentrations in soil to acceptable levels in a reasonable amount of time. Reported removal rates for TNT, HMX, and RDX are 99.7 percent, 99.8 percent, and 96.8 percent, respectively (DOD, 1994). The allowable residual concentrations must be considered on a site-specific basis. In addition, the time to reach acceptable concentrations is influenced by several factors, including soil loading rate, contaminant concentrations, and the presence of potentially toxic inorganics. Ongoing pilot studies have indicated the formation of potentially toxic intermediary products during the degradation process.

Because composting is proven effective for the treatment of explosives in soil, and because the TNT Washout Facility has space for a composting facility, this option is retained for further consideration. The CMS Report will include a detailed evaluation of a treatability study on the applicability of composting explosives-contaminated soil at SWMU 10.

- Slurry phase biological treatment uses a slurry phase bioreactor to treat explosives-contaminated soil. This technology involves mixing the soil with water (a typical slurry contains 10 to 40 percent solids by weight);

suspending the mixture in a reactor vessel; and mixing it with nutrients, oxygen, and an acid or base (as appropriate to control pH). The soil's own microorganisms or microorganisms from other sources are used if the indigenous population is inadequate. Once biodegradation is complete, the suspension is dewatered using clarifiers, filters, drying beds, or centrifuges. As with composting, bench-scale studies have shown a greater than 99 percent reduction in RDX and TNT concentrations in soil.

Although slurry phase treatment is effective for the removal of explosives in soil at the bench-scale level, both pilot- and full-scale treatment are unproven. (Note: Pilot tests have reported difficulties with dewatering the slurry (FRTR, 1994).) However, because the process has the potential to be effective and is comparable to composting, it is retained for further consideration.

B.2.5.2 Anaerobic Treatment The ex situ anaerobic bioremediation process is similar to bioslurry treatment; however, selected (proprietary) soil microorganisms are added to the slurry, and conditions in the bioreactor are allowed to become anaerobic by eliminating the flow of oxygen. When degradation is allowed to occur in an anaerobic environment, the microbes completely degrade the nitroaromatic contaminants without producing potentially toxic intermediaries.

Recent field studies of the anaerobic process have indicated effective treatment of elevated concentrations of explosives in soil (USEPA, 1995c). Therefore, because the process has the potential to be effective and is comparable to composting, it is retained for further consideration.

B.2.6 Phytoremediation

Phytoremediation refers to a broad class of remediation techniques applicable to a variety of both organic and inorganic contaminants. It is an emerging technology that takes advantage of the natural ability of plants to remove, destroy, or stabilize chemical contaminants present in soil, sediment, groundwater, or surface water.

Several phytoremediation processes evaluated for use at the Known Releases SWMUs are described below:

- **Phytoextraction** – also called phytoaccumulation – refers to the uptake of metal contaminants by plant roots, followed by transfer of the contaminants to aboveground plant shoots or leaves. Specially selected plants, known as hyperaccumulators, can extract and accumulate large amounts of toxic metals from soil. When the plants are harvested, the plant wastes can be treated to reduce their volume or possibly to recover the metals, or be disposed of in a hazardous waste landfill. The planting-harvesting cycle is repeated until the concentrations of metals in soil are reduced to acceptable levels.

- Phytostabilization refers to the use of certain plant species to immobilize toxic metals in soil through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants. This process reduces the mobility of the contaminants and prevents migration to groundwater or air, and also reduces bioavailability for entry into the food chain.
- Phytodegradation refers to the metabolic breakdown of organic contaminants taken up by plants. Plants produce enzymes that catalyze these metabolic reactions within the plant tissues. The organic contaminants and their breakdown products are either incorporated into the plant tissues, or released to the atmosphere by volatilization from the plants. This process is almost exclusively used for groundwater applications.
- Rhizodegradation – also called plant-assisted biodegradation – refers to the enhanced biodegradation of organic contaminants that takes place in the soil surrounding plant roots. As the natural substances released by plant roots supply nutrients to microorganisms, a larger and more diverse microbial population is available for rhizodegradation. The plant roots also loosen the soil and then die, leaving paths for transport of water and aeration, which also enhances biodegradation.

While phytoremediation is a promising technology for cleaning up many different types of contaminants and sites, it is still mainly in the research, testing, and demonstration phase of development. It has been studied extensively in relatively small-scale research and demonstration projects, but full-scale applications are very limited (USEPA, 1998). Phytoremediation has reportedly been selected as a partial remedy at one Superfund site and at several private sites (Flathman, 1998). However, generally no long-term monitoring or assessment has been conducted or reported at these sites (Schnoor, 1997). Additional testing is needed before phytoremediation can be considered ready for full-scale commercial application. Therefore, this technology is not further considered for use at the Known Releases SWMUs.

B.2.7 Solidification/Stabilization

For solidification or stabilization – which are most applicable to inorganic contamination – excavated waste or soil is mixed with a binder material, such as cement, thermoplastic, or other proprietary reagents. Solidification/stabilization improves the handling of the contaminated material, decreases the surface area available for contaminant transfer, and limits the solubility of the contaminants (thereby eliminating or retarding their migration). A treatability study is required to select the optimum reagent. For the type and volume of contamination identified at SWMU 25, cement-based immobilization is considered. Cement-based solidification/stabilization involves the addition of concrete to the screened, contaminated material. It is then placed in a mixer until amendments and soil are thoroughly mixed. The batch is then discharged either into the excavated area or into forms for curing. The treated soil may be placed back into the excavated area, used as fill elsewhere on post, or disposed of in a landfill.

Thermoplastic methods were excluded from further consideration due to their high cost. Specialized stabilization processes that employ phosphate-based reagents have been developed and used commercially since the early 1990s to chemically immobilize lead and other metal contaminants in soil. These processes employ liquid or granular materials, such as phosphoric acid, phosphorous rock, or phosphate-containing fertilizers. In addition to the phosphate compounds, other additives (including sulfates and calcium or iron compounds) have also been used as reagents. The effectiveness of these processes is based on chemical reactions between the metal contaminants, the phosphates, and other anions and cations present in the soil to form stable, essentially insoluble phosphate compounds (e.g., pyromorphites) (Laperche, 1997; Ruby et al., 1994). Although the phosphate-based processes are promising for reducing the bioavailability of lead and other metals in addition to reducing their leachability, they will not be retained in this CMS because of recent uncertainties regarding the bioavailability of the immobilized lead. Because of its potential advantages for immobilizing lead in dissolved form, the phosphate processes should be reconsidered during final design, and ongoing research reviewed to re-evaluate the bioavailability concerns.

Solidification generally produces a monolith and improves the physical handling characteristics of the waste. Stabilization typically converts inorganic material into its least soluble and most environmentally inert form. Stabilized soil meeting TCLP standards may be returned to the SWMU for beneficial reuse in accordance with UAC R315-13 "Land Disposal Restrictions." The primary disadvantage of solidification or stabilization is an approximately 20 to 50 percent increase in soil volume. In addition, soil with a high percentage of fines, and high concentrations of oil and grease may slow the curing process and weaken the bonds formed during solidification/stabilization. Cost estimates for cement-based solidification/stabilization were obtained from Means (1998) and Battelle (1997). Because cement-based solidification and stabilization is a proven method for addressing metals- and explosives-contaminated soil, it is retained for further evaluation (DOD, 1994).

B.2.8 Soil Washing

Soil washing is primarily a volume-reduction technology applicable to inorganics in soil. The most effective application of soil washing considers the size distribution of soil particles and the contaminant distribution relative to particle size. In general, because contaminants adsorb proportionally to the available surface area of the soil particle, they are usually concentrated in the fines fraction (i.e., particles with a diameter of less than 63 micrometers (μm)), which must then be further treated or disposed of.

The first step of soil washing involves mechanical separation techniques, such as particle size separation, gravity separation, and attrition scrubbing, to segregate soil into three discrete soil fractions – coarse, sand, and fines. The fines, which are assumed to contain the majority of contaminants, are further treated with an acid leach. The acid leach solution is regenerated onsite using an ion exchange resin, which – when fully loaded – is shipped off post for treatment/disposal at a subtitle C landfill or TSDF as

appropriate. The coarse, sand, and treated fines may be placed back into the excavated area, used as fill elsewhere on post, or disposed of in a landfill.

Soil washing is most effective for soil containing mostly sand and gravel, and least effective for soil containing greater than 30 to 40 percent fines (i.e., silt/clay particles less than 63 μm in diameter). Ongoing pilot- and full-scale testing of this process has shown that it does not "rinse" the contaminants from the soil particle in the conventional sense, and that additional treatment is almost always required.

Metals are present in the contaminated surface soil at SWMU 25, and because the soil particle size is likely to be appropriate for this technology, it is retained for further consideration at SWMU 25. However, this process is not considered for SWMUs 12/15 because of the large volume of soil and the presence of organics at the landfill.

B.2.9 Electrokinetics

Electrokinetic soil processing is an in situ separation and removal technique for extracting heavy metals and polar organic contaminants from soil. Electrodes inserted into the contaminated soil apply a constant, low direct current between ceramic electrodes. The current mobilizes charged species, causing ions and water to move toward the electrodes. Metal ions and positively charged organic compounds move toward the cathode, and anions such as chlorides and negatively charged organic compounds move toward the anode. The current creates an acid front at the anode and a base front at the cathode. The generation of acidic conditions in situ helps to mobilize sorbed metal contaminants for transport to a collection system at the cathode.

Contaminants that are concentrated around the electrodes are removed for subsequent treatment or disposal. Removal options are electroplating on the electrodes, precipitation at the electrodes, pumping of water collected around the electrodes, or complexing with ion exchange resins.

The types and concentrations of contaminants in soil, and the properties of the soil matrix determine the efficiency of this technology. Electrokinetics is most applicable in fine-grained, low permeability soil, such as saturated or partially saturated clays and silt-clay mixtures. Soil at the Known Releases SWMUs consists primarily of gravel and sandy material and, therefore, is not well-suited to electrokinetic processing. In addition, because electrokinetics is still primarily in the testing and demonstration stage of development, its full-scale commercial application is limited (USEPA, 1994; 1995d). Therefore, electrokinetics is not retained for further consideration.

B.2.10 Incineration

Incineration uses elevated temperatures (1,600° to 1,800°F) to completely destroy organics, including explosives, VOCs, SVOCs, pesticides, and PCBs. However, metals are not removed from the soil; they become concentrated in the residual ash, potentially creating hazardous material that requires additional treatment prior to disposal. Because

elevated concentrations of metals are present at SWMUs 12/15 and 25, incineration is considered only for explosives-contaminated soil at the TNT Washout Facility (SWMU 10).

The destruction and removal efficiency of incinerators exceeds 99 percent for explosives in soil (DOD, 1994). Commercial incinerators consist of both transportable onsite units and stationary offsite facilities. Onsite units are typically more cost-effective than offsite facilities for large volumes of contaminated soil. Rotary kilns equipped with an afterburner, quench, and air pollution control system are the commercial incinerators most commonly used to destroy constituents in soil. The rotary kiln is a refractory-lined, slightly inclined, rotating cylinder that serves as a combustion chamber. Other types of incinerators include the circulating fluidized bed, which uses high velocity air to circulate and suspend the waste in a combustion loop; and the infrared unit, which uses electrical resistance heating elements or indirect-fired radiant U-tubes to heat material in the chamber.

The presence of a high fraction of fine particles can cause high particulate loading in fine gases. Similarly, a high soil moisture content can also adversely affect the incineration process. These parameters will be evaluated further if incineration is selected as a remedy.

Because of the relatively small volume of soil at SWMU 10 and the proximity of TEAD to an off-post incinerator, and because incineration is a proven technology for the treatment of soil contaminated with explosives, it is retained for further consideration.

B.2.11 On-Post Disposal

Although there is a sanitary landfill at TEAD (SWMU 12/15) it no longer accepts hazardous or industrial waste and is not permitted to do so. In addition, TEAD does not consider the long-term liability associated with placement of these wastes in the sanitary landfill to be compatible with future facility plans. For these reasons, on-post disposal is not considered applicable for the Known Releases SWMUs.

B.2.12 Off-Post Disposal

Off-post disposal at an approved facility (including landfill, recycling, and treatment facilities) involves dewatering (if required); placement of soil in containers (individual or bulk); and transport of the containerized waste by an approved, licensed contractor. For some of the constituents present, particularly metals, it may be necessary to pretreat the soil prior to disposal depending on the concentration of contaminants and the applicability of LDRs under RCRA. Pretreatment methods that might be required include off-post incineration for SVOCs or PCBs, or solidification/stabilization for metals. Specific off-post disposal facilities and the possible need for pretreatment are evaluated in the CMS Report as part of the detailed analysis of alternatives.

Off-post disposal eliminates exposure to potential future receptors and is readily implemented. It is applicable to all Known Releases SWMUs and COCs. However, off-post disposal is generally less efficient for the management of large volumes of soil (e.g., at the Sanitary Landfill) or for soil contaminated with explosives (e.g., at the TNT Washout Facility). For these reasons, this technology is retained for further consideration only at the Battery Shop (SWMU 25).

B.3 TREATMENT TECHNOLOGIES FOR GROUNDWATER

There is currently no exposure to groundwater at the Known Releases SWMUs, and future exposure is unlikely based on the future land use scenarios outlined in Appendix A. Therefore, there are no quantitative CAOs for groundwater. However, there are qualitative CAOs, as listed below:

- To prevent further degradation of a valuable resource.
- To further restrict and prevent possible exposure to contaminated groundwater.
- To protect human health and the environment in compliance with regulatory requirements.

These CAOs are applicable for explosives at SWMU 10 and VOCs at SWMUs 12/15.

Although metals are not COCs in groundwater, metals pretreatment may be required in conjunction with the identified primary treatment technologies. Continued groundwater investigations at SWMUs 10 and 12/15 will further evaluate the impacts (if any) of constituents on groundwater (see *Addendum to DCQAP*, Volume II of the Planning Documents). Treatment technologies are selected considering the depth to groundwater at these SWMUs (average of 250 to 300 feet bgs) and specific COCs.

B.3.1 Land Use Restrictions

Land use restrictions (specifically, restrictions placed on well installation and aquifer usage) are effective in controlling exposure to contaminated groundwater. As with the land use restrictions identified for soil (Section B.2.1), these groundwater restrictions are incorporated into TEAD's master land use plan, which is used to mitigate future risks and hazards to human health and the environment from authorized U.S. Army activities and environmental conditions. Possible controls at TEAD include limiting the placement of additional wells near SWMUs 10 and 25 and restricting the use of water in the vicinity of nonpotable activities.

Land use restrictions are applicable to site characteristics and COCs identified at SWMUs 10 and 12/15. Because these restrictions are effective in preventing exposure and minimizing risk, they are retained for further consideration.

B.3.2 Groundwater Monitoring

Groundwater monitoring provides for the analysis of trends in contaminant concentrations and plume movement. A review of site data will determine when monitoring can be discontinued. If the plume moves downgradient faster than predicted, a contingency plan would be enacted to consider the installation of additional monitoring wells. The need for corrective actions such as groundwater extraction and treatment would also be reevaluated.

B.3.3 Natural Attenuation

Natural attenuation includes the reduction of contaminant concentrations to environmentally acceptable levels through natural, in situ processes. It includes – but is not limited to – advection, dispersion, diffusion, volatilization, biotic transformation (mineralization and degradation), sorption/desorption, ion exchange, complexation, abiotic transformation, and plant and animal uptake (U.S. Army Science Board, 1995). As discussed for soil, natural attenuation differs from “no further action” in that data analyses and contaminant migration modeling and monitoring are required to verify that the attenuation processes are actively reducing contaminant concentrations. This technology has been selected at sites where other measures were determined to be technically impracticable, and where active corrective measures were not expected to significantly enhance the rate of natural attenuation.

Successful implementation of natural attenuation for explosives (SWMUs 10 and 11) and VOCs (SWMUs 12/15) is currently preliminary and limited. However, the U.S. Department of Defense (DOD), industry, and regulatory agencies are interested in obtaining more data on and implementing natural attenuation.

Trichloroethylene (TCE) in groundwater at the Sanitary Landfill (SWMU 12/15) and the Industrial Waste Lagoon (SWMU 2) appears to be present in the dissolved phase. To evaluate the potential presence of dense nonaqueous phase liquids (DNAPLs), Environmental Protection Agency (EPA) guidance (EPA/540/F-94/049) suggests comparing chemical results and field conditions to those suggestive of DNAPLs. The following characteristics of DNAPLs do not match the data collected at SWMU 12/15:

- Chemical concentrations in groundwater are greater than one percent of the pure phase solubility ($200 \mu\text{g/L} < 11,000 \mu\text{g/L}$, which is 1 percent of the solubility of TCE).
- Chemical concentrations in soil are greater than 10,000 mg/kg ($9.4 \text{ mg/kg} < 10,000 \text{ mg/kg}$).
- Chemical concentrations in soil gas exceed 100 – 1,000 parts per million (ppm) ($16.53 \text{ ppm} < 100 \text{ ppm}$).

- Chemical concentrations increase hydraulically up gradient from the potential source area.
- Irregular patterns of dissolved hits detected in groundwater.

In addition to waste characteristics, site characteristics strongly influence the applicability of natural attenuation. SWMUs 10, 11, and 12/15 may be particularly amenable to natural, in situ processes because of the following:

- Low concentrations of explosives detected in groundwater at SWMUs 10 and 11. There are no human health risks associated with groundwater because no exposure pathways exist either on or offsite.
- Distance of the SWMUs from the downgradient boundary.
- Depth to groundwater (approximately 300 feet bgs).
- Potential application of source control for contaminated soil.

Based on this evaluation, natural attenuation is retained for further consideration.

B.3.4 Groundwater Containment/Extraction

Groundwater containment/extraction is a proven technology for the mitigation of groundwater contamination. It is effective for all of the identified COCs at SWMUs 10 and 12/15. Because of the depth to groundwater at the SWMUs, vertical recovery wells are considered the most efficient method to extract and contain groundwater and, therefore, to control plume migration. The wells must be accurately placed to ensure the capture and containment of the contaminant plume. The effectiveness of this technology depends on soil permeability, hydrogeologic properties, contaminant characteristics, and the magnitude and extent of the contaminant plume.

Vertical recovery wells, which are typically used to extract groundwater for remediation purposes, have been successfully installed and operated at TEAD. They have limited effects on surrounding utilities and buildings, and their installation requires minimal preparation and implementation time. Groundwater extraction using vertical wells is applicable to the site and COC characteristics at SWMUs 10 and 12/15, and is retained for further consideration.

B.3.5 Ex Situ Groundwater Treatment

Following groundwater extraction, the contaminants in groundwater must be treated to meet CAOs prior to discharge or reinjection into the aquifer. Several technologies have been demonstrated to be effective in removing a variety of COCs from groundwater, including explosives and VOCs. The technologies presented below include those most applicable for treatment of the identified COCs. Because some metals are

present in groundwater at the SWMUs, metals pretreatment technologies are also discussed.

B.3.5.1 Granular Activated Carbon. Granular activated carbon (GAC), or carbon adsorption, is a full-scale, proven technology that involves selective adsorption of polar organic compounds onto adsorbent carbon by physical or chemical forces. The activated carbon granules selectively attract molecules of organic compounds to their surface and internal pores. GAC is an excellent adsorbent for many organic compounds because of its high surface area. Carbon adsorption may be accomplished by batch, column, or fluidized-bed operations, with either fixed or counter-current moving beds as a contacting system.

The successful removal of contaminants from groundwater via GAC is dependent on contact time, pretreatment requirements (e.g., removal of suspended solids, oil and grease, or iron), the nature of contaminants, and surface area. The solubility and concentration of contaminants in groundwater can affect process performance. Removal efficiencies of up to 99 percent are reported for VOCs and explosives (Nyer, 1992).

Although GAC effectively removes many organics, many low molecular-weight VOCs (i.e., TCE) are poorly adsorbed – which reduces its effectiveness as a treatment technology. In addition, carbon has a limited useful life and must be replaced once saturated. Spent carbon can be transported and disposed of as a RCRA hazardous waste, reactivated (on or off post), or regenerated (on post). It is unlikely, however, that the carbon used for explosives can be regenerated or reactivated; it should be removed and disposed of off post.

GAC is an established and proven technology for the removal of explosives and VOCs. However, because of its limited effectiveness in treating TCE, it is retained for further evaluation only at SWMU 10.

Metals pretreatment – which includes precipitation, flocculation, and filtration – may be required before treating contaminated groundwater at SWMUs 10 and 12/15. Without pretreatment, metals present in the soluble form in groundwater become oxidized in the primary treatment system, which intensifies operation and maintenance (O&M) requirements, significantly increases costs, and reduces treatment efficiency.

If further treatment of effluent is required prior to primary treatment, the groundwater can be pumped through a sand or multimedia filtration unit. Filtration is the physical process of removing suspended solids from solution by forcing the fluid through a porous medium. Because the backflush water contains high concentrations of solids, it requires further treatment or off-post disposal.

Metals pretreatment is proven and is included as part of this groundwater treatment technology.

B.3.5.2 Air Stripping. Air stripping is a full-scale, proven technology that involves the mass transfer of VOCs from the aqueous to the gaseous phase. It can be performed with different process configurations, such as packed towers, cross-flow towers, and diffused aeration. Packed towers use packing material that provides a large surface area for mass transfer. The counter-flow configuration adds turbulence to the system to further aid removal. The towers are designed such that contaminated water flows down through the tower filled with packing material, while air moves up through the column counter-currently. Diffused aeration is a low-profile design most commonly used for groundwater treatment. It consists of a series of aeration trays that blow air through a thin film of water as it flows over the blowers.

The effective removal of contaminants from groundwater via air stripping is dependent on the volatility of the contaminant, water temperature, air-to-water ratio, and packing surface area. Removal efficiencies for VOCs range from 95 to 99 percent, with the highest percentages for highly volatile compounds with low solubility (Byers, 1987). The volatility of a contaminant is determined as a function of its Henry's Law Constant. In general, the higher the Henry's Law Constant for a given contaminant, the higher the removal efficiency by air stripping. Compounds with constants above 0.1 are readily amenable to air stripping; those with constants less than 0.1 may be removed by air stripping, but with some difficulty. GAC is often combined with air stripping for post-treatment polishing.

Explosives have extremely low Henry's Law Constants and are not amenable to air stripping. However, air stripping has been successfully used to treat TCE (which has a high Henry's Law Constant) in groundwater; it is currently being used for remediation at the IWL (SWMU 2).

Because air stripping is applicable for the treatment of VOC-contaminated groundwater, such as that at SWMUs 12/15, it is retained for further consideration.

Metals pretreatment – which includes precipitation, flocculation, and filtration – may be required before treating contaminated groundwater at SWMUs 10 and 12/15. Without pretreatment, metals present in the soluble form in groundwater become oxidized in the primary treatment system, which intensifies operation and maintenance (O&M) requirements, significantly increases costs, and reduces treatment efficiency.

If further treatment of effluent is required prior to primary treatment, the groundwater can be pumped through a sand or multimedia filtration unit. Filtration is the physical process of removing suspended solids from solution by forcing the fluid through a porous medium. Because the backflush water contains high concentrations of solids, it requires further treatment or off-post disposal.

Metals pretreatment is proven and is included as part of this groundwater treatment technology.

B.3.5.3 Ultraviolet (UV)/Oxidation. UV/oxidation uses UV irradiation and an oxidizing agent, such as ozone or hydrogen peroxide, to catalyze the oxidation organic compounds to carbon dioxide and water. This system consists of a series of high-powered mercury lamps that emit UV radiation through a quartz sleeve into the recovered groundwater. The UV light activates the oxidizing agent that is added to the water to form hydroxyl radicals, which react with the chlorinated organic molecules and produce carbon dioxide, water, and small amounts of chloride ions.

UV/oxidation is a full-scale treatment process proven to eliminate chlorinated organic compounds and explosives in groundwater. It is a destructive process and does not transfer the contaminants to another phase (such as air or carbon). Its removal efficiencies for VOCs and explosives range from 90 to 99 percent (Roy, 1990).

As described for previous ex situ groundwater treatment technologies, metals pretreatment may be required and is included as part of this groundwater treatment technology.

However, UV/oxidation has high energy requirements, which can significantly increase cost when compared with other technologies. In addition, though UV/oxidation is effective in treating both TCE and explosives, several studies indicate that it is less effective than carbon (for explosives) and air stripping (for TCE) at full-scale operation; and is also less cost-effective for lower contaminant concentrations, such as those identified at SWMUs 10 and 12/15 (FRTR, 1994). For these reasons, UV/oxidation is not retained for further consideration.

B.3.6 In Situ Groundwater Treatment

Bioremediation and air sparging are in situ treatment technologies for explosives and VOCs in groundwater.

B.3.6.1 Bioremediation. In situ bioremediation uses the microorganisms in groundwater and saturated zone soil to biologically transform the organic constituents in groundwater. These constituents are directly metabolized by the microorganisms or are degraded by the enzymes produced during the metabolization of other constituents (cometabolized).

Although both classes of COCs have been shown to degrade in a controlled environment, maintaining the necessary conditions at a depth of 250 feet bgs has proven to be difficult during pilot-scale applications at similar sites (FRTR, 1994). Therefore, in situ bioremediation is not retained for further consideration.

B.3.6.2 Air Sparging. Air sparging combined with soil vapor extraction is a proven full-scale treatment technology for removing VOCs from the subsurface saturated soil and groundwater zones through volatilization. This technology introduces contaminant-free air into the groundwater of an affected aquifer to transfer the contaminants from the

saturated soil and groundwater to the unsaturated soil pore space, from which they can be removed by soil vapor extraction.

The effectiveness of air sparging depends on spargeable contaminants in the saturated zone, homogeneous conditions in the saturated zone, and permeable soil layers. Performance is expected to be best for well-graded, medium-to-coarse sand, where the depth to groundwater is shallow (i.e., less than 50 feet bgs). Because the depth to groundwater in the vicinity of SWMUs 12/15 (where VOCs were detected) exceeds 200 feet bgs, air sparging is not retained for further consideration.

B.3.6.3 Phytoremediation. This technology involves the use of plants and trees to treat contaminated groundwater. Plants have the ability to degrade organic contaminants, and can be used as filters and containers to accumulate toxic metals from contaminated groundwater. The plants are then harvested, leaving groundwater in place with only residual levels of pollutants. Certain trees can also be used to treat deep soil and groundwater. Poplar trees have been shown to take up TCE and transpire the contaminant through the leaves and into the atmosphere. About 10 percent of the TCE oxidizes into carbon dioxide in the plant tissue. Research is currently being conducted to increase this amount by genetic manipulation (Matso, 1995). Rhizofiltration – a technique for metals phytoremediation – uses plants that absorb and precipitate metals from solution, making the technology appropriate for groundwater remediation. Because plants can precipitate up to 60 percent of their dry weight as chemicals, rhizofiltration could represent real cost savings in terms of hazardous waste disposal.

Phytoremediation is currently considered as a polishing step in the treatment of hazardous wastes after the removal of contamination from hot spots; or as a long-term solution for more isolated, less contaminated sites. Currently, the most appropriate plants for phytoremediation are tropical and have slow growth rates. Furthermore, because most plant roots extend only through the top 7 feet of soil, this technology is limited to sites with relatively shallow contamination. Although phytoremediation has been successfully tested in the laboratory and in field trials, further research is needed before it can be used in full-scale operations (Matso, 1995). Because of this factor, and because the depth to groundwater at the Known Releases SWMUs is greater than 200 feet bgs, phytoremediation is not retained for further consideration.

B.3.7 Groundwater Effluent Disposal/Discharge to Groundwater

Options for discharging treated groundwater to the subsurface include recharge wells, recharge galleries, or recharge basins, as described below:

- Recharge wells are used in conjunction with groundwater recovery wells to provide hydraulic control and to assist in contaminant removal. This technology meets two of the identified CAOs – protection of a resource and protection of human health and the environment. Depending on aquifer conditions, recharge wells can be located upgradient of recovery wells, interspersed with them, or located downgradient.

- Recharge galleries consist of perforated horizontal piping installed below grade in the unsaturated zone. Depending on subsurface conditions, recharge galleries may require a large land area.
- Recharge basins consist of aboveground earthen containment structures that allow effluent water to infiltrate into the subsurface. However, they require substantial land area and can be less effective than recharge wells or galleries.

Because of the depth to groundwater at SWMUs 10 and 12/15, and the successful use of recharge wells at the IWL (SWMU 2), they are retained for further consideration; because of the available land area at TEAD, recharge galleries are also retained for further evaluation as a component of corrective measures alternatives.

B.3.8 Abandonment of Groundwater Monitoring Wells

Abandonment of groundwater monitoring wells is conducted in accordance with the TEAD Well Drilling and Installation Plan which is included as an attachment to Appendix B. The abandonment procedure is detailed in Section 3-12 of this document and is summarized below:

- Stainless steel and PVC wells are grouted with the well screen and casing in place by grouting from the bottom of the well to the ground surface.
- Grout is installed by placing a tremie pipe to the bottom of the well (i.e., to the maximum depth drilled/bottom of the well) and pumping grout through this pipe until undiluted grout flows from the well at ground surface. Any open or ungrouted portion of the annular space between the well casing and borehole is grouted in the same manner.
- After 24 hours, the abandoned site is checked for grout settlement. That day, any settlement depression is filled with grout and checked 24 hours later. This process is repeated until firm grout remains at ground surface.

Well abandonment is a proven technology and is retained for further consideration for SWMU 3.

B.4 SUMMARY

Table B-1 lists the treatment technologies and management measures considered for each medium of concern. The technologies are retained based on their ability to meet the qualitative and quantitative CAOs established in Appendix A, as well as on their applicability to the identified site and COC characteristics. As discussed above, proven treatment technologies and management measures are preferred. Sections 3.0 through 7.0 assemble the technologies and management measures retained in this appendix into corrective measures alternatives for each SWMU.

TABLE B-1

Summary of Treatment Technologies
Known Releases SWMUs

Treatment Technology/ Management Measure	Advantages	Disadvantages	Retained?
SOIL			
Land use restrictions	Reduces human health exposure	Does not reduce exposure of animals to contamination	Yes
Fencing	Reduces human health exposure	Does not reduce exposure of some animals to contamination	Yes
Natural attenuation	Requires limited resources; causes little or no disruption to ongoing activities	Does not limit or reduce existing risk; time for natural degradation and flushing may be extensive	No
Capping/soil covers	Reduces human health exposure, mitigates erosion, and limits stormwater infiltration; requires no excavation	Limits future uses of covered area	Yes
Excavation	Eliminates exposure and migration of contaminants to groundwater	Handling of potentially hazardous material; inappropriate for large volumes of soil	Yes
Composting	Effectively degrades explosives	Increases volume, requires substantial space and potentially extensive treatment period, and forms potentially toxic intermediary products	Yes
Slurry phase biological treatment	Effectively degrades explosives	Requires excessive dewatering; wastewater must be treated and disposed of offsite	Yes
Anaerobic treatment	Effectively degrades explosives	Requires excessive dewatering; wastewater must be treated and disposed of offsite	Yes
Phytoremediation	Effectively degrades organics and removes metals from soil	Very limited full-scale application; vegetation used for phytoremediation may not be suitable for temperate climates	No
Solidification/stabilization	Effectively binds metals into a molecular matrix	Increases the volume of waste by 20-50 percent	Yes
Soil washing	Reduces the volume of contaminated soil that requires treatment	Ineffective for soil with high fines content	Yes
Electrokinetics	Extracts metals and organic contaminants from soil	Very limited full-scale application	No
Incineration	Effectively treats organics, including explosives	Potentially high cost	Yes

TABLE B-1 (cont'd)

Treatment Technology/ Management Measure	Advantages	Disadvantages	Retained?
Off-post disposal	Permanently removes contaminated soil from the site	Extended liability and potentially high cost	Yes
GROUNDWATER			
Land use restrictions	Reduces human health exposure	Does not reduce exposure of animals to contamination	Yes
Monitoring	Provides data to track contaminant concentrations and plume migration	Does not limit or reduce existing risk; time for plume degradation may be extensive	Yes
Natural attenuation	Requires limited resources; causes little or no disruption to ongoing activities	Does not limit or reduce existing risk; time for natural degradation and flushing may be extensive	Yes
Vertical recovery wells	Provides groundwater extraction to required depths	Potentially high cost	Yes
Carbon adsorption (GAC)	Effectively adsorbs and removes organic contaminants, including explosives	May require metals pretreatment; high disposal cost, high regeneration cost	Yes
Air stripping	Effectively treats organic contaminants	May require metals pretreatment and offgas treatment	Yes
UV/oxidation	Destroys organic contaminants, including explosives; no residuals required for treatment or disposal	May require pretreatment for metals; possible high power cost	No
In situ treatment	Limits interruption of ongoing activities	Removal of contaminants trapped in unsaturated soil may be extensive and costly because of depth to groundwater	No
Recharge wells	Provides hydraulic control and allows sufficient recharge of treated groundwater	Potentially high cost of deep wells	Yes
Recharge galleries	Allows sufficient recharge of treated groundwater	Requires large land area	Yes
Recharge basins	Allows sufficient recharge of treated groundwater	Discharge to aboveground basins is inappropriate during winter months	No
Well abandonment	Permanently removes a potential pathway for downward migration of constituents to aquifers.	Eliminates monitoring points for groundwater quality	Yes

ATTACHMENT 1

Tooele Army Depot Well Drilling and Installation Plan

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TOOELE ARMY DEPOT

Well Drilling and Installation Plan

November 2, 1993

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CHAPTER 1
INTRODUCTION

1-1. Objective. The objective of this plan is to set forth the geotechnical criteria and procedures for Tooele Army Depot (TEAD) used in technical support of geotechnical exploration and reporting. The application of geotechnology to environmental programs should begin with project conception. The application of this plan is intended to provide acceptable technical data to accurately obtain, describe, and evaluate representative samples of the subsurface environment in terms of geology, hydrology, and groundwater chemistry.

1-2. Terminology

a. Definitions (alphabetically arranged). These definitions are intended to guide the reader through the use of this handbook. While other terms with equivalent definitions may be familiar to some readers; the terminology as defined here, provides a common basis for the CONSISTENT understanding by ALL readers.

(1) Monitor Well: A monitor well is a device designed and constructed for the acquisition of groundwater samples that are representative of the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process; and which, if so designed, provides access to measure the potentiometric surface of the aquifer.

(2) Peeling: A process whereby that portion of a sample which was in direct contact with a sampler, as well as the ends of the sample, are removed and discarded.

(3) Redevelopment/Well Rehabilitation: A procedure which removes sediment or other built-up materials from a "clogged," existing well.

(4) Site Specific Safety Plan/Safety Plan: A project unique document approved by the Army for contractor compliance, which includes the identification of hazardous substances present, recommended action upon encountering those substances, project/site safety requirements, organizational safety responsibilities, and the identification of supporting health and safety activities.

(5) Well Development: A procedure which improves or restores the aquifer's hydraulic conductivity and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent a newly installed well.

b. Acronyms.

(1)	ASTM	American Society of Testing Materials
(2)	GDQM	Geotechnical Data Quality Management
(3)	ID	Inside Diameter
(4)	mm	Millimeter
(5)	NSF	National Sanitation Foundation
(6)	N.W.	Northwest
(7)	CD	Outside Diameter

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(8)	OSHA	Occupational Safety and Health Administration
(9)	PCB	Polychlorinated biphenyl
(10)	PTFE	Polytetrafluoroethylene
(11)	PVC	Polyvinyl chloride
(12)	SPCS	State Plane Coordinate System
(13)	um	micrometer
(14)	U.S.	United States
(15)	USEPA	United States Environmental Protection Agency
(16)	UTM	Universal Transverse Mercator
(17)	'	Foot or Feet
(18)	"	Inch or Inches
(19)	%	Percent

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CHAPTER 2

BOREHOLES AND WELLS: LOCATIONS, QUANTITIES, AND DESIGNATIONS

2-1. Locations and Quantities. The locations and quantities of boreholes and wells shall be selected to effectively ascertain desired geologic, hydrologic, and/or geochemical parameters. The contractor shall neither relocate a boring or well nor alter the number of borings or wells specified by the Army without prior coordination with the Army. The drilling and well installation plan will allow relocations when necessitated by proximal utilities or drilling difficulties.

2-2. Designations. Borehole and well designations (identification numbers) shall not be unilaterally changed in the field or in a centralized computer database without prior approval of the Army once the boring or well has been created. After receiving approval, the contractor shall physically renumber those sites where a designation is posted in the field. Temporary conversions not involving the alteration of either field markings or centralized database may be done for reporting study purposes without the approval of the Army. A conversion table should be included in the final report to document any permanent or temporary boring/well designation changes.

CHAPTER 3
DRILLING OPERATIONS

3-1. Drilling Safety and Underground Utility Detection. When drilling in areas of known or suspected hazardous materials, appropriate health and safety precautions must be implemented. Guidance adaptable for drilling activities are available in Occupational Safety and Health Administration (OSHA) documents (particularly 29 CFR 1910.120 and 29 CFR 1926). The contractor should determine any and all applicable regulations, requirements, and permits with regard to drilling safety and underground utility detection. These items shall be included in the safety plan. The safety plan shall be approved by the Army prior to any drilling.

3-2. Permits, Licenses, State Construction Standards, and Rights-of-Entry. The contractor shall be responsible for securing and complying with any and all boring and/or well drilling permits and/or procedures required by state and local authorities and for determining and complying with any and all state or local regulations with regard to the submission of well logs, samples, etc. Submission of these items to state or local authorities shall be coordinated through TEAD. The contractor shall telephonically notify the TEAD immediately in the event of any apparent discrepancy between contractual and state or local requirements. Notification shall include the nature of the discrepancy; the name, agency, and telephone number of the person noting the discrepancy; and the current status. Any rights-of-entry will be obtained for and supplied to the contractor by TEAD. The contractor shall ensure that all drilling of boreholes, well installation, and topographic surveying is accomplished by companies appropriately licensed in the State of Utah, if required. A copy of each current license (denoting expiration date) shall be provided in the contractor's work Plan.

3-3. Site Geologist. A "site geologist" (geologist, hydrogeologist) experienced in soil and rock logging, and monitor well installation, shall be present at each operating drill rig. This geologist shall be responsible for the logging of samples, monitoring of drilling operations, recording or water losses/gains and groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures of that rig. Each site geologist shall be responsible for only one operating rig. The geologist shall have onsite sufficient tools, forms, and professional equipment in operable condition to efficiently perform his/her duties. Each site geologist shall also have onsite a water level measuring device, preferably electrical, and materials necessary to prepare the samples for storage or shipment. At some sites, the geologist is also responsible for monitoring gases during drilling. If so, the geologist shall have the necessary instruments and be proficient in their use.

3-4. Equipment.

a. Condition. All drilling, sampling and support equipment brought to a site shall be in operable condition and free of leaks in the hydraulic, lubrication, fuel, and other fluid systems that would or could be detrimental to the project effort. All switches (to include safety switches), gages, and other electrical, mechanical, and hydraulic systems shall be in a safe and operable condition prior to arrival onsite.

b. Cleaning. All drilling equipment shall be steam cleaned before arriving at the project installation/site. After arrival but prior to project commencement, all drilling equipment to include rigs, support vehicles, water tanks (inside and out), augers, drill casings, rods, samplers, tools, recirculation tanks, etc., shall be steam cleaned with approved water at the installation wash point. A similar cleaning shall also occur between each boring/well site. After the on-site cleaning, only the equipment used or soiled at a particular boring or well needs to be recleaned between sites.

Unless circumstances require otherwise, water tank interiors do not have to be cleaned between each boring/well at a given project. Prior to use, all casings, augers, recirculation and water tanks, etc., shall be devoid both inside and out of any asphaltic, bituminous, or other encrusting or coating materials, grease, grout, soil, etc. Paint, as required by the equipment manufacturer, need not be removed from drill equipment. Equipment should be decontaminated before it is removed from the project site. Waste solids and water from the cleaning/decontamination process shall be properly disposed of and this may require that cleaning be conducted on a concrete pad or other surface from which the waste materials may be collected.

3-5. Drilling Methods.

a. Objective. The object of drilling method selection is to use that technique which:

- (1) Provides representative data and samples.
- (2) Eliminates or minimizes the potential for subsurface contamination or cross contamination.
- (3) Minimizes drilling costs.

b. Typical Drilling Methods. To this end, the following drilling methods are typically used:

- (1) Hollow stem augers.
- (2) Cable tool/churn drill.
- (3) Water/mud rotary.
- (4) Air systems.

c. Recommended Methods. Of these, hollow stem auger is technically advantageous in most situations because of its "dry" method of drilling. The drilling method shall be specified and described in the drilling plan.

3-6. Air Systems.

a. Plans. In general, air system plans shall:

- (1) Specify the type of air compressor and compressor lubricating oil and require pint samples of the initial reservoir and any refill oil be retained by the contractor, along with a record of oil loss (on the boring log), for evaluation in the event of future problems.
- (2) Require an air line oil filter and that the filter be changed per manufacturer's recommendation during operation with a record kept (on the boring log) of this maintenance. More frequent changes shall be made if oil is visibly detected in the filtered air: as by an oil stain on clean, writing paper after directing the filtered air onto the paper for 15 seconds.
- (3) Prohibit the use of any additive except approved water for dust control and cuttings removal.
- (4) Detail the use of any downhole hammer/bit with emphasis upon those procedures to be taken to preclude residual groundwater sample contamination caused by the lubrication of the downhole equipment.
- (5) Discuss the volume of air and pressure rating required for drilling and whether a downhole hammer, rotary bit, or both can be used. Air volume and pressure shall be adequate for the hole diameter, equipment, and depth to be drilled.

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(6) Detail the use of any bottled gas with emphasis on air composition, quality, method of bottling, and anticipated use.

b. Reporting. Air usage shall be described in the log to include equipment description(s), manufacturer(s), model(s), air pressures used, frequency of oil filter change, and evaluation of the system performance, both design and actual.

3-7. Recirculation Tanks and Sumps. Portable recirculation tanks are required for mud/water rotary operations and similar requirements. The use of dug sumps or pits (lined or unlined is expressly prohibited to minimize cross contamination and to enhance both personal safety and work area restoration.

3-t. Materials.

a. Bentonite. Bentonite is the only drilling fluid additive allowed. This includes any form of bentonite (powders, granules, or pellets) intended for drilling mud, grout, seals, etc. Organic additives shall not be used. Exception may be made for some high yield bentonites; e.g., Quik-Gel or a technical equivalent, to which the manufacturer has added a small quantity of polymer. The use of any bentonite shall be discussed in the work plan and approved by the Army.

b. Water.

(1) The source of any water to be used in drilling, grouting, sealing, filter placement, well installation, or equipment washing will be approved by the Army prior to arrival of the drilling equipment onsite and specified in the drilling plan. Desirable characteristics for the source include:

- An uncontaminated aquifer origin.
- Wellhead upgradient of potential contaminant sources.
- Free of survey-related contaminants by virtue of pretesting (sampling and analysis) by the contractor. Knowledge of the water-chemistry is the most important factor in water approval.
- The water shall be nontreated and nonfiltered.
- The tap shall have a 24-hour per day, 7-day per week access with plumbing sufficient to allow the filling of a 500-gallon tank in less than 20 minutes.
- The use of only one designated tap for access.

(2) Surface water bodies should not be used, if at all possible.

(3) The contractor has the responsibility to procure, transport, and store the water required for project needs in a manner to avoid the chemical contamination or degradation of the water once obtained. The contractor is also responsible for any heating, thermal insulation, or agitation of the water to maintain the water as a fluid for its intended uses.

c. Grout.

(1) Materials and Mixing Sequence. Grout, when used in monitor well construction or borehole/well abandonment, should be composed of portland cement, Type II or V, bentonite (4 to 5 pounds of bentonite powder per 94-pound sack of cement), and a maximum of 8 gallons of approved water per sack of cement.

(2) Equipment. All grout materials shall be combined in a...

ground rigid container or mixer and mechanically (not manually) blended onsite to produce a thick, lump-free mixture throughout the mixing vessel. The mixed grout shall be recirculated through the grout pump prior to placement. Grout shall be placed using a grout pump and pipe. The grout pipe shall be of rigid construction for vertical control of pipe placement. Drill rods, rigid polyvinyl chloride (PVC) or metal pipes are acceptable stock for tremies. Grout pipes shall have SIDE discharge holes, NOT end discharge. The side discharge will help to maintain the integrity of the underlying material (especially the bentonite seal).

d. Granular Filter Pack.

Granular filter packs shall be chemically clean and free of material that would pass through a No. 200 (75 um) sieve (as seen through a 10-power hand lens), inert, siliceous, composed of rounded grains and of appropriate size for the well screen and host environment. The filter material shall be packaged in bags by the supplier and thereby delivered to the site.

The filter pack shall extend above the top of the screen by at least 5 feet, unless otherwise specified in the statement of work. The final depth to the top of the granular filter shall be directly measured (via tap or rod) and recorded. Final depths are not to be estimated; as, for example, based on volumetric measurements.

e. Well Screens, Casings, and Fittings.

(1) Typically, only polyvinyl chloride (PVC), polytetrafluoroethylene (PTFE), and/or stainless steel shall be used. All PVC screens, casings, and fittings shall conform to National Sanitation Foundation (NSF) Standard 14 for potable water usage or Annual Book of ASTM Standards; Volume 08.04, F 480 and bear the appropriate rating logo. If the contractor uses a screen and/or casing manufacturer or supplier who removes or does not apply this logo, the contractor shall include in the drilling plan a written statement from the manufacturer/supplier (and endorsed by the contractor) that the screens and/or casing have been appropriately rated by NSF/ASTM. All materials shall be as chemically inert as technically possible and practical with respect to the site environment.

(2) All well screens shall be commercially fabricated, slotted or continuously, and have an inside diameter equal to or greater than the inside diameter of the well casing. For PVC and PTFE screens, their schedule/thickness shall be the same as that of the PVC/PTFE well casing. Stainless steel screens may be used with PVC or PTFE well casing. No fitting shall restrict the inside diameter of the joined casing and/or screen. All screens, casings, and fittings shall be new. Screens shall have the largest open area per unit length that is practical for the aquifer of concern and available filter.

(3) Couplings within the casing and between the casing and screen should be compatibly threaded. Thermal or solvent welded couplings on plastic pipe shall not be used. This prohibition includes threaded or slip joint couplings thermally welded to the casing by the manufacturer or in the field. Several thermally welded joints have been known to break during well installation on a single project. The avoidance shall remain until the uniform integrity of thermal welds in the field has been substantiated.

(4) Gaskets, pop rivets, or screws shall not be used on monitor wells. Particular problems with their use may cause include anomalous analytical results, restriction of the well ID, and a loss of well integrity at the point of application.

f. Well Caps and Centralizers.

(1) The tops of all well casings shall be telescopically covered with a slip joint-type cap. Each cap shall be composed of PVC, PTFE, or

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stainless steel and LOOSELY fitted to the riser. The caps shall be constructed to preclude binding to the well casing due to tightness of fit, unclean surface, or frost; and secure enough to preclude debris and insects from entering the well. Caps and risers may be threaded. However, sufficient annular space must be allowed to enable one to thaw any frosted threads. No vents shall be placed in these caps or in the well risers/stickup. Therefore, the caps should be LOOSE enough to allow stabilization between hydrostatic and atmospheric pressures.

(2) The use of well centralizers is optional. When used, they shall be of PVC, PTFE, or stainless steel and attached to the casing via stainless steel fasteners or strapping. Centralizers shall not be attached to the well screen or to that part of the well casing exposed to the granular filter or bentonite seal.

g. Well Protection Materials. Elements of well protection are intended to protect the monitoring well from physical damage, to prevent erosion and/or ponding in the immediate vicinity of the monitoring well, and to insure the validity of the water samples.

(1) Physical damage is prevented by the installation of protective iron/steel casing over the monitoring well and iron/steel post around the installation. The casing and post will be new. Any annulus formed between the outside of the protective casing and borehole shall be filled to ground surface with grout as part of the grouting procedure. The casing diameter or minimum dimension will be four inches greater than the nominal diameter of the monitoring well and the nominal length shall be five feet. The post will be at least three inches in diameter and the top will be modified to preclude the entry of water. Nominal length of the post shall be six feet. Special circumstances necessitating different materials shall be addressed in the technical plan.

(2) The validity of the water samples is insured by a locking cover on the protective casing.

h. Glues and Solvents. The use of glues and solvents in monitor well installation is prohibited.

i. Other Substances. Other substances shall not be used or otherwise introduced into borings, wells, grout, backfill, groundwater, or surface water unless specifically approved in the drilling plan. The work plan shall describe the approved usage, chemical and/or biological composition of the substances, and potential effects upon subsequent chemical/biological analyses and visual appearance of the media into which the substances were introduced. The discussion shall also include Federal and state regulations and/or opinions relative to the approved usage.

j. Lubricants. If lubrication is needed on the threads or couplings of downhole drilling equipment, only vegetable oil/shortening, petroleum jelly, polytetrafluoroethylene (PTFE) tape, lithium grease, Dow Corning fluorosilicone grease FS-3451, Dow Corning fluorosilicone lubricant FS-33452, DuPont KRYTOX grease of a technical equivalent to the Dow/DuPont products may be used. Additives containing lead or copper shall not be used. The only lubricant recommended on monitor well joints is PTFE tape. The use and type of lubricants shall be included in the drilling plan.

k. Hydraulic Fluids. Any hydraulic or other fluids in the drilling rig, pumps, transmissions, or other field equipment/vehicles shall NOT contain any polychlorinated biphenyls (PCBs).

l. Antifreeze. If antifreeze has been added to any pump, hose, etc., where contact with drilling fluid is possible, this antifreeze should be completely purged with approved water prior to the equipment's use in drilling, mud mixing, or any other part of the overall drilling operation. No

antifreeze shall be used in the drilling operation.

m. Agents and Additives. The use of any materials or substances other than those recommended herein for drilling, well installation, or development is prohibited. Included in this prohibition are lead shot, lead wool, burlap, dispersing agents (e.g., phosphates), acids, explosives, disinfectants, etc.

3-9. Surface Runoff. Surface runoff; e.g., precipitation, wasted or spilled drilling fluid, and miscellaneous spills and leaks, shall not enter any boring or well either during or after construction. To help avoid such entry, the use of starter casing, recirculation tanks, berms around the borehole, surficial bentonite packs, etc., are recommended.

3-10. Drilling Through Contaminated Zones. Many borings and wells are drilled in areas that are clean relative to the deeper zones of interest. However, circumstances do arise which require drilling where the overlying soils or shallow aquifer may be contaminated relative to the underlying environment. This situation may be addressed by the placement of, at least, double casing: an outer permanent (or temporary) casing sealed in place and cleared of all previous drill fluids prior to proceeding into the deeper, "cleaner" environment. In this procedure, the outer drill casing is set and sealed within an "impermeable" layer or at a level below which the underlying environment is thought to be "cleaner" than the overlying environment. The drilling fluids used to reach this point are appropriately discarded, replaced by a new or fresh supply. This system can be repeated, resulting in telescopic drill casing through which the final well casing is placed. These situations shall be addressed on a case-by-case basis in the work plan.

3-11. Soil Sampling.

a. Unless otherwise specified in the drilling plan, intact soil samples for physical descriptions, retention, and physical analyses shall be taken continuously and retained every 5 feet or at each change of material, whichever occurs first, thereafter. These samples shall be representative of their host environment and should be obtained with driven (e.g., split spoon), pushed (e.g., thin wall), or rotary (e.g., Denison) type samplers. Borehole cuttings will not satisfy this requirement. Sampling procedures shall be detailed in the work plan.

b. At the detection of any anomalous odors (or vapor readings) from the boring or intact samples, drilling shall cease for an evaluation of the odors and crew safety. After the field safety representative completes this evaluation and implements any appropriate safety precautions, drilling can resume. If the odors or vapor readings are judged by the field crew to be contaminant-related, intact soil samples shall be continuously taken until the odors/readings are within background ranges. These samples shall be retained in appropriate screw-capped sample jars for possible chemical analysis. With the resumption of background readings routine sampling shall resume. Specific procedures shall be detailed in the safety plan.

c. Representative soil samples of sufficient volume for physical testing from each sampled interval shall be retained for future reference or appropriate analysis.

d. Physical soil testing is a function of the project. The drilling plan shall detail specific testing guidance and requirements. Physical soil testing shall be conducted on 10 to 20 percent of the soil samples using procedures and equipment described in the Annual Book of ASTM Standards, American Society of Testing and Material, Part 19. Tested samples shall be representative of the range and frequency of soil types encountered and shall specifically include the screened interval of each completed well. In addition, they shall be obtained from borings that cover the geographic and geologic range within the project area. The contractor shall select the particular samples. Tests shall include moisture content, sieve grain size

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distribution, and those tests necessary to determine the Unified Soil Classification.

e. Soil samples for chemical analysis shall be extracted from their in-situ environment in as near an intact, minimally disturbed condition as technically practical. Once at the surface, the sampler shall be opened, sample extracted, peeled, and bottled in as short a time as possible. "Peeling" is a process whereby that portion of the sample which was in direct contact with the sampler, as well as the ends of the sample, are removed and discarded. Samples for volatile analysis shall be peeled, bottled, and capped within 15 seconds from the time of opening the sampler. Each soil sample for volatile analysis should have minimal head space for representative analytical results.

f. If sample liners are used, the following are applicable:

- (1) Use clear liners or take extra samples to ensure that the sample is of sufficient quantity and quality for the intended analyses.
- (2) Liner seams and ends shall be "air tight"; i.e., "chemically impermeable."
- (3) Borehole/drilling fluids shall not be trapped within the liner.
- (4) Liner or sealant interaction with the sample will not alter the sample's chemical composition.

3-12. Abandonment. Abandonment is that procedure by which any boring or well is permanently closed. Abandonment procedures shall preclude any current or subsequent discharges from entering along the axis or endpoint of any boring or well and thereby terminate access to and intracommunication within the subsurface environment.

a. Planned abandonment requirements and procedures shall be described in the work plan and incorporate any applicable state and/or Federal regulatory abandonment requirements.

b. The abandonment of any borings or wells shall be approved by the Army prior to any casing removal, sealing, or backfilling.

c. Each boring or well to be abandoned will be sealed by grouting from the bottom of the boring/well to ground surface. This shall be done by placing a tremie pipe to the bottom of the boring/well (i.e., to the maximum depth drilled/bottom of well screen) and pumping grout through this pipe until undiluted grout flows from the boring/well at ground surface. Any open or ungrouted portion of the annular space(s) between the innermost well casing and borehole (to include any casings in between) will be grouted in the same manner also.

d. After 24 hours, the contractor will check the abandoned site for grout settlement. That day, any settlement depression shall be filled with grout and rechecked 24 hours later. Additional grout shall be added using a tremie pipe inserted to the top of the grout unless the depth of the unfilled portion of the hole is less than 10 feet and this portion is dry. This process is repeated until firm grout remains at ground surface.

e. An abandoned well may be grouted either with the well screen and casing in place or after removal of the well materials and a partial or total hole redrilling.

f. For each abandoned boring/well, a record shall be prepared to include the following as applicable.

- (1) Project and boring/well designation.

(2) Location with respect to the replacement boring or well (if any); e.g., 20 feet north and 20 feet west of Well 14.

(3) Open depth of well/annulus/boring prior to grouting.

(4) Casing or items left in hole by length, depth, composition, description, and size.

(5) Copy of the boring log.

(6) Copy of construction diagram for abandoned well.

(7) Reason for abandonment.

(8) Description and total quantity of grout used initially.

(9) Description and daily quantities of grout used to compensate for settlement.

(10) Dates of grouting.

(11) Water or mud level (specify) prior to grouting and date measured.

(12) Remaining casing above ground surface: type (well, drill, protective) height above ground, size, and composition of each. Report all depths/heights from ground surface.

g. Replacement well/borings (if any) shall be offset at least 20 feet from any abandoned site in a presumed up- or cross-gradient groundwater direction. Site-specific conditions may necessitate variation to this placement.

3-13. Work Area Restoration and the Disposal of Drilling and Cleaning Residue. All work areas around the wells and/or borings installed as part of any contract shall be restored to a condition essentially equivalent to that of preinstallation. This includes the disposal of borehole cuttings and rut removal. Borehole cuttings discarded samples, drilling fluids, equipment cleaning residue, and water removed from a well during installation, development, and aquifer testing shall be disposed of both in a manner approved by TEAD and the State of Utah. Whatever procedures are followed, the leaving of barrels containing drill cuttings, excess samples, and water at various unsecured locations around the site at the completion of well installation is prohibited. Any container (barrel) used shall be labeled and recorded so that its contents can be identified as to materials and source. Restoration and disposal procedures (to include disposal location(s)) shall be discussed in the work plan.

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CHAPTER 4
BOREHOLE LOGGING

4-1. General. Each boring log shall fully describe the subsurface environment and the procedures used to gain that description.

4-2. Format. The format of the boring log shall be determined by the contractor.

4-3. Routine Entries. In addition to the data desired by the contractor and uniquely required by contract, the following information shall be routinely entered on the boring log:

a. All borings and wells (active and abandoned) shall be uniquely numbered and located on a sketch map as part of the log.

b. Depths/heights shall be recorded in feet and fractions thereof (tenths of feet). Metric measurements are acceptable if typically used by the site geologist.

c. Soil classifications shall be in accordance with the Unified Soil Classification System and shall be prepared in the field at the time of sampling by the geologist and are subject to change based upon laboratory tests and/or subsequent review. The mere difference between laboratory and field classification is not sufficient to change the field classification. Additional factors to consider before changing a field determination include the expertise of the field geologist and laboratory personnel, representative character of the tested sample, labeling errors, etc. Any changes made after this consideration shall be discussed and incorporated in the project report(s).

d. Each soil sample taken shall be fully described on the log. The descriptions of intact samples shall include the following parameters:

<u>PARAMETER</u>	<u>EXAMPLE</u>
Classification	Sandy Clay
Depositional Environment and Formation, if known	Glacial till, Twin Cities Formation
Unified Soil Classification Symbol	CL
Secondary Components and Estimated Percentages	Sand: 25% (Fine sand 5%, Coarse sand 20%)
Color (using Munsell Soil or Geological Society of America (GSA) Rock Color Chart). Each chart can be used for both soil and rock. Give both narrative and numerical description and note which chart was used.	Gray: 7.5 YR 5.0 (Munsell)
Plasticity	Low Plasticity
Consistency (cohesive soil)	Very soft, soft, medium stiff, very stiff, hard
Density (non-cohesive soil)	Loose, medium loose, dense, very dense

<u>PARAMETER</u>	<u>EXAMPLE</u>
Moisture Content. Use relative term. Avoid a percentage unless a value has been measured.	Dry, damp, moist, wet, saturated
Texture/Fabric/Bedding and orientation	No apparent bedding: numerous vertical, iron- stained, tight fractures
Grain Angularity	Rounded

e. In the field, visual numeric estimates shall be made of secondary soil constituents; e.g., "silty sand with 20-percent fines" or "sandy gravel with 40-percent sand." If such terms as "trace," "some," "several," etc., are used, their quantitative meaning shall be defined on each log.

f. When used to supplement other sampling techniques, disturbed samples, e.g., wash samples, cuttings, and auger flight samples, shall be described in terms of the appropriate soil/rock parameters to the extent practical. "Classification" shall be minimally described for these samples, along with a description of drill action and water losses/gains for the corresponding depth.

g. Record the brand name and amount of any bentonite used for each boring along with the reason for and start (by depth) of this use.

h. The drilling equipment used shall be generally described on each log. Record such information as rod size, bit type, pump type, rig manufacturer and model.

i. Each log shall include the circulation time for the cuttings and shall record the drilling sequence; e.g.:

- (1) Opened hole with 8" auger to 9'.
- (2) Set 8" casing to 10'.
- (3) Cleaned out and advanced hole with 8" roller bit to 15' (clean water, no water loss).
- (4) Drove 1 3/8" ID x 2" OD sampler to 16.5'.
- (5) Advanced with 8" roller bit to 30', 15-gallon water loss.
- (6) Drove 1 3/8" ID x 2" OD sampler to 31.5'.
- (7) Hole heaved to 20'.
- (8) Mixed 25 pounds of ABC bentonite in 100 gallons of water for hole stabilization and advanced with 8" roller bit to 45', etc.

j. Record all special problems and their resolution on the log; e.g., hole squeezing, recurring problems at a particular depth, sudden tool drops, excessive grout takes, drilling fluid losses, unrecovered tools in hole, lost casings, etc.

k. The dates and times for the start and completion of borings shall be recorded on the log along with notation by depth for drill crew shifts and individual days.

1. Each sequential boundary between the various soils and individual

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lithologies shall be noted on the log by depth. When depths are estimated, the estimated range should be noted along the boundary.

m. The depth of first encountered free water shall be indicated along with the method of determination; e.g., "37.6' from direct measurement after drilling to 40.0'"; or "40.1' from direct measurement in 60' hole when boring left overnight, hole dry at end of previous shift;" or "25.0' based on saturated soil sample while sampling 24-26'." Before proceeding, the first encountered water shall be allowed to partially stabilize (5 to 10 minutes) and recorded along with the time between measurements. Any other distinct water level(s) found below the first shall also be described.

n. The interval by depth for each sample taken, classified, and/or retained shall be noted on the log. For each driven (split spoon), thin wall (shelby), and cored sample, record the length of sampled interval, length of sample recovery, and the sampler type and size (diameter and length).

o. A record of the blow counts, hammer type and weight, and length of hammer all for driven samplers shall be made. For thin wall samplers, indicate whether the sampler was pushed or driven and the pressure/blow count per drive. Blow counts shall be recorded in half foot increments when standard penetration samplers (1 3/8" ID x 2" OD) are used. For penetration less than a half foot, annotate the count with the distance over which the count was taken.

p. When drilling fluid is used, quantitatively record fluid losses and/or gains and the interval over which they occur. Adjust fluid losses for spillage and intentional wasting (e.g., recirculation tank cleaning) to more closely estimate the amount of fluid lost to the subsurface environment.

q. Record the drilling fluid pressures typically used during all drilling operations (aqueous and pneumatic) and the driller's comments on drillability, drill speed, down pressure, rotation speed, etc.

r. Note the total depth of drilling and sampling on the log.

s. Record significant color changes in the drilling fluid return, even when intact soil samples or rock core are being obtained. Include the color change (from and to), depth at which change occurred, and a lithologic description of the cuttings before and after the change.

t. Soil gas readings, if taken, shall be recorded on the log. Each notation should include interval sampled and reading. A general note on the log should indicate meter manufacturer, model, and calibration material. If several meters are used, key the individual readings to the specific meter.

u. Special abbreviations used on a log and/or well diagram shall be defined in the log/diagram where used.

CHAPTER 5

MONITOR WELL INSTALLATION

5.1. General. A "monitor well" is a device principally designed and constructed for the acquisition of groundwater samples that are representative of the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process; and which, if so designed, provides access to measure the potentiometric surface for that screened interval. The "screened interval" consists of that portion of the device which is directly open to the host aquifer by way of openings in the well casing (hereafter called the "screen") AND indirectly open to the aquifer by way of the filter pack (or other permeable material) extending below and/or above the screen. While the length of the screened interval is fixed for a given well, the effective or functional length may vary with water table fluctuations or sampling techniques. In this plan, the term "monitor well" is used in a generic sense to include observation wells and open tube piezometers. Open tube piezometers are usually of small inside diameter to allow a quicker response to pressure change. Wellpoints are a rapid and uncontrolled means to obtain groundwater levels. They may be used, with Army approval, to supplement potentiometric data in areas of known stratigraphy. Lysimeters may be used to sample interstitial fluids in the vadose or unsaturated zone. Specific criteria for monitor wells and any special instrumentation shall be discussed in the drilling plan. The USEPA "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document" (September 1986) has general well construction diagrams (Figures 3-1. and 3-2).

5-2. Well Clusters. Each monitor well is a mechanism through which to obtain a representative sample of groundwater and to measure the potentiometric surface seen by that well. To help ensure this representation in the case of well clusters, each well of a cluster shall be installed in a separate boring. Multiple well placements in a single boring are too difficult for effective execution and evaluation to warrant single hole usage.

5-3. Well Screen Usage. Each well shall have a screen as specified in the work plan. The extra effort for screen installation in bedrock wells can be more than offset by the assurance of an unobstructed opening to the required depth during repeated usage. Consistency of the sampled interval during prolonged monitoring is thereby maintained.

5-4. Beginning Well Installation.

a. The installation of each monitor well shall begin within 12 hours of boring completion for holes uncased or partially cased with temporary drill casing. Installation shall begin within 48 hours in holes fully cased with temporary drill casing. Once installation has begun, no breaks in the installation process shall be made until the well has been grouted and drill casing removed.

b. In cases of unscheduled delay such as personal injury, equipment breakdowns, sudden inclement weather; or scheduled delays such as borehole geophysics, an acceptable delay may occur. In those cases, resume installation as soon as practical. In cases where a partially cased hole into bedrock is to be partially developed prior to well insertion, the well installation shall begin within 12 hours after this initial development.

c. Temporary casing and hollow stem augers may be withdrawn from the boring prior to well installation if the potential for cross-contamination is not likely and if the borehole walls will not slough during the time required for well installation. This procedure is usually successful in firm clays, and in bedrock that is not intensely fractured or highly weathered.

d. If the borehole will not remain stable long enough to complete

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placement of all necessary well materials in their proper position, it will be necessary to install some or all of the well materials prior to removal of the casing or hollow stem augers. In this situation, the hollow stem augers or casing shall have an inside diameter sufficient to allow the installation of the prescribed diameter screen and casing plus annular space for a pipe (commonly 3/4" minimum ID) through which to place the filter pack and grout.

e. Any materials, especially soils, blocking the bottom open end of the drill casing or hollow stem auger shall be dislodged and removed from the casing prior to well insertion. This action both reduces the potential for cross-contamination and makes well installation easier.

f. Once begun, well installation shall not be interrupted due to the end of the driller's work shift, darkness, weekend, or holiday.

g. The contractor shall ensure that all materials and equipment for drilling and installing a given well are available and onsite prior to drilling that well. The contractor shall have all equipment and materials onsite prior to drilling and installing any well if the total well drilling and installation effort is scheduled to take 14 days or less. For longer schedules, the contractor shall ensure that the above materials needed for at least 14 days of operation are onsite prior to well drilling. The balance of materials shall be in transit prior to well drilling.

5-5. Screens, Casings, and Fittings.

a. All well screens and well casings shall be free of foreign matter (e.g., adhesive tape, labels, soil, grease, etc.) and washed with approved water prior to use. Prewashing is not necessary if the materials have been packaged by the manufacturer and have their packaging intact up to the time of installation. Pipe nomenclature stamped or stenciled directly on the well screen and/or blank casing within and below the bentonite seal shall be removed via SANDING, unless removable in approved water. Solvents, except approved water, shall NOT be used for marking removal. Washed screens and casings should be stored in plastic sheeting prior to insertion.

b. Bottoms of well screens shall be placed no more than 3 feet above the bottom of the drilled borehole. If significant overdrilling is required (as for determining stratigraphy), a pilot boring shall be used. The intent here is to both narrow the interval of aquifer being sampled, limit the potential for stagnant or no-flow areas near the screen, and preclude unwanted backfill materials; e.g., grout or bentonite from entering or passing through the interval to be screened and sampled.

c. All screen bottoms shall be securely fitted with a threaded cap or plug of the same composition as the screen. This cap/plug shall be within 0.5' of the open portion of the screen (see figure 5). No solvents or glues are permitted for attachment.

d. Silt or sediment traps (also called "cellars" "tail pipes," or "sumps") shall NOT be used. A silt trap is a blank length of casing attached to and below the screen. Trap usage fosters a stagnant, turbid environment which could influence analytical results for trace concentrations.

e. Joints within and between the casing and screen shall be compatibly threaded. Thermally welded joints or couplings shall not be used. This prohibition includes threaded or slip joint couplings thermally welded to casing by the manufacturer or in the field. Solvent welded joints may be used only to make casing repairs or to adjust casing height. Any glue or solvent usage shall be described on the log or well diagram. During these repairs or adjustments which require solvent/glue usage, a clean rag should be tightly fit into the intact well casing to catch any glue spillage. This rag shall be attached to a strong twine for ease of rag removal and to preclude rag loss down the well. The rag and twine shall be removed upon repair completion.

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f. Gaskets shall not be used on monitor wells.

g. The top of each well shall be level such that the differences in elevation between the highest and lowest points on the top of the well casing or riser should be less than or equal to 0.02'

h. The borehole shall be of sufficient diameter to permit at least 2 inches of annular space between the borehole wall and all screens of the well (centered riser and screen). When telescoping casings (one casing within another), the full 2-inch annulus may not be practical or functional. In this case, the lesser spacing will be acceptable.

i. Well screen lengths may be a function of hydrostratigraphy, temporal considerations, environmental setting, analytes of concern, and/or regulatory mandate. Screen lengths shall be specified in the work plan.

j. The actual inside diameter of nominally sized well is a function of screen construction and the wall thickness/schedule of both the screen and casing. In the case of continuously wound screens, their interior supporting rods may reduce the full inside diameter. This consideration is critical when planning the sizes for pumps, bailers, surge devices, etc.

5-6. Granular Filter Pack.

a. The use of a tremie pipe for filter pack placement is recommended, especially when the boring contains drilling fluid or mud.

b. The filter pack shall extend at least 5 feet above the top of the screen unless otherwise specified in the drilling plan. The filter pack location shall not cross any confining layer.

c. The final depth to the top of the granular filter shall be directly measured (via tape or rod) and recorded. Final depths shall not be estimated; as, for example, based on volumetric measurements of placed filter.

5-7. Bentonite Seals.

a. Bentonite seals (especially those set in water) shall be composed of commercially available pellets. Pellet seals shall be a minimum of 5 feet thick as measured immediately after placement, without allowance for swelling. Granular bentonite may be an alternate if the seal is set in a dry condition.

b. Slurry seals shall be used only as a last resort, as when the seal location is too far below water to allow for pellet or containerized-bentonite placement or within a narrow well-borehole annulus. Slurry seals shall have a thick, batter-like (high viscosity) consistency with a placement thickness of 3 to 5 feet.

c. The final depth to the top of the bentonite seal shall be directly measured (via tape or rod) and recorded. Final depths shall not be estimated; as, for example, based on volumetric measurements of placed bentonite

d. Numerous opinions have been expressed regarding bentonite hydration time, bentonite placement procedures under water versus in a dry condition, and the potential installation delays and other consequences caused by these factors. These and related issues are still being investigated. In the meanwhile, the use of a 3 to 5-foot bentonite pellet seal is considered an adequate barrier to protect the screen and filter pack from downhole grout migration. If the seal is located above the fluid levels, a 1- or 2-foot layer of fine to medium sand placed atop the bentonite seal may enhance this barrier. Therefore, any time delay in well installation to allow for bentonite hydration, in a wet or dry hole, is necessary.

5-8. Grouting. All prescribed portions of grout material should be combined

in an above-ground rigid container and mechanically (not manually) blended to produce a thick, lump-free mixture throughout the mixing vessel.

a. Grout should be placed around the monitor well as follows:

(1) The grout shall be placed from within a rigid grout pipe located just over the top of the seal.

(2) Prior to exposing any portion of the borehole above the seal by removal of any drill casing (to include hollow-stem augers), the annulus between the drill casing and well casing shall be filled with sufficient grout to allow for planned drill casing removal. The grout shall not penetrate the well screen or granular filter pack. Disturbance of the bentonite seal shall be minimal.

(a) If all drill casing is to be removed in one operation, the grout shall be pumped through the grout pipe until undiluted grout flows from the annulus at ground surface forming a continuous grout column from the seal to ground surface. The drill casing shall then be removed making certain that no portion of the borehole is exposed. When removing hollow stem augers, this may necessitate reinsertion of the grout pipe and additional grout before the entire drill string is removed.

(b) If drill casing is to be incrementally removed with intermittent grout addition, the grout shall be pumped through the grout pipe until it reaches a level which will permit at least 10 feet of grout to remain in the well/drill casing annulus AFTER removing the selected length of drill casing. This method requires that at least 20 feet of grout be to within the drill casing before removing 10 feet of driven casing or considerably more than 20 feet of grout for the removal of 10 feet of hollow stem auger. With this method, the grout pipe needs only to be reinserted to the base of the casing yet to be removed before repeating the grout insertion process.

(3) If the ungrouted portion of the hole is less than 10 feet deep and without fluids after casing removal, the ungrouted portion may be filled by pouring grout from the surface without a pipe.

(4) If drill casing (to include hollow-stem auger) was not used, proceed with grouting to surface in one, continuous operation.

(5) Once begun, the grouting process should be continuous until all the drill casing has been removed and all annular spaces are grouted to the ground surface.

(6) Install protective casing on the same day.

(7) After 24 hours, the contractor shall check the site for grout settlement and that day add more grout to fill any depression. Repeat this process until firm grout remains at ground surface. Incremental quantities of grout added in this manner shall be recorded on the well completion diagram.

(8) A special circumstance that permits deviation from prescribed practice is the following: for grout placement in a dry and open hole less than 10 feet deep, the grout may be manually mixed and poured in from the surface as long as seal integrity is maintained.

(9) No grout shall be placed below the well screen.

5-9. Well Protection.

a. Protective casing shall be installed around each monitor well the same day as initial grout placement around that well. Any annulus formed between the outside of the protective casing and borehole or between the monitor well and protective casing shall be filled to ground surface with

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grout as part of the overall grouting procedure. Specific details of well protection shall be approved by the Army and specific well protection elements to be included in the well construction diagrams described in the work plan.

b. All protective casing shall be steam or hot water-pressure cleaned prior to placement, free of extraneous openings, devoid of any asphaltic, bituminous, encrusting, and/or coating materials (except the black paint or primer applied by the manufacturer).

c. Minimum elements of protection design are:

(1) A 5-foot minimum length of new, black iron/steel pipe extending about 2.5 feet above ground surface and set in grout (see Figure 1).

(2) A protective casing inside diameter at least 4 inches greater than the nominal diameter of the well riser.

(3) A hinged cover or loose fitting telescopic slip joint-type cap to keep direct precipitation and cap runoff out of the casing. Threaded covers shall be avoided because of the tendency to rust shut.

(4) All protective casing covers/caps secured to the casing by means of a padlock from the date of protective casing installation.

(5) All padlocks at a given site opened by the same key. The (6) No more than .2' from the top of protective casing to the top of well casing. This, or a smaller spacing, is needed for subsequent water level determination via some acoustical equipment.

(6) The outside only of the protective casing, hinges (if present), and covers/caps painted with a paint brush (not aerosol can). Painting required to be completed and dry prior to initially sampling that well.

(7) The painting of the well designation on the outside of the protective casing, using white paint and a brush. The identification shall be done after the casing is painted as described above. Painting required to be completed and dry prior to initially sampling that well.

(8) The placement of an internal mortar collar within the well-protective casing annulus from ground surface to 1/2 foot above ground surface and a 1/4 inch diameter hole (drainage port) in the protective casing centered 1/8 inch above this level (see figure 5). The mortar mix shall be (by weight) 1 part cement to 2 parts sand (the granular filter used around the well screen), with minimal water for placement. Placement is required on the day of firm grout remaining at ground surface and at least 48 consecutive hours prior to well development.

(9) All elements of well protection shall be detailed in the work plan. In addition, unique well protection requirements for flood plains, frost heaving, heavy traffic areas, parking lots, wells finished at or below grade, and other special circumstances, shall also be covered on a case-by-case basis.

5-10. Shallow Wells. Shallow (less than 15-foot) well construction may be more problematical than deep. The contractor shall tailor design criteria to the actual environment and project objectives for appropriate shallow well construction.

5-11. Drilling Fluid Removal. When a borehole, made with or without the use of drilling fluid, contains and excessively thick, particulate-laden fluid which would preclude or hinder the specified well installation, the borehole fluid should be removed or displaced with approved. This removal is intended to remove or dilute the thick fluid and thus facilitate the proper placement of casing, screen, granular filter, and seal. Fluid losses in this operation

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shall be recorded on the well diagram or boring log and later on the well development record. Any fluid removal prior to well placement should be contingent upon the driller's and the geologist's evaluation of hole stability: long enough for the desired well and seal placement.

5-12. Well Construction Diagrams.

a. Each installed well shall be depicted in a well diagram. This diagram should be attached to the original bore log for that installation and graphically denote, by depth from ground surface (unless otherwise specified):

(1) The bottom of the boring (that part of the boring most deeply penetrated by drilling and/or sampling) and boring diameter(s).

(2) Screen location.

(3) Joint locations.

(4) Granular filter pack.

(5) Seal.

(6) Grout.

(7) Cave-in.

(8) Centralizers.

(9) Height of riser (stickup) without cap/plug above ground surface.

(10) Protective casing detail.

(a) Height of protective casing, without cap/cover, above ground surface.

(b) Base of protective casing below ground surface.

(c) Drainage port location and size.

(d) Internal mortar collar location.

(e) Gravel blanket height and extent.

(f) Protective post configuration.

(11) Water level 24 hours after completion with date and time of measurement.

b. Describe on the diagram:

(1) The actual quantity and composition of the grout, bentonite seals, and granular filter pack used for each well.

(2) The screen slot size (in inches), slot configuration, total open area per foot of screen, outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer.

(3) The material between the bottom of the boring and the bottom of the screen.

(4) The outside diameter, nominal inside diameter, schedule/thickness, composition, and manufacturer of the well casing.

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- (5) The joint design and composition.
 - (6) Centralizer design and composition.
 - (7) Protective casing composition and nominal inside diameter.
 - (8) Special problems and their resolutions; e.g., grout in wells, lost casing and/or screens, bridging, casing repairs or adjustments, etc.
 - (9) Dates and times for the start and completion of well installation.
- c. Special abbreviations used on the well completion diagram shall be defined on the diagram.

CHAPTER 6

WELL DEVELOPMENT

6-1. General. Well development is that process which restores or improves the aquifer's hydraulic conductivity and removes well drilling fluids, muds, cuttings, mobile particulates, and entrapped gases from within and adjacent the well. The resulting inflow should be physically and chemically representative of the aquifer.

6-2. Timing and Record Submittal. The development of monitor wells shall be initiated not sooner than 48 hours after, nor longer than 7 days beyond internal mortar collar placement.

6-3. Pump and Bailer Usage. Development shall be accomplished with a pump and may be supplemented with a bottom discharge/filling bailer (for sediment removal) and surge block. Pumps may be replaced by bottom filling bailers where well size or slow recharge rates restrict pump usage. The use of a surge block or periodically stopping the pump can agitate and mobilize particulates around the well screen. By pumping the well at a higher rate than that expected during sampling, one may remove the mobilized particulates, thereby providing a cleaner well for sampling.

6-4. Development Criteria. Development shall proceed until the following criteria are met:

a. The well water must have a turbidity of no more than 5 nephelometric turbidity units. If this standard cannot be achieved, justification must be included in the report describing monitoring well installation.

b. The sediment thickness remaining within the well is less than 1% of the screen length of less than 0.1' for screens equal to or less than 10 feet long.

c. In addition to minimally removing 5 times the standing water volume in the well (to include the well screen and casing plus saturated annulus, assuming 30% porosity), the following shall apply:

(1) For those wells where the boring was made without the use of drilling fluid (mud and/or water), 5 times any water used in granular filter pack placement shall be removed.

(2) For those wells where the boring was made or enlarged (totally or partially) with the use of drilling fluid (mud and/or water), remove an additional 5 times the measured amount of total fluids lost while drilling plus 5 times that used in filter pack placement as above.

(3) Should recharge be so slow that the required volume cannot be removed in 48 consecutive hours, the water remains discolored, or excess sediment remains after the 5 volume removal; contact the Army for guidance.

d. Water SHALL NOT be added to a well as part of development once the initial seal atop the filter pack is placed.

e. The use of air to develop a well SHALL NOT be allowed. The introduction of air into a well enhances the occurrence of chemical, physical, and biological changes to the local aquifer system monitored by the well.

6-5. Development-Sampling Break. Well development shall be completed at least 14 days before well sampling. The intent of this hiatus is to provide time for the newly installed well and backfill materials to surficially equilibrate to their new environment and for that environment to re-stabilize after the disturbance of drilling. Though a significant volume of water may

be pulled through the well during development, the well and granular backfill surfaces over which this water passes are not likely to be at chemical equilibrium with the aquifer. Intuitively, the hiatus allows time for that equilibrium to be created, thereby enhancing the probability of the resulting sample to be more representative of the host aquifer. The 14-day hiatus is an arbitrary value. Therefore, if a different value is suggested based upon technical data or overall project considerations, then such a change shall be evaluated and, if deemed appropriate, implemented.

6-6. Pump/Bailer Movement. During development, water shall be removed throughout the entire water column in the well by periodically lowering and raising the pump intake (or bailer stopping point).

6-7. Well Washing. Part of well development shall include the washing of the entire well cap and the interior of the well casing above the water table using only water from that well. The result of this operation will be a well casing free of extraneous materials (grout, bentonite, sand, etc.) inside the well cap and blank casing, between the top of the well and the water table. This washing shall be conducted before and/or during development, not after development.

6-8. Well Development Record. The following data shall be recorded as part of development and submitted:

- a. Project name, location.
- b. Well designation, location.
- c. Date(s) and time(s) of well installation.
- d. Date(s) and time(s) of well development.
- e. Static water level from top of well casing before and 24 hours after development.
- f. Quantity of mud/water:
 - (1) Lost during drilling.
 - (2) Removed prior to well insertion.
 - (3) Lost during thick fluid displacement.
 - (4) Added during granular filter placement.
- g. Quantity of fluid in well prior to development:
 - (1) Standing in well.
 - (2) Contained in saturated annulus (assume 30% porosity).
- h. Field measurement of pH, conductivity, and temperature before, twice during, and after development using an appropriate device and method according to EPA 600/4-79-020: Methods for Chemical Analysis of Water and Wastes.
- i. Depth from top of well casing to bottom of well.
- j. Screen length.
- k. Depth from top of well casing to top of sediment inside well, before and after development (from actual measurements at time of development).

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1. Physical character of removed water, to include changes during development in clarity, color, particulates, and any noted odor, as well as all turbidity measurements.

m. Type and size/capacity of pump and/or bailer used.

n. Description of surge technique, if used.

o. Height of well casing above ground surface (from actual measurement at time of development).

p. Typical pumping rate.

q. Estimated recharge rate.

r. Quantity of fluid/water removed and time for removal (present both incremental and total values).

6-9. Potential Difficulties. Many difficulties may arise during development and presample purging. Some are readily apparent but troublesome to resolve; e.g., a well that is easily pumped dry but slow to recharge; or one that will not produce clear, particulate free water. Other difficulties are not easily observed but may bias the analytical results; e.g., pulling-in distant parts of the aquifer in an effort to achieve a repetitively consistent field reading; or aerating the aquifer adjacent the well in a hurried attempt at well development. The anticipation, evaluation, and tentative solution for these problems shall begin early in the formulation of each work plan.

CHAPTER 7

WELL AND BORING ACCEPTANCE CRITERIA

7-1. Well Criteria. Wells must be acceptable to the Army. Well acceptance shall be on a case-by-case basis. The following criteria shall be used along with individual circumstances in the evaluation process.

a. The well and material placement shall meet the construction and placement specifications of this plan unless modified, if at all, by the project specific workplan.

b. Wells shall not contain portions of drill casing or augers unless they are contractually required as permanent casing.

c. All well casing and screen materials shall be free of any unsecured couplings, ruptures or other physical breakage/defects before and after installations.

d. The annular material (filter pack, bentonite, and grout) of the installed well shall form a continuous and uniform structure, free of any detectable fractures, cracks or voids.

e. Any casing or screen deformation or bending shall be minimal to the point of allowing the insertion and retrieval of the pump and/or bailer optimally designed for that size casing (e.g., a 4-inch pump in a 4-inch schedule 40, PVC casing is optimal; a 2-inch pump in a 4-inch casing is not optimal).

f. All joints shall be constructed to provide a straight, nonconstricting, and watertight fit.

g. Completed wells shall be free of extraneous objects or materials; e.g., tools, pumps, bailers, packers, excessive sediment thickness, grout, etc. This prohibition shall not apply to intentionally installed equipment per the work plan.

h. For those monitor wells where the screen depth was determined by the contractor, the well shall have sufficient free water at the time of the water level measurement to obtain a representative groundwater level for that well. These same wells shall have sufficient free water, at the time of initial sampling, which is representative of the desired portion of the aquifer for the intended chemical analysis.

i. All boring logs, well diagrams, and development records shall have been completed per the work plan.

j. Keys to the padlocks securing the well covers should be in the possession of TEAD prior to well acceptance.

7-2. Abandoned Borings and Wells. Borings not completed as wells should be abandoned per section 3-12.

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CHAPTER 8

WATER LEVELS

8-1. Measurement Frequency. The frequency of water level measurement is a function of each project. At a minimum, for those projects involving the installation of any monitoring wells, at least 1 complete set of static water level measurements shall be made over a single, consecutive 10 hour period for all wells, both newly installed and specified, existing wells. These measurements shall be taken at least 24 hours after development for newly installed wells and at least 24 hours after sampling for existing wells. Static levels in borings not converted to wells shall be included if practical and technically appropriate. This set of measurements should include a notation for the presence of any streams, lakes, and/or open water bodies (natural and manmade), within proximity; i.e., about 300 feet, of these wells. The measurement of any surficial bodies shall be a consideration within the drilling and well installation plan.

8-2. Vertical Control. The depth to groundwater shall be measured and reported to the nearest .01 foot. Measurement shall be made from the highest point on the rim of the well casing or riser (not protective casing). This same point on the well casing shall be surveyed for vertical control. Surface water levels shall be measured at least to the nearest .1 foot using an adjacent temporary or permanent survey marker as a datum for future reference.

8-3. Reporting and Usage. All water level data should be presented as elevations in tabular form. Where sufficient data points exist, the elevations should be contoured to denote flow directions, gradients, and any hydrological interconnections between aquifers and surficial water bodies.

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CHAPTER 9
TOPOGRAPHIC SURVEY

9-1. Licensing. All topographic survey efforts conducted under contract shall be certified by a surveyor with a current, surveyor's license in the State of Utah. Any licensing requirements within the state for contract surveyors shall be determined by the Army.

9-2. Horizontal Control. Each boring and/or well installation shall be locationally surveyed to determine its map coordinates referenced to either a Universal Transverse Mercator (UTM) grid or the State Plane Coordinate System (SPCS) to within ± 0.5 feet (± 15 cm). This also includes temporary or permanent markers for surface water data points. These surveys shall be connected to the UTM or SPCS by 3rd order, class II control surveys in accordance with the "Standards and Specifications for Geodetic Control Networks."

9-3. Vertical Control. Elevations for the natural ground surface (not the top of the coarse gravel blanket) and a designated point on the rim of the uncapped well casing (not protective casing) for each bore/well site shall be surveyed to within ± 0.01 feet (± 0.3 cm) referenced to the National Geodetic Vertical Datum of 1929 (NGVD of 1929). These surveys shall be connected by 3rd order leveling to the NGVD of 1929 in accordance with the "Standards and Specifications for Geodetic Control Networks."

9-4. Field Data. The topographic survey shall be completed as near to the time of last well completion as possible, but no longer than 5 weeks after well installation. Survey field data (as corrected), to include loop closures and other statistical data in accordance with the "Standards and Specifications" referenced in paragraph 9-2, to indicate survey accuracy shall be included within the geotechnical or final report. Closure should be within the horizontal and vertical limits given above. These data shall clearly be listed in tabular form: the coordinates (and system) and elevation (ground surface and top of well) as appropriate, for all borings, wells, and reference marks. All permanent and semipermanent reference marks used for horizontal and vertical control (bench marks, caps, plates, chiseled cuts, rail spikes, etc.) shall be described in terms of their name, character, physical location, and reference value.

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CHAPTER 10

GEOPHYSICS

10-1. Usage and Reporting. The use of geophysical techniques, if required, will be specified in the project specific workplan. These techniques may enhance the technical acuity and cost-effectiveness of his efforts. Special applications may be useful in unexploded ordnance detection, disturbed area delineation, contaminant detection, depth to bedrock determination, buried drum detection, borehole and well logging, etc. Safety aspects of geophysical applications shall be included in the safety plan, especially for those areas where induced electrical currents of seismic waves could detonate unexploded ordnance or other explosive materials. All geophysical data will be accompanied by appropriate logs or other information necessary to properly interpret or correct the data (e.g. caliper logs).

10-2. Methods. General discussions of geophysical techniques are found in USEPA, EPA 600/2-87/078, Nondestructive Testing Techniques to Detect Contained Subsurface Hazardous Waste; and Benson, R.C., et al, Geophysical Techniques for Sensing Buried Wastes and Waste Migration.

CHAPTER 11

VADOSE ZONE MONITORING

11-1. Usage and Reporting. Data acquisition from the vadose (unsaturated) zone shall be addressed on a case-by-case basis. The use of lysimeters in a silica flour matrix, soil-gas monitors, and analysis of bulk soil samples are mechanisms which may be employed.

11-2. Methods. A general discussion of vadose monitoring is found in Everett, L.G., et al, Vadose Zone Monitoring for Hazardous Waste Sites.

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APPENDIX C

Chemical Data Results Figures Phase II RFI (Rust E&I, 1995)

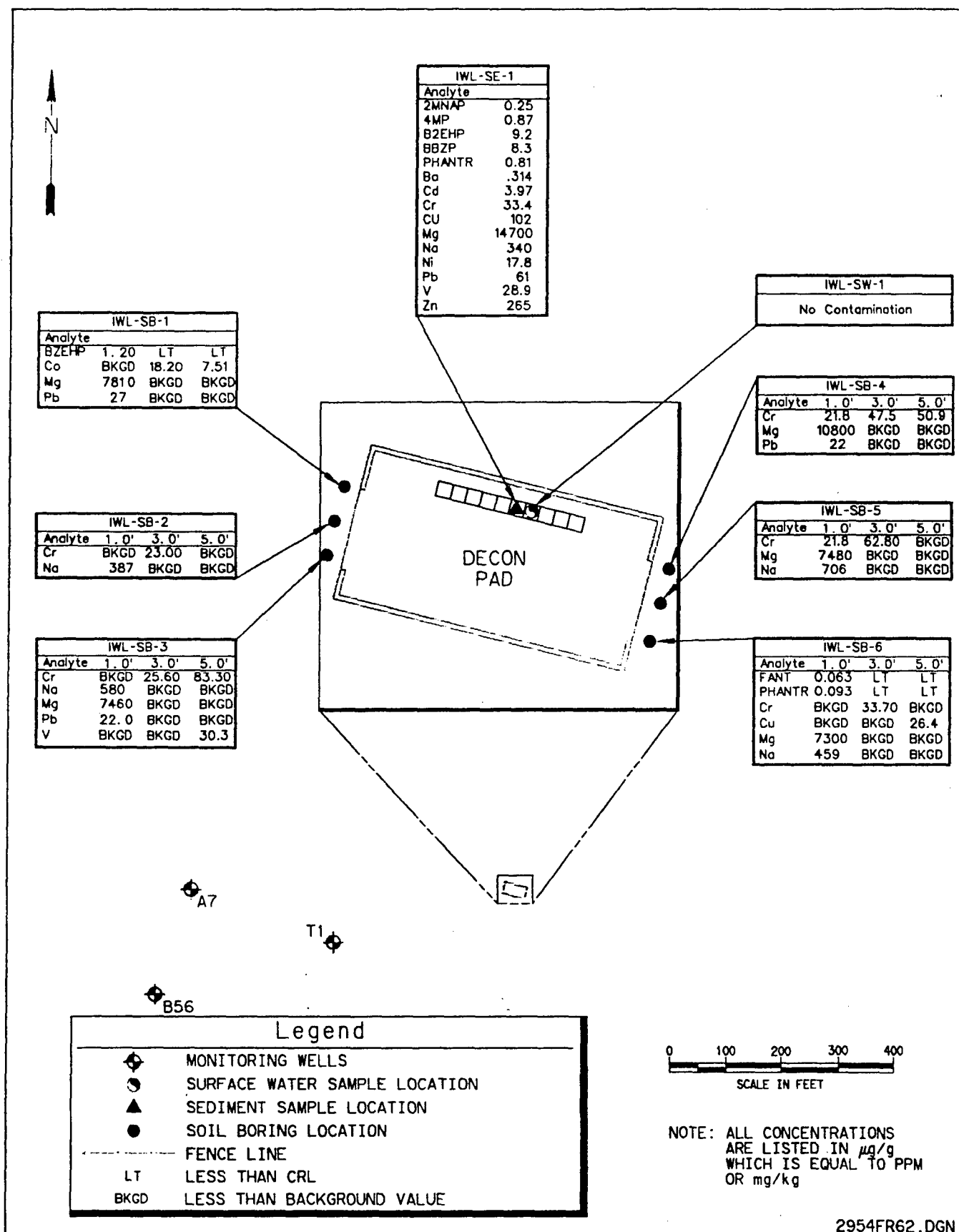


Figure 5-2. Phase II RFI Sample Location Map Showing Contaminants Identified for the IWL (SWMU 2)

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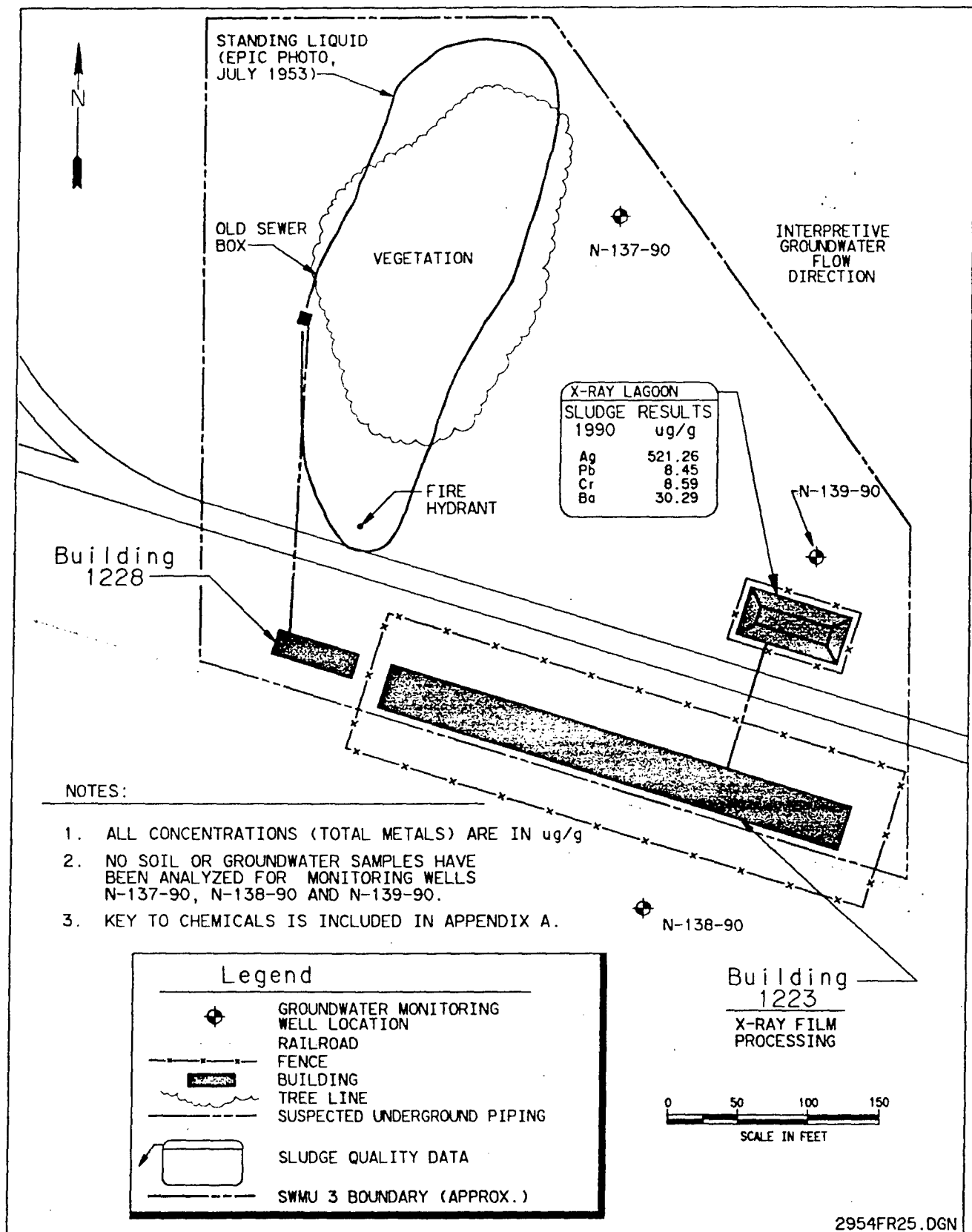


Figure 6-4. Previous Investigation Sample Location and Results

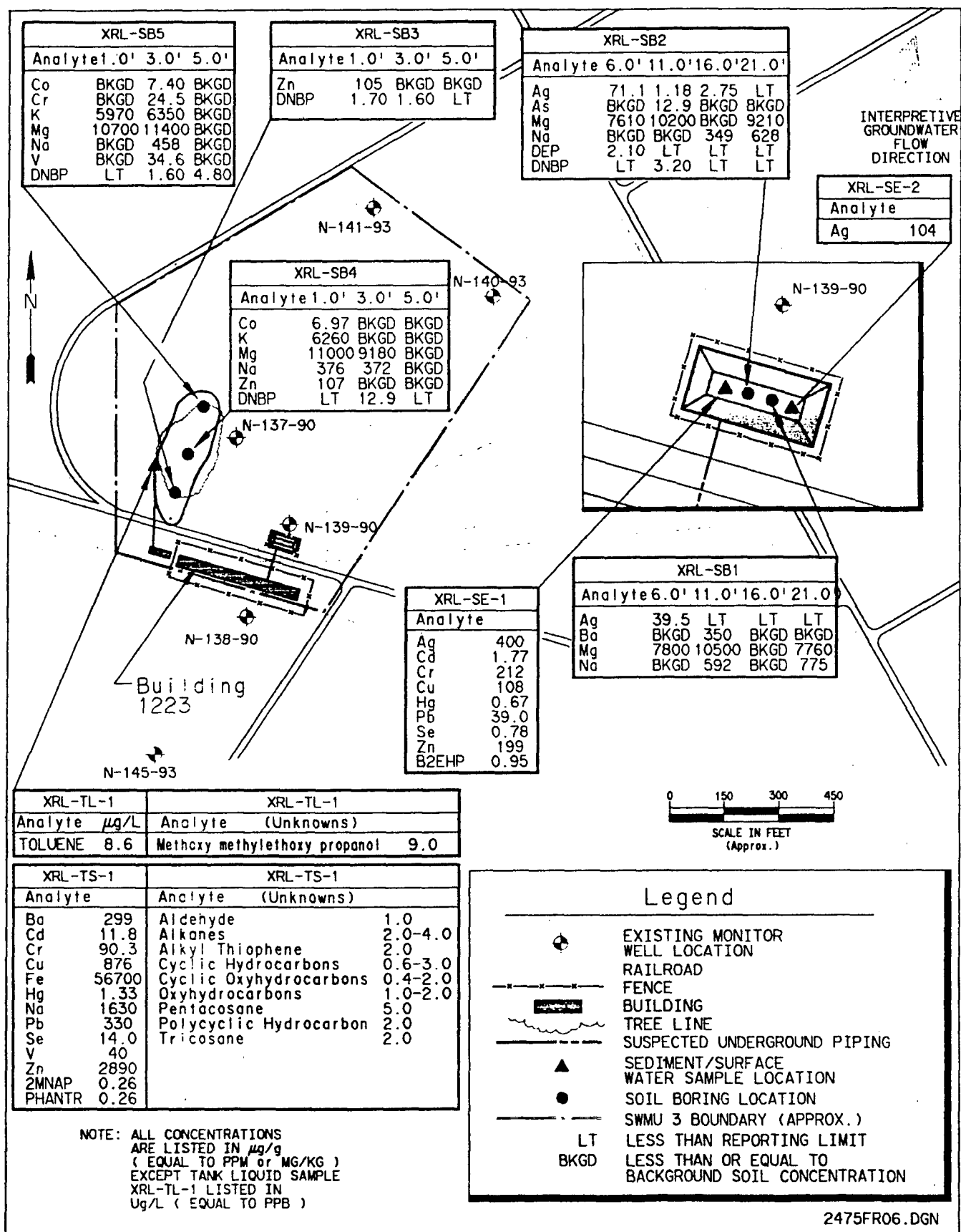


Figure 6-5. Round 1 Sample Locations and Results for SWMU 3

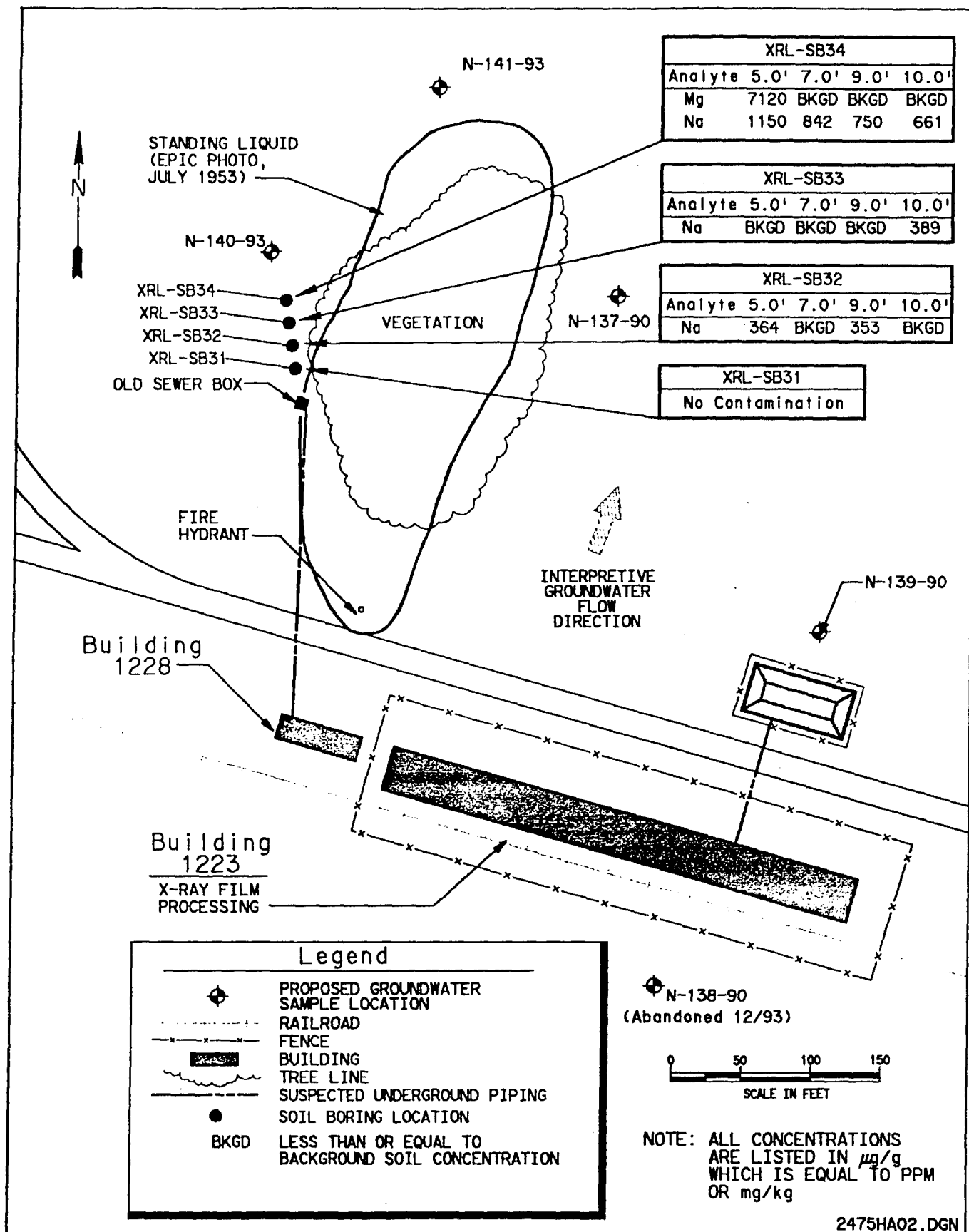


Figure 6-6. Round 2 Sample Location Map for the Septic Tank Area of SWMU 3
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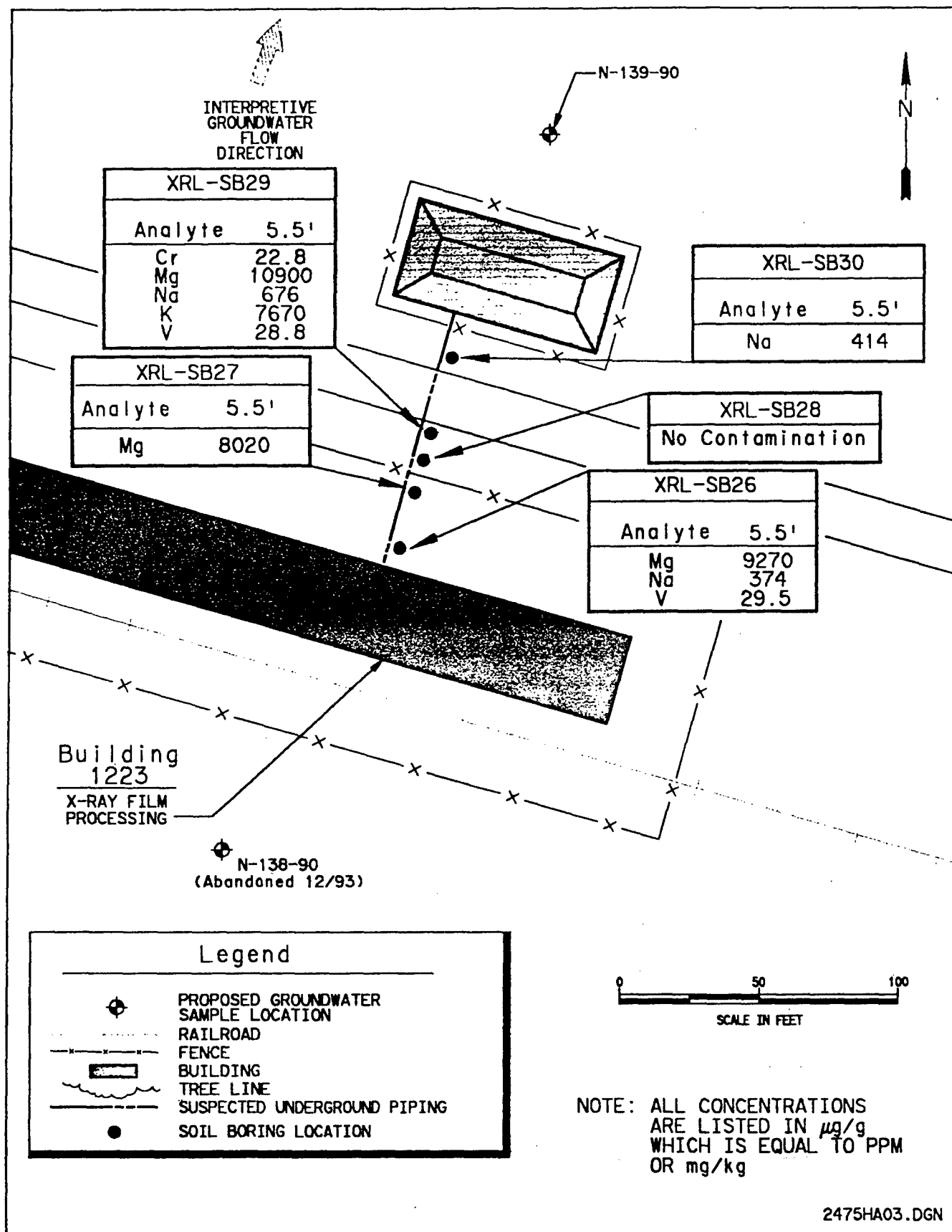


Figure 6-7. Round 2 Sample Locations and Results for the X-Ray Lagoon and Associated Pipeline
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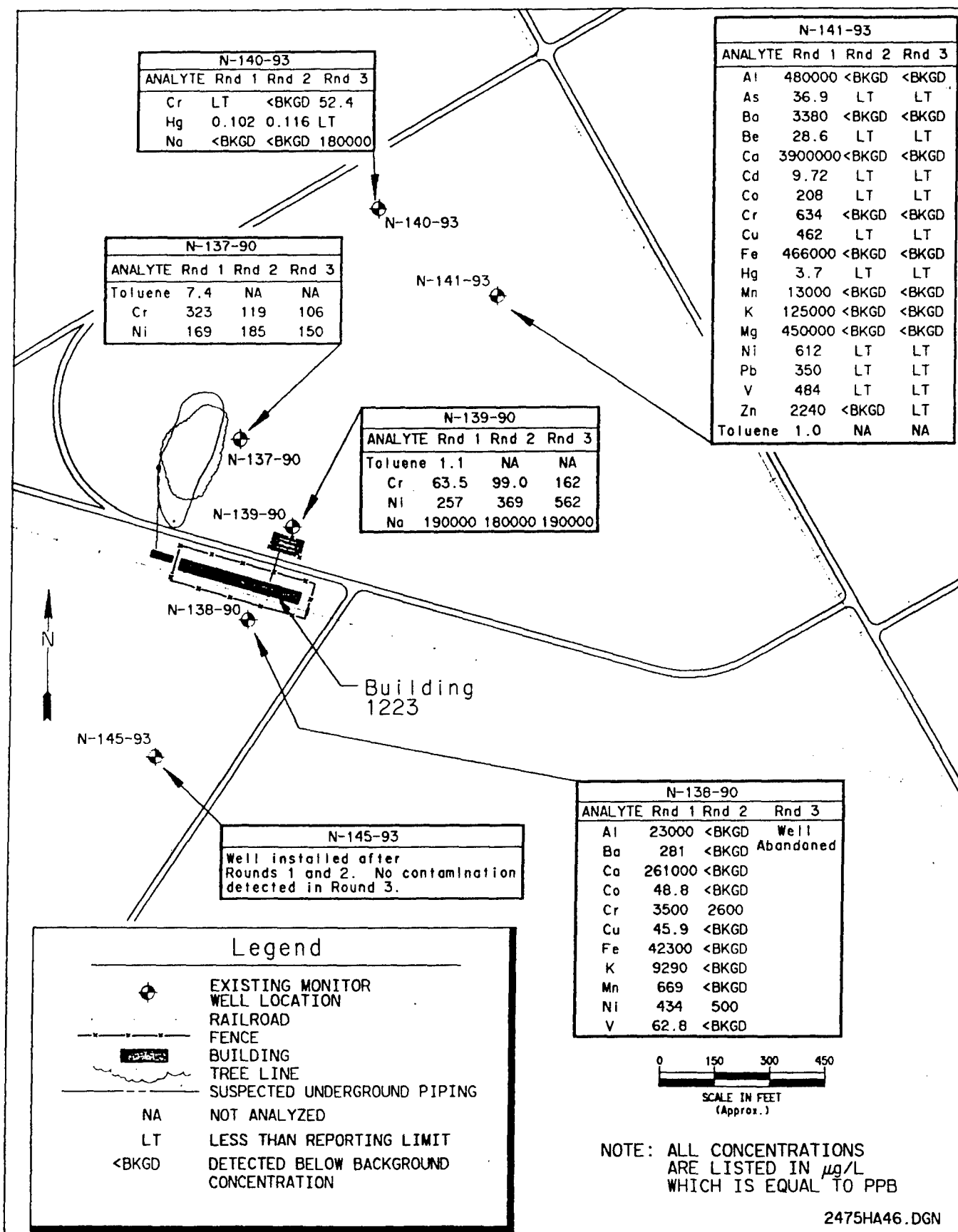
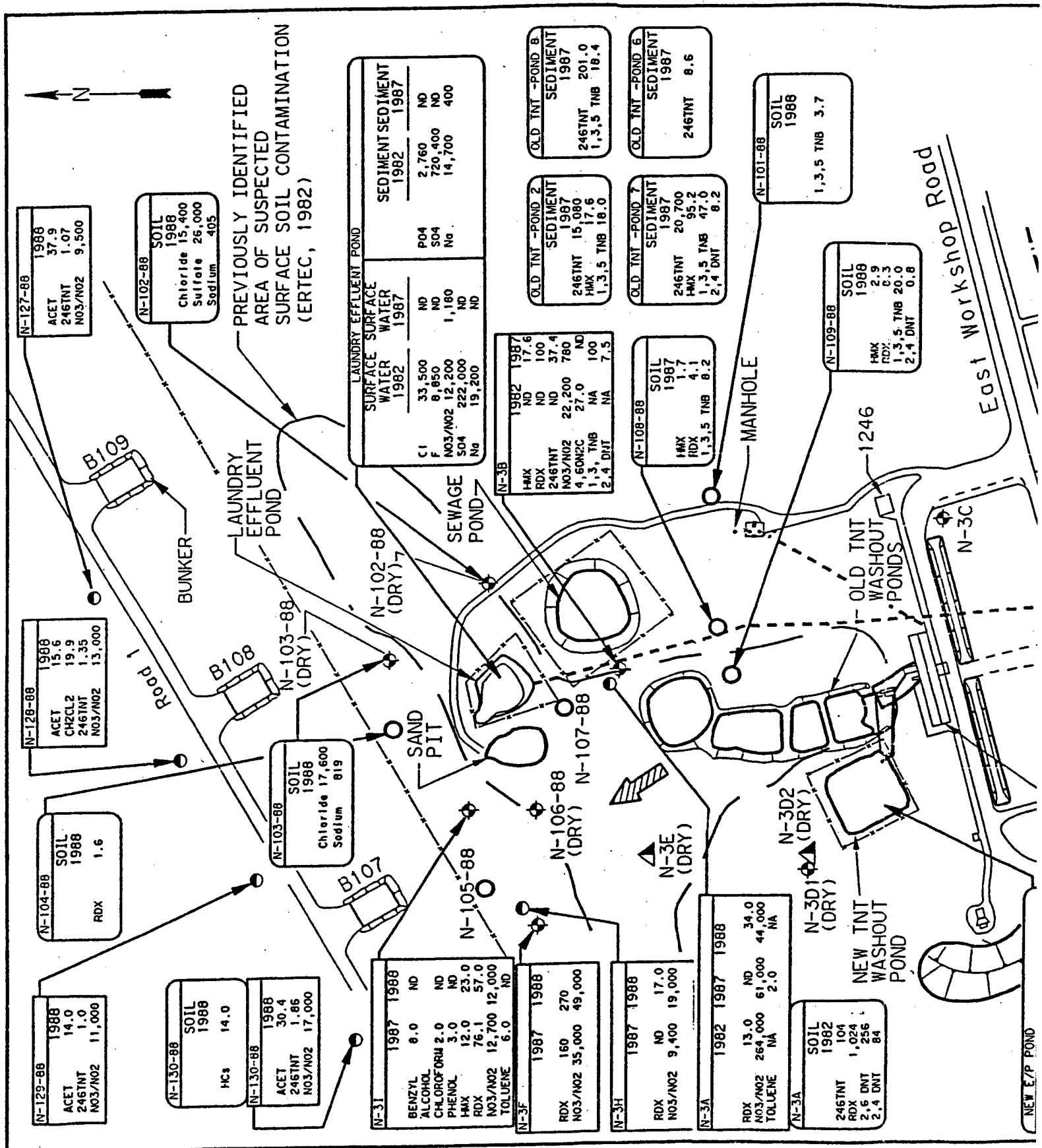
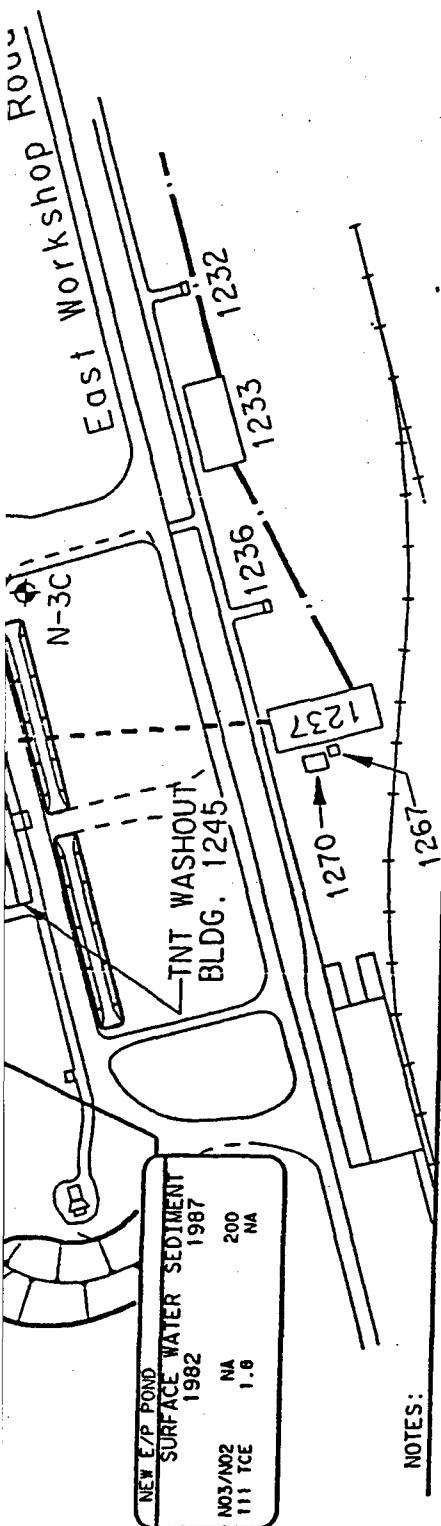


Figure 6-8. Groundwater Sample Locations/Results for Rounds 1, 2, and 3 at the X-Ray Lagoon
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Figure 7-14. Previous Investigation Sample Locations and Results for the TNT Washout Facility/Laundry Effluent Pond

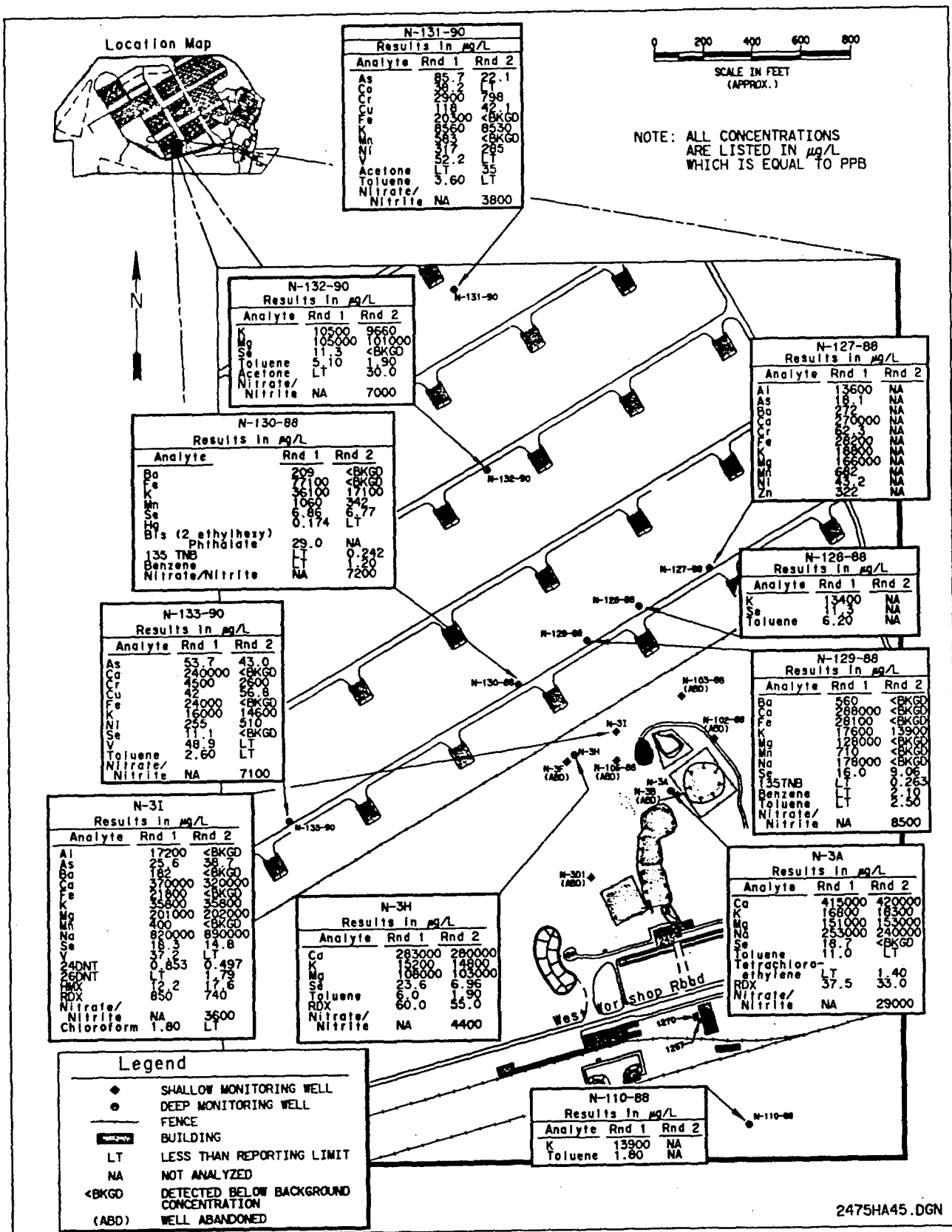


Figure 7-17. Groundwater Sample Locations/Results for Rounds 1 and 2 at the TNT Washout Ponds
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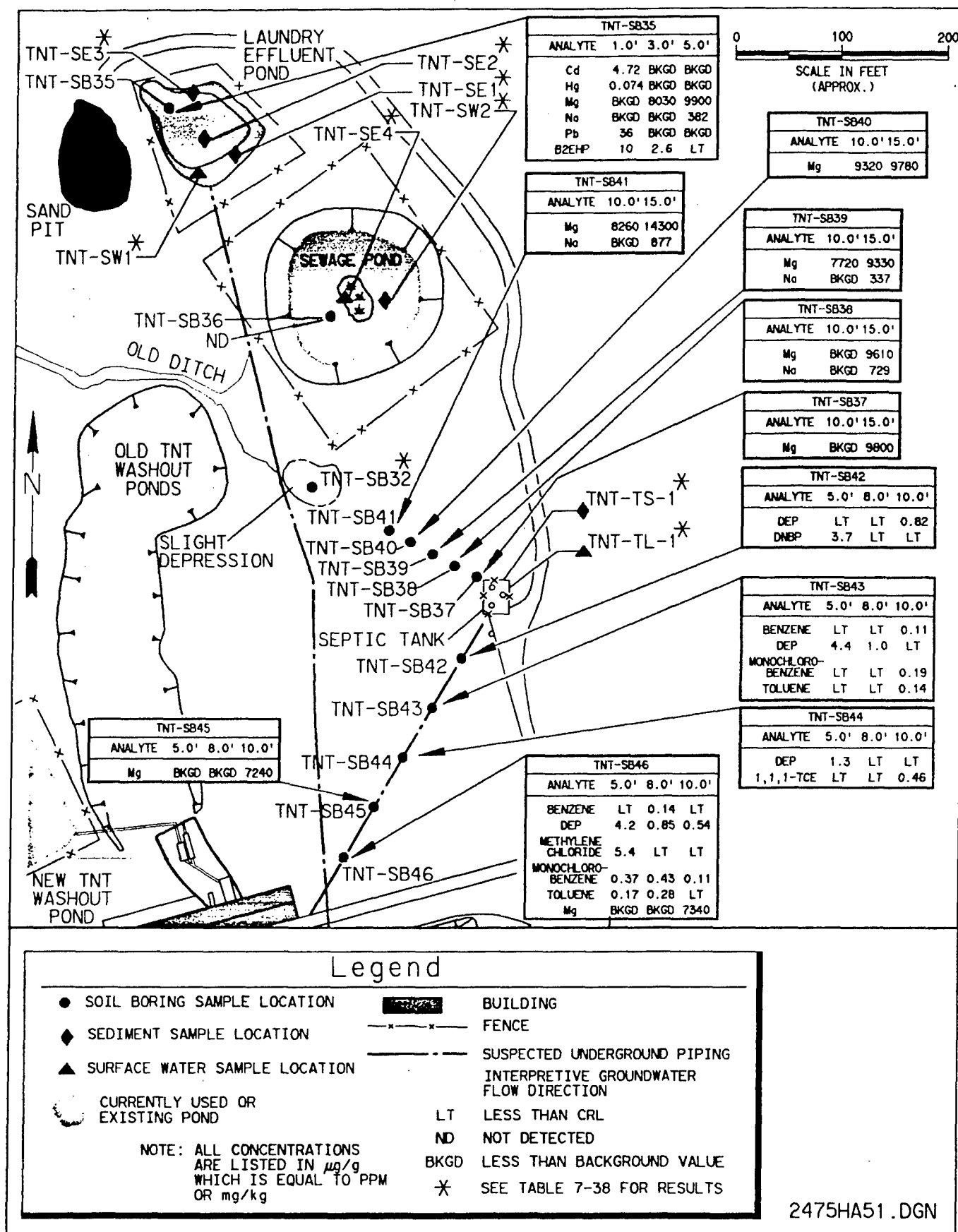


Figure 7-26. Phase II RFI Sample Location Map and Results for the Laundry Effluent Pond

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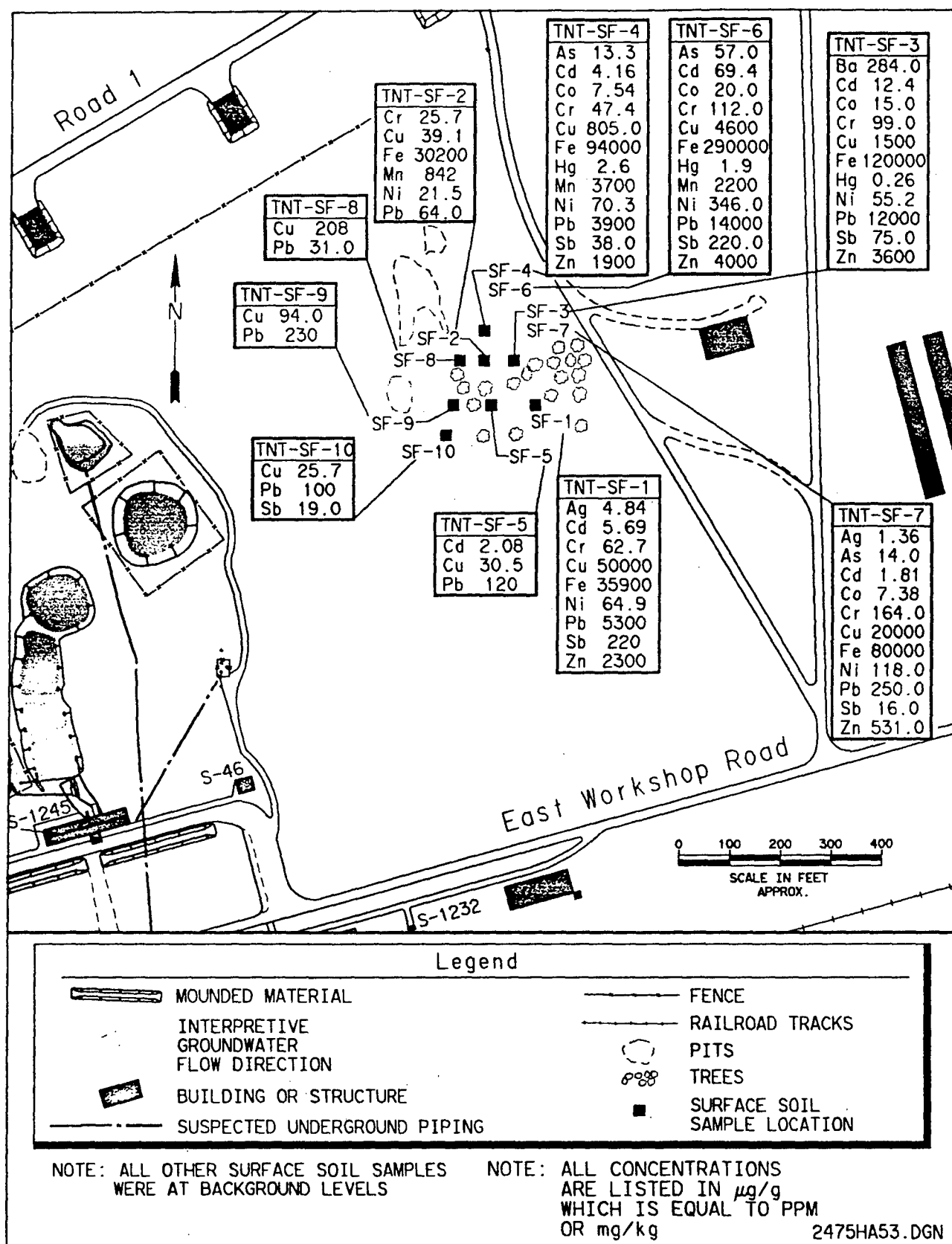


Figure 7-27. Round 1 Sample Location Map and Metals Results for the Waste Pile Area East of the Laundry Effluent Pond

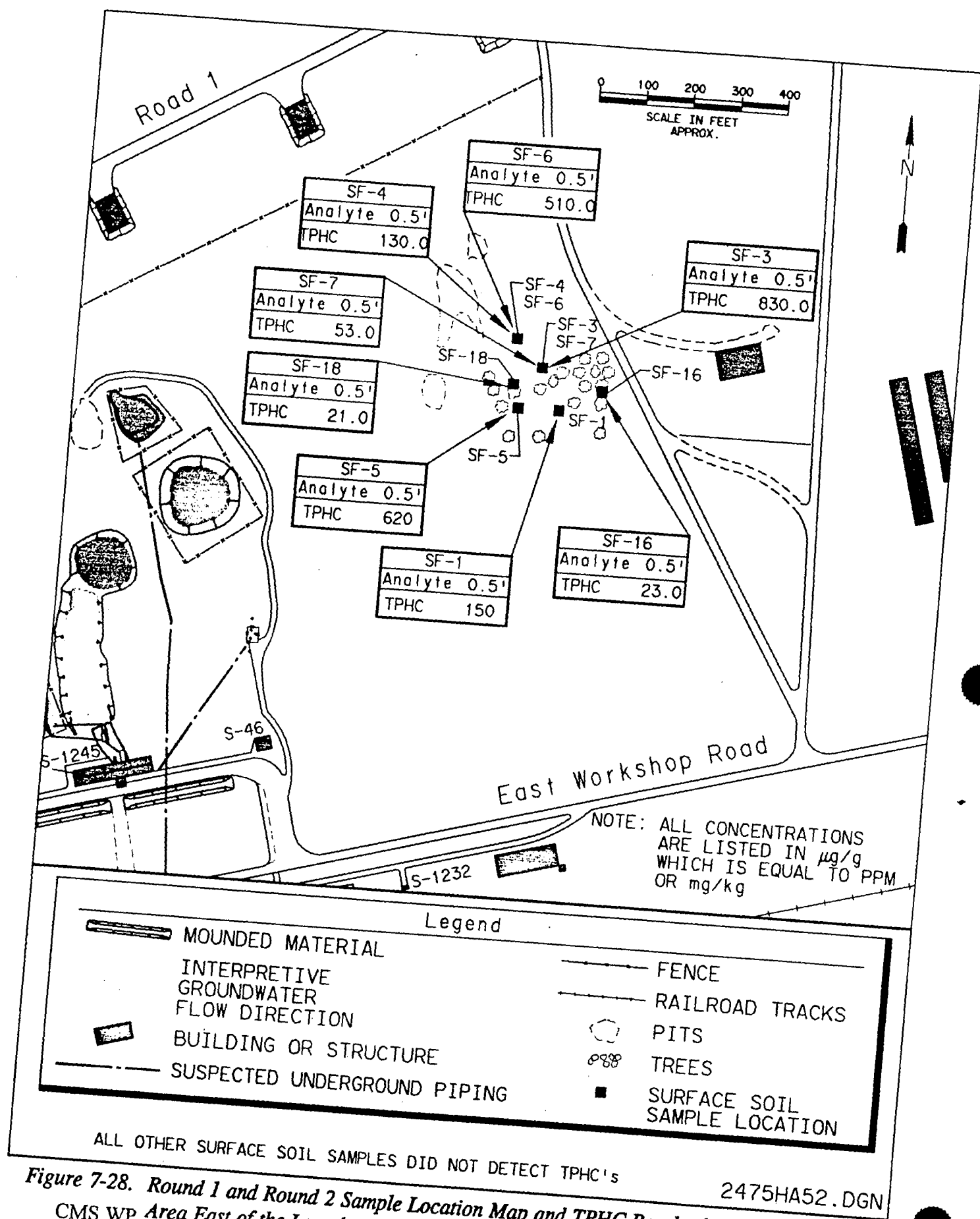


Figure 7-28. Round 1 and Round 2 Sample Location Map and TPHC Results for the Waste Pile
 CMS WP Area East of the Laundry Effluent Pond
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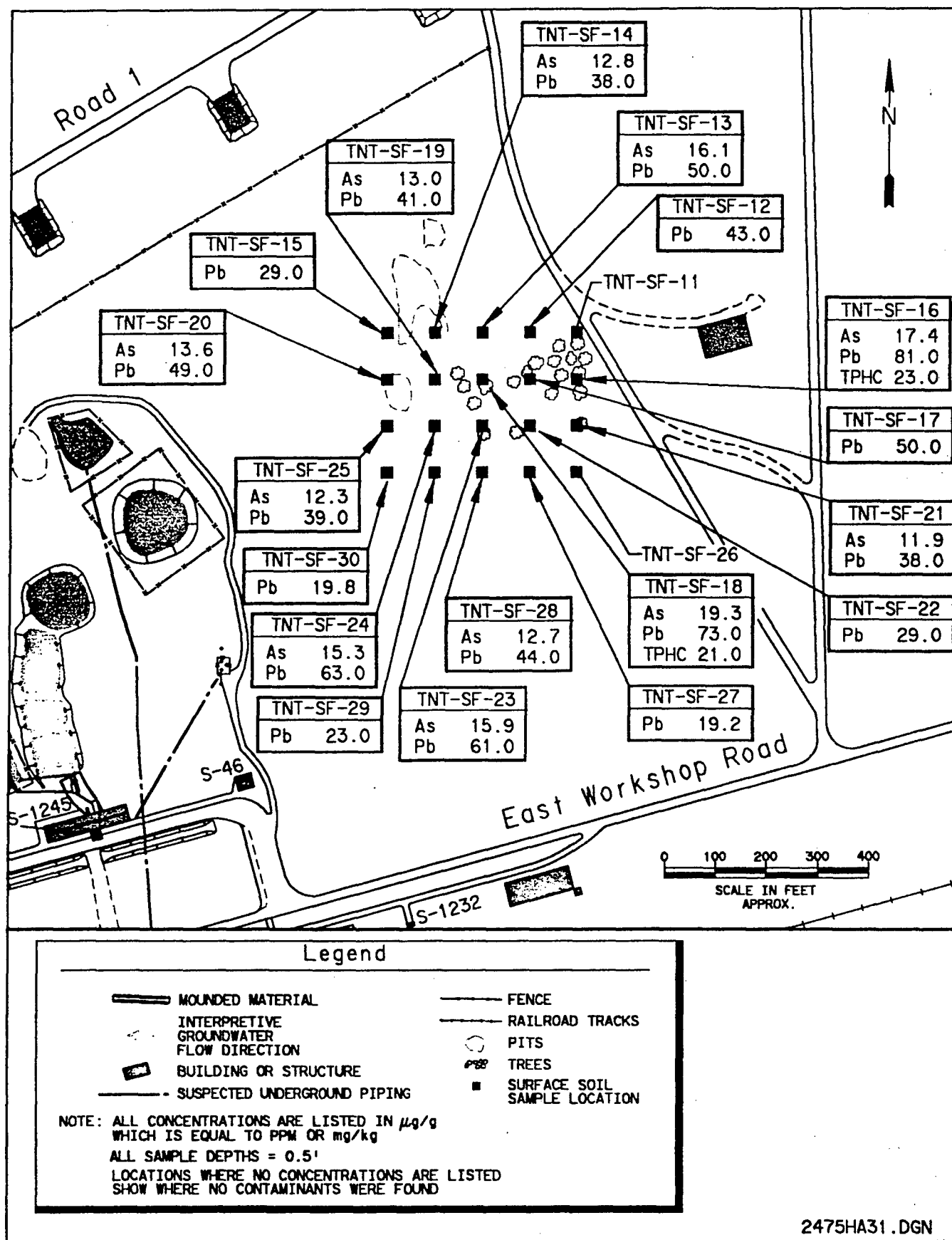


Figure 7-29. Round 2 Surface Sample Location Map and Results for the Waste Pile Area East of the Laundry Effluent Pond

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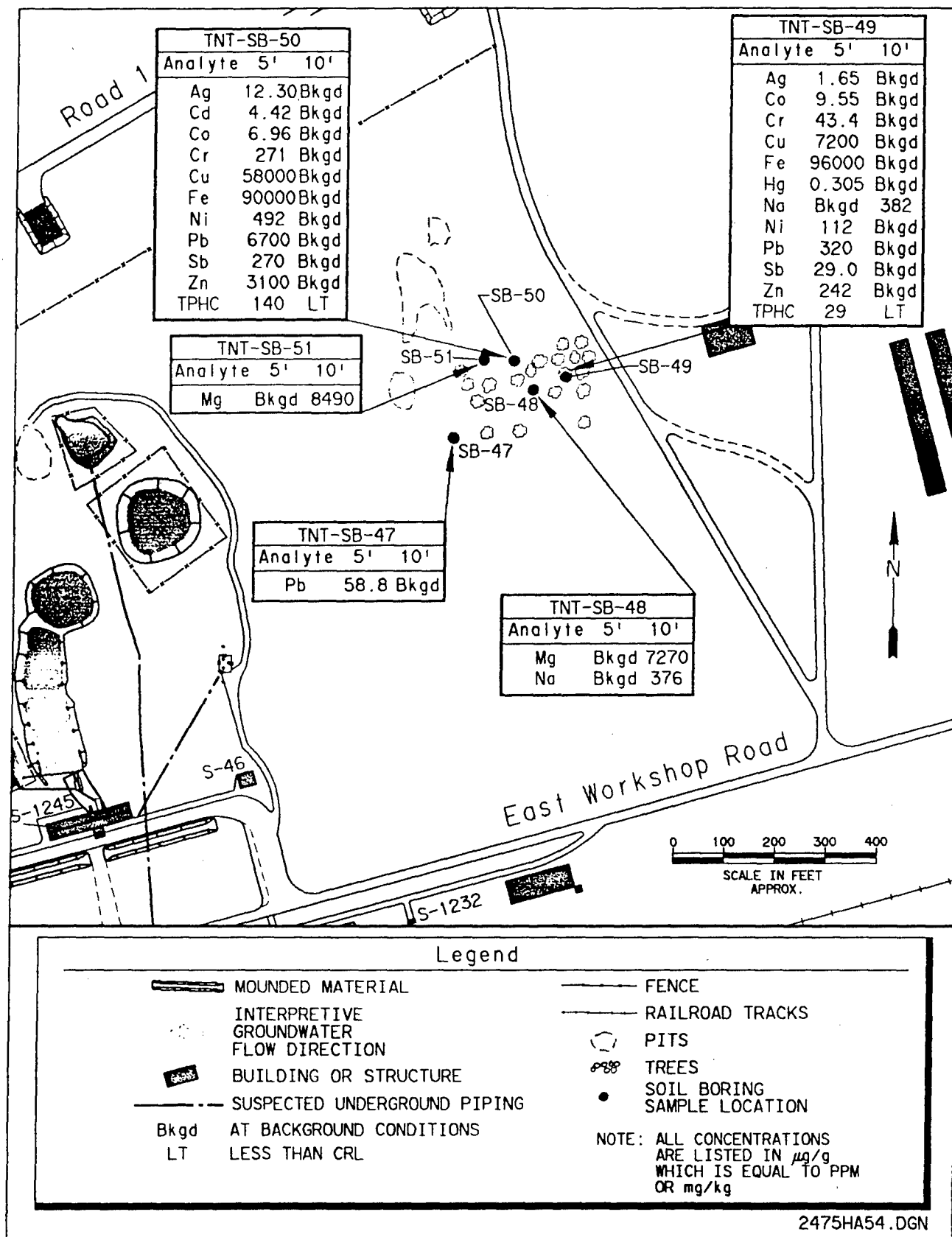


Figure 7-30. Soil Boring Subsurface Soil Sample Locations and Results for the Waste Pile Area East of the Laundry Effluent Pond

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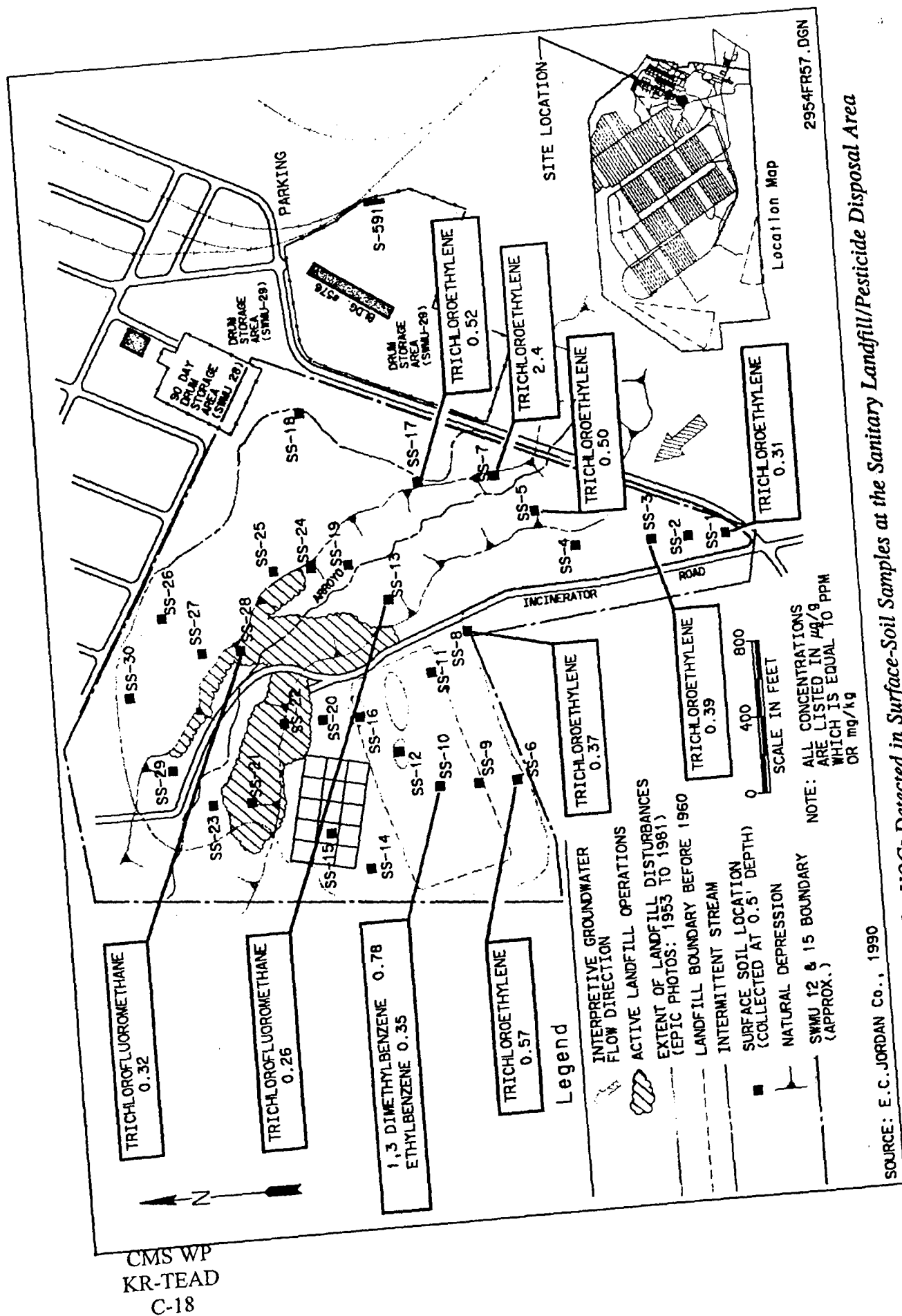
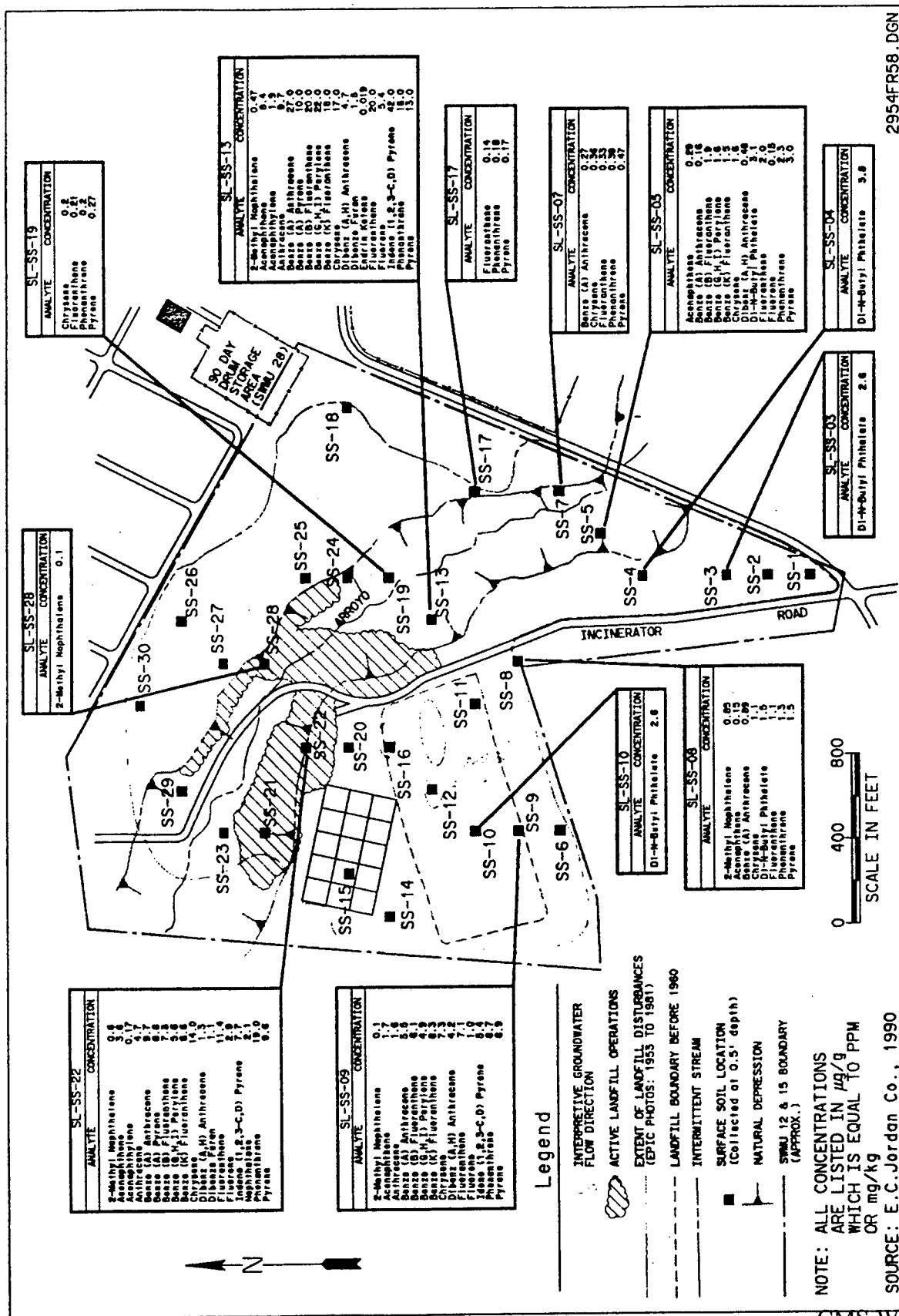


Figure 8-9. VOCs Detected in Surface-Soil Samples at the Sanitary Landfill/Pesticide Disposal Area

SOURCE: E.C. JORDAN Co., 1990



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Figure 8-10. SVOCs Detected in Surface-Soil Samples at the Sanitary Landfill/Pesticide Disposal Area

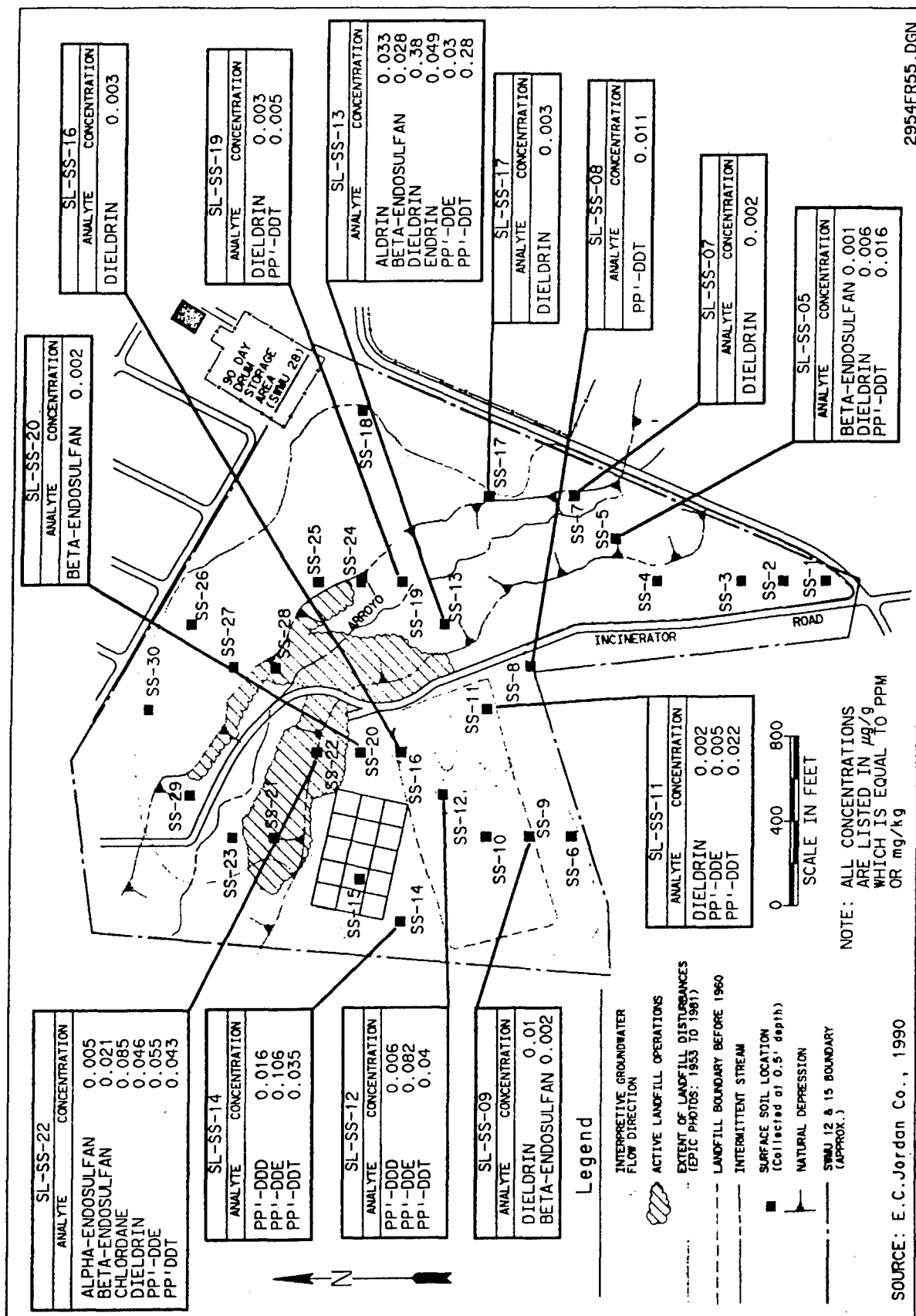
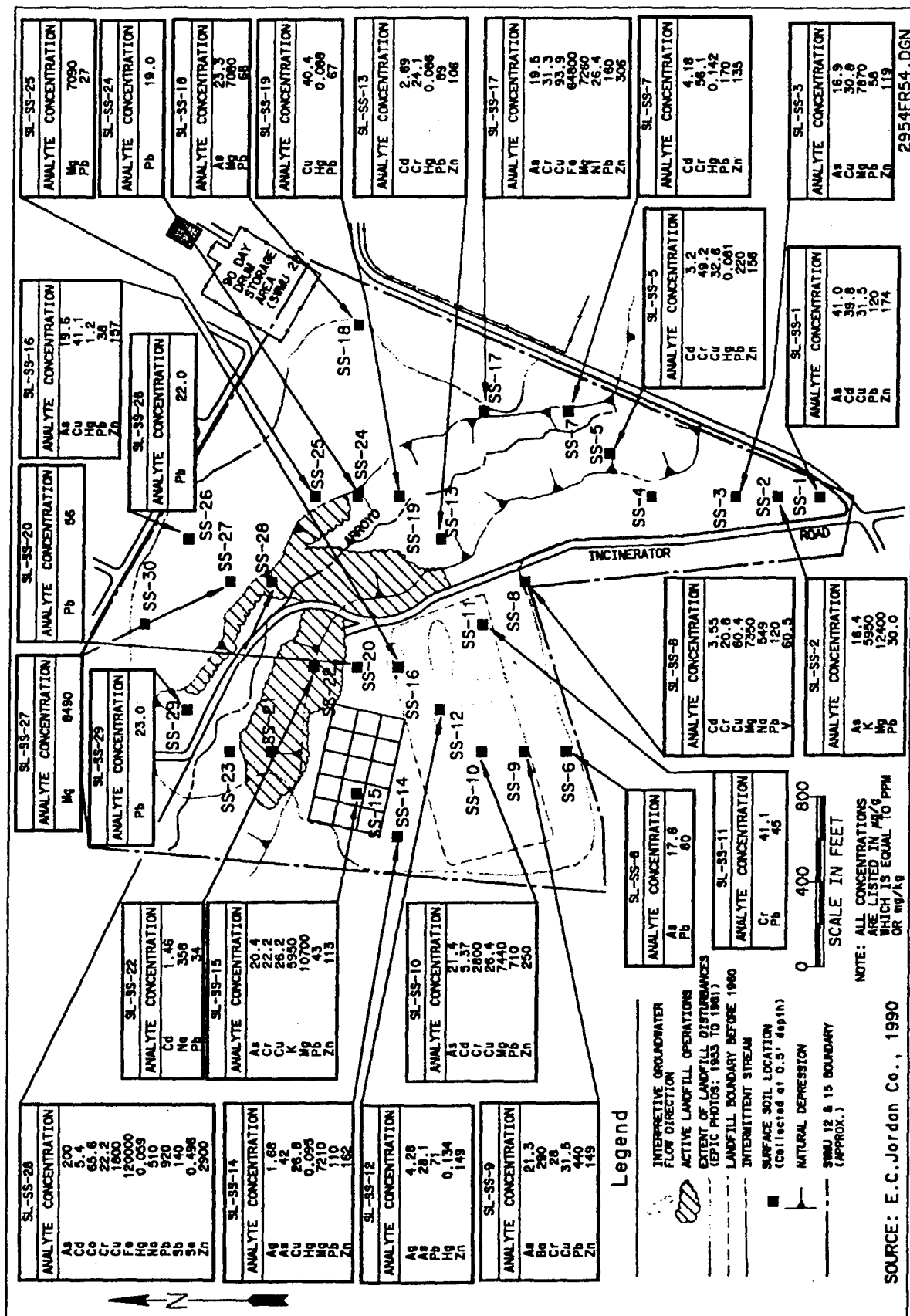


Figure 8-11. Pesticides Detected in Surface-Soil Samples at the Sanitary Landfill/Pesticide Disposal Area



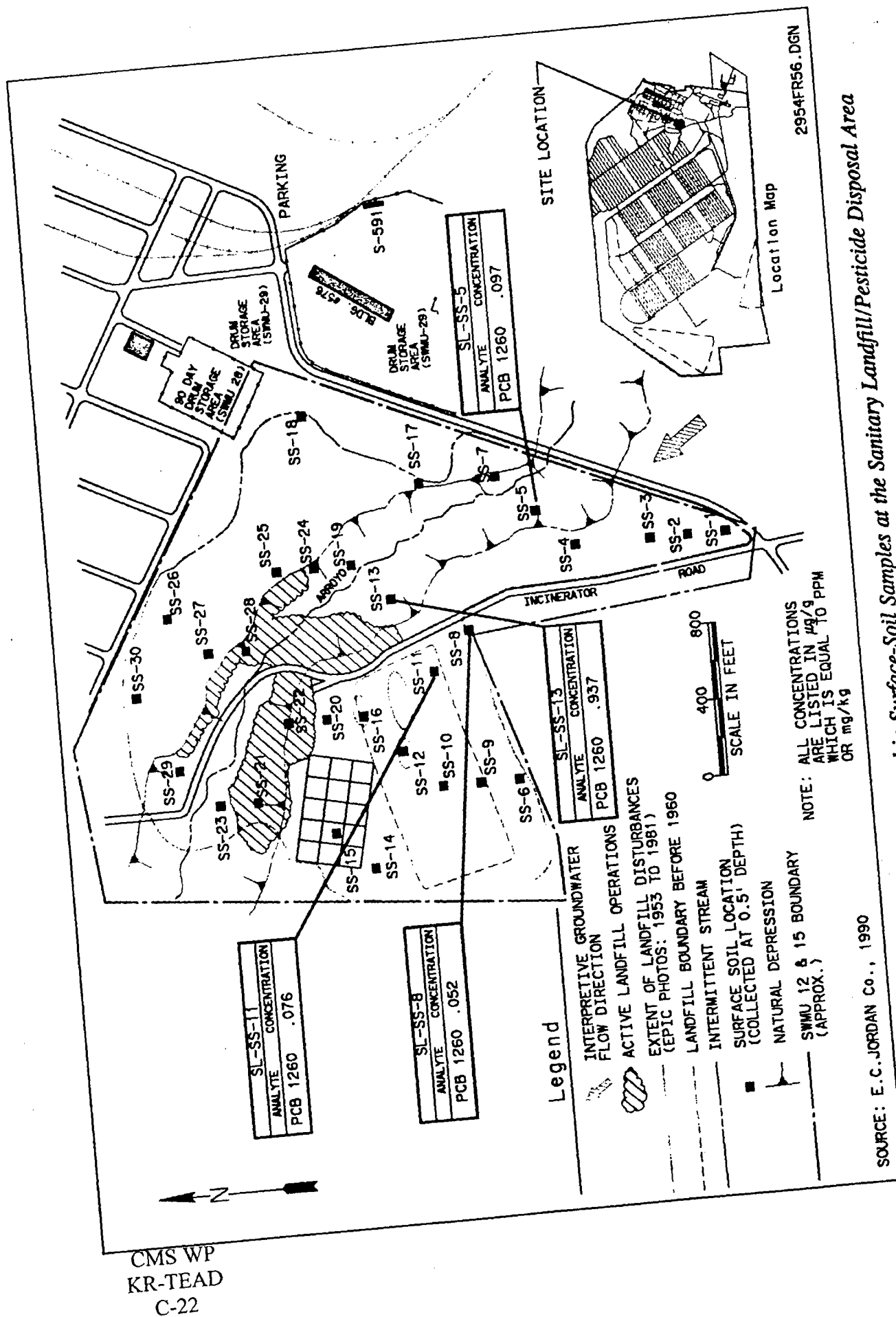


Figure 8-13. PCBs Detected in Surface-Soil Samples at the Sanitary Landfill/Pesticide Disposal Area

SOURCE: E.C. JORDAN Co., 1990

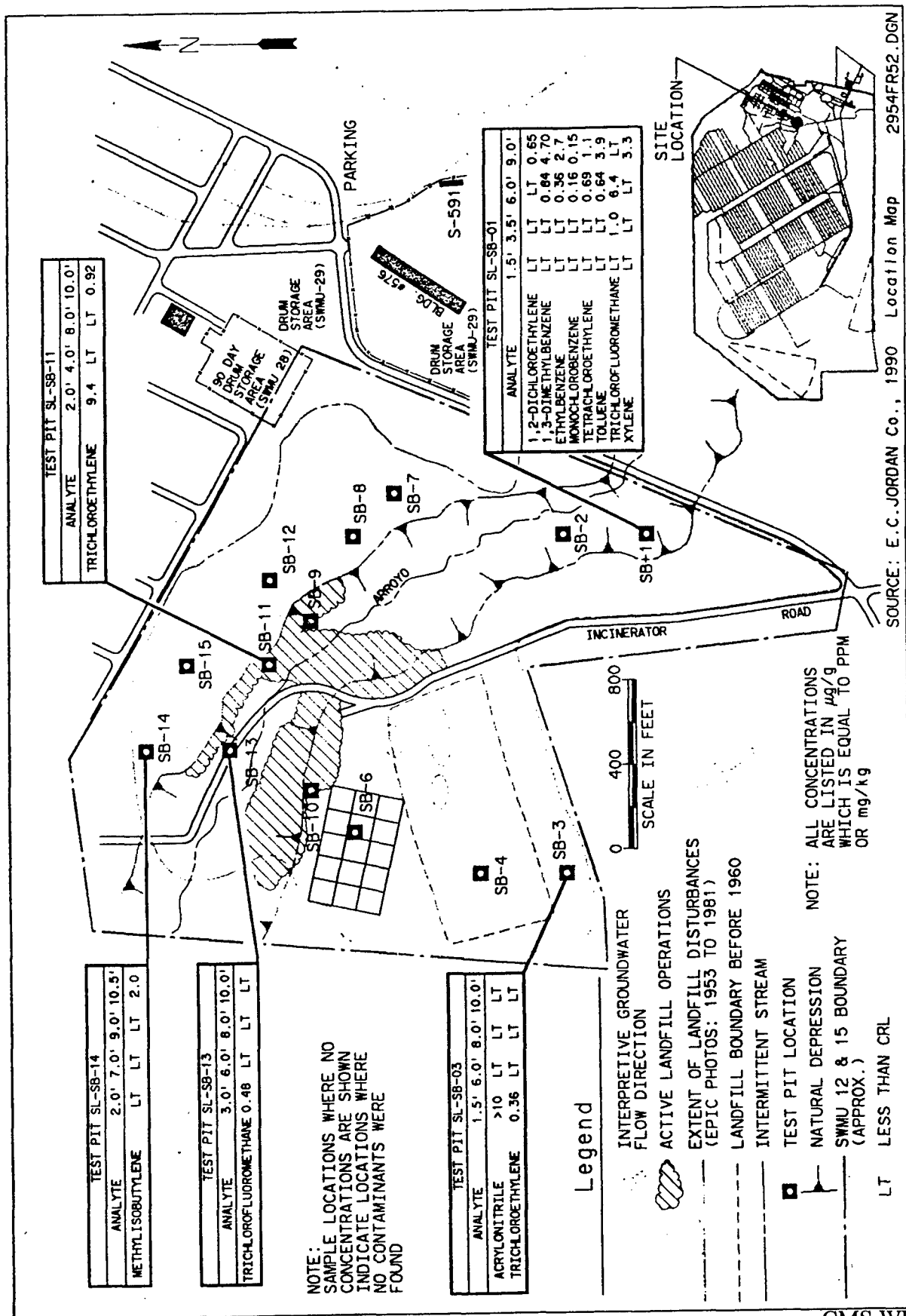


Figure 8-14. VOCs Detected in Test Pits at the Sanitary Landfill/Pesticide Disposal Area

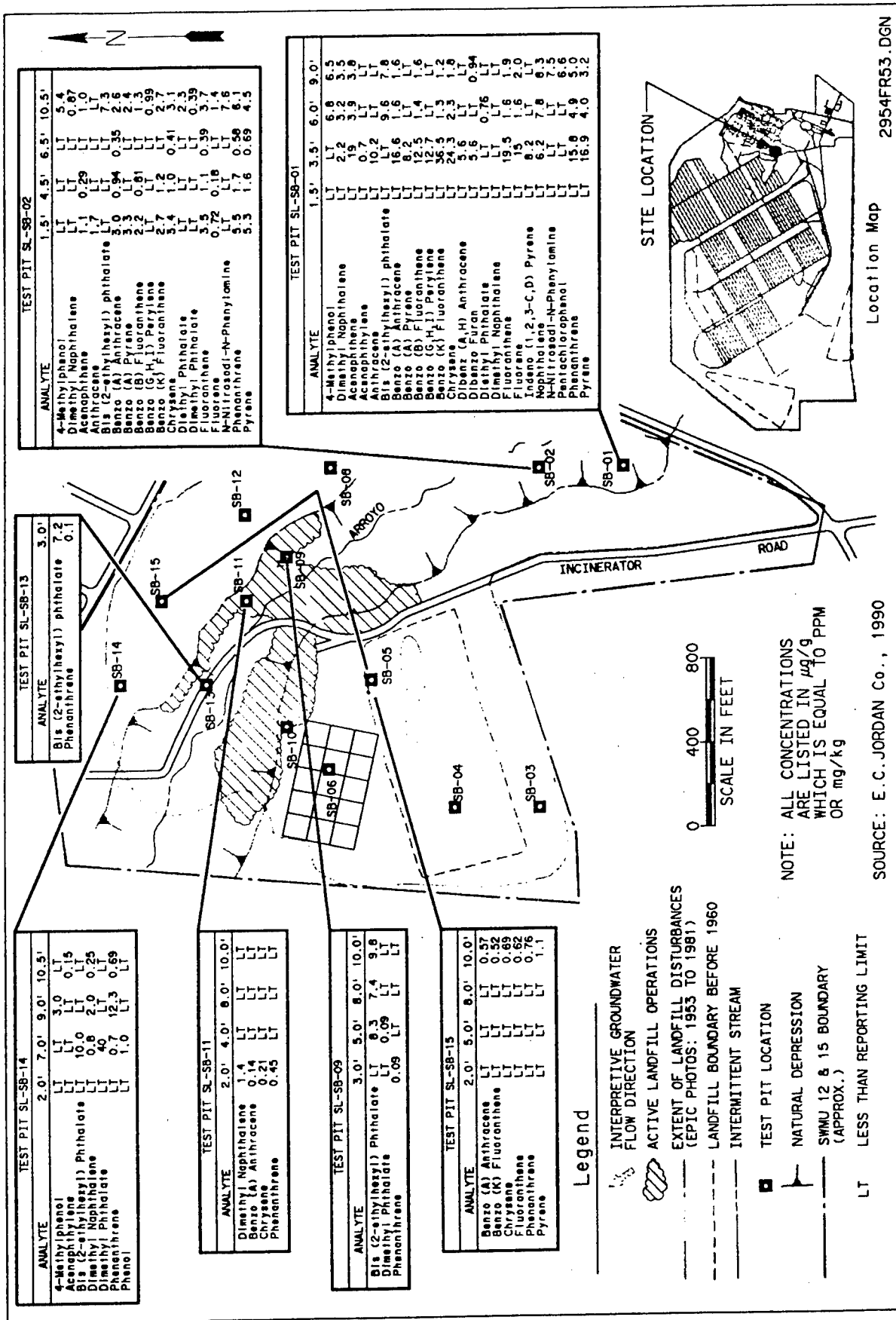


Figure 8-15. Semi-VOCs Detected in Test Pits at the Sanitary Landfill/Pesticide Disposal Area

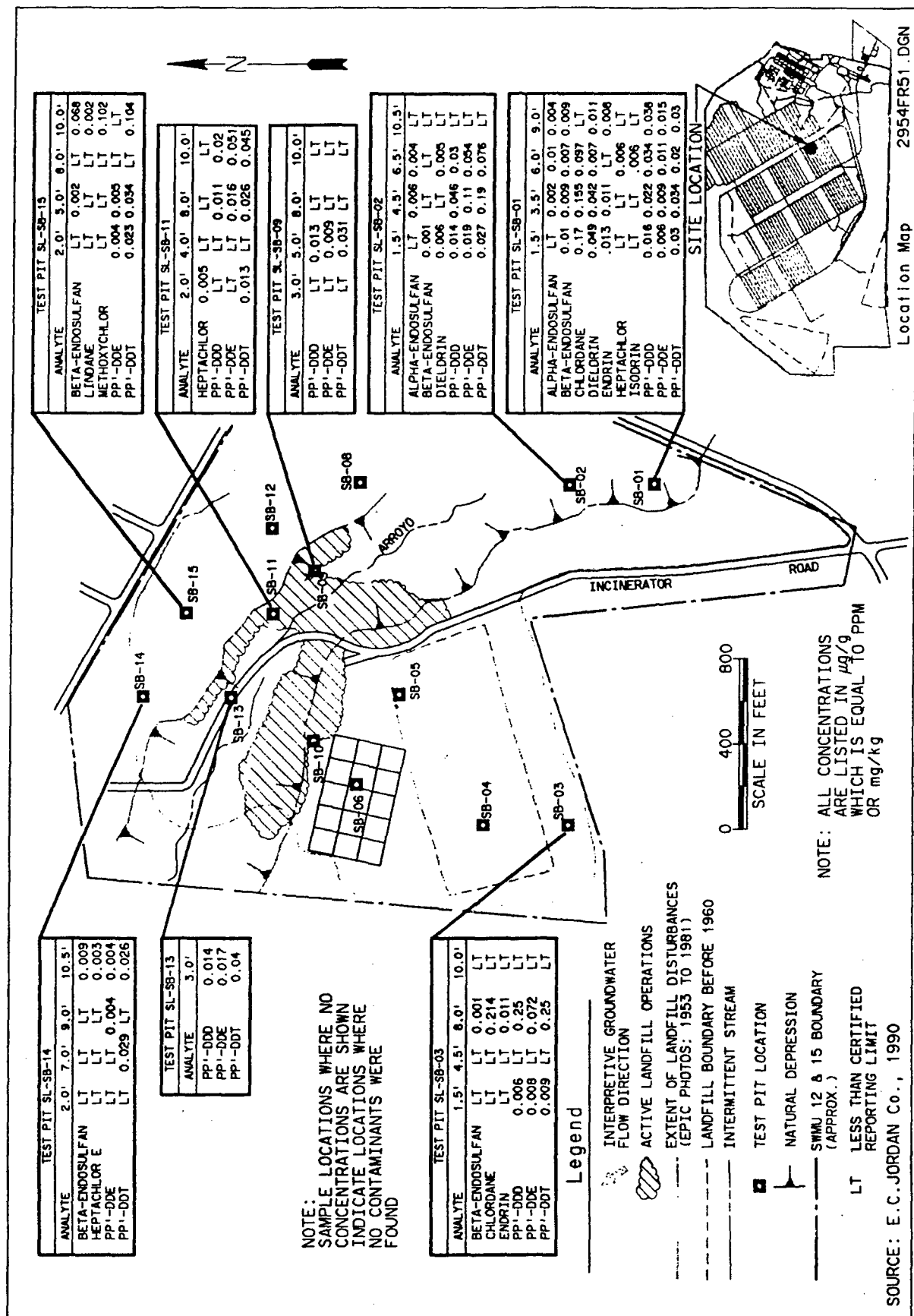


Figure 8-16. Pesticides Detected in Test Pits at the Sanitary Landfill/Pesticide Disposal Area

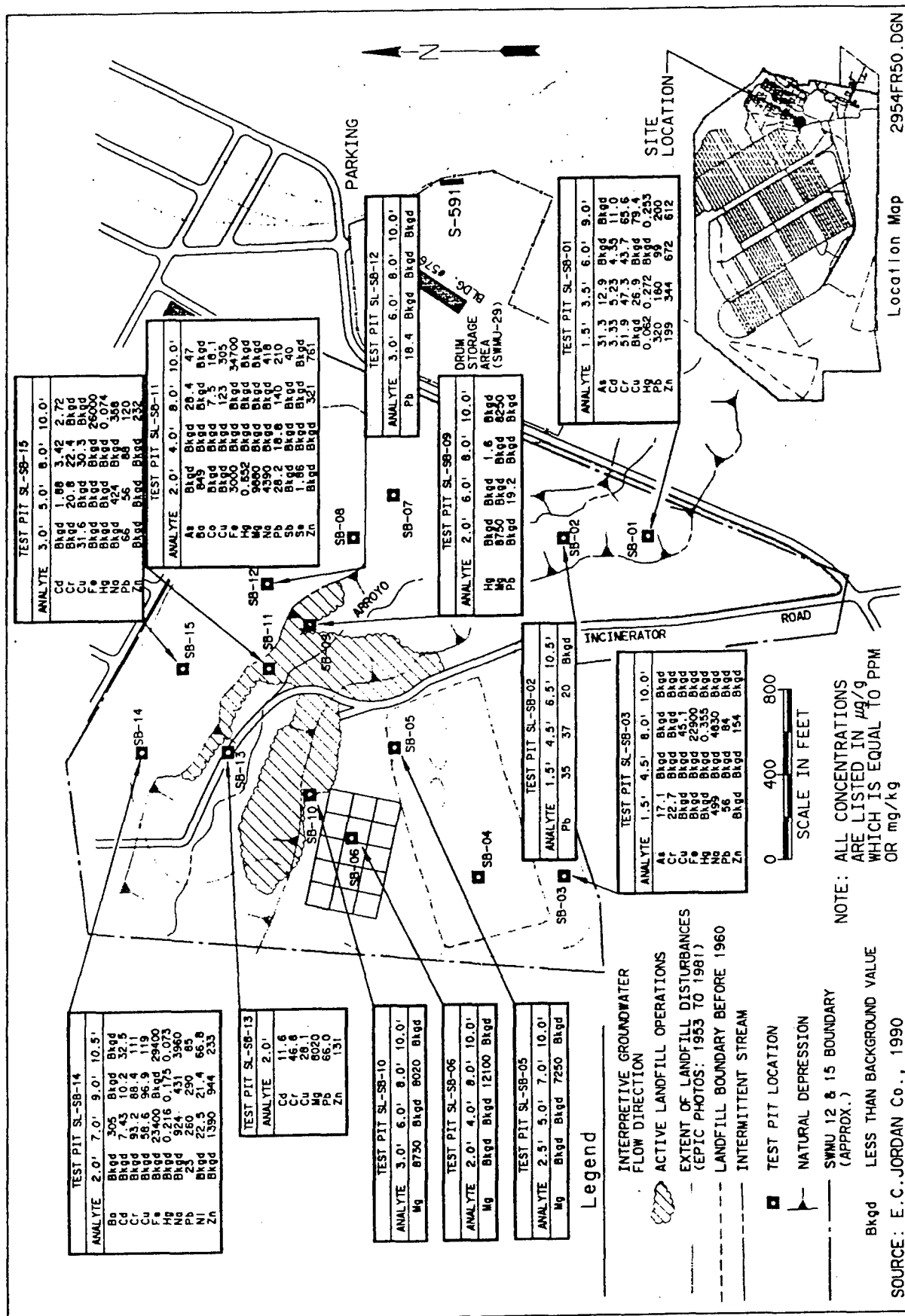
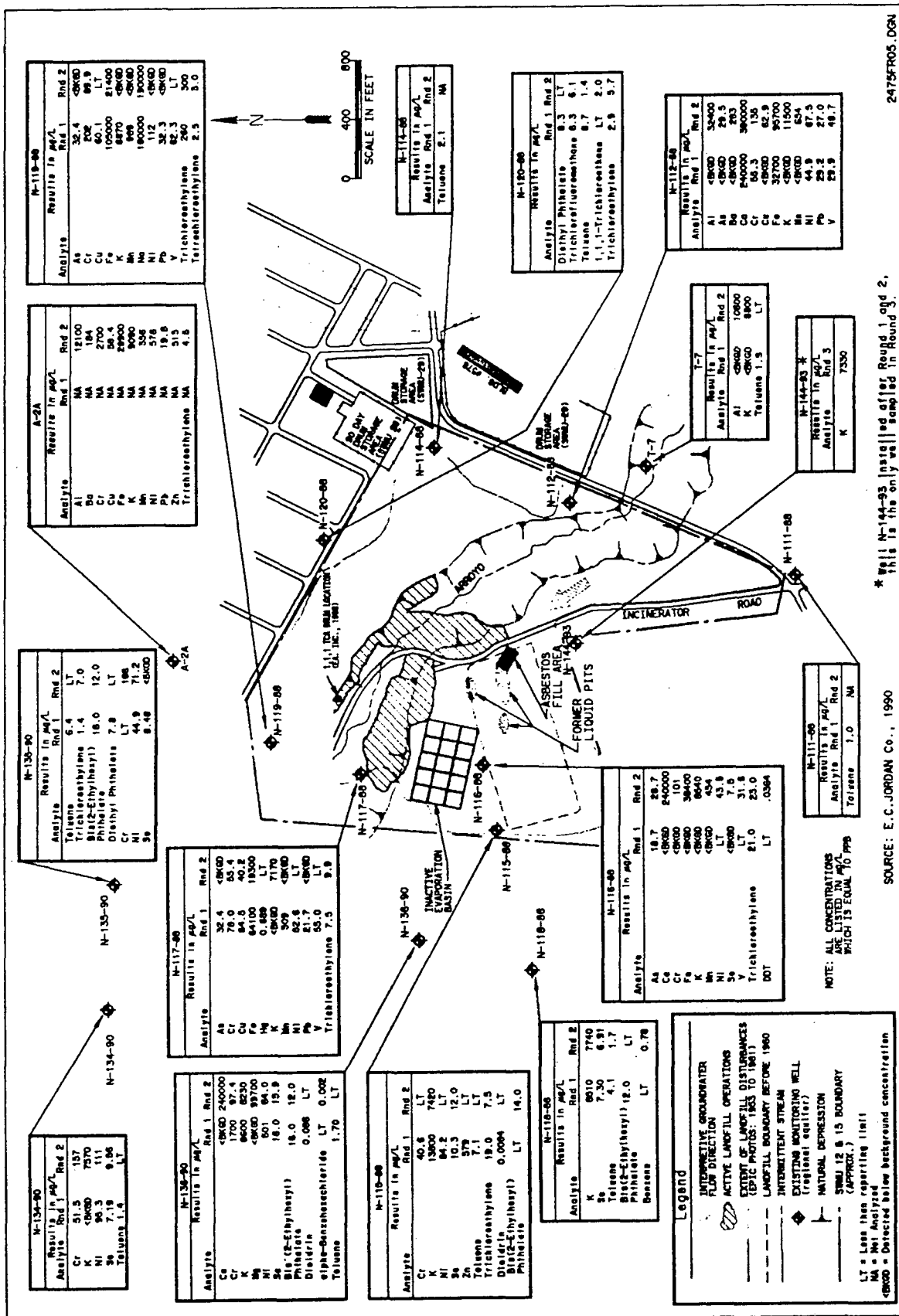


Figure 8-17. Metals Exceeding Background Concentrations in Test Pits at the Sanitary Landfill/Pesticide Disposal Area



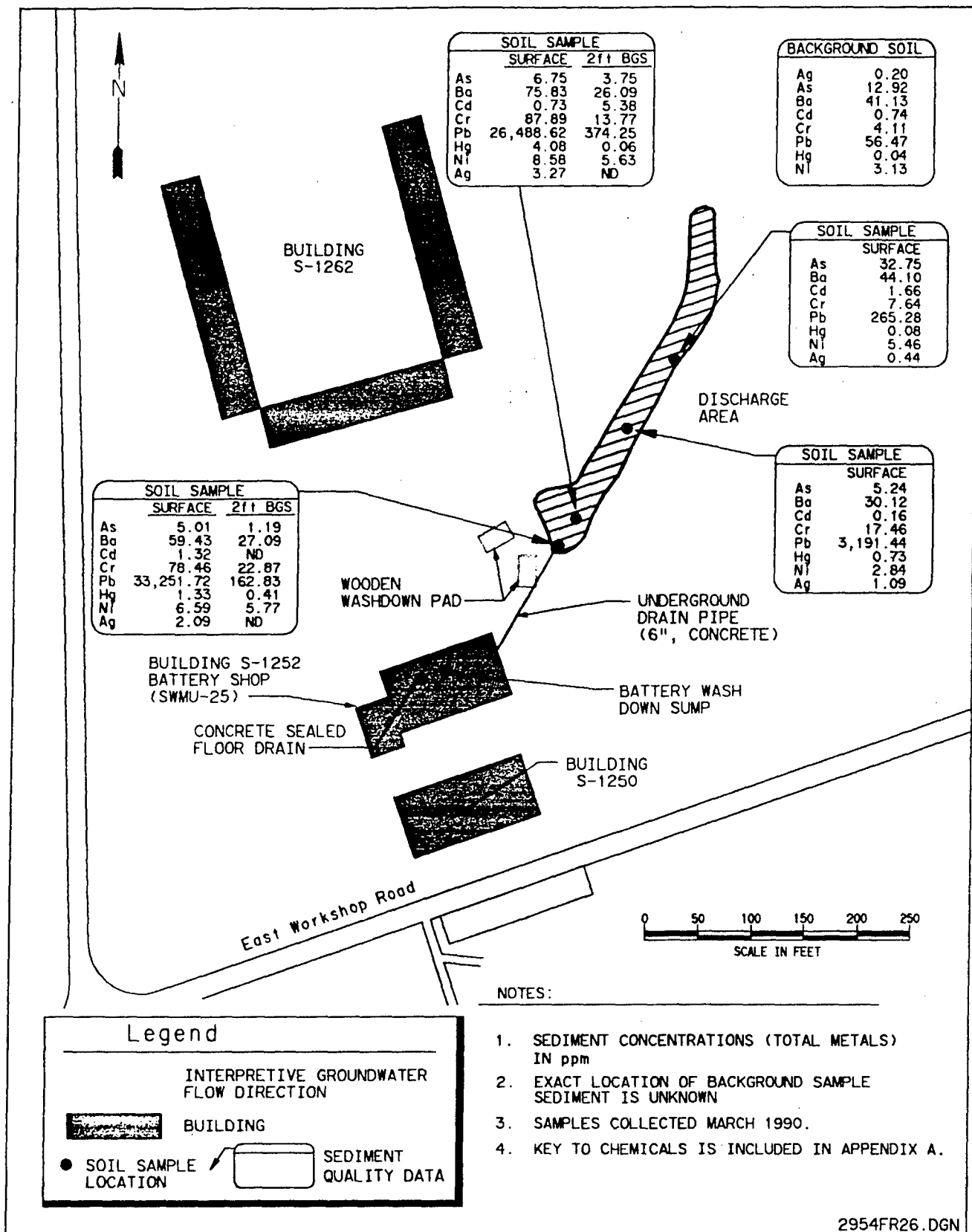


Figure 10-2. Location Map of Previous Investigation Results for the Battery Shop (SWMU 25)
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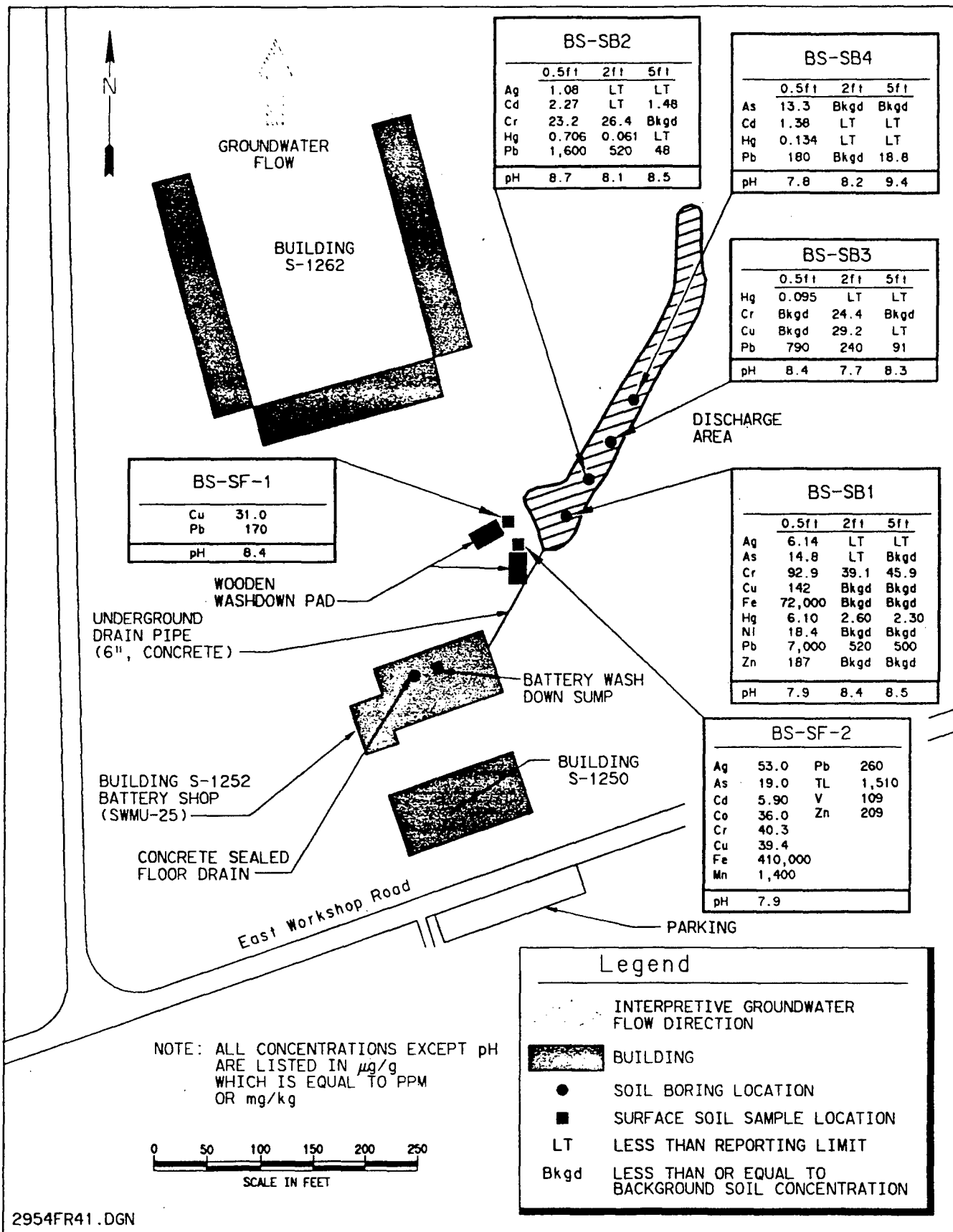


Figure 10-3. Round 1 Sample Location Map and Results for the Battery Shop (SWMU 25)
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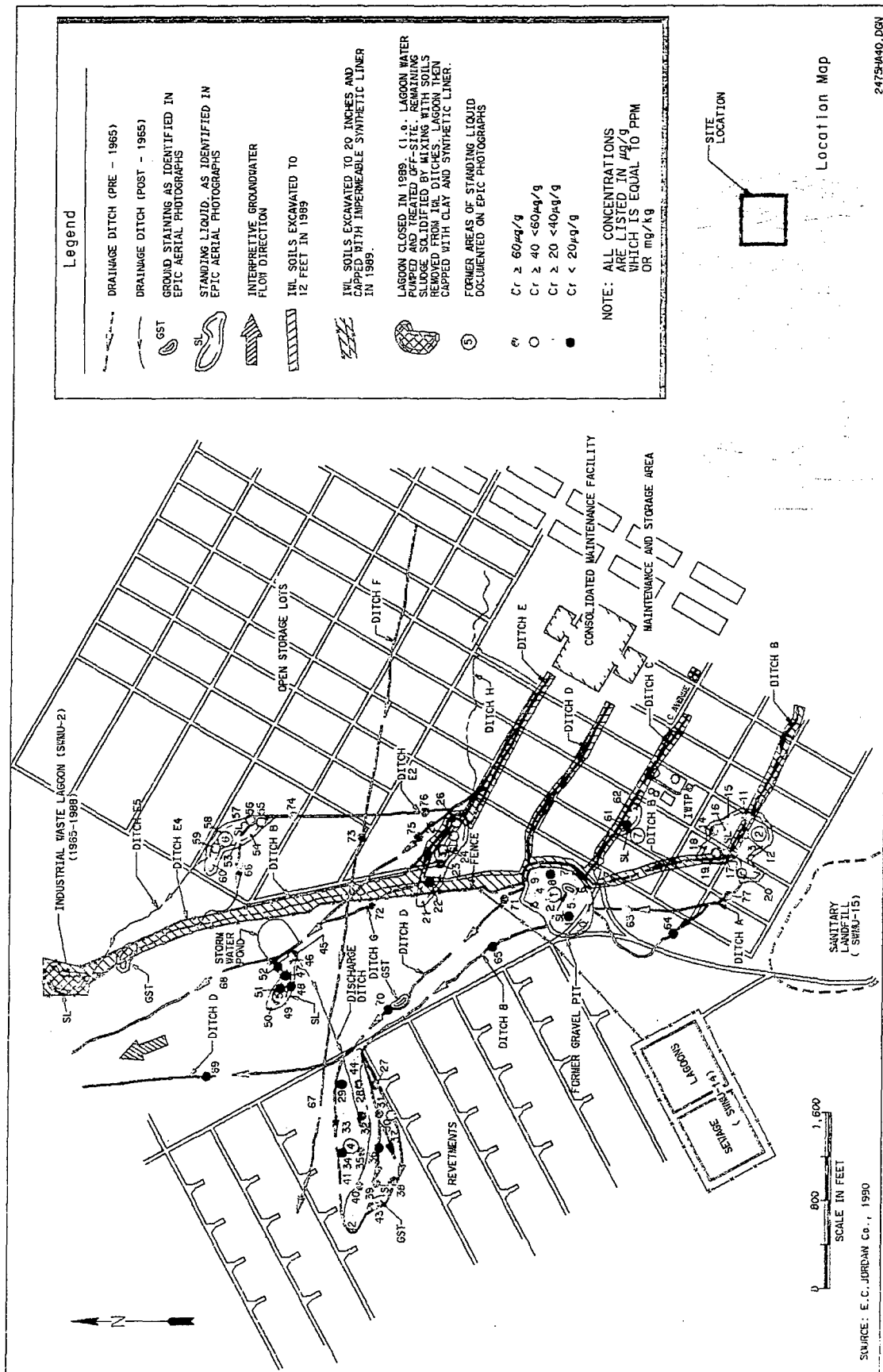
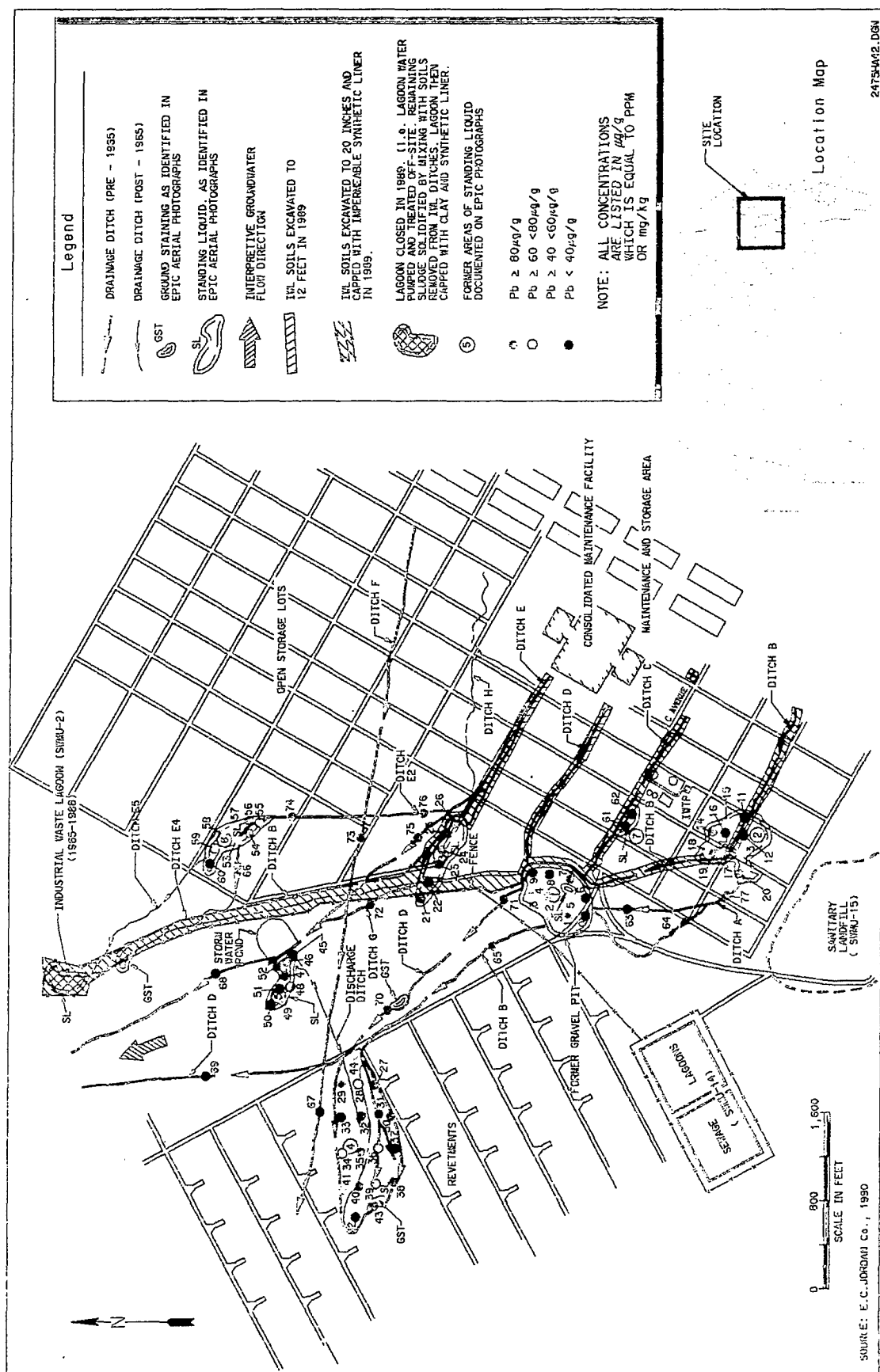


Figure 11-5. Map Showing Distribution of Chromium in Surface Soils at the OIWL (SWMU 30)



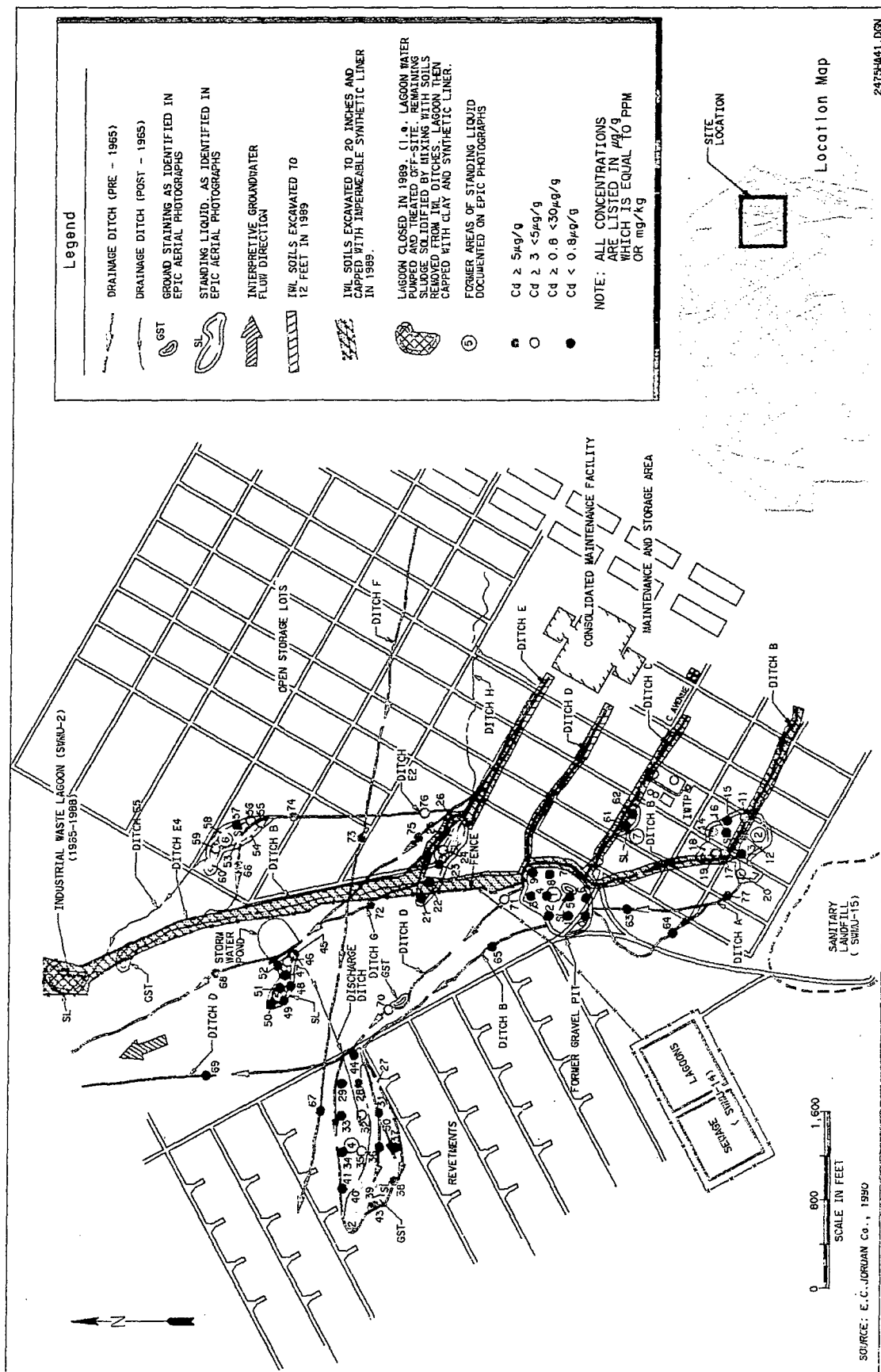


Figure 11-6. Map Showing Distribution of Cadmium in Surface Soils at the OIWL (SWMU 30)

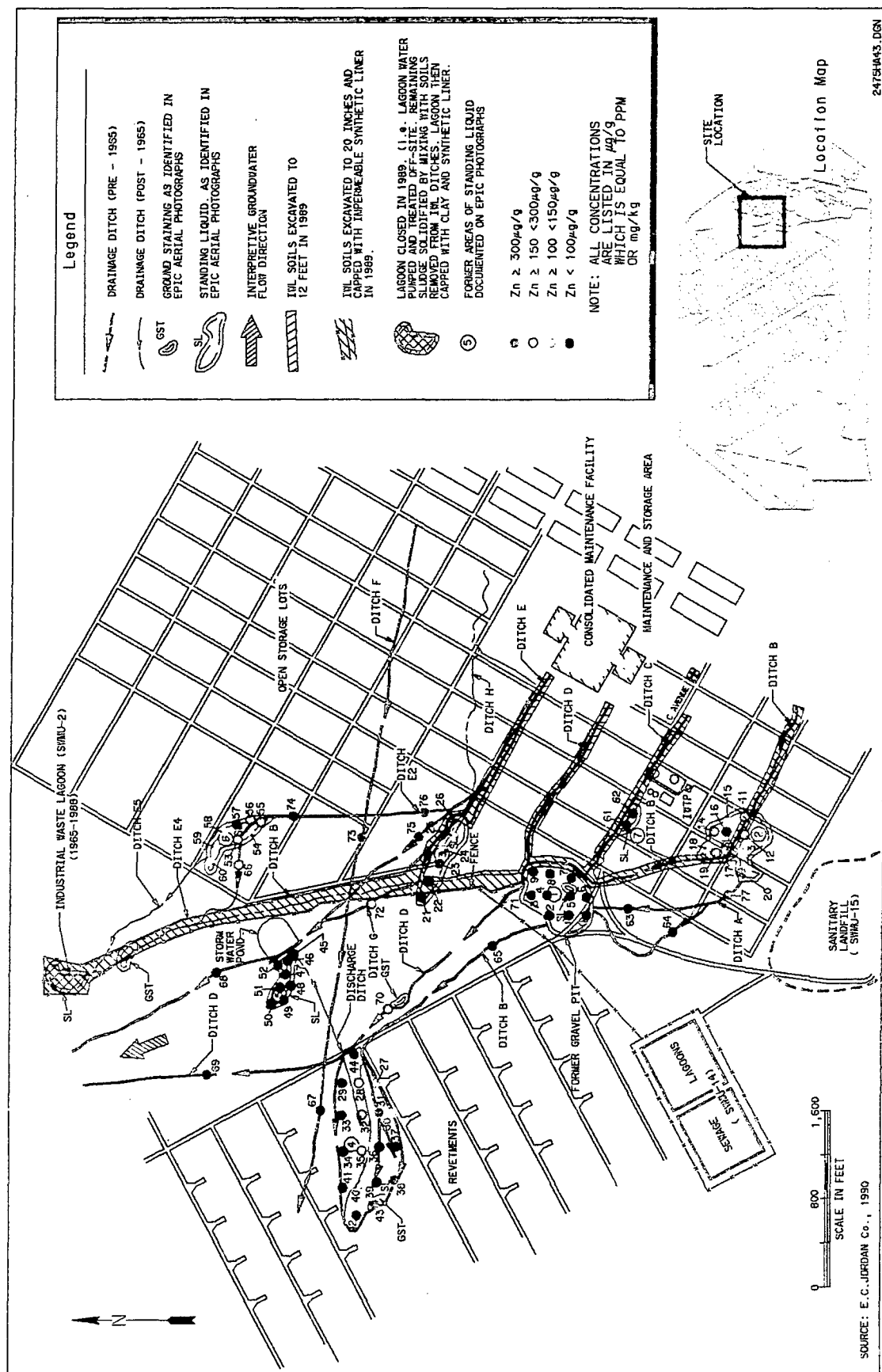


Figure 11-8. Map Showing Distribution of Zinc in Surface Soils at the OIWL (SWMU 30)

APPENDIX D

Procedure for Evaluating Ecological Risks

PROCEDURE FOR EVALUATING ECOLOGICAL RISKS

D.1 INTRODUCTION

The purpose of this appendix is to outline the approach to be used in the evaluation of residual ecological risk under post-corrective measures conditions. The Site-Wide Ecological Risk Assessment (SWERA; Rust E&I, 1997) performed at the Tooele Army Depot (TEAD) characterized each Known Releases solid waste management unit (SWMU) as posing low, moderate, or potentially unacceptable ecological risk. For those SWMUs characterized as posing potentially unacceptable ecological risk, the SWERA recommended consideration of ecological risk reduction as part of corrective measures to be implemented based on human health concerns. The potential for unacceptable ecological risk was identified at Known Releases SWMUs 10, 11, 12/15, and 25. The SWERA does not recommend the consideration of active corrective measures at SWMU 3.

D.2 METHODOLOGY

D.2.1 ECOLOGICAL RISK ESTIMATES

The SWERA used both a "historic" and a "current" dataset in the evaluation of ecological risk. The historic dataset consists of data obtained through the Installation Restoration Data Management Information System (IRDMIS) database for 1994 to 1995. Because additional sampling has occurred since 1995 for some SWMUs, there may be differences between the data currently available for each SWMU and the historic data used in the SWERA. The current dataset consists of data collected by Rust E&I for biotic and abiotic media at the reference study area (RSA; i.e., the background site) and at SWMUs 10, 11, 12/15, and 25. Additional data were also collected at other groups of SWMUs at TEAD. Potential ecological risks were calculated using the historic or current datasets for each SWMU, depending on data availability.

Because the two datasets contain different types and amounts of data, the SWERA estimated ecological risks from each set of data using different methodologies. For the historic dataset, ecological risks to various receptors were calculated based on the soil consumption route of exposure only. For the current dataset, ecological risks to various receptors were calculated using a dynamic food chain model. Risk estimates based on the current dataset include both soil and prey consumption routes of exposure. For those SWMUs for which both historic and current data are available, two separate estimates of ecological risk were generated, and the higher risk level was used to characterize the risk identified at the SWMU.

D.2.2 ECOLOGICAL RISK EVALUATION STRATEGY

The SWERA states that, for the SWMUs identified as posing potentially unacceptable ecological risk, the risks must be considered in evaluating the corrective measures identified for the SWMU to reduce human health risk. Therefore, in selecting a corrective measure, post-corrective measure residual risks will be evaluated as part of the CMS Report using the methodology described in the SWERA to quantify ecological risk. In general, this evaluation will involve the following steps:

- Identify all data used in the SWERA for each SWMU and identify the risk drivers (those contaminants of potential concern (COPCs) that contribute to the ecological risk) for each receptor.
- Identify the corrective measures to be considered at the SWMU.
- Spatially locate each sample on a map of the SWMU.
- Identify those samples that will be changed as a result of each corrective measure.
- Estimate post-corrective measure soil concentrations for each sample previously identified.
- Recalculate the SWMU soil concentration terms (C_{term}) for the risk drivers using methods identified in the SWERA.
- Recalculate the hazard quotients (HQs) and hazard indices (HIs) for each receptor of concern at the SWMU using the procedures identified in the SWERA. Compare the recalculated SWMU risk estimate to the RSA risk, and calculate the percent risk reduction associated with each corrective measure evaluated.

The method used to calculate ecological risk from soil concentration (C_{term}) is dependent on the source of the data used (historic or current) to characterize the SWMU. For those sites in which the risk characterization is based on the historic data set, the HQ is calculated as:

$$HQ = \frac{C_{term} * SIR * AUF}{TBV} \quad (\text{Eq D-1})$$

where:

C_{term} = recalculated soil concentration term
 SIR = soil ingestion rate for the receptor of concern
 AUF = area use factor for the receptor of concern

TBV = toxicity benchmark value for the receptor of concern.

The *SIR*, *AUF*, and *TBV* values are defined in the SWERA and will be used in the CMS Report without modification. The HI is calculated as the sum of all of the HQ values calculated for a specific SWMU.

For those sites in which the risk characterization is based on the current data set, the HQ is calculated as:

$$HQ = \frac{\text{exposure intake}}{TBV} \quad (\text{Eq D-2})$$

where:

exposure intake = dose to the receptor through several different media and pathways of exposure (estimated by use of a model).

For each corrective measure, the resulting post-corrective measure HI, the multiple in excess of the ecological risk estimated at the RSA, and the percent of the reduction in ecological risk will be calculated.