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THE MEMPHIS DEPOT
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ADMINISTRATIVE RECORD
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FINAL

Memphis Depot

Main Installation
Remedial Investigation Report

Volume II

(Sections 16 – 36)

January 2000

CH2MHILL

U.S. Army Engineering
and Support Center, Huntsville

U.S. Army Engineering and Support Center, Huntsville
Contract No. DACA87-94-D-0009
Delivery Order No. 11

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Memphis Depot

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Prepared for
Defense Logistics Agency

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Acronyms

ABS	Absorption factors
AEHA	U.S. Army Environmental Hygiene Agency (formerly known as USAEHA, currently known as USACHPPM)
AIC	U.S. Agency Information Consultants
AOC	Area of concern
ARAR	Applicable or relevant and appropriate requirement
AST	Aboveground storage tank
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	Ambient water quality criteria
AWQC-AO	Ambient water quality criteria-protection of freshwater aquatic life
AWQC-HH	Ambient water quality criteria-protection of human health
BaP	Benzo(a)pyrene
BAT	Best available technology
BCF	Bioconcentration factor
BCP	BRAC Cleanup Plan
BCT	BRAC Cleanup Team
BEHP	bis(2-ethylhexyl)phthalate
beta-BHC	beta-hexachlorocyclohexane
bgs	Below ground surface
BHC	beta-benzene hexachloride
bls	Below land surface
BNA	Base/neutral acid
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethyl benzene, and xylene
BX	Base exchange
CAA	Clean Air Act
CCl_4	Carbon tetrachloride
CDD	Chlorinated dibenzo-p-dioxin
CDF	Chlorinated dibenzofurans
CDI	Cumulative daily intake
CEC	Cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CESAM	U.S. Corps of Engineers, Mobile District
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
cm^2	Square centimeters
cm/sec	Centimeters per second
CO_2	Carbon dioxide
COC	Constituent of concern
COE	U.S. Army Corps of Engineers

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COPC	Constituent of potential concern
CRDL	Contract-required detection limit
CRQL	Contract-required quantitation limit
CSF	Cancer slope factor
CSM	Conceptual site model
CVOC	Chlorinated volatile organic contaminant
CWA	Chemical warfare agents
°C	Degrees Celsius
DCBM	Dibromochloromethane
DCE	Dichloroethene
DDC	Defense Distribution Center
DDD	Dichlorodiphenyldichloroethane
DDE	1,1,1-Dichloro-2,2-bis(4-chlorophenyl)ethylene
DDMT	Defense Depot Memphis, Tennessee
DDT	Dichlorodiphenyltrichloroethane
DLA	Defense Logistics Agency
DNAPL	Dense nonaqueous phase liquid
2,4-D	2,4-Dichlorophenoxyacetic acid
DNBP	Di-n-butylphthalate
DO	Dissolved oxygen
DOD	U.S. Department of Defense
DOI	U.S. Department of Interior
DQE	Data quality evaluation
DQO	Data quality objective
DR	Data report
DRMO	Defense Reutilization and Marketing Office
ECAO	Environmental Criteria and Assessments Office
ECBSOPQAM	Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual
ED	Exposure duration
EE/CA	Engineering Evaluation/Cost Analysis
EF	Exposure frequency
EISOPQAM	Environmental Investigations Standard Operating Procedures and Quality Assurance Manual
ELCR	Excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ER	Environmental restoration
ERA	Ecological risk assessment
ERL	Effects range low
ERM	Effects range medium
ESE	Environmental Science & Engineering, Inc.
ET	Exposure time
FDA	U.S. Food and Drug Administration
FFA	Federal Facilities Agreement
FI	Fraction ingested
FLB	Fixed-based laboratory

FOD	Frequency of detection
FOSL	Finding of suitability to lease
FR	*Federal Register*
FRL	Final remediation level
FSP	Field Sampling Plan
ft	Feet
ft^2	Square feet
FU	Functional unit
GC	Gas chromatographic
GW	Groundwater
GWP	Groundwater protection
HASP	Health and Safety Plan
HCl	Hydrochloric acid
HEAST	Health Effects Assessment Summary Tables
HI	Hazard index
HOC	Halogenated organic compound
HPCDF	Heptachlorinated dibenzofuran
HQ	Hazard quotient
HRS	Hazard Ranking System
IA	Installation assessment
ID	Inside diameter
IDL	Instrument detection limit
IEPA	Illinois Environmental Protection Agency
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
Kd	Soluble fraction
K_d	Distribution coefficient
K_{oc}	Organic carbon water partition coefficient
K_{ow}	Octonal water partitioning coefficient
LCS	Laboratory control standard
LDR	Land disposal restriction
LOAEL	Lowest observed adverse effects level
LOEL	Lowest observed effects level
$\mu g/kg$	Micrograms per kilogram
$\mu g/L$	Micrograms per liter
$\mu s/cm$	MicroSiemens per centimeter
m^3	Cubic meters
m^3/kg	Cubic meters per kilogram
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
MDL	Method detection limit
MEK	Methyl ethyl ketone(2-Butanone)
MF	Modification factor
mg/kg	Milligrams per kilogram
mg/kg/day	Milligrams per kilogram per day
mg/L	Milligrams per liter

mgd	Million gallons per day
MHSPE	Ministry of Housing, Spatial Planning, and Environment
MIBK	Methyl isobutyl ketone
mL/day	Milliliters per day
MLGW	Memphis Light, Gas, and Water
MOGAS	Motor vehicle gasoline
MS/MSD	Matrix spike/matrix spike duplicate
MSCHD	Memphis-Shelby County Health Department
msl	Mean sea level
MW	Monitoring well
NAAQS	National Ambient Air Quality Standards
NAPL	Nonaqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No further action
NGVD	National Geodetic Vertical Datum
NIOSH	National Institute for Occupational Safety and Health
NMSZ	New Mexico Seismic Zone
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No observed adverse effects level
NOEL	No observed effects level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTU	Nephelometric turbidity units
NWI	National Wetlands Inventory
OD	Outside diameter
OERR	Office of Enforcement and Remedial Response
OPD	Office of Planning and Development
OSDP	Off-site drainage pathways
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OU	Operable unit
OVA	Organic vapor analyzer
PA/SI	Preliminary assessment/site investigation
PAH	Polynuclear aromatic hydrocarbon
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PC	Permeability constants
PCA	Tetrachloroethane
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated bibenzo-p-dioxin
PCDF	Polychlorinated bibenzofuran
PCE	Tetrachloroethylene
PCP	Pentachlorophenol
PDO	Property Disposal Office
PEF	Particulate emission factor
PEL	Probable effects level

PID	Photoionization detector
POL	Petroleum, oils, and lubricants
POTW	Publicly owned treatment works
ppb	Parts per billion
ppm	Parts per million
PRE	Preliminary risk evaluation
PRG	Preliminary remediation goals
PSC	Potential source of contamination
PUF	Polyurethane foam
PVC	Polyvinyl chloride
QA/QC	Quality assurance/quality control
QAPP	Quality Assurance Project Plan
RA	Risk assessment
RAB	Restoration Advisory Board
RAGS	*Risk Assessment Guidance for Superfund*
RAL	Removal action level
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RF	Retardation factor
RFA	RCRA Facility Assessment
RfD	Reference dose
RFI	RCRA Facility Investigation
RGO	Remedial goal option
RI/FS	Remedial investigation/feasibility study
RIVM	Netherlands National Institute of Public Health and Environment
RL	Reporting limit
RME	Reasonable maximum exposure
ROD	Record of Decision
RPD	Relative percent difference
RPM	Remedial project manager
SARA	Superfund Amendments and Reauthorization Act
SD	Sediment
SDG	Sample delivery group
SDWA	Safe Drinking Water Act
SF	Slope factor
SMDP	Scientific management decision point
SMP	Site Management Plan
SMSA	Standard metropolitan statistical area
SOP	Standard operating procedure
SOW	Statement of Work
SQL	Sample quantitation limit
SS	Surface soil
SSL	Soil screening level
STB	Statigraphic test boring
SVOC	Semivolatile organic compound
SW	Surface water

SWDA	Solid Waste Disposal Act
SWMU	Solid waste management unit
TBC	To be considered
TBD	To be determined
1,1,1-TCA	1,1,1-Trichloroethane
TCA	Tetratcholorethane
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzofuran
TCE	Trichloroethene
TCL/TAL	Target compound list/target analyte list
TCLP	Toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDOH	Tennessee Department of Health
TDS	Total dissolved solids
TEC	Topographic Engineering Center
TEL	Threshold effects level
TEF	Toxicity equivalent factor
THI	Target hazard index
TM	Technical memorandum
TOC	Total organic carbon
TPC	Total petroleum hydrocarbon
TRL	Target risk level
TRV	Toxicity reference value
TRW	Technical Review Workgroup
TU	Tritium unit
UCL	Upper confidence limit
UF	Uncertainty factor
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAESCH	U.S. Army Engineering and Support Center, Huntsville
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency (now referred to as the U.S. Army Environmental Center [AEC])
USDA	U.S. Department of Agriculture
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground storage tank
VOC	Volatile organic compound
WoE	Weight of evidence
WQC	Water quality criteria
yd^3	Cubic yards
ZnO	Zinc oxide

TAB

Section 16

TAB

16. Nature and Extent of Contamination
at FU3

16.0 Nature and Extent of Contamination at FU3

This section addresses the nature and extent of contamination within FU3, the Southwest Open Area. The subsections below provide a description of how FU3 was defined, discuss the probable sources of contamination that exist within FU3, and identify the nature and extent of contamination at FU3 by identifying the distribution and location of widespread contaminants. There are no surface water bodies in this FU; the groundwater beneath FU3 is addressed in Section 32.0.

As described in the following subsections, FU3 contains CERCLA sites identified in the original RI activities prior to 1990, as well as screening sites and TEC sites identified by CH2M HILL. These sites were investigated as possible sources of contaminant releases to the environment. Sampling of areas not associated with a specific site occurred as part of the BRAC characterization program. This section discusses the nature and extent of contamination within the entire FU area by evaluating the combined CERCLA and BRAC data.

16.1 Functional Unit Background

16.1.1 FU3 Description

FU3 is the Southwest Open Area, consisting of BRAC Parcel Areas 23, 24, 25, 26, 27, 28, and 35 (see Figure 1-1). As discussed in Section 1.1, FU3 was established based on similar operational activities in the southwestern portion of the Main Installation, including sandblasting and painting operations, storage of flammables and solvents, and maintenance and hazardous material recovery activities.

16.1.2 FU3 History

Most of the land cover in FU3 consists of buildings surrounded by gravel and/or asphalt. Railroads used for the transport of warehoused materials also are adjacent to some of the buildings. The westernmost border of this FU is a grassy area currently separating the functional area of the Main Installation from Perry Road. FU3 was used mostly for hazardous material storage and recoupment, sandblasting and painting activities, and cleaning and maintenance. Figure 16-1 shows the building locations where these activities took place. The four large warehouses previously were used to store flammables, solvents, and waste oil (Building 972); chlorinated solvents, corrosives, petroleum, oil, and lubricants (POL) (Building 873); steel, rope, hardware, and hoses (Building 970); and other hazardous materials (Building 875) (BCP, 1998). Building 1087 is the former location of a spray paint booth used to conduct major stock primer and enamel spray paint operations. There were three open storage areas (X02, X03, and X04) located in this FU, as well.

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A contaminated soil drum storage/staging area (NFA Site 47) also was located in this FU. All NFA sites are presented in Section 1.6 of this document and are not discussed further herein.

16.2 Summary of Remedial Investigations at FU3

16.2.1 Historical Remedial Investigations

Initial sampling of surface soil at three RI sites occurred at FU3 as part of the 1990 RI conducted by Law Environmental (Law Environmental, 1990a). Four surface soil samples were collected at RI Site 27 (Former Recoupment Area [Building S-873]) in areas where spills may have occurred; four surface soil samples were collected at RI Site 34 (Building 770 Underground Oil Storage Tanks) in the vicinity of waste oil storage tanks; and six surface soil samples were collected at RI Site 32 (Sandblasting Waste Accumulation Area) in the vicinity of sandblasting and waste accumulation activities. General types of chemicals detected at these sites during the 1990 Law Environmental investigation included metals, VOCs, pesticides, PCBs, and SVOCs.

16.2.2 Summary of Key Findings from Past Remedial Investigations

The results of the surface soil sample data collected during the 1990 RI investigation indicated that the soil was contaminated with solvents, organic compounds, and/or metals at the sampling locations (Law Environmental, 1990a). Some samples were contaminated with pesticides and PAHs.

On the basis of the fate and transport analysis, Law Environmental concluded that metals and organic compounds were capable of migration. Pesticides, PCBs, and PAHs were not determined to be very mobile, and it was concluded that these compounds were detected at locations proximate to their original sources of contamination.

The extent of contamination from the constituents detected was not defined by Law Environmental. Results from the Law Environmental RI were used to evaluate potential problem areas in FU3 and provided the basis for additional sampling. Additional sampling was conducted for areas where data gaps existed and where sampling and analyses were required to characterize the nature and extent of contaminants from past activities of the site.

16.2.3 Current Remedial Investigations

The areas of most concern within this FU (including the RI sites, screening sites, TEC sites, and BRAC sites) initially were investigated by CH2M HILL from December 1996 through January 1997. At that time, the surface soil was sampled to assess the nature and horizontal extent of contamination at these sites, and the subsurface soil was sampled at most of these sites to assess the vertical extent of contamination. A single BRAC sediment sample was collected from a sump within Building 1086. No surface water bodies exist at FU3, so no surface water data were collected.

Additional investigations of RI sites and initial investigations of areas of potential concern identified in aerial photographs taken by the TEC were conducted from September 1998 through October 1998. Additional surface and subsurface soil sample data were needed to accomplish the following:

- Further characterize the nature and extent of contamination;
- Collect a sufficient number of data points to perform an RA;
- Confirm the absence of contamination at some screening sites based on initial (1996-1997) screening results;
- Assess the groundwater contamination; and
- Collect feasibility samples where remedial activities were considered likely.

The sites investigated within FU3 and the sampling rationale for each site are presented in Table 16-1. Figure 16-1 shows the location of these sites. The basis for the 1996 sampling rationale was the same for each site identified at the time: 1) to collect soil samples representative of site conditions; 2) to compare the detected concentrations to background and screening levels; and 3) to develop appropriate recommendations. The 1998 sampling rationale was developed based on the recommendations resulting from the 1996-1997 sampling events. Specific activities that occurred at the FU3 sites are discussed in Section 16.3.

16.3 Potential Sources of Contamination

Because hazardous materials were handled and stored at a number of buildings within FU3, there was the potential for spills of hazardous materials to soil surrounding the buildings. Furthermore, soil may have been contaminated with sandblasting and painting materials that were used within and outside the general vicinity of Buildings 1087 and 1088. Other areas of concern within FU3 (and also throughout the Main Installation) include releases associated with transport along railroad tracks and pesticide/herbicide application in grassy areas. Table 16-1 lists the sites of most concern at FU3, Figure 16-1 presents the locations of these sites, and the following paragraphs provide a description of operations that have taken place at these sites, plus other areas of concern within FU3.

16.3.1 Building 873 (RI Site 27)

Building 873 was used to store hazardous materials such as chlorinated solvents, corrosives, and POL. The southern end of the building and the gravel area east of the building served as the Depot's materials recoupment or recovery area from 1942 until about 1987. The recoupment area formerly was used for packing and repacking hazardous and nonhazardous materials from damaged and leaking containers. The former recoupment area is designated as RI Site 27.

16.3.2 Buildings 1087 and 1088 (Painting, Sandblasting, and Waste Accumulation; Screening Sites 31 and 33, RI Site 32)

Building 1087 was formerly the location of a drive-through, water cascade, spray paint booth, and drying oven, which was used to conduct major stock primer and enamel spray painting operations. The building was used to store freshly painted equipment until it dried.

Painting operations at Building 1087 were performed from the 1950s through 1985. The water cascade booth in Building 1087 was replaced in late 1985 with a dry filter paint booth located in Building 1086. The area surrounding Building 1087 is designated as Screening Site 31.

Building 1088 was installed in 1953 and was used for sandblasting. Adjacent to the southern end of Building 1088 was the sandblasting waste accumulation area, just west of Building 1087 and north of the sandblasting waste drum storage area. The area consists of a corrugated steel shed with a gravel floor. Three hoppers in the shed collected the dust from the sandblasting operations taking place in Building 1088 and directed it into 55-gallon drums in the sandblasting waste drum storage area. The sandblasting waste drum storage area consists of an open-sided, metal-roofed shed with a gravel floor. Spent sandblasting material was stored in 55-gallon drums in this area. The sandblasting waste accumulation area is designated as RI Site 32 and the sandblasting waste drum storage area is designated as Screening Site 33.

Prior to the use of Building 1088 and the hopper system at the waste accumulation area, sandblasting operations were performed on the open ground in the general vicinity of Building 1087, according to the RFA report (EPA, 1990).

16.3.3 Building 770 (RI Site 34)

Two 1,000-gallon steel USTs previously were located west of the vehicle maintenance shop (Building 770). The tanks stored waste motor oil from vehicles from the 1960s until they were removed in 1989. Prior to 1969, Building 770 was used for cleaning and preserving heavy equipment before it was shipped overseas. A satellite drum accumulation area (proposed NFA site), used to store drums of waste material before shipment off-site, also was located at Building 770. The former location of the two USTs is designated as RI Site 34 (see Figure 16-1).

16.3.4 Buildings 783 and 793 (Screening Site 82)

Buildings 783 and 793 previously were designated as storage areas for flammable items and ordnance material. The interior floors of Buildings 783 and 793 are constructed of concrete and slope to the north and south walls. Along these walls are drains that lead to the exterior of the buildings (on the eastern side). These buildings are designated as Screening Site 82.

16.3.5 Building 972 (Screening Site 84)

Building 972 previously was used to store flammables, solvents, and waste oil as an open shed building. The building was converted to a closed building for the storage and handling of packing material. Because of the potential that stored materials may have been released to the soils surrounding Building 972 during material handling, the area was designated as Screening Site 84.

16.3.6 Building 1089 (Screening Site 89)

Past uses of Building 1089 include storing acids, paints, and cleaning solvents. According to the *Remedial Investigation at DDMT, Final Report* (Law Environmental, 1990a), spills reportedly have occurred at this site; however, specific spill information (such as location, date, and quantity) has not been identified. In addition to acid and paint storage, the *Installation Assessment of Defense Depot Memphis, Tennessee* (USATHAMA, 1982) indicated that sandblasting operations had been performed in the northern portion of this building. The area surrounding this building is designated as Screening Site 89.

16.3.7 Old Pond Area

Evidence of an old pond in FU3 was identified through fly-over images (TEC, 1998). The pond, evident in photographs from 1945 to 1952, was approximately 200 ft long by 100 ft wide, with its long axis oriented in a northwest/southeast direction. It was located southeast of the current location of K Street and northwest of Building 689 (see Figure 16-1). Its depth is not known, but based on the permanent berm along its northwestern edge (now K Street) and other visual evidence, it may be assumed that the deeper end of the pond was to the northwest. This site is designated as TEC 90.

16.3.8 Mallory Avenue Ground Scar

The Mallory Avenue Ground Scar can be observed in the aerial photographs from 1949 to 1953 (TEC, 1998). As shown on Figure 16-1, it occurs in the mid-western boundary of the installation, along the perimeter just east of Mallory Avenue and just south of the current location of MW-21. The nature of the soil disturbance has not been determined. This site is designated as TEC 93.

16.3.9 Open Storage Areas

There are three open storage areas within the Southwest Open Area–X02, X03, and X04 The open storage area X02 was used to store PVC and steel pipe, along with petroleum and fuel. The open storage area X03 was used until 1988 for the storage of flammable materials in 55-gallon drums. Open storage area X04 was used to store feed stock material. Open storage area X04 has not been known to store hazardous materials.

16.3.10 Railroad Tracks (Screening Site 70/71)

Railroad operations were the main means of transporting materials to the warehouses for storage. Throughout the Main Installation, railroad tracks historically were sprayed with pesticides, herbicides, and waste oil containing PCP.

16.3.11 All Grassed Areas (Screening Site 73)

Grassed areas throughout the Main Installation were treated as one screening site during the investigation. The historical application of pesticides such as dieldrin on grassy areas was cause to consider the grassed areas as a potential source of contamination.

16.3.12 BRAC Parcels

Environmental sampling was performed at BRAC property parcels to assess whether the property was suitable for transfer or lease. Sampling was conducted to assess whether chemicals existed in the surface and subsurface soils in concentrations that might present a concern for industrial, and in some portions of the Main Installation, residential uses.

16.4 Nature and Extent of Soil and Subsurface Soil Contamination

To characterize the nature and extent of contaminants within FU3, surface and subsurface soil samples were collected and analyzed for VOCs, SVOCs, metals, and the TCL/TAL parameters (organochlorine pesticides, herbicides, PCBs, and hexavalent chromium). Figure 16-2 shows the sample locations for FU3, and Table 16-2 lists the parameters analyzed for at each site. Appendix N provides a list of all detected parameters in the surface and subsurface soil samples collected at FU3 and compares them to screening and background values. The nature and extent of the contaminants detected above background values at the FU are discussed below.

16.4.1 Nature and Extent of Metals Contamination

Several metals were detected throughout FU3 at concentrations above background values. The results of the analyses are presented in Table 16-3. The metals that exceeded background values were divided into three categories based on the number of sample concentrations that exceeded background values and the relative importance of the metal as a potential contaminant. Each metal that exceeded a background value was classified as a primary metal of concern, a distributed metal, or a naturally occurring metal. Primary metals of concern were detected above background values in a significant number of samples and may indicate a release from source areas in FU3. Distributed metals were detected above background values in a relatively small and insignificant number of samples. Naturally occurring metals were associated with the natural soil conditions detected above background levels.

The three-tiered grouping described above is a means to present the potentially most important metals as the first group, followed by the metals that occurred with enough frequency to warrant a shorter discussion. The final grouping was metals that occurred often, but because they were naturally occurring metals, their abundance was not an environmental issue. The primary use of the three-tiered grouping was for presentation in the nature and extent sections, for clarity, rather than as an extra step in the risk assessment

16.4.1.1 Primary Metals of Concern

On the basis of the results of the surface and subsurface soil sampling, arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc were designated as the primary metals of concern throughout FU3. The soil samples that exceeded the background values for these constituents are shown on Figures 16-3 through 16-16. These constituents were designated as primary metals of concern primarily because they, with the exception of arsenic, exceeded background levels in a number of concentrated regions throughout FU3.

Chromium. Sixty-six total chromium concentrations, including 8 duplicates, exceeded the established background value of 24.8 mg/kg in the 126 surface soil samples analyzed for chromium at FU3. As shown on Figure 16-3, chromium concentrations that exceeded the background value were present in almost every surface sample collected near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33). Concentrations as high as 915 mg/kg, 530 mg/kg, and 403 mg/kg were observed at RI Site 32 and Screening Sites 31 and 33. Elevated chromium concentrations also were detected near the Building 1089 acids area (Screening Site 89). Soil samples from Screening Site 89 contained concentrations as high as 539 mg/kg, 443 mg/kg, and 126.4 mg/kg.

Other areas such as the former recoupment area (RI Site 27), the Building 770 underground oil storage tanks (RI Site 34), the Building 783 flammables area (Screening Site 82), and Building 972 flammables, solvents, and waste oil area (Screening Site 84) also contained chromium concentrations above the background value. However, these concentrations were significantly less than the concentrations observed near RI Site 32 and Screening Sites 31, 33, and 89. A chromium concentration of 145 mg/kg was analyzed at Screening Site 84 and chromium concentrations of 124 mg/kg and 107 mg/kg were analyzed at RI Site 34 The other chromium concentrations detected in these areas were below 100 mg/kg. Overall, total chromium was detected in 126 surface soil samples, including 13 duplicates. The detected concentrations ranged from 5.5 mg/kg to 915 mg/kg.

Chromium concentrations in 42 of the 106 subsurface soil samples, including three duplicates, exceeded the background value of 26.4 mg/kg. As shown on Figures 16-4 through 16-7, the elevated chromium concentrations were dispersed throughout FU3, with Screening Sites 82 and 89 having the greatest number of elevated chromium concentrations in the subsurface soil. In general, the higher elevated chromium concentrations were located in the 4-6-ft and the 8- to 10-ft interval. For example, SB33B, a typical boring, contained chromium concentrations of 44.1 mg (4 ft to 6 ft), 43.1 mg/kg (8 ft to 10 ft), 16 mg/kg (18 to 20 ft), and 12.5 mg/kg (38 ft to 40 ft). Only three chromium concentrations exceeded the background value at a depth greater than 15 ft. SB82D contained a chromium concentration of 102 mg/kg in the 18- to 20-ft interval, SB82C contained a chromium concentration of 79.2 mg/kg in the 18- to 20-ft interval, and SB33C contained a chromium concentration of 26 mg/kg in the 38- to 40-ft interval. Overall, chromium was detected in all 109 subsurface soil samples analyzed for it, including five duplicates. The detected concentrations ranged from 2.1 mg/kg to 102 mg/kg.

Chromium was present in surface soil samples at concentrations that significantly exceeded the background value. The highest chromium values were concentrated near the sandblasting waste areas, the Building 1087 paint spray booth, and the Building 1089 acids area. Other areas throughout FU3 also contained chromium concentrations that exceeded the background value. Concentrations of chromium in surface soil samples from the grassy area surrounding the southwestern perimeter of FU3 were below background or generally lower than those observed in samples from the sandblasting and painting areas, thus indicating that the chromium is contained within Depot property. Elevated chromium concentrations that may be attributable to surface infiltration also appeared in the subsurface. However, 39 of the 42 samples that exceeded the background value occurred at a depth of less than 15 ft.

Lead. Of the 126 surface soil samples analyzed for lead, 77 samples, including 9 duplicates, contained lead concentrations that exceeded the background value of 30 mg/kg. As shown on Figure 16-8, the elevated lead values were concentrated near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33) and the Building 1089 acids area (Screening Site 89). Fifty-two of the 77 surface soil samples that exceeded the background value for lead in FU3 were located in the southwestern corner of FU3 in these four areas. In addition, the lead concentrations in these areas were significantly higher than the background value. For example, the average lead concentrations in Screening Site 31, RI Site 32, Screening Site 33, and Screening Site 89 were 157 mg/kg, 1,082 mg/kg, 294 mg/kg, and 465 mg/kg, respectively. In addition, a small cluster of five surface soil samples exceeded the background value near the Building 770 underground oil storage tanks (RI Site 34). The average lead concentration in this area was 399 mg/kg.

Elevated lead concentrations also were detected near the former recoupment area (RI Site 27), the Building 783 flammables area (Screening Site 82), the Building 972 flammables, solvents, waste oil area, (Screening Site 84), the southeastern corner of Building 970, and just west of Building 972 at Building 1085 (see Section 1.7). However, the lead concentrations were much more scattered and smaller in magnitude in these areas. For example, the average detected lead concentrations for RI Site 27, Screening Site 82, and Screening Site 84 were 25 mg/kg, 27 mg/kg, and 40 mg/kg, respectively.

Lead was below background in samples from the grassy area separating the former painting and sandblasting area from off-site areas, indicating that the lead contamination is contained on Depot property. Lead concentrations were somewhat elevated in samples along the Depot perimeter adjacent to Ball Street and Perry Road, possibly because of deposition from vehicle exhaust.

Lead concentrations in 17 of the 106 subsurface soil samples, including 1 duplicate, exceeded the background value of 23.9 mg/kg. The elevated lead concentrations were dispersed throughout the borings and not concentrated in any one location. Only two of the subsurface soil samples contained a lead concentration that exceeded 32 mg/kg. The sample collected from the 4- to 6-ft interval of SB84D, located at Building 972, contained a lead concentration of 282 mg/kg (see Figure 16-9). The sample collected from the 6.5- to 8.5-ft interval of TEC90B, located at the Old Pond Area, contained a lead concentration of 114 mg/kg. However, samples collected from deeper intervals within these borings contained lead concentrations that were below the background limit (Figure 16-10).

Overall, lead was detected in significant concentrations near the sandblasting waste areas, the paint booth, Building 1089, and the USTs near Building 770. Many of these lead concentrations greatly exceeded the background value. However, lead does not generally appear to be leaching to the subsurface. Only two subsurface samples contained lead concentrations that exceeded 32 mg/kg.

Arsenic. Twelve of the 126 surface soil samples analyzed for arsenic, including 1 duplicate, contained an arsenic concentration that exceeded the background value of 20 mg/kg. As shown on Figure 16-11, these samples were scattered throughout FU3. No significant cluster of elevated arsenic concentrations that might indicate a release from a specific source was noted. In addition, the arsenic concentrations remained relatively close to the established background value of 20 mg/kg. Only 3 surface soil arsenic concentrations exceeded two times the background limit. SB32A contained an arsenic concentration of 42.5 mg/kg, SS34D contained an arsenic concentration of 49.2 mg/kg, and BRAC sample B(24.2) contained an arsenic concentration of 42.1 mg/kg.

Of the 106 subsurface soil samples analyzed for arsenic, 17 samples contained arsenic concentrations that exceeded the background value of 17 mg/kg. However, the concentrations of arsenic in the subsurface samples did not greatly exceed the established background value. In fact, the highest arsenic concentration was only 26.5 mg/kg (4- to 6-ft interval of SB82D). In addition, no arsenic concentrations from samples collected in the 1- to 5-ft interval exceeded the background value. Sixteen of the 17 samples that exceeded the background value for arsenic occurred in the 4- to 15-ft interval. The only elevated arsenic concentration deeper than the 15-ft interval occurred in the 18- to 20-ft interval of SB84D (18.8 mg/kg). These factors indicate that the intermediate subsurface arsenic concentrations may occur as a result of natural soil formations and not surface infiltration.

As described above, the arsenic samples that exceeded the background values in both the surface and subsurface were broadcast throughout FU3. In most cases, the concentrations of arsenic did not significantly exceed the background value. The highest surface or subsurface concentration of arsenic was only 49.2 mg/kg, and only four surface or subsurface samples contained arsenic concentrations that exceeded 27 mg/kg. Arsenic is present in low concentrations throughout the Depot, probably because of site-wide pesticide management activities and naturally elevated background levels in soil that may be misinterpreted as specific source areas in FU3.

Cadmium. Of the 126 surface soil samples analyzed for cadmium, 15 samples (including 1 duplicate) contained cadmium concentrations that exceeded the background value of 1.4 mg/kg. As shown on Figure 16-12, the majority of the soil samples with elevated cadmium values were concentrated near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33). Elevated cadmium concentrations also were detected near the former recoupment area (RI Site 27) and the Building 1089 acids area (Screening Site 89).

The cadmium concentrations in the surface soil samples did not significantly exceed the background value. For example, only two cadmium concentrations of 8.1 mg/kg in SS31A and 5.8 mg/kg in SB32A were greater than twice the background limit of 1.4 mg/kg Cadmium was detected in 62 of the 125 surface soil samples, including 5 duplicates. The detected concentrations ranged from 0.08 mg/kg to 8.1 mg/kg.

One subsurface soil sample from the 8- to 10-ft interval of SB33A contained a cadmium concentration of 1.5 mg/kg that slightly exceeded the background value of 1.4 mg/kg. This sample was located near the sandblasting waste drum storage area (Screening Site 33). In addition, cadmium was detected in only 13 of the 106 subsurface soil samples.

On the basis of these results, the surface and subsurface soil in FU3 did not appear to be significantly affected by cadmium. However, slightly elevated cadmium values were concentrated near the sandblasting waste areas and the Building 1087 paint booth. As stated above, these concentrations do not greatly exceed the background value.

Copper. Copper concentrations in 37 of the 126 surface soil samples, including 6 duplicates, exceeded the background value of 33.5 mg/kg. As shown on Figure 16-13, the elevated copper values were concentrated near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33) and the Building 1089 acids area (Screening Site 89). However, the copper concentrations remained relatively low. Only four surface soil copper concentrations exceeded 100 mg/kg. SB32 contained a copper concentration of 235 mg/kg, SS32D

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contained a copper concentration of 103 mg/kg, SS33K contained a copper concentration of 163 mg/kg, and FS89P contained a copper concentration of 111.75 mg/kg. In addition, only 10 of the 125 copper concentrations exceeded twice the background value.

Sporadic copper concentrations in surface soil samples also exceeded the background value near the former recoupment area (RI Site 27), the Building 770 underground oil storage tanks (RI Site 34), and Building 783 flammables area (Screening Site 82). However, as shown on Figure 16-13, the elevated concentrations were scattered throughout these areas. In addition, the copper concentrations were relatively low. The highest copper concentration for these three sites was 53.6 mg/kg.

With the exception of station SS33D, copper concentrations in surface soil were below background in the grassy areas surrounding the painting and sandblasting area, again indicating that surface soil effects are limited to the industrial area.

Of the 106 subsurface soil samples analyzed for copper, 16 samples, including 1 duplicate, contained copper concentrations that exceeded the background value of 32.7 mg/kg. The elevated copper concentrations were scattered throughout the borings and not concentrated at any one depth. In addition, the copper concentrations were not significantly higher than the background value of 32.7 mg/kg. The highest detected copper concentration in the subsurface (49.3 mg/kg) occurred at the 3- to 5-ft interval of SB89B (duplicate sample).

Copper concentrations that exceeded the background value were concentrated near the sandblasting waste areas, the Building 1087 paint booth, and Building 1089. However, these concentrations remained relatively low, and elevated copper concentrations did not consistently appear in the subsurface.

Nickel. Twenty-one nickel concentrations, including 5 duplicates, exceeded the value of 30 mg/kg in the 126 surface soil samples analyzed for nickel at FU3. As shown on Figure 16-14, the samples collected near the sandblasting waste accumulation area, the sandblasting waste drum storage area, the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33), and the Building 1089 acids area (Screening Site 89) contained the majority of the nickel concentrations that exceeded the background value. However, the nickel concentrations did not significantly exceed the background limit. Only 1 nickel concentration of 76.3 mg/kg, analyzed in SB32A, was greater than two times the background value of 30 mg/kg. Furthermore, the average nickel concentration in FU3 was only 18.3 mg/kg.

Nine of 106 subsurface soil samples, including 1 duplicate, contained nickel concentrations that exceeded the background value of 36.6 mg/kg. The elevated nickel concentrations were located near the Building 783 flammables area (Screening Site 82) and the Building 972 flammables, solvents, waste oil area (Screening Site 84). However, the 9 concentrations that exceeded the background value of 36.6 mg/kg only ranged from 40 mg/kg to 48.2 mg/kg.

The sandblasting waste accumulation areas, the paint booth, and Building 1089 appear to have concentrated nickel values that exceeded the background limit in the surface soil. However, the nickel concentrations in both the surface and subsurface do not significantly exceed the background values.

Selenium. Selenium concentrations in 29 of the 126 surface soil samples, including 3 duplicates, exceeded the established background value of 0.8 mg/kg. As shown on Figure 16-15, the elevated selenium concentrations are somewhat concentrated near the former recoupment area (RI Site 27), the sandblasting waste accumulation area, the sandblasting waste drum storage area, the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33), and the Building 1089 acids area (Screening Site 89). A significant percentage of samples collected from RI Site 27 and Screening Sites 33 and 89 exceeded the background limit for selenium. However, the selenium concentrations did not greatly exceed this value. In fact, only 4 concentrations exceeded twice the background limit. Selenium concentrations in A(23.9), SS89A, SS27T, and SS27L contained selenium concentrations of 9.5 mg/kg, 3.8 mg/kg, 1.9 mg/kg, and 1.7 mg/kg, respectively.

Unlike other metals, selenium also was detected above background in most of the samples within the perimeter grassy areas. As previously discussed, other metals associated with operations in the southwestern corner of the Main Installation were not elevated in the grassy area, indicating that it was not affected by the Depot. It is therefore likely that the elevated selenium results from natural variation in soil conditions.

Nine of the 126 subsurface soil samples, including 1 duplicate, contained selenium concentrations that exceeded the background value of 0.6 mg/kg. The elevated selenium concentrations were dispersed throughout FU3 at varying depths. In addition, the elevated concentrations only ranged from 0.78 mg/kg to 2.3 mg/kg.

Elevated, but relatively low, selenium concentrations appear to be lightly concentrated in the surface soil near Screening Site 27, RI Site 32, and Screening Site 89. However, selenium does not occur in significant amounts in the subsurface.

Zinc. Fifty-five of the 126 surface soil samples analyzed for zinc, including 8 duplicates, contained zinc concentrations that exceeded the background value of 126 mg/kg. As shown on Figure 16-16, the elevated zinc values were concentrated near the sandblasting waste accumulation area, the sandblasting waste drum storage area, the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33), and the Building 1089 acids area (Screening Site 89). The highest average zinc concentrations were located in Screening Site 31, RI Site 32, and Screening Site 89. The average zinc concentration at these sites was 330 mg/kg, 1,005 mg/kg, and 482 mg/kg, respectively, compared to the FU3-wide average of 257 mg/kg. High individual zinc concentrations also were encountered. SS32F, SS89J, and SS31A contained zinc concentrations of 4,000 mg/kg, 1,600 mg/kg, and 1,560 mg/kg, respectively.

Zinc concentrations in 8 of the 106 subsurface soil samples, including 1 duplicate, exceeded the background value of 114 mg/kg. The elevated zinc concentrations were located near the Building 783 flammables area (Screening Site 82), the Building 972 flammables, solvents, and waste oil area, (Screening Site 84), and the Building 1089 acids area (Screening Site 89). The zinc concentrations in the subsurface did not significantly exceed the background limit. In fact, the zinc concentrations that exceeded the background limit of 114 mg/kg only ranged from 120 mg/kg to 145 mg/kg. In addition, the elevated zinc concentrations were widely dispersed and not concentrated in one boring or strata.

Overall, elevated zinc concentrations were observed in the surface soil at the sandblasting waste accumulation areas, the Building 1087 paint booth, and Building 1089. Some of these concentrations significantly exceeded the background limit. However, zinc was not detected in significant quantities in the subsurface.

16.4.1.2 Distributed Metals

Antimony, barium, beryllium, mercury, silver, and vanadium were detected at concentrations that exceeded background values. However, the elevated concentrations for these constituents occurred infrequently (see Table 16-3) and were widely dispersed. As a result, the elevated concentrations of these constituents were not considered indicative of a release from a source area in FU3, and these constituents were classified as distributed metals.

Antimony. Antimony concentrations in 2 of the 119 surface soil samples exceeded the background value of 7 mg/kg. These two surface soil samples were located near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33). Antimony was detected in only 31 of the 119 surface soil samples. The detected concentrations ranged from 0.23 mg/kg to 22.3 mg/kg. Only 3 antimony concentrations were detected in 103 subsurface soil samples. No background value was established for the subsurface antimony concentrations.

Barium. Two of the 30 surface soil samples contained barium concentrations that exceeded the background value of 234 mg/kg. These two surface soil samples were located near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33) Each of the 30 surface soil samples collected contained a detected barium concentration. The detected concentrations ranged from 28.7 mg/kg to 432 mg/kg. None of the 21 subsurface samples contained a barium concentration that exceeded the background concentration of 300 mg/kg.

Beryllium. The background value of 1.1 mg/kg for beryllium was exceeded in one surface soil sample. This soil sample was located near the Building 770 underground oil storage tanks (RI Site 34). Beryllium was analyzed in 125 surface soil samples and detected in 58 surface soil samples, including 4 duplicates. The detected concentrations ranged from 0.05 mg/kg to 2 mg/kg.

Beryllium concentrations in 9 subsurface soil samples, including 1 duplicate, exceeded the background value of 1.2 mg/kg. However, the beryllium concentrations that exceeded the background value of 1.2 mg/kg only ranged from 1.3 mg/kg to 1.7 mg/kg. In addition, the elevated beryllium subsurface concentrations were scattered throughout the soil borings and not concentrated in any one area. Beryllium was detected in 47 of the 106 subsurface soil samples, including 2 duplicates.

Mercury. A mercury concentration of 2.1 mg/kg in one surface soil sample exceeded the background value of 0.4 mg/kg. This sample was located west of Building 972. A mercury concentration of 0.37 mg/kg in one subsurface soil sample exceeded the background value of 0.2 mg/kg. This sample was located near the northeastern corner of FU3. Mercury was analyzed in 125 surface soil samples and 106 subsurface soil samples; it was detected in 32 surface soil samples and only 4 subsurface soil samples.

Silver. A silver concentration of 2.5 mg/kg in one surface soil sample exceeded the background value of 2 mg/kg. This sample (SB32A) was located near the sandblasting waste accumulation area, the sandblasting waste drum storage area, and the Building 1087 paint booth (RI Site 32; Screening Sites 31 and 33). No subsurface soil sample contained a silver concentration that exceeded the background value of 1 mg/kg. Silver was only detected in 3 of the 125 surface soil samples and 1 of the 106 subsurface soil samples. The detected concentrations ranged from 0.31 mg/kg to 2.5 mg/kg.

Vanadium. Vanadium concentrations in two surface soil samples exceeded the background value of 48.4 mg/kg. These two samples were located near the former recoupment area (RI Site 27). Vanadium was detected in all 31 surface soil samples and all 21 subsurface soil samples. However, no vanadium concentration in a subsurface sample exceeded the background value of 51.3 mg/kg.

16.4.1.3 Naturally Occurring Metals

Various samples collected throughout FU3 contained concentrations of calcium, iron, magnesium, and potassium that exceeded background values. However, these metals frequently occur in the natural clay soils beneath the site. Specifically, almost every soil sample analyzed for these constituents at FU3 contained a detected concentration of calcium, iron, magnesium, and potassium. In addition, these metals do not pose significant health risks and are not generally indicative of a release from source areas in FU3. Therefore, the constituents described below were classified as naturally occurring minerals.

Calcium. Calcium concentrations in 19 surface soil samples, including3 duplicates, exceeded the background value of 5,840 mg/kg. The surface soil samples with elevated calcium concentrations were broadcast throughout FU3. Calcium concentrations in 3 subsurface soil samples exceeded the background value of 2,432 mg/kg. The 3 subsurface soil samples were located near the Old Pond Area (TEC Site 90) and west of Building 972. Calcium was detected in all 31 surface soil samples, including 4 duplicates, and in all 24 subsurface soil samples.

Iron. Iron was detected in all 31 surface soil samples, including 4 duplicates, and all 21 subsurface soil samples. Iron concentrations in 2 surface soil samples exceeded the background value of 37,040 mg/kg. The elevated iron concentrations were detected near the former recoupment area (RI Site 27). No iron concentration in a subsurface sample exceeded the background value of 3,850 mg/kg.

Magnesium. The background value of 4,600 mg/kg for magnesium was exceeded in 4 surface soil samples. The magnesium concentrations were located northeast and southeast of Building 970, west of Building 972, and near the Building 1089 acids area (Screening Site 89). A magnesium concentration in one subsurface soil sample exceeded the background value of 4,900 mg/kg. This sample was located west of Building 972. Magnesium was detected in all 31 surface soil samples, including 4 duplicates, and in all 24 subsurface soil samples.

Potassium. Potassium concentrations in 4 surface soil samples exceeded the background value of 1,820 mg/kg. These elevated potassium concentrations were detected near the former recoupment area (RI Site 27) and at the northeastern and southeastern corners of Building 970. Potassium concentrations in 6 subsurface soil samples exceeded the background value of 1,800 mg/kg. The elevated potassium concentrations were located near the Building 770 underground oil storage tanks (RI Site 34), the Old Pond Area (TEC Site 90), and between Buildings 873 and 875. Potassium was detected in 29 of the 30 surface soil samples, including 4 duplicates, and in 18 of the 21 subsurface soil samples.

16.4.1.4 Metals below Background Values

Aluminum, cobalt, and manganese were detected in each of the 30 surface and 21 subsurface soil samples analyzed for these constituents. However, no concentrations of these constituents exceeded the background values of 23,800 mg/kg, 18.3 mg/kg, and 1,300 mg/kg, respectively, in the surface and 21,800 mg/kg, 20 4 mg/kg, and 1,540 mg/kg, respectively, in the subsurface.

16.4.2 Nature and Extent of SVOC Contamination

16.4.2.1 Surface Soil

On the basis of soil sample results for FU3, the primary SVOCs of concern in the surface soil were determined to be polynuclear aromatic hydrocarbons (PAHs). As shown on Figure 16-17 and Table 16-4, 51 surface sample locations contained detectable concentrations of total PAHs. The total PAH concentrations were detected throughout FU3 in RI Site 27, Screening Site 31, RI Site 32, Screening Site 33, RI Site 34, Screening Site 82, Screening Site 84, Screening Site 89, and TEC Site 93. The detected total PAH concentrations ranged from 0.085 mg/kg to 454.8 mg/kg. The highest total PAH concentrations (454.8 mg/kg and 182.43 mg/kg) were observed in B(26.2) and A(26.2), respectively, located on the northeastern and southeastern corners of Building 970, between the building and adjoining railroad tracks. Sites 27 and 34 also contained relatively high concentrations of total PAHs. Samples from Site 27 contained total PAH concentrations of 100.8 mg/kg, 21.72 mg/kg, and 16.35 mg/kg; samples from Site 34 contained total PAH concentrations of 121 8 mg/kg, 111.1 mg/kg, and 46.5 mg/kg.

PAHs have been observed throughout the Main Installation, generally from surface soil samples in proximity to railroad tracks and those not adjacent to railroad tracks. PAH compounds can generate from creosote seepage that comes from railroad track cross ties, from historical railcar leaks to the surface, or from the application of a PCP/used-oil mixture that historically was applied for weed control along the tracks. PAH compounds also can be generated as a result of engine exhaust from trucks, automobiles, and trains. To further assess the presence of PAH compounds in surface soil from railroad track cross ties and asphalt, two samples (RR57A and RR65A) were collected from the cross ties and two samples were collected from asphalt (RD57A and RD65A) and analyzed for PAHs (see Figure 8-2).

As shown in Table 16-5, high concentrations of the following PAHs were detected in the railroad cross tie samples, indicating potential source contamination from railroad tracks: benzo(a)anthracene, chrysene, flouranthene, naphthalene, phenanthrene, and pyrene.

However, as shown in Tables 16-4 and 16-6, a number of other PAHs were detected throughout FU3, as well as in areas throughout the Main Installation. These are benzo(a)anthracene, BaP, benzo(b)flouranthene, benzo(g,h,i)perylene, benzo(k)flouranthene, and indeno(1,2,3-c,d)pyrene. Table 16-6 indicates that approximately

80 percent of the PAH concentrations detected at FU3 occurred in samples not adjacent to railroad tracks.

The relationship between detected PAHs in surface soil and asphalt could not be evaluated, because of the difficulty in analyzing the asphalt samples (Table 16-5). Excessive matrix interference caused unusually high dilution factors, which resulted in elevated reporting limits (matrix interference was anticipated before analysis, and thus, only 6 grams of sample rather than the typical 30 grams were analyzed). Therefore, PAHs at the requested reporting limits were masked by the sample matrix. PAHs may be present, but were masked at the reporting levels requested.

Concentrations of other SVOCs and PAHs (acenaphthene, acenaphthylene, benzyl butyl phthalate, BEHP, diethyl phthalate, di-n-butyl phthalate, fluorene, 2-Methylnaphthalene, naphthalene, and PCP) were detected in surface soil samples. However, no concentration of these constituents exceeded a background value. In some cases, no background value was available.

16.4.2.2 Subsurface Soil

As shown in Table 16-4, PAHs were not frequently detected in subsurface soil samples. Total PAH concentrations were detected in only four subsurface soil sample borings (A(23.9), A(25.2), SB34C, and TEC90B) located in the southwestern corner of the FU:

- A(23 9), near the Building 770 former underground oil storage tanks;
- SB34C;
- TEC90B, the Old Pond Area; and
- Between Buildings 873 and 875–A(25.2).

The detected total PAH concentrations ranged from 0.176 mg/kg to 15.327 mg/kg. However, each boring contained deeper samples that did not contain detected total PAH concentrations. Specifically, a total PAH concentration of 0.6 mg/kg was analyzed in the sample from the zero- to 4-ft interval of boring A(23.9); samples collected from the 4- to 7-ft and 7- to 10-ft intervals in A(23.9) did not contain detected total PAH concentrations. Total PAH concentrations of 0.328 mg/kg and 0.176 mg/kg were detected in the zero- to 4-ft and 4- to 7-ft intervals of A(25.2), respectively, and a sample collected from the 8- to 10-ft interval in A(23.9) did not contain a detected total PAH concentration. A total PAH concentration of 15.327 mg/kg was detected in the 6.5- to 8.5-ft interval of TEC90B, but the sample collected from the 9- to 11-ft interval in TEC90B did not contain a detected total PAH concentration

Fluoranthene and pyrene concentrations exceeded background values in the four subsurface samples discussed above. The four detected fluoranthene concentrations ranged from 0.069 mg/kg to 2.4 mg/kg, exceeding the background value of 0.045 mg/kg. The four detected pyrene concentrations ranged from 0.064 mg/kg to 2.4 mg/kg, exceeding the background value of 0.042 mg/kg.

Concentrations of acenaphthene, anthracene, benzo(a)anthracene, BaP, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, carbazole, chrysene, fluorene, indeno(1,2,3-c,d) pyrene, 2- ethylnaphthalene, naphthalene, and phenanthrene were detected in subsurface soil sample TEC90B at the Old Pond Area at a depth of 6 5 to 8.5 ft. These compounds were not detected at the lower sample interval of 9 to 11 ft, nor were these PAHs detected in the subsurface soil at TEC 90A. Because the boring was not located near a railroad track and because PAHs are typically surface soil contaminants, it is speculated that the PAH detection at that depth may be due to exposure of the dry pond bottom before being reworked when the pond was filled in.

16.4.3 Nature and Extent of Pesticide Contamination

A total of 7 pesticides were detected in 80 pesticide surface soil samples at FU3. The pesticides are DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, dieldrin, and heptachlor. Table 16-7 lists these pesticides, the number of times for which they were analyzed, and the minimum and maximum concentrations detected.

In the majority of the sample locations analyzed for pesticides within FU3, the results indicated *no detections* or *detections are below background concentrations*. However, the pesticides that were detected exceeded background values in at least one sample location when a background value was available. There are three general areas in which elevated concentrations of pesticides were detected in FU3:

- The southwestern corner of FU3 (near Buildings 1086, 1087, and 1088);
- The northwestern corner of FU3 (just east of the northeastern corner of Building 972); and
- The southeastern corner of FU3 (just east of the southeastern corner of Building 873).

Elevated concentrations of DDT, DDE and DDD were detected above background in the extreme southwestern and northwestern portions of the FU. DDT was detected in 39 sample locations (see Figure 16-18), with 14 detections above its background value of 0.074 mg/kg (see Table 16-7). Most elevated concentrations of DDT were detected near Buildings 1086, 1087, and 1088 at concentrations ranging from 0.077 mg/kg to 0.41 mg/kg and just east of the northeastern side of Building 972 at concentrations ranging from of 0.4 mg/kg and 0.12 mg/kg.

Two elevated concentrations of DDD and one elevated concentration of DDE were detected in the western area of FU3 (see Figures 16-19 and 16-20). These two constituents frequently were not detected or were detected below background values.

Alpha-chlordane and gamma-chlordane were detected at elevated concentrations in two locations in FU3, on the southeastern corner of Building 873 and the northeastern corner of Building 972 (see Figures 16-21 and 16-22). Alpha-chlordane was detected in 15 samples in which 9 of the detected concentrations exceeded the background value of 0.029 mg/kg. Gamma-chlordane was detected in 15 samples in which 10 of the detected concentrations exceeded the background value of 0.087 mg/kg. The elevated concentrations of alpha-chlordane were detected just east of the southeastern corner of Building 873 at concentrations ranging from 0.059 mg/kg to 0.23 mg/kg and just east of the northeastern corner of Building 972 at concentrations ranging from 0.072 to 0.61 mg/kg. Gamma-chlordane was detected in the same locations at concentrations ranging from 0.087 mg/kg to 0.24 mg/kg and from 0.081 mg/kg to 0.58 mg/kg, respectively. With the exception of these two locations, alpha-chlordane and gamma-chlordane normally were not detected in most of FU3.

Dieldrin was detected throughout the Main Installation and is not associated with known sources of contamination at FU3. It was sprayed routinely on grassy areas and around warehouses. In FU3, dieldrin exceeded its background concentration in 2 samples, which were taken in grassy areas. The remaining 78 sample results at FU3 showed dieldrin below background concentrations or not detected. Heptachlor was detected in one sample location, but there is no background value for this chemical and the significance of this detection cannot be assessed.

16.4.3.1 Pesticides in Subsurface Soil

A total of 59 subsurface soil samples were analyzed for pesticides. DDE and dieldrin were detected in one sample (TEC90B) at a depth of 6.5 to 8 ft and DDT was detected in another sample (SB82A) at a depth of 9 to 10.5 ft. DDE and DDT slightly exceeded background values and dieldrin exceeded its GWP value. Both of these sample points were located in grassy areas on the eastern side of FU3, near K Street and 9th Street (see Figure 16-2). The remaining subsurface samples showed *no detections* of pesticides in the subsurface soil

16.4.4 Nature and Extent of Dioxin and Furan Contamination

Dioxins are ubiquitous in the urban environment and have been detected in the background samples. Dioxins were analyzed for in surface soil and subsurface soil at Screening Site 82 (Buildings 783 and 793) because of the past storage of dioxin-laden soils in Buildings 783 and 793 at the former contaminated Soil Drum Storage Area. Table 16-8 presents the number of times that dioxins and furans were detected in the soils near these buildings, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected. As shown in Table 16-8, estimated concentrations of TCDD equivalents exceeded established background TCDD equivalent values in surface soil samples. However, the maximum TCDD equivalent concentration in the site samples of 0.000013 mg/kg is similar to the background TCDD equivalent concentration of 0.000010 mg/kg.

Of the different isomers of dioxins and furans, the higher chlorinated isomers such as octa-isomers are the most persistent and are commonly detected in the general environment (ATSDR, 1998). Detections indicate that the observed concentrations probably are a result of atmospheric deposition that result from waste incineration and burning activities. The TCDD equivalent concentration detected in Sample SS82A only slightly exceeded the background value, and TCDD itself was not detected in any of the samples. These findings indicate that site activities at Building 783 may not be the source for the observed dioxins and furans, and that they probably are a result of atmospheric deposition from non-point sources within the urban environment.

The samples analyzed for dioxins and furans indicated low-level detected concentrations in the subsurface soil located near the Buildings 783 and 793 flammables area (Screening Site 82). However, these chemicals are not leachable and are not expected to be present in the subsurface soils (ATSDR, 1998; EPA, 1989). The detected values are interpreted to be sampling and analysis artifacts, based on the technical information of these groups of compounds' physical and chemical properties. Similar artifacts may have resulted in positive detections in the background subsurface soils, also. The observed TCDD equivalent values are similar in the site samples and the background (see Table 16-8).

16.4.5 Nature and Extent of VOC and Other Organics Contamination in Surface and Subsurface Soil

16.4.5.1 VOCs in Surface Soil

A total of 11 VOCs were detected in the 80 surface soil samples analyzed for VOCs throughout FU3. The VOCs are 2-Hexanone, acetone, benzene, bromomethane, carbon disulfide, MEK, methyl isobutyl ketone (MIBK), methylene chloride, toluene, total xylenes, and TCE. Table 16-9 presents a list of these compounds, the number of times they were detected, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected.

The majority of the surface soil sample results for VOCs within FU3 indicate *no detections*. However, there are three isolated areas in which elevated concentrations of VOCs were detected in the surface soil in FU3:

- MEK, 2-Hexanone, benzene, bromomethane, and MIBK were detected at elevated concentrations on the northwestern corner of Building 972 at sample points SS84H and SB84A (see Figure 16-2). These detections could have resulted from an isolated spill associated with waste oil and solvent handling in Building 972;
- MEK, benzene, and toluene were detected at elevated concentrations at sample point SS33M (Screening Site 33), taken in the gravel area just east of the concrete pad between Buildings 1087 and 1088 where sandblasting and waste operations took place. MEK and toluene were detected at concentrations slightly above background. A background value was not established for benzene; and
- TCE was detected at an estimated value of 0.001 mg/kg at sample point SS27F (RI Site 27), located near the southeastern corner of Building 873. This isolated occurrence may be due to isolated spills resulting from handling chlorinated solvents in Building 873.

16.4.5.2 VOCs in Subsurface Soil

A total of 106 subsurface soil samples were analyzed for VOCs. The same VOCs detected in surface soil, plus chromomethane and minus MIBK, were detected in the subsurface soils (see Table 16-9). Most subsurface soil results showed no detected concentrations. Background values for most of the VOC constituents that were detected are not available in the subsurface soil. However, none of the detected concentrations exceeded the GWP values.

A number of the VOCs (MEK, toluene, total xylenes, bromomethane, benzene, carbon disulfide, and 2-Hexanone) detected in the subsurface soil were located in the Old Pond Area. At sample point TEC90A, the VOCs bromomethane (0.007 mg/kg), benzene (0.001 mg/kg), MEK (0.038 mg/kg), and 2-Hexanone (0.001 mg/kg) were detected at the only sample interval of 5 to 7 ft. At sample point TEC90B, the VOCs benzene (0.001mg/kg), carbon disulfide (0.023 mg/kg), 2-Hexanone (0.003 mg/kg), MEK (0.02 and 0.016 mg/kg), toluene (0.004J mg/kg), and total xylenes (0.002J mg/kg) were detected at the sample interval depth of 6.5 to 8.5 ft. It does not appear that the vertical extent of VOC contamination has been bounded at the Old Pond Area, because MEK was detected at the lowest sample depth of 9 to 11 ft at TEC90B. Nonetheless, detected VOC concentrations did not exceed the GWP values.

Probably because of volatilization at the surface, detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations, as follows:

- MEK was not detected in the subsurface soil at Screening Site 33, where elevated concentrations were detected in the surface soil. However, concentrations of MEK were detected in the subsurface soil on the northwestern and northeastern corners of Building 972 at depths ranging from 8 to 11 ft (sample points SB84A [0.019 mg/kg], SB84B [0.004J mg/kg] and SB84C [0.013 mg/kg]), as well as in the Old Pond Area at depths ranging from 6.5 to 11 ft (sample points TEC90A [0.001J mg/kg] and TEC90B [0.023 mg/kg]). MEK was not detected in the lowest sample depth of 18 to 20 ft; and
- TCE was not detected in the subsurface soil at Building 873 (RI Site 27), where an estimated concentration was detected in the surface soil. Estimated concentrations of TCE were detected in the subsurface soil on the northwestern corner of Building 972 (sample point SB34A [0.002 through 0.007 mg/kg] at depths of 8 to 20 ft) and just west of Building 770 (sample point SB84C [0.013 mg/kg] at depths of 4 to 21 ft). The vertical extent of contamination has not been bounded because estimated concentrations of these constituents were detected in the lowest sample depths. Spills from drum storage and solvent handling reported at these two buildings are likely sources.

The GWP values for the VOCs detected in the subsurface soil are: 1.4 mg/kg (2-Hexanone), 16 mg/kg (acetone), 0.03 mg/kg (benzene), 0.2 mg/kg (bromomethane), 32 mg/kg (carbon disulfide), 17 mg/kg (MEK), 0.02 mg/kg (methylene chloride), 12 mg/kg (toluene), 0.2 mg/kg (total xylenes), and 0.06 mg/kg (TCE). None of the detected VOC concentrations exceeded the GWP values.

16.4.5.3 Other Organics

Petroleum hydrocarbons were analyzed for in four locations: just south of Building 1084 (see Section 1.7); an old concrete grease rack in Building 1085 (see Section 1.7); a storage area for POL at surface soil sample locations A(35.2), B(35.2), C(35.2); and boring SB-15. Concentrations of petroleum were detected in the surface soil at depths of zero to 0.5 ft. No concentrations were detected in the subsurface soils in this area. Petroleum hydrocarbons also were analyzed for at sample location A(23.9), the area outside of Building 995 that is associated with the location of a gasoline spill. There were no detects in the surface soil, but there was a detected concentration of 3.2 mg/kg in the subsurface soil at a depth of zero to 4 ft. Concentrations of petroleum hydrocarbons were not detected at the lower sample interval depths of 4 to 7 ft and 7 to10 ft in this area.

Background values were not established for petroleum hydrocarbons, but the detected concentrations in the three surface soil samples (ranging from 35.8 mg/kg to 274 mg/kg) exceeded the Region III RBC direct exposure value of 34 mg/kg. The GWP value of 340 mg/kg was not exceeded in the subsurface sample detection.

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16.5 Nature and Extent of Surface Water Contamination

Stormwater in FU3 is routed by drop inlets to the underground drainage pipe system and flows north, where it is discharged to Tarrant Branch at Gate 9 (Outfall 5) in FU4 (Black & Veatch, 1999). Tarrant Branch discharges to Nonconnah Creek west of the Depot.

16.6 Nature and Extent of Sediment Contamination

To evaluate the environmental conditions in Building 1086, one BRAC sediment sample, A(35.3), was collected from the sump located in Building 1086, which houses a spray paint booth. Contaminants detected in the sump sediment at Building 1086 are listed in Table 16-10 and include metals (antimony, cadmium, copper, lead, nickel, and zinc) and an SVOC (naphthalene). Naphthalene is a solvent commonly used for cleaning paint equipment; it also is a constituent in various paints. These sediments are beneath a grate and are not subject to direct surface water transportation because they are within a covered building. Therefore, the sediments do not present a direct exposure to humans or aquatic organisms.

TABLE 16-1
Sampling Rationale at FU3
Memphis Depot Main Installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media*
RI 27 - Former Recoupment Area (Building S-873)	Assess the vertical and horizontal extent of soil contamination at the southeastern corner of Building S-873	Confirm the presence of chemicals of concern detected in the 1996-1997 sampling event, Assess the extent of contamination along the foundation of the building and delineate the horizontal contamination	39 Surface Soil 20 Subsurface Soil
RI 32 - Sandblasting Waste Accumulation Area	Assess the vertical and horizontal extent of soil contamination in and around Buildings 1087 and 1088	Delineate horizontal contamination of metals, PAHs, and pesticides and provide a consistent data set, assess surface soil depth distribution of contamination to evaluate quantities for remediation	7 Surface Soil 2 Subsurface Soil
Screening Site 31 - Former Paint Spray Booth (Building 1087)	Assess the vertical and horizontal extent of soil contamination in and around Building 1088	Delineate horizontal contamination of metals, PAHs, and pesticides and provide a consistent data set, assess surface soil depth distribution of contamination to evaluate quantities for remediation	6 Surface Soil 8 Subsurface Soil
Screening Site 33 - Sandblasting Waste Drum Storage Area	Assess the vertical and horizontal extent of soil contamination in and around Buildings 1087 and 1088	Delineate horizontal contamination of metals, PAHs, and pesticides and provide a consistent data set, assess surface soil depth distribution of contamination to evaluate quantities for remediation	4 Surface Soil 12 Subsurface Soil
RI 34 - Building 770 Underground Oil Storage Tanks	Assess the vertical and horizontal extent of soil contamination near Building 770	Delineate the lateral extent of PAH contamination in surface soil	9 Surface Soil 12 Subsurface Soil
Screening Site 70/71 – All Railroad Tracks	Evaluate whether releases have occurred to surface soils and subsurface soils.	Further delineate PAH contamination in surface soils based on previous sampling	21 Surface Soil 2 Subsurface Soil
Screening Site 73 – All Grassed Areas	Evaluate whether releases have occurred to surface soil from past pesticide use	No additional environmental sampling was necessary	5 Surface Soil
Screening Site 82 - Flammables (Building 783 and 793)	Assess the vertical and horizontal extent of soil contamination near Buildings 783 and 793	No additional environmental sampling was necessary	2 Surface Soil 24 Subsurface Soil
Screening Site 84 - Flammables, Solvents, Waste Oil, etc (Building 972)	Assess the vertical and horizontal extent of soil contamination near Building 972	Assess the lateral extent of PAHs in surface soil and analyze one sample for TAL/TCL to support the risk assessment	8 Surface Soil 12 Subsurface Soil

TABLE 16-1
Sampling Rationale at FU3
Memphis Depot Main Installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media*
Screening Site 89 - Acids (Building 1089)	Assess the vertical and horizontal extent of soil contamination around Building 1089	Assess the effect of elevated chromium in subsurface soil to groundwater and assess the lateral extent of metals in surface soil	17 Surface Soil 13 Subsurface Soil
TEC 90 - Old Pond Area	Site not identified at this time	Evaluate evidence of a pond bottom with 2 Rotosonic cores and sample area of pond where runoff from a pile of mounded material may have occurred.	3 Subsurface Soil
TEC 93 - Mallory Avenue Ground Scar	Site not identified at this time	Analyze surface soil for TCL/TAL	1 Surface Soil
BRAC - Parcels 23, 24, 25, 26, 27, 28, and 35	Assess the environmental condition of soil in Parcels 23, 24, 25, 26, 27, 28, and 35	Delineate the lateral extent of PAH contamination in surface soil and assess surface soil quantities for remediation	17 Surface Soil 18 Subsurface Soil 1 Sediment

Notes
RI - Remedial Investigation Site
BRAC - Baseline Realignment and Closure Site
SS–Surface Soil Sample
SB–Subsurface Soil Sample
SE–Sediment Sample
SW–Surface Water Sample
TEC–Topographic Engineering Center
* Groundwater samples were collected throughout the Main Installation and are identified under FU7, which is discussed in Section 32 0

TABLE 16-2
Analytes Investigated for FU3
Memphis Depot Main Installation RI

Functional Unit	Site	Matrix[1]	Event	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	OC Pesticides	OC Pesticides, TCLP	OC Pesticides/PCB	OC Pesticides/PCBs	PAHs	Pet_ Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
7	GW	GW	GW[2]		X					X								X		X
3	27	SB	MAINRIFS[3]												X					
3	27	SB	RI[4]							X				X	X					X
3	27	SS	MAINRIFS		X	X				X					X				X	
3	27	SS	RI							X				X	X			X		X
3	31	SB	SS[5]							X				X	X					X
3	31	SS	SS							X				X	X			X		X
3	32	SB	RI							X				X	X					
3	32	SS	RI							X				X	X			X		X
3	33	SB	SS							X				X						X
3	33	SS	MAINRIFS		X	X			X	X	X				X			X		X
3	33	SS	SS							X				X				X		X
3	34	SB	RI							X				X	X			X		X
3	34	SS	MAINRIFS												X					
3	34	SS	RI							X					X					X
3	70	SB	SS							X				X				X		X
3	82	SB	SS	X						X				X				X		X
3	82	SS	SS	X						X				X				X		X
3	84	SB	SS							X				X				X		X
3	84	SS	MAINRIFS							X	X				X			X		X
3	84	SS	SS							X				X				X		X
3	87	SS	MAINRIFS		X	X					X	X								
3	89	SB	MAINRIFS							X										
3	89	SB	SS							X										X
3	89	SS	MAINRIFS		X	X			X	X										
3	89	SS	SS		X					X				X				X		X
3	90	SB	MAINRIFS							X	X							X		X
3	93	SS	MAINRIFS							X	X				X					
3	BRAC	SB	BRAC[6]							X				X		X		X		X
3	BRAC	SE	BRAC							X						X		X		
3	BRAC	SS	BRAC							X				X		X		X		X
3	BRAC	SS	MAINRIFS		X	X									X				X	

Notes

[1]Matrix	GW-groundwater, SB-subsurface soil, SS-surface soil, SE-sump sediment
[2]GW	Groundwater sampled in March 1996, March 1997, September 1997, June 1998, and October 1998
[3]MAINRIFS	Additional samples for RI, BRAC and Screening Sites (and initial investigations for TEC sites) collected in September and October 1998
[4]RI	RI Sites sampled in December 1996 and January 1997
[5]SS	Screening Sites sampled in December 1996 and January 1997
[6]BRAC	Base Realignment and Closure

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TABLE 16-3

Frequency of Metals Detection in Surface and Subsurface Soil at FU3

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALUMINUM	30	30	2,820	J	13,600	=	23,810	0
SS	ANTIMONY	119	31	0 230	J	22 3	=	7 00	2
SS	ARSENIC	125	122	0 430	J	49 2	=	20 0	11
SS	BARIUM	30	30	28 7	=	432	=	234	2
SS	BERYLLIUM	125	57	0 050	J	2 00	=	1 10	1
SS	CADMIUM	125	61	0 080	J	8 10	=	1 40	15
SS	CALCIUM	30	30	951	=	227,000	=	5,840	19
SS	CHROMIUM III	5	5	13 1	=	403	=		
SS	CHROMIUM, TOTAL	125	125	5 50	J	915	=	24 8	66
SS	COBALT	30	30	0 880	J	8 80	J	18 3	0
SS	COPPER	125	123	4 10	=	235	=	33 5	37
SS	IRON	30	30	3,960	=	51,300	=	37,040	2
SS	LEAD	125	125	2 80	J	4,150	=	30 0	77
SS	MAGNESIUM	30	30	263	J	10,900	=	4,600	4
SS	MANGANESE	30	30	60 2	=	634	=	1,304	0
SS	MERCURY	125	32	0 015	J	2 10	=	0 400	1
SS	NICKEL	125	125	3 20	=	76 3	=	30 0	21
SS	POTASSIUM	30	29	190	J	4,650	J	1,820	4
SS	SELENIUM	125	36	0 290	=	9 50	J	0 800	29
SS	SILVER	125	3	0 310	J	2 50	=	2 00	1
SS	SODIUM	30	9	62 1	J	863	J		
SS	VANADIUM	30	30	6 80	=	76 7	=	48 4	2
SS	ZINC	125	125	20 9	=	4,000	=	126	55
Subsurface Soil									
SB	ALUMINUM	21	21	5,990	J	19,500	J	21,829	0
SB	ANTIMONY	103	3	0 740	J	7 80	=		
SB	ARSENIC	106	101	2 10	=	26 5	=	17 0	17
SB	BARIUM	21	21	58 7	J	240	=	300	0
SB	BERYLLIUM	106	44	0 100	J	1 70	=	1 20	9
SB	CADMIUM	106	13	0 070	J	1 50	=	1 40	1
SB	CALCIUM	21	21	912	=	50,300	=	2,432	3
SB	CHROMIUM, TOTAL	106	106	2 10	=	102	=	26 4	42
SB	COBALT	21	21	2 70	J	10 0	=	20 4	0
SB	COPPER	106	103	2 50	J	49 3	=	32 7	16
SB	IRON	21	21	11,100	=	24,200	=	38,480	0
SB	LEAD	106	106	1 10	=	282	=	23 9	17
SB	MAGNESIUM	21	21	816	=	7,760	=	4,900	1
SB	MANGANESE	21	21	206	J	1,170	J	1,540	0
SB	MERCURY	106	3	0 030	J	0 050	=	0 200	0
SB	NICKEL	106	105	0 570	J	48 2	=	36 6	9
SB	POTASSIUM	21	18	625	=	3,190	=	1,800	6
SB	SELENIUM	106	10	0 360	J	2 30	=	0 600	8
SB	SILVER	106	1	0 380	J	0 380	J	1 00	0
SB	VANADIUM	21	21	13 8	J	38 4	=	51 3	0
SB	ZINC	106	106	1 70	J	145	=	114	8

Notes

All units are mg/kg

TABLE 16-4

Frequency of SVOC Detections in Surface and Subsurface Soil in FU3

Memphis Depot Main Installation RI

Matrix	Chem Group	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil										
SS	PAH	**Total Polynuclear Aromatic Hydrocarbons**	**107**	**51**	8 50E-02	J	4 55E+02	=		
SS	PAH	2-METHYLNAPHTHALENE	107	2	0 084	J	0 510	=		
SS	PAH	ACENAPHTHENE	107	12	0 063	J	5 000	J		
SS	PAH	ACENAPHTHYLENE	107	2	0 088	J	0 140	=	0 190	0
SS	PAH	ANTHRACENE	107	14	0 070	=	11 000	J	0 096	12
SS	PAH	**BENZO(a)ANTHRACENE**	**107**	**43**	0 039	J	40 000	=	0 710	13
SS	PAH	**BENZO(a)PYRENE**	**107**	**42**	0 039	J	37 000	=	0 960	11
SS	PAH	**BENZO(b)FLUORANTHENE**	**107**	**43**	0 038	J	39 000	=	0 900	12
SS	PAH	**BENZO(g,h,i)PERYLENE**	**107**	**35**	0 037	J	22 000	=	0 820	8
SS	PAH	**BENZO(k)FLUORANTHENE**	**107**	**41**	0 043	J	34 000	=	0 780	12
SS	PAH	**CHRYSENE**	**107**	**45**	0 043	J	46 000	=	0 940	11
SS	PAH	DIBENZ(a,h)ANTHRACENE	107	2	0 210	=	1 200	=	0 260	1
SS	PAH	**FLUORANTHENE**	**107**	**50**	0 040	J	71 000	=	1 600	12
SS	PAH	FLUORENE	107	14	0 056	J	4 800	J		
SS	PAH	**INDENO(1,2,3-c,d)PYRENE**	**107**	**36**	0 048	J	22 000	=	0 700	11
SS	PAH	**NAPHTHALENE**	**107**	**4**	0 085	J	0 630	J		
SS	PAH	**PHENANTHRENE**	**107**	**44**	0 043	J	52 000	=	0 610	18
SS	PAH	**PYRENE**	**107**	**49**	0 043	J	71 000	=	1 500	11
SS	SVOC	BENZYL BUTYL PHTHALATE	37	1	0 083	J	0 083	J	0 645	0
SS	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	37	11	0 040	J	5 600	=		
SS	PAH	CARBAZOLE	37	7	0 080	J	10 000	J	0 067	7
SS	SVOC	DIETHYL PHTHALATE	37	1	0 900	=	0 900	=		
SS	SVOC	DI-n-BUTYL PHTHALATE	37	1	0 180	J	0 180	J		
SS	SVOC	PENTACHLOROPHENOL	37	1	0 680	=	0 680	=		
Subsurface Soil										
SB	PAH	Total Polynuclear Aromatic Hydrocarbons	89	5	1 76E-01	J	1 53E+01	=		
SB	PAH	2-METHYLNAPHTHALENE	89	1	0 057	J	0 057	J		
SB	PAH	ACENAPHTHENE	89	1	0 480	=	0 480	=		
SB	PAH	ANTHRACENE	89	1	0 670	=	0 670	=		
SB	PAH	BENZO(a)ANTHRACENE	89	4	0 044	J	1 200	=		
SB	PAH	BENZO(a)PYRENE	89	3	0 080	J	1 000	=		
SB	PAH	BENZO(b)FLUORANTHENE	89	3	0 088	J	1 000	=		
SB	PAH	BENZO(g,h,i)PERYLENE	89	3	0 100	J	0 710	=		
SB	PAH	BENZO(k)FLUORANTHENE	89	3	0 081	J	0 720	=		
SB	PAH	CHRYSENE	89	5	0 043	J	1 200	=		
SB	PAH	FLUORANTHENE	89	4	0 069	J	2 400	=		
SB	PAH	FLUORENE	89	2	0 150	=	0 380	J		
SB	PAH	INDENO(1,2,3-c,d)PYRENE	89	2	0 090	J	0 670	=		
SB	PAH	NAPHTHALENE	89	1	0 240	J	0 240	J		
SB	PAH	PHENANTHRENE	89	3	0 056	J	2 200	=		
SB	PAH	PYRENE	89	4	0 064	J	2 400	=		
SB	SVOC	BENZYL BUTYL PHTHALATE	45	1	0 510	=	0 510	=		
SB	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	45	17	0 045	J	7 800	=		
SB	PAH	CARBAZOLE	45	1	0 480	=	0 480	=		
SB	SVOC	DI-n-BUTYL PHTHALATE	45	4	0 075	J	1 200	=		

Notes

Bolded PAHs were detected in railroad track samples or throughout FU3

Background values were not detected for most SVOCs in subsurface soil

All units are mg/kg

TABLE 16-5
PAH Detections from Asphalt and Railroad Track Samples
Memphis Depot Main Installation RI

Analyzed PAH Compound	Roadway Asphalt Samples				Railroad Tie Samples			
	Station RD57A		Station RD65A		Station RR57A		Station RR65A	
	Result	Q	Result	Q	Result	Q	Result	Q
1-METHYLNAPHTHALENE	250	U	250	U	760	U	51	U
2-METHYLNAPHTHALENE	250	U	250	U	380	J	51	U
ACENAPHTHENE	250	U	250	U	**880**	=	41	J
ACENAPHTHYLENE	250	U	250	U	760	U	51	U
ANTHRACENE	250	U	250	U	300	J	38	J
BENZO(a)ANTHRACENE	250	U	250	U	760	U	**66**	=
BENZO(a)PYRENE	250	U	250	U	760	U	51	U
BENZO(b)FLUORANTHENE	250	U	250	U	760	U	51	U
BENZO(g,h,i)PERYLENE	250	U	250	U	760	U	51	U
BENZO(k)FLUORANTHENE	250	U	250	U	760	U	51	U
CHRYSENE	250	U	250	U	760	U	**78**	=
DIBENZ(a,h)ANTHRACENE	250	U	250	U	760	U	51	U
FLUORANTHENE	250	U	250	U	**830**	=	**290**	=
FLUORENE	250	U	250	U	740	J	39	J
INDENO(1,2,3-c,d)PYRENE	250	U	250	U	760	U	51	U
NAPHTHALENE	250	U	250	U	**1000**	=	51	U
PHENANTHRENE	250	U	250	U	**2600**	=	**270**	=
PYRENE	250	U	250	U	630	J	**220**	=
Note: All units are mg/kg								

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TABLE 16-6

Frequency of PAH Detections Near Railroad Tracks at FU3

Memphis Depot Main Installation RI

Matrix	Functional Unit	ChemGroup	Parameter	Number Analyzed	Number FU3 Detections	Number FU10 Detection3	Ratio FU10 FU3 (Percent)
SS	3	PAH	Total Polynuclear Aromatic Hydrocarbons	107	51	8	16%
SS	3	PAH	2-METHYLNAPHTHALENE	107	2	1	50%
SS	3	PAH	ACENAPHTHENE	107	12	3	25%
SS	3	PAH	ACENAPHTHYLENE	107	2	1	50%
SS	3	PAH	ANTHRACENE	107	14	3	21%
SS	3	PAH	BENZO(a)ANTHRACENE[1 2]	107	43	8	19%
SS	3	PAH	BENZO(a)PYRENE[2]	107	42	8	19%
SS	3	PAH	BENZO(b)FLUORANTHENE[2]	107	43	8	19%
SS	3	PAH	BENZO(g,h,i)PERYLENE[2]	107	35	5	14%
SS	3	PAH	BENZO(k)FLUORANTHENE[2]	107	41	8	20%
SS	3	PAH	CHRYSENE[1]	107	45	8	18%
SS	3	PAH	DIBENZ(a,h)ANTHRACENE	107	2	0	0%
SS	3	PAH	FLUORANTHENE[1]	107	50	8	16%
SS	3	PAH	FLUORENE	107	14	3	21%
SS	3	PAH	INDENO(1,2,3-c,d)PYRENE[2]	107	36	6	17%
SS	3	PAH	NAPHTHALENE[1]	107	4	1	25%
SS	3	PAH	PHENANTHRENE[1]	107	44	7	16%
SS	3	PAH	PYRENE[1]	107	49	8	16%

Notes:

[1] These PAHs were detected in railroad track samples

[2] These PAHs were detected throughout FU 3 and the Main Installation

[3] FU10 detections represent those samples collected near railroad tracks throughout the Main Installation
In this table, FU10 detections are presented for those samples collected within FU3

TABLE 16-7

Frequency of Pesticides Detections in Surface and Subsurface Soil in FU3

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Units	Background Value	Number Background Exceedances
Surface Soil										
SS	ALPHA-CHLORDANE	80	15	0 0014	J	0 610	=	MG/KG	0 0290	9
SS	DDD	80	4	0 0290	J	0 046	=	MG/KG	0 0067	4
SS	DDE	80	33	0 0014	J	0 170	J	MG/KG	0 1600	1
SS	DDT	80	39	0 0020	J	0 410	=	MG/KG	0 0740	14
SS	DIELDRIN	80	24	0 0012	J	0 180	=	MG/KG	0 0860	2
SS	GAMMA-CHLORDANE	80	15	0 0017	J	0 580	=	MG/KG	0 0260	10
SS	HEPTACHLOR	80	1	0 0350	J	0 035	J	MG/KG		
Subsurface Soil										
SB	DDE	59	1	0 0400	=	0 040	=	MG/KG	0 0015	1
SB	DDT	59	1	0 0079	=	0 008	=	MG/KG	0 0072	1
SB	DIELDRIN	59	1	0 0049	J	0 005	J	MG/KG	0 3700	0

TABLE 16-8

Frequency of Dioxins/Furans Detections in Surface and Subsurface Soil in FU3

Memphis Depot Main Installation RI

Matrix	Chem Group	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil										
SS	Dioxin	1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	6	6	4 00E-06	J	2 90E-04	J		
SS	Dioxin	1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	6	2	2 00E-06	J	3 00E-06	J		
SS	Dioxin	1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	6	2	4 00E-06	J	4 00E-06	J		
SS	Dioxin	1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	6	2	1 00E-06	J	2 00E-06	J		
SS	Dioxin	1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	6	1	8 00E-06	J	8 00E-06	J		
SS	Dioxin	1 2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	6	2	5 00E-06	J	5 00E-06	J		
SS	Dioxin	2 3,4,6,7,8-HEXACHLORODIBENZOFURAN	6	1	3 00E-06	J	3 00E-06	J		
SS	Dioxin	OCTACHLORODIBENZOFURAN	6	6	6 00E-06	J	0 00070	J	0 00039	2
SS	Dioxin	OCTACHLORODIBENZO-p-DIOXIN	6	6	0 0028	J	0 0103	=	0 0097	1
SS	Dioxin	TCDD Equivalent	6	6	2 83E-06	=	0 000013	=	0 000010	2
SS	Dioxin	DIBENZOFURAN	37	3	0 490	=	2 40	J	0 647	2
Subsurface Soil										
SB	Dioxin	1,2,3 4,6,7,8-HEPTACHLORODIBENZOFURAN	13	4	2 00E-06	J	3 00E-06	J		
SB	Dioxin	1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	13	1	1 00E-06	J	1 00E-06	J		
SB	Dioxin	1,2,3,7,8 9-HEXACHLORODIBENZOFURAN	13	1	2 00E-06	J	2 00E-06	J		
SB	Dioxin	1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	13	1	3 00E-06	J	3 00E-06	J		
SB	Dioxin	2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	13	1	2 00E-06	J	2 00E-06	J		
SB	Dioxin	OCTACHLORODIBENZOFURAN	13	8	2 00E-06	J	8 00E-06	J		
SB	Dioxin	OCTACHLORODIBENZO-p-DIOXIN	13	13	0 000026	J	0 0079	=	0 0094	0
SB	Dioxin	TCDD Equivalent	13	13	5 00E-08	=	7 87E-06	=	6 00E-06	1
SB	Dioxin	DIBENZOFURAN	45	1	0 190	J	0 190	J	0 720	0

Note

All units are mg/kg

TABLE 16-9

Frequency of VOC and Other Organic Detections in Surface and Subsurface Soil in FU3

Memphis Depot Main Installation RI

Matrix	Functional Unit	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil											
SS	3	VOC	2-HEXANONE	80	3	0 0010	J	0 0080	J		
SS	3	VOC	ACETONE	80	34	0 0020	J	0 1400	=		
SS	3	VOC	BENZENE	81	3	0 0010	J	0 0070	J		
SS	3	VOC	BROMOMETHANE	80	4	0 0020	J	0 0020	J		
SS	3	VOC	CARBON DISULFIDE	80	2	0 0020	J	0 0020	J	0 0020	0
SS	3	VOC	METHYL ETHYL KETONE (2-BUTANONE)	80	5	0 0020	J	0 0440	=	0 0020	4
SS	3	VOC	METHYL ISOBUTYL KETONE (4-METHYL-2 PENTANONE)	80	1	0 0020	J	0 0020	J		
SS	3	VOC	METHYLENE CHLORIDE	80	28	0 0010	J	0 0070	J		
SS	3	VOC	TOLUENE	81	5	0 0010	J	0 0040	J	0 0020	1
SS	3	VOC	Total Xylenes	81	3	0 0010	J	0 0030	J	0 0090	0
SS	3	VOC	TRICHLOROETHYLENE (TCE)	80	1	0 0010	J	0 0010	J		
SS	3	ORG	PETROLEUM HYDROCARBONS	4	4	26 3	=	274	=		
Subsurface Soil											
SB	3	VOC	2-HEXANONE	106	2	0 0010	J	0 0030	J		
SB	3	VOC	ACETONE	106	46	0 0030	J	0 1000	=		
SB	3	VOC	BENZENE	106	2	0 0010	J	0 0010	J		
SB	3	VOC	BROMOMETHANE	106	4	0 0020	J	0 0070	J		
SB	3	VOC	CARBON DISULFIDE	106	4	0 0010	J	0 0230	=	0 0020	1
SB	3	VOC	CHLOROMETHANE	106	1	0 0020	J	0 0020	J		
SB	3	VOC	METHYL ETHYL KETONE (2-BUTANONE)	106	15	0 0020	J	0 0380	=		
SB	3	VOC	METHYLENE CHLORIDE	106	28	0 0010	J	0 0040	J		
SB	3	VOC	TOLUENE	106	1	0 0040	J	0 0040	J		
SB	3	VOC	Total Xylenes	106	1	0 0020	J	0 0020	J	0 0020	0
SB	3	VOC	TRICHLOROETHYLENE (TCE)	106	5	0 0020	J	0 0100	J		
SB	3	ORG	PETROLEUM HYDROCARBONS	2	1	3 20	=	3 20	=		

Notes

Background values were not detected for most VOCs

All units are mg/kg

487 77

TABLE 16-10

Frequency of Contaminant Detections in Sump at Building 1086 (FU3)

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Metals									
SE	ALUMINUM	1	1	3,550	J	3,550	J	10,085	0
SE	ANTIMONY	1	1	28.40	J	28.4	J	8	1
SE	ARSENIC	1	1	5.90	J	5.90	J	12	0
SE	BARIUM	1	1	1,120	J	1,120	J	118	1
SE	CADMIUM	1	1	84.3	=	84.3	=	29	1
SE	CALCIUM	1	1	15,900	=	15,900	=	14,860	1
SE	CHROMIUM, TOTAL	1	1	1,700	J	1,700	J	20	1
SE	COBALT	1	1	44.4	J	44.4	J	14	1
SE	COPPER	1	1	153	J	153	J	58	1
SE	IRON	1	1	24,700	J	24,700	J	23,080	1
SE	LEAD	1	1	3,820	J	3,820	J	35	1
SE	MAGNESIUM	1	1	1,590	=	1,590	=	2,440	0
SE	MANGANESE	1	1	224	J	224	J	871	0
SE	MERCURY	1	1	0.100	J	0.100	J	4	0
SE	NICKEL	1	1	30	=	30	=	31	0
SE	POTASSIUM	1	1	173	J	173	J	1,560	0
SE	SODIUM	1	1	1,330	J	1,330	J	240	1
SE	VANADIUM	1	1	0.100	J	0.100	J	30	0
SE	ZINC	1	1	2,550	J	2,550	J	797	1
Organics									
SE	PETROLEUM HYDROCARBONS	1	1	5,980	=	5,980	=		–
SE	Total Polynuclear Aromatic Hydrocarbons	1	1	29	=	29	=		
PAHs									
SE	2-METHYLNAPHTHALENE	1	1	8.20	=	8.20	=		
SE	ACENAPHTHENE	1	1	0.39	J	0.390	J	0.77	0
SE	ANTHRACENE	1	1	0.51	J	0.510	J	1.60	0
SE	BENZO(a)ANTHRACENE	1	1	1.20	J	1.20	J	2.90	0
SE	BENZO(a)PYRENE	1	1	0.84	J	0.84	J	2.50	0
SE	BENZO(b)FLUORANTHENE	1	1	1.40	J	1.40	J	2.22	0
SE	BENZO(k)FLUORANTHENE	1	1	1.10	J	1.10	J	2.30	0
SE	CHRYSENE	1	1	1.60	J	1.60	J	3.20	0
SE	FLUORANTHENE	1	1	2.40	J	2.40	J	7.10	0
SE	FLUORENE	1	1	0.70	J	0.70	J	0.87	0
SE	NAPHTHALENE	1	1	5.50	=	5.50	=	0.13	1
SE	PHENANTHRENE	1	1	3.10	=	3.10	=	6.90	0
SE	PYRENE	1	1	2.20	J	2.20	J	2.88	0
SVOCs									
SE	2,4-DIMETHYLPHENOL	1	1	16.0	=	16.0	=		
SE	bis(2-ETHYLHEXYL) PHTHALATE	1	1	12.0	J	12.0	J	0.48	1
SE	CARBAZOLE	1	1	0.400	J	0.400	J	1.10	0
SE	ISOPHORONE	1	1	0.400	J	0.400	J		

Note

All units are mg/kg

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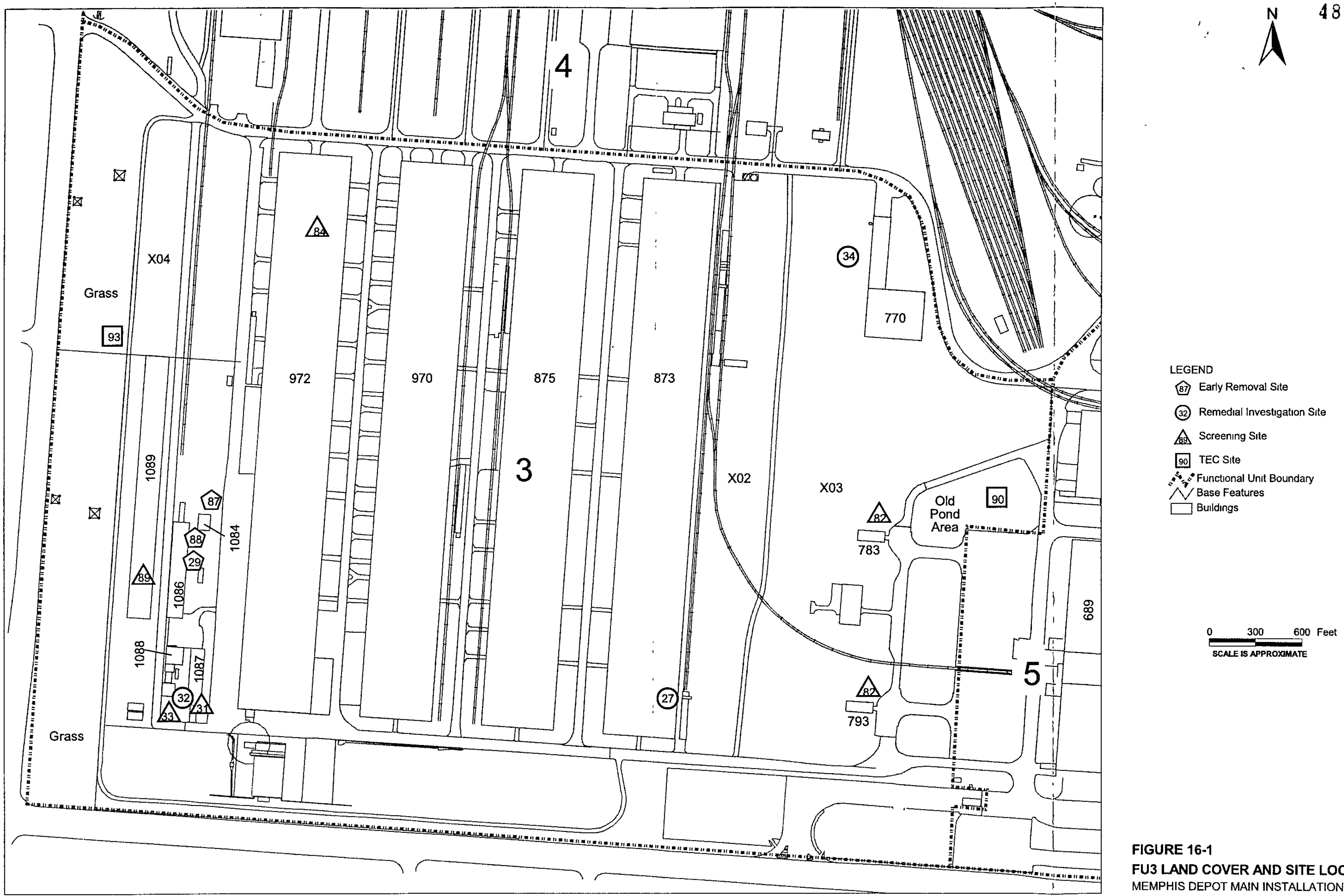
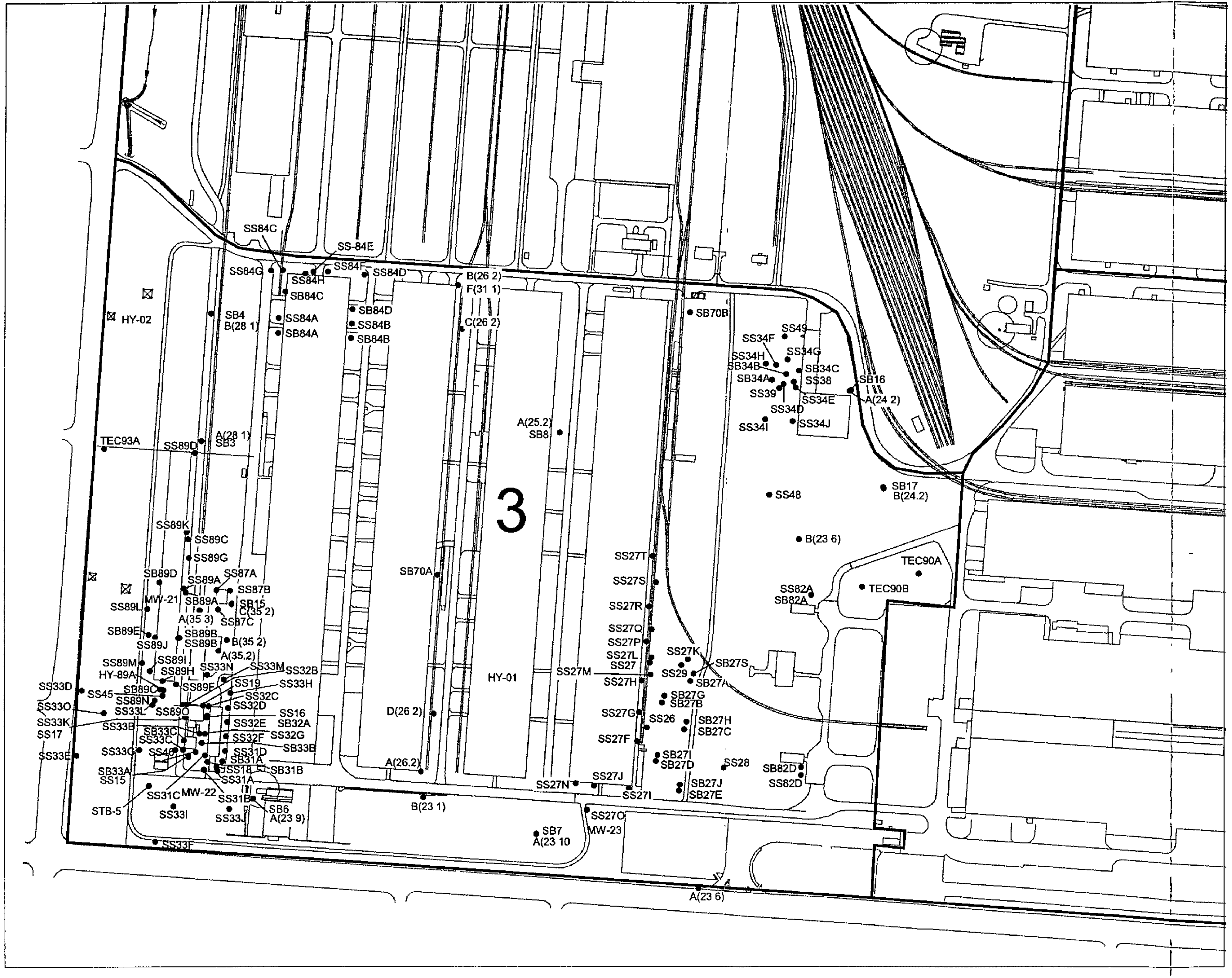


FIGURE 16-1
FU3 LAND COVER AND SITE LOCATIONS
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL



LEGEND

- ● Sample Location
- ── Functional Unit Boundary

FIGURE 16-2
SAMPLE LOCATIONS IN FUNCTIONAL UNIT 3
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

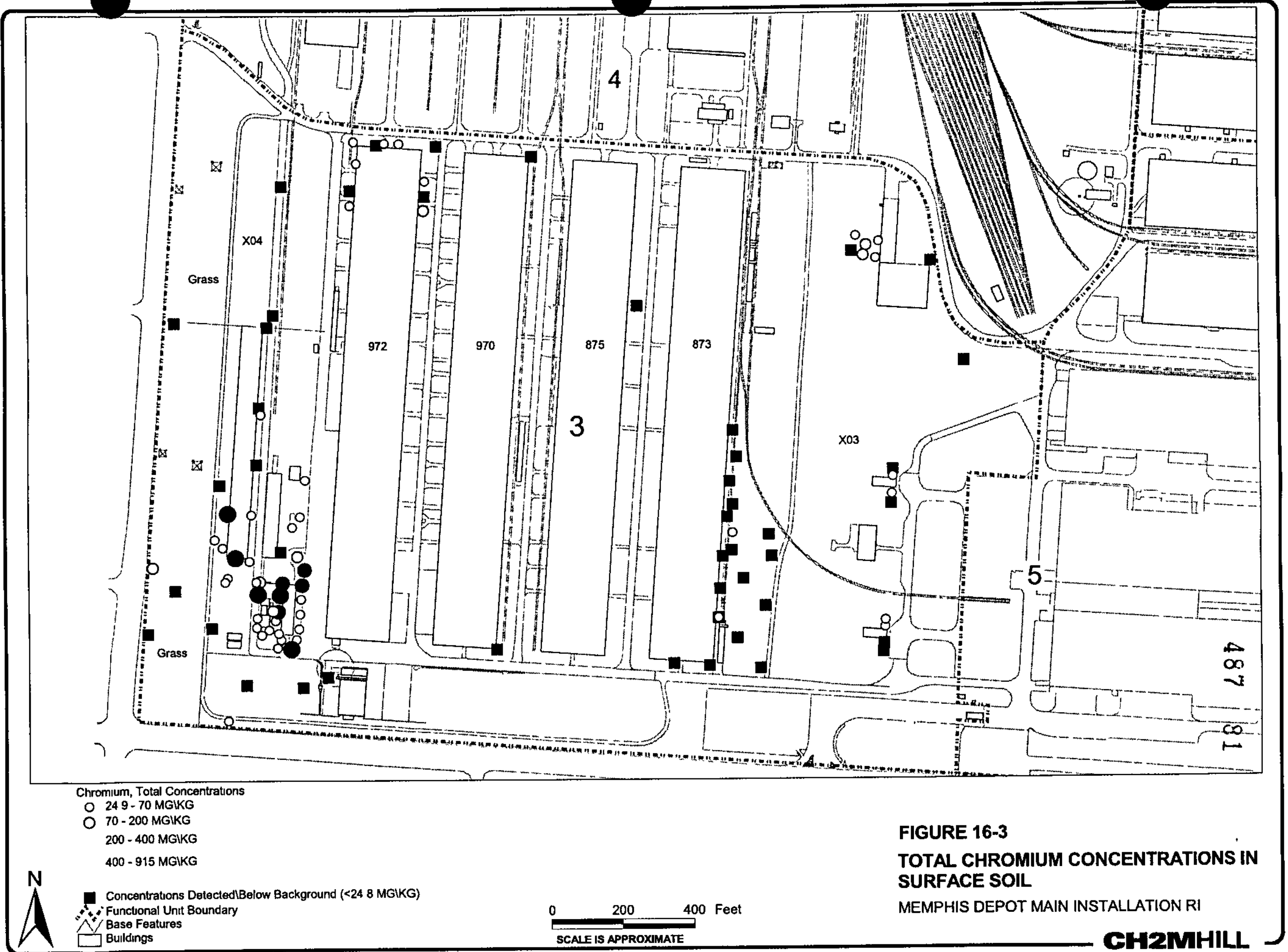


FIGURE 16-3
TOTAL CHROMIUM CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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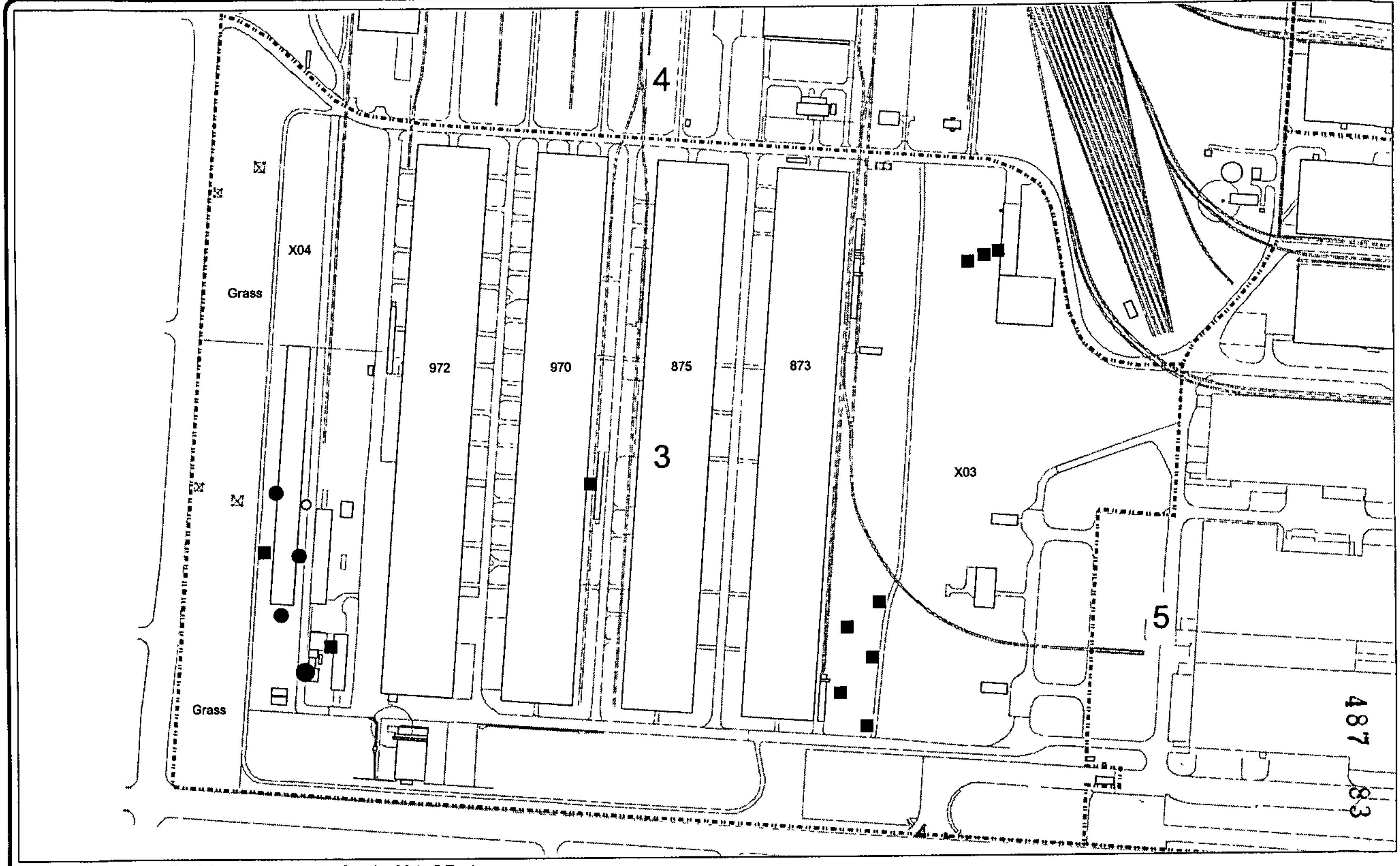

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FIGURE 16-4

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 3-5 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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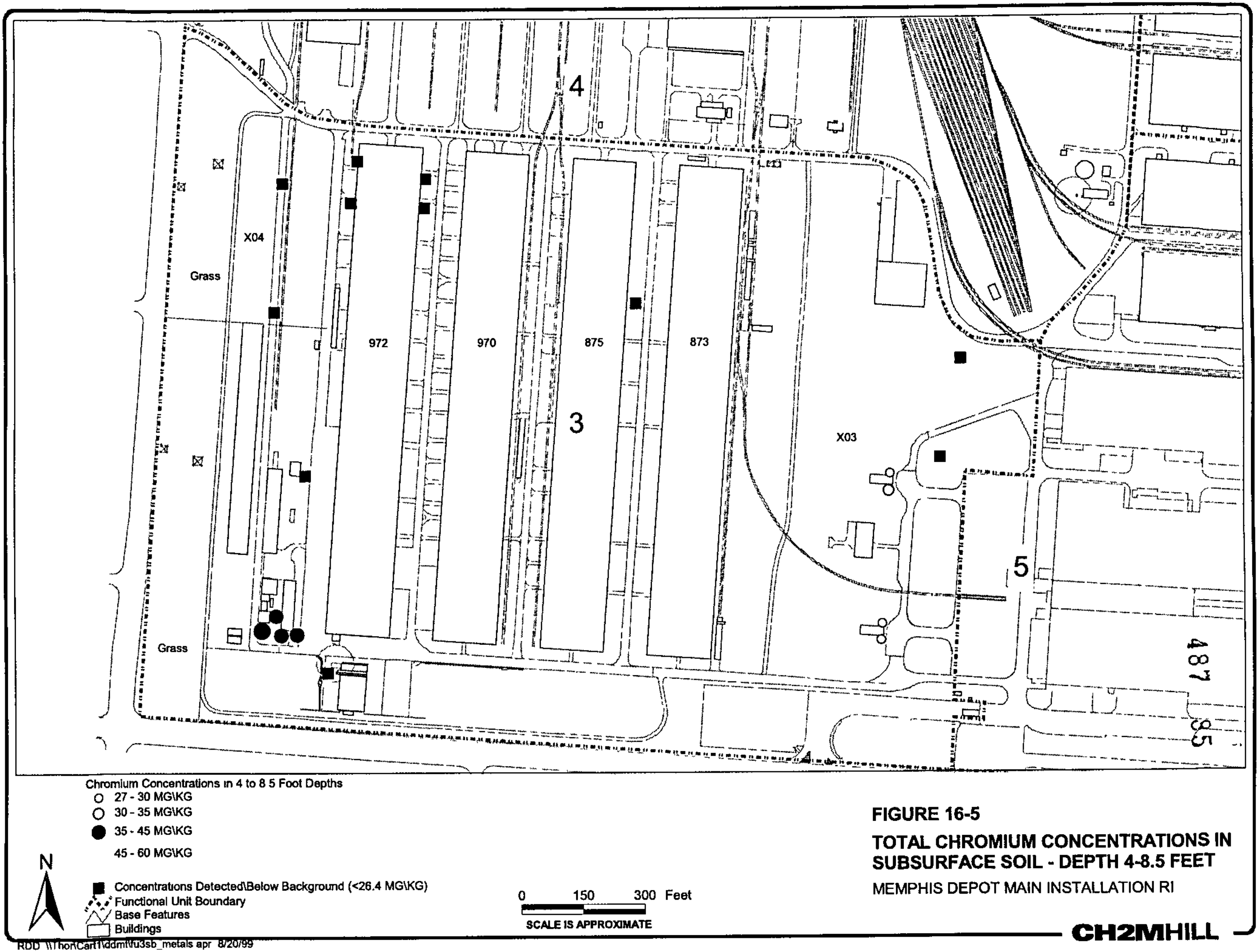

FIGURE 16-5

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-8.5 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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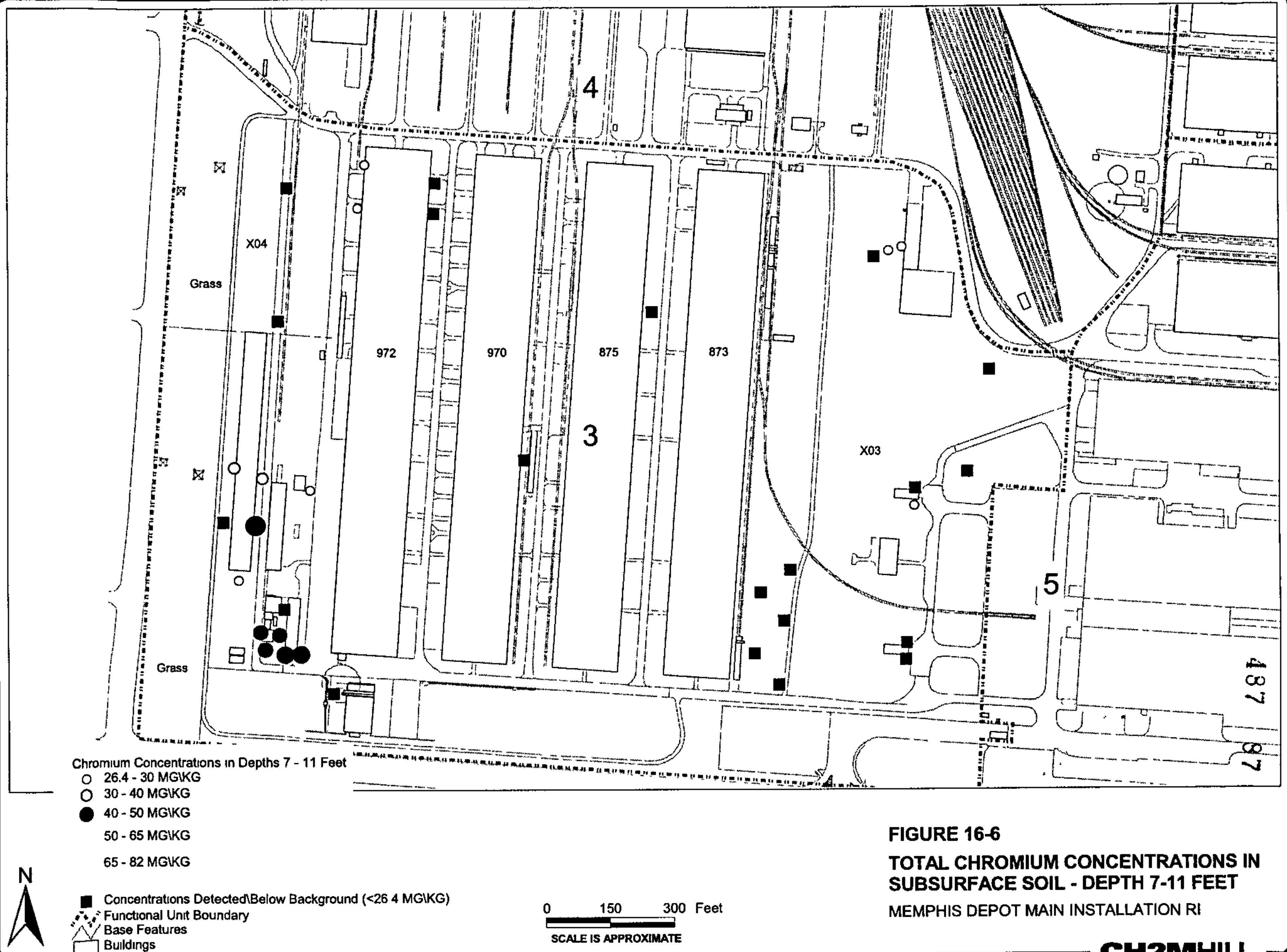

FIGURE 16-6

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 7-11 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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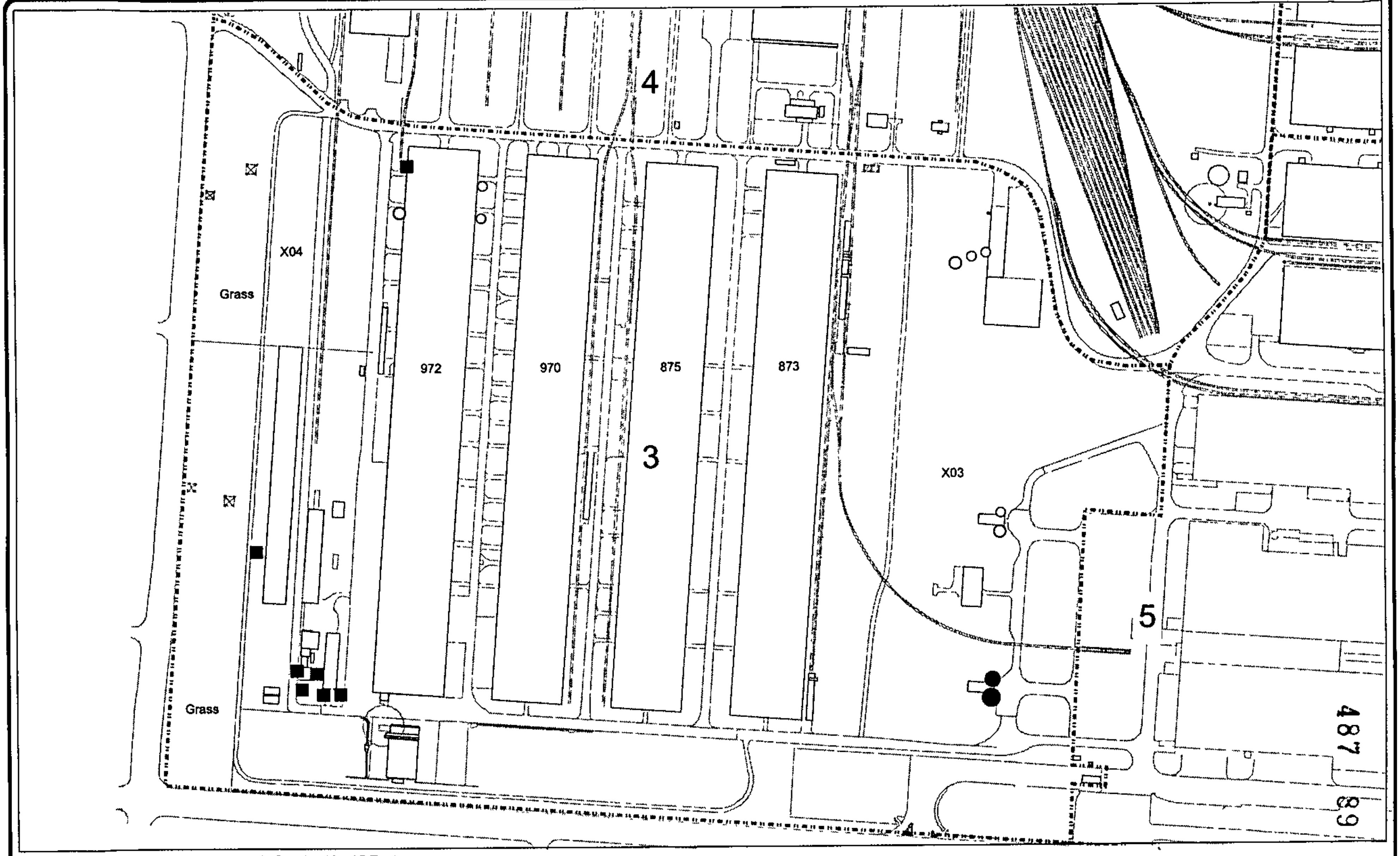

FIGURE 16-7

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 13-15 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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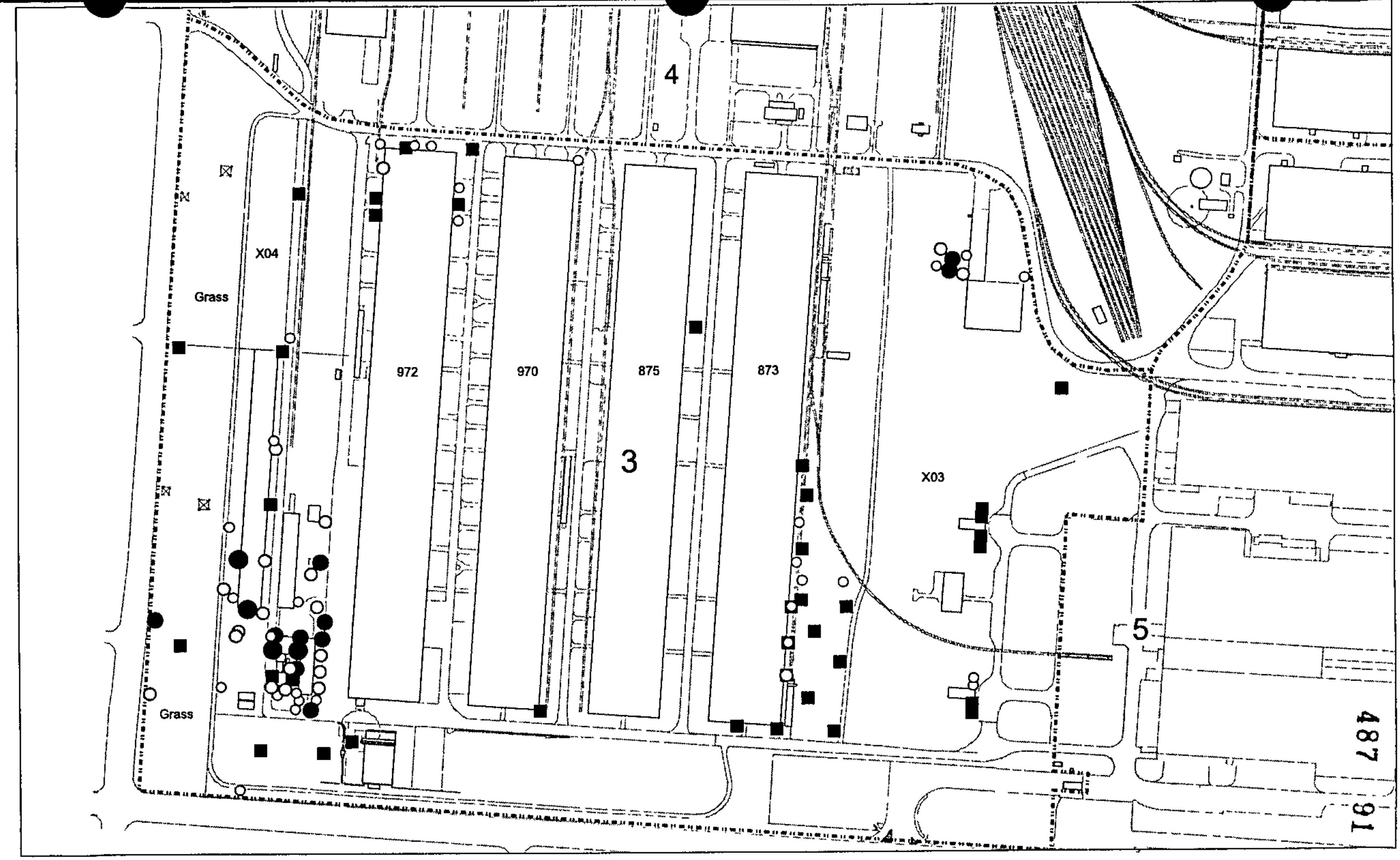

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FIGURE 16-8
LEAD CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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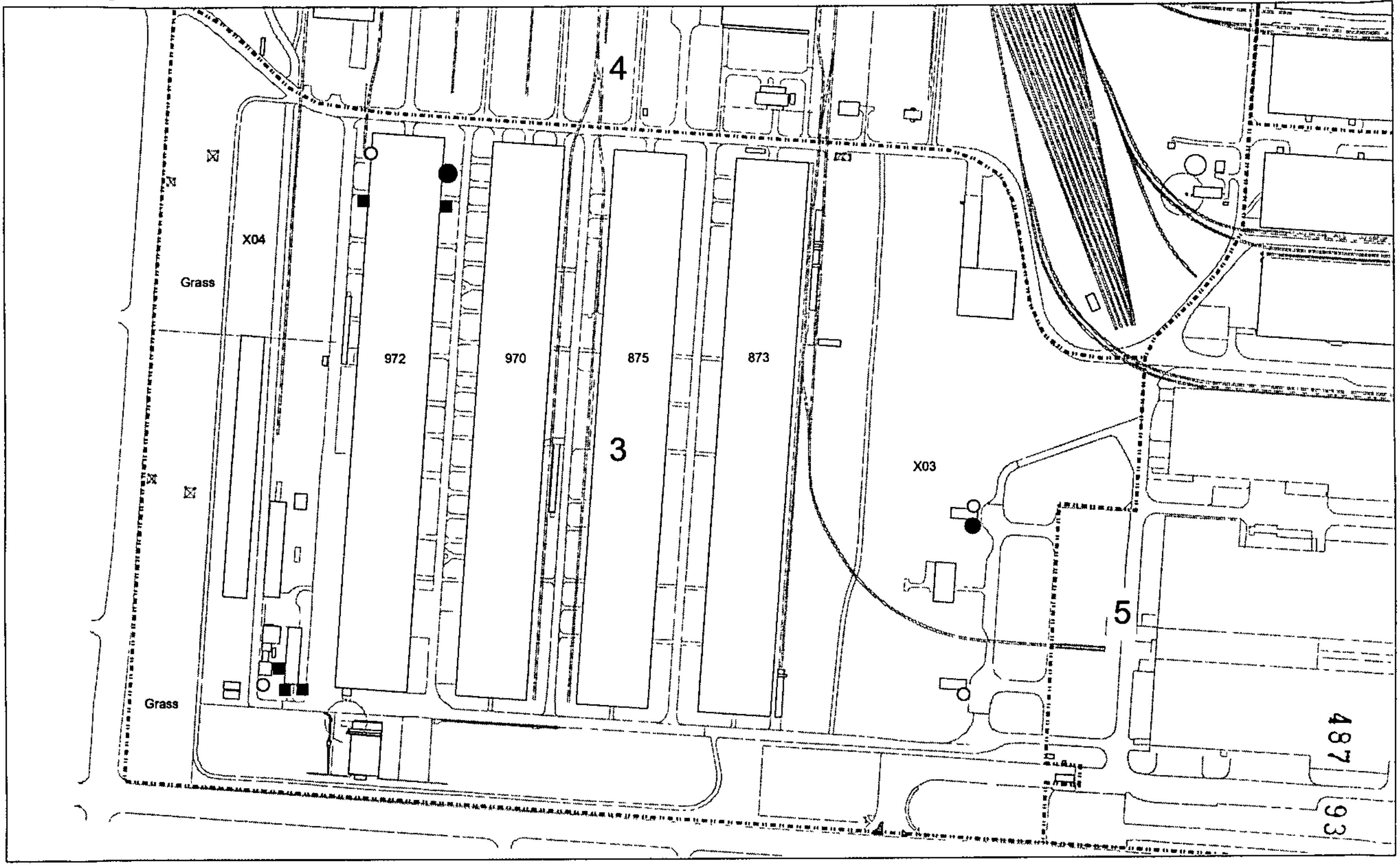

Lead Concentrations Depth 4-6 Feet
○ 25.5 - 30 MG\KG
● 30 - 32 MG\KG
282 MG\KG

■ Concentrations Detected\Below Background (<23.9 MG\KG)
Functional Unit Boundary
Base Features
Buildings

N

0 200 400 Feet
SCALE IS APPROXIMATE

FIGURE 16-9

LEAD CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-8 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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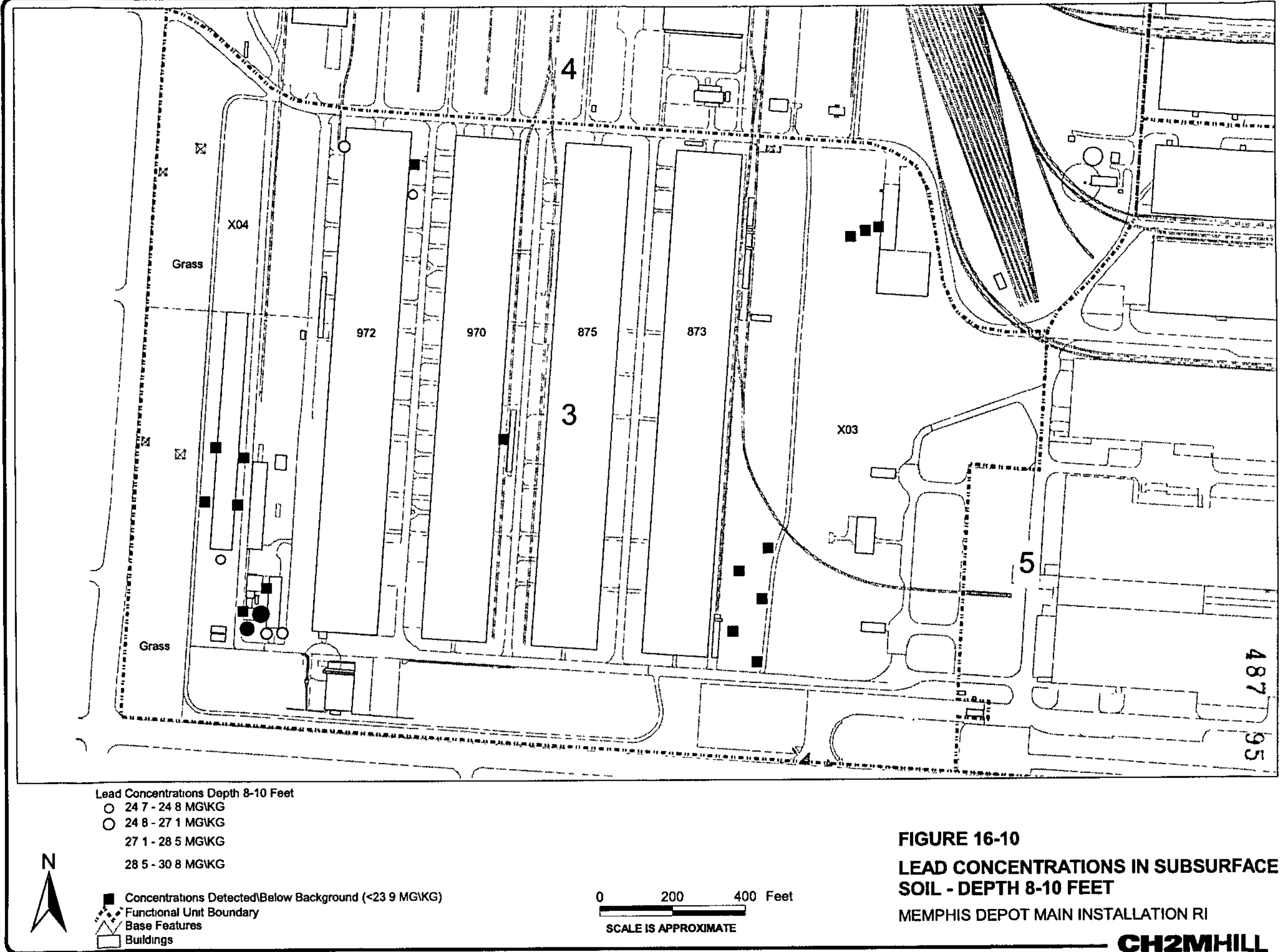

FIGURE 16-10

LEAD CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 8-10 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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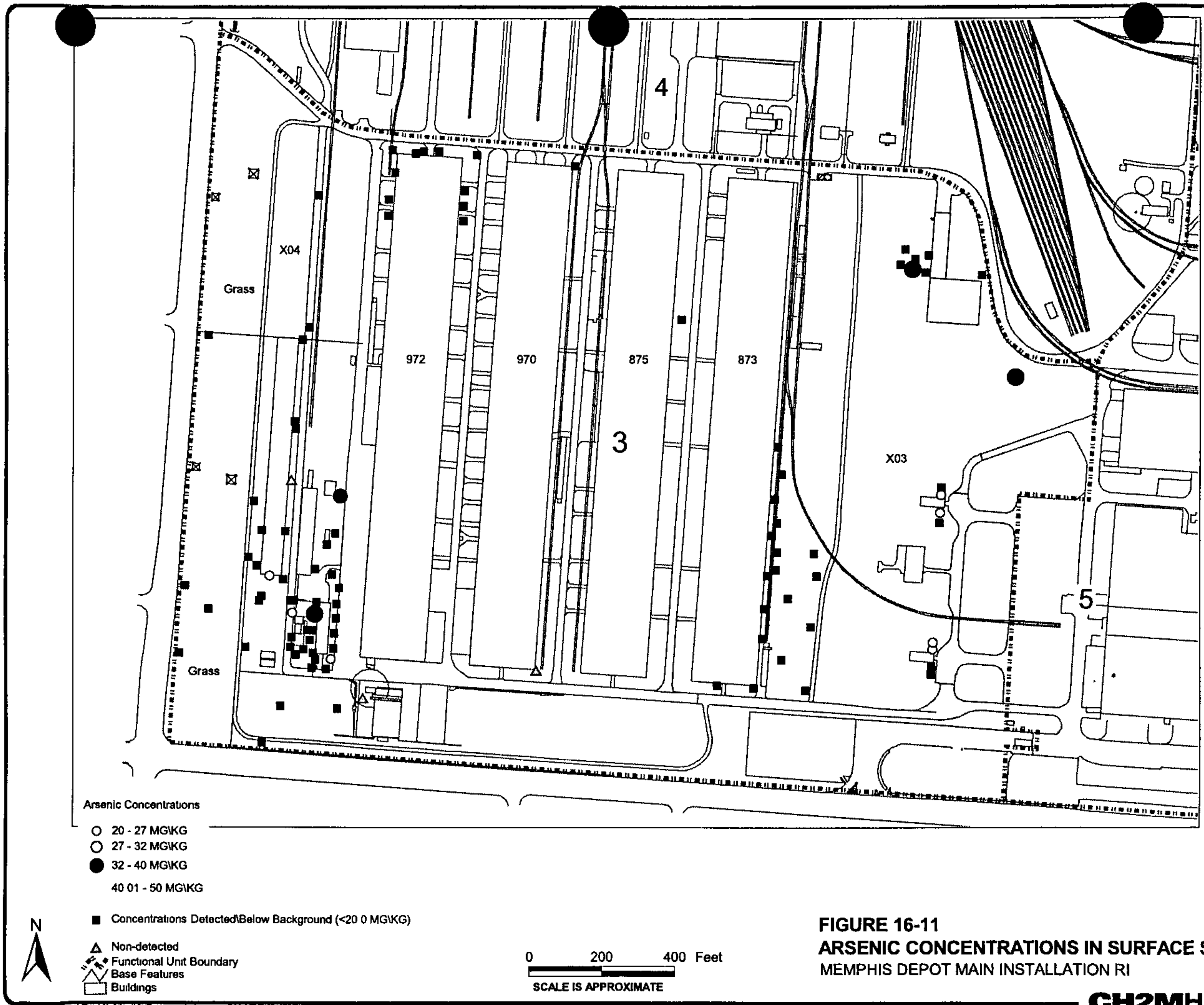

FIGURE 16-11
ARSENIC CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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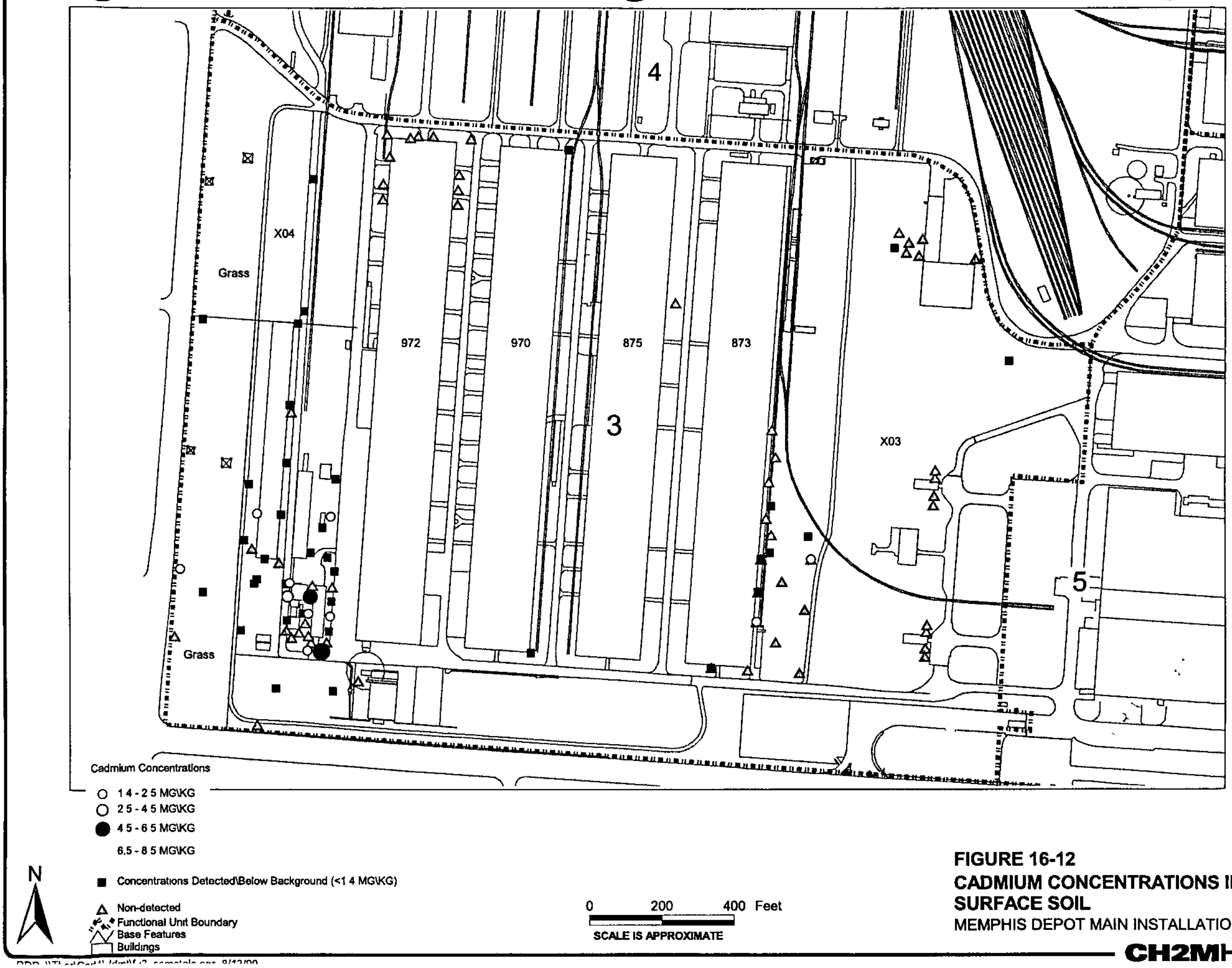

FIGURE 16-12
CADMIUM CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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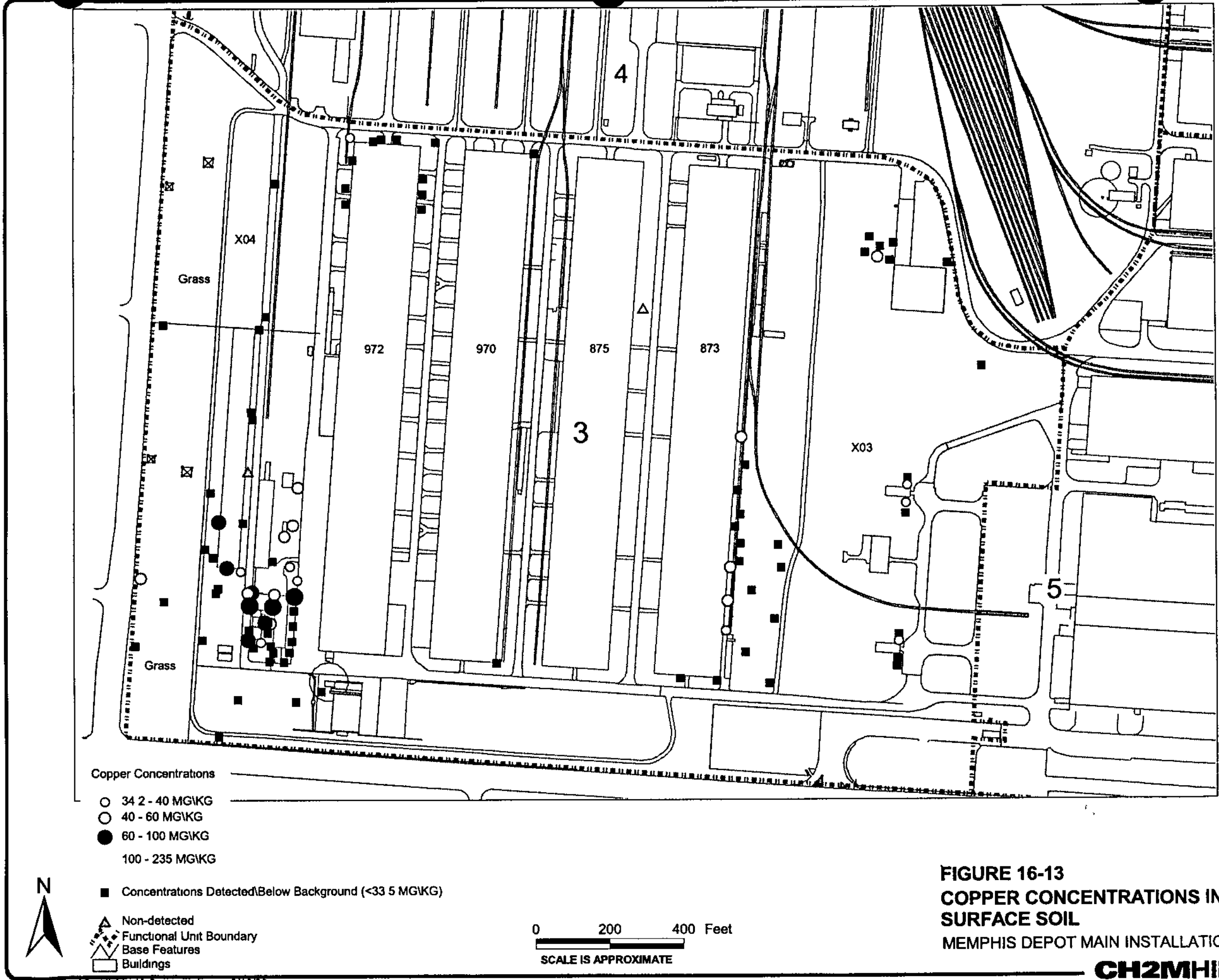

FIGURE 16-13
COPPER CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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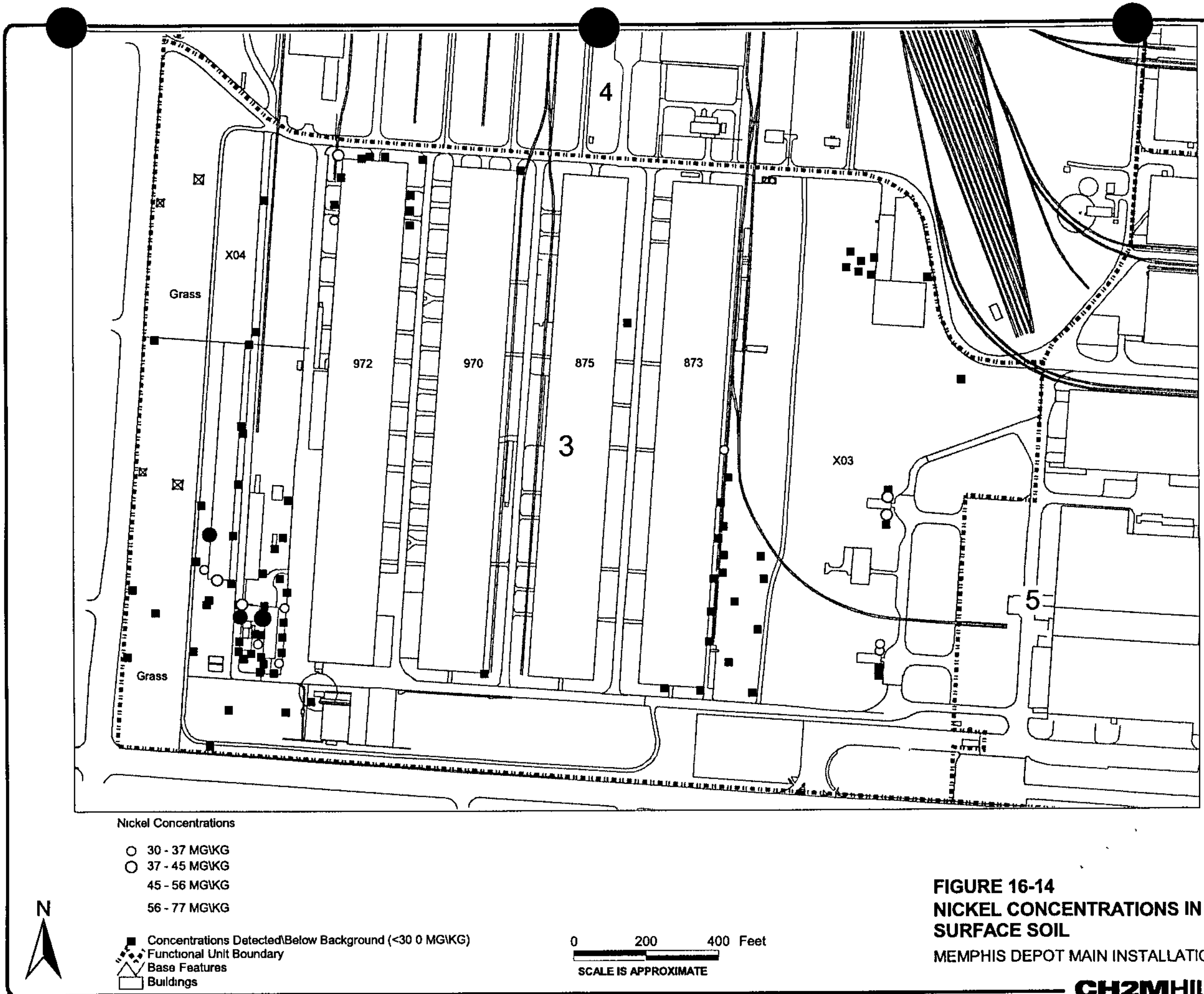

FIGURE 16-14
NICKEL CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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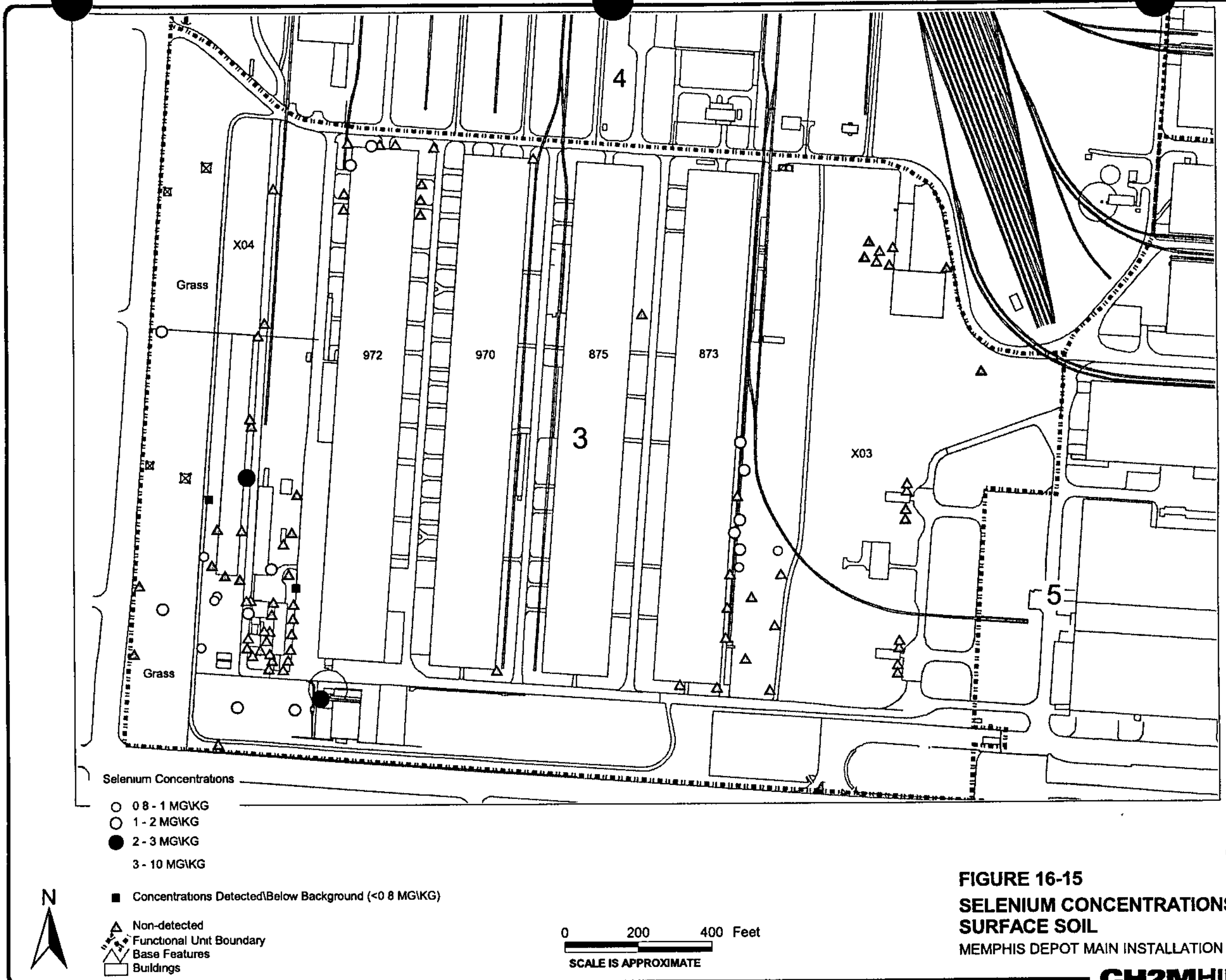

FIGURE 16-15
SELENIUM CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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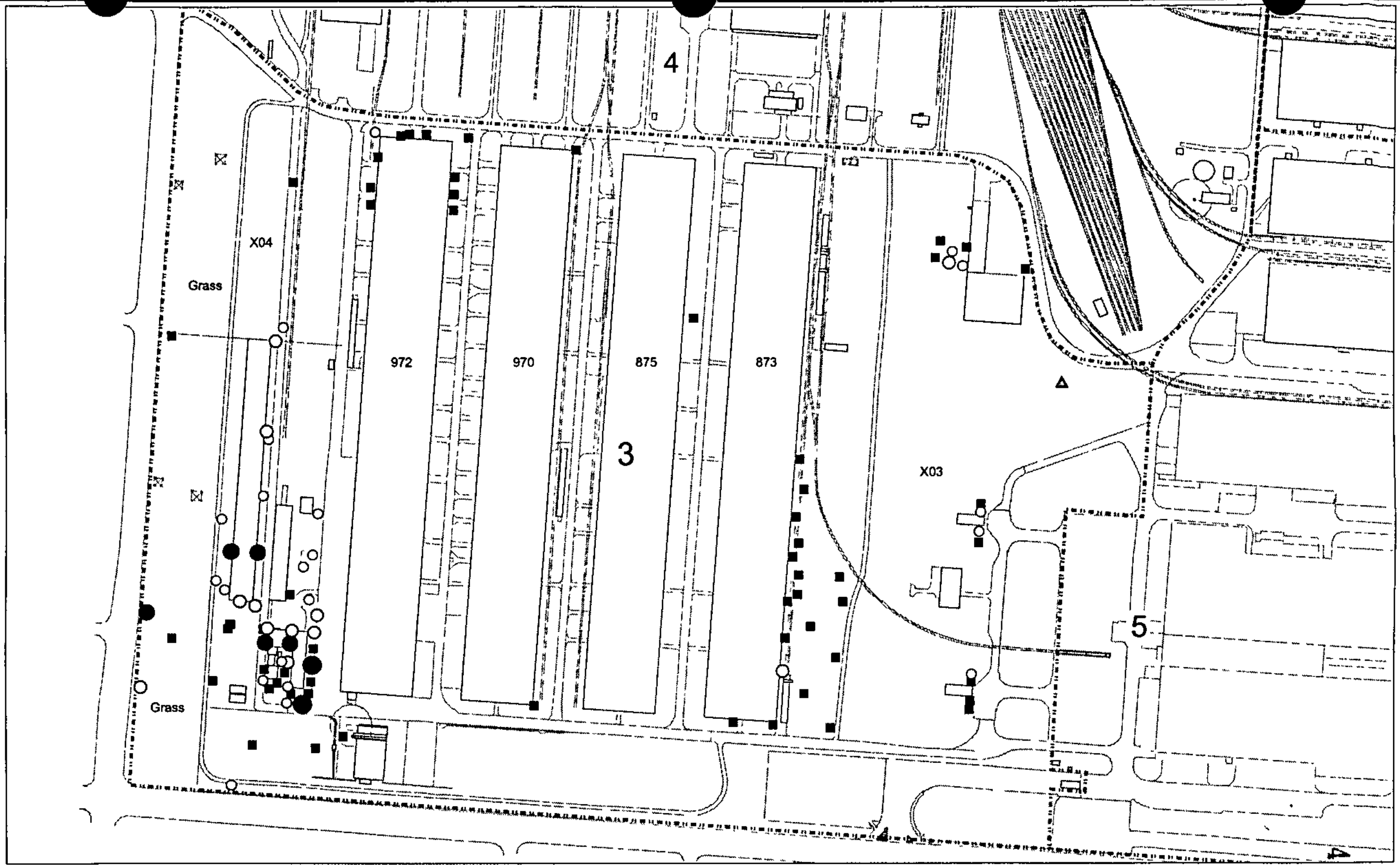

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FIGURE 16-16

ZINC CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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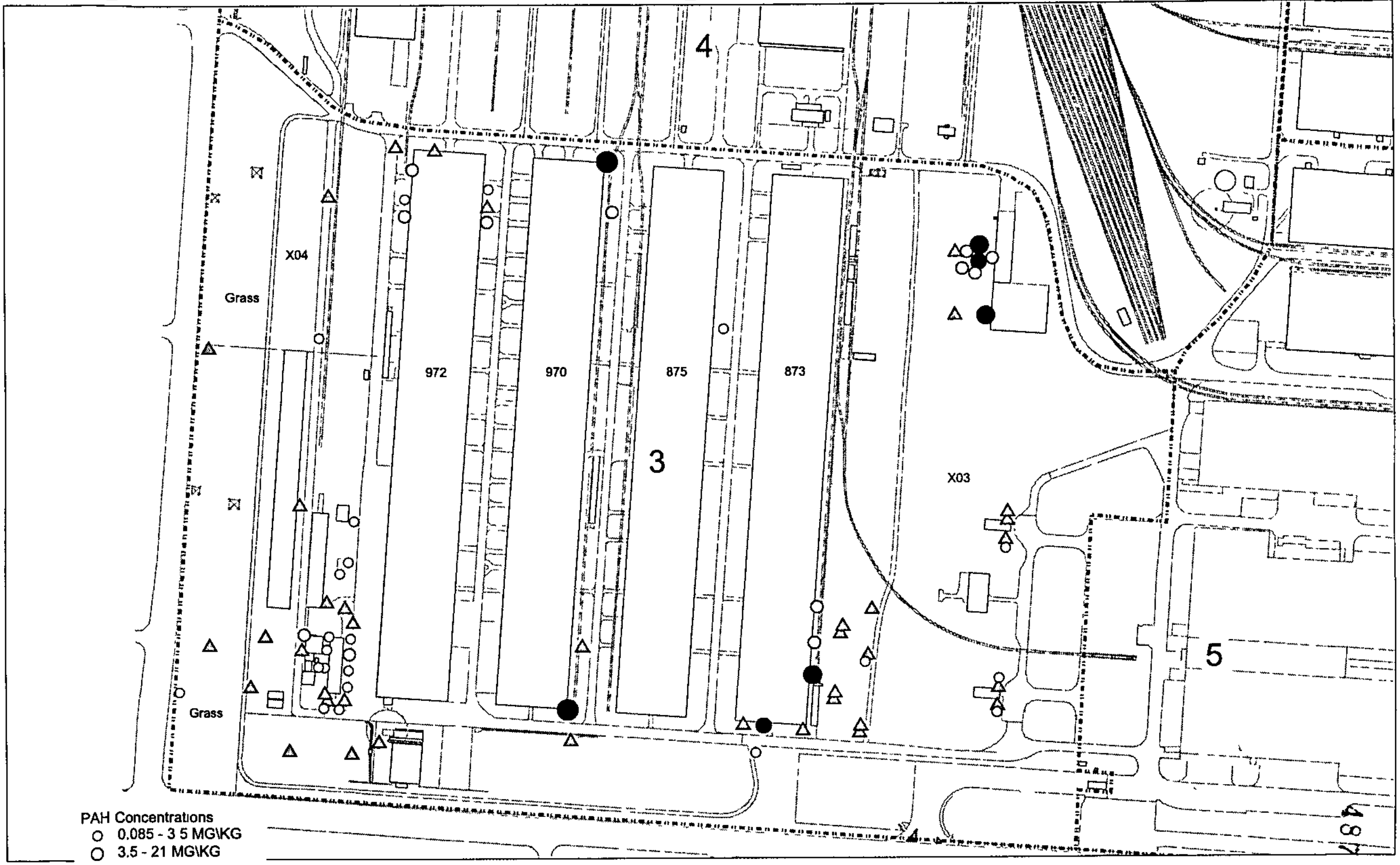

FIGURE 16-17

TOTAL PAH CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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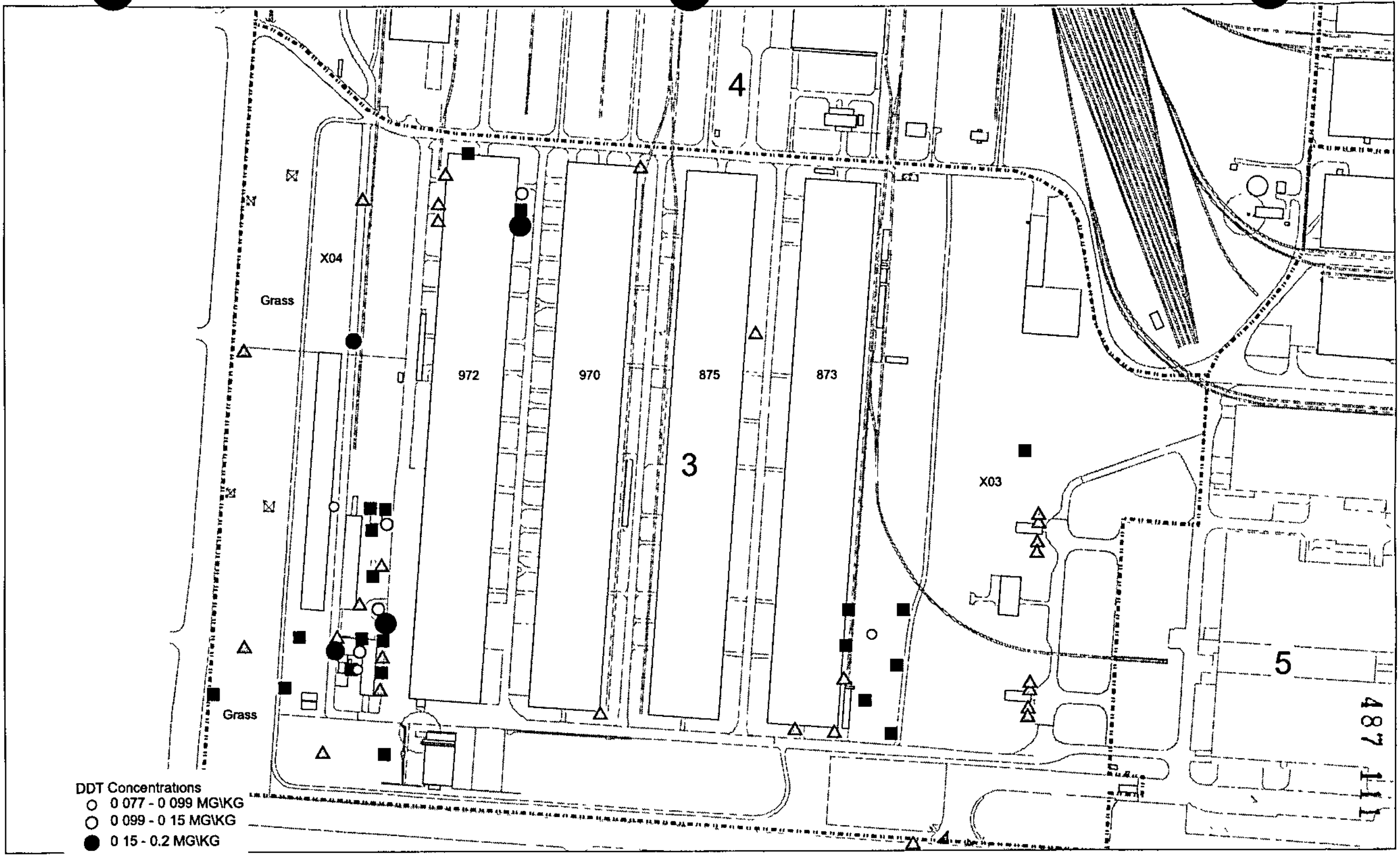

DDT Concentrations
- ○ 0 077 - 0 099 MG\KG
- ○ 0 099 - 0 15 MG\KG
- ● 0 15 - 0.2 MG\KG
- 0.2 - 0 28 MG\KG
- 0 28 - 0 41 MG\KG

■ Concentrations Detected\Below Background (<0 074 MG\KG)

△ Non-detected
Functional Unit Boundary
Base Features
Buildings

N

0 200 400 Feet
SCALE IS APPROXIMATE

FIGURE 16-18
DDT CONCENTRATIONS IN SURFACE SOIL
DEFENSE DISTRIBUTION DEPOT, MEMPHIS, TN

CH2MHILL

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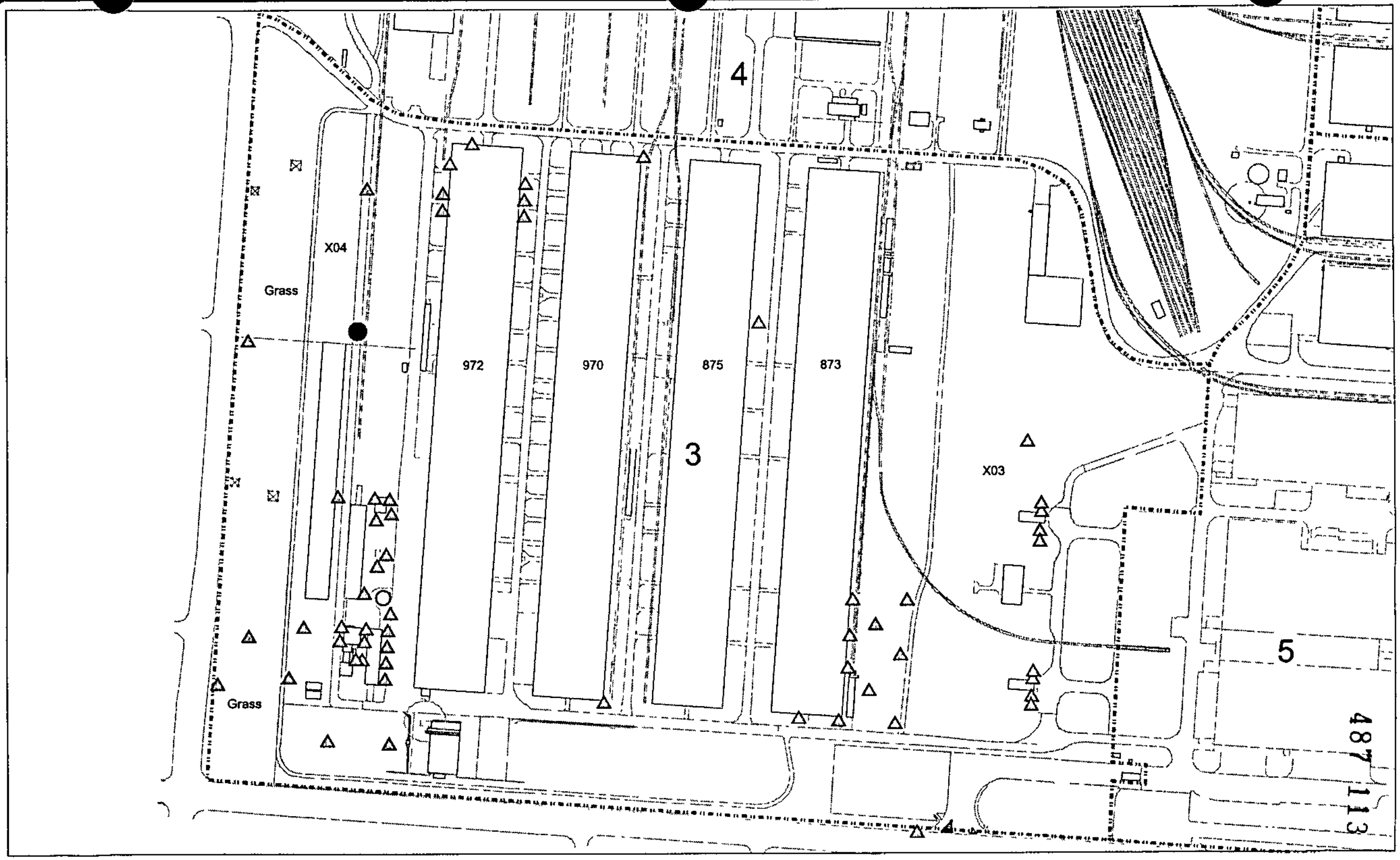

FIGURE 16-19
DDD CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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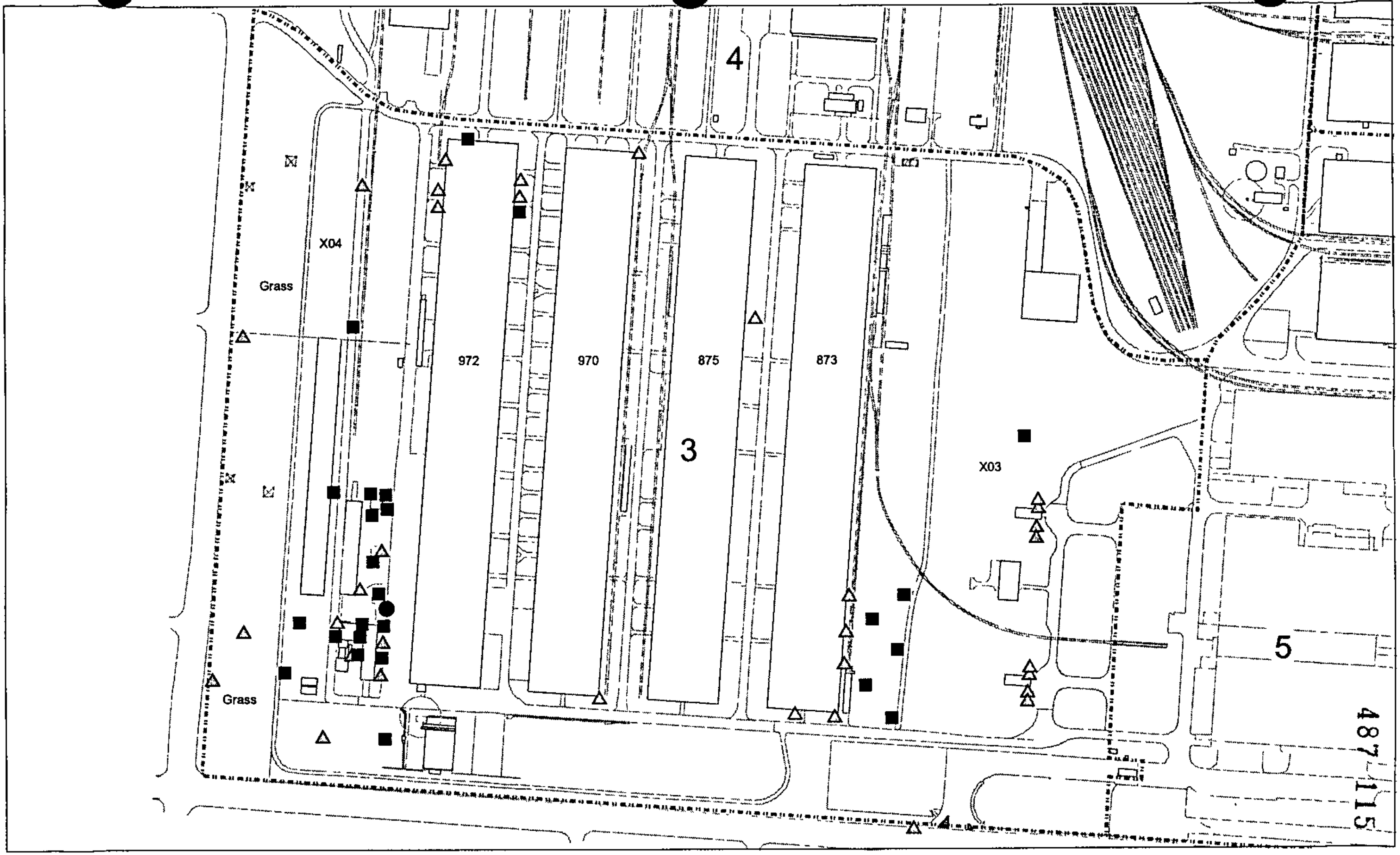

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FIGURE 16-20

DDE CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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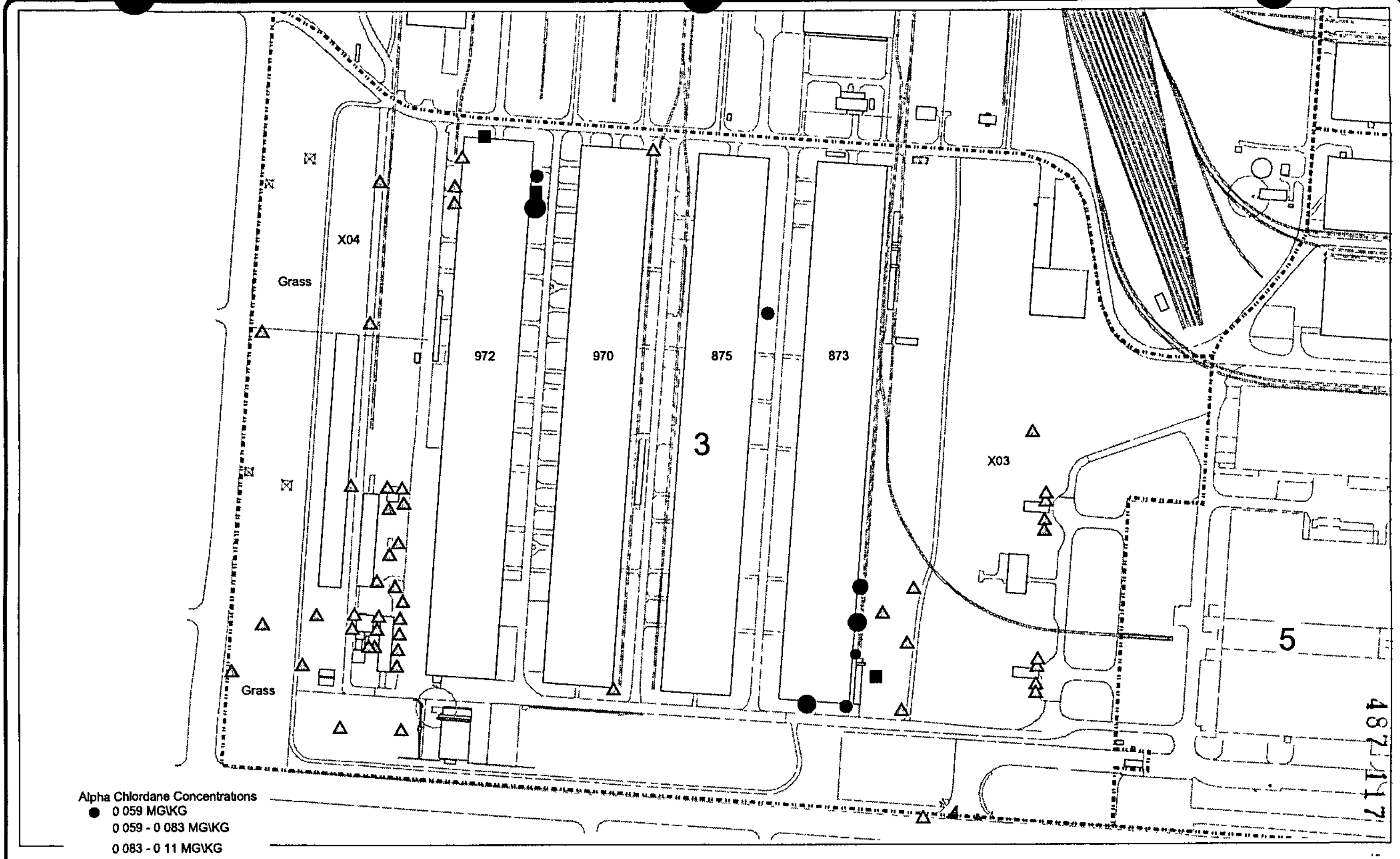

FIGURE 16-21

ALPHA CHLORDANE CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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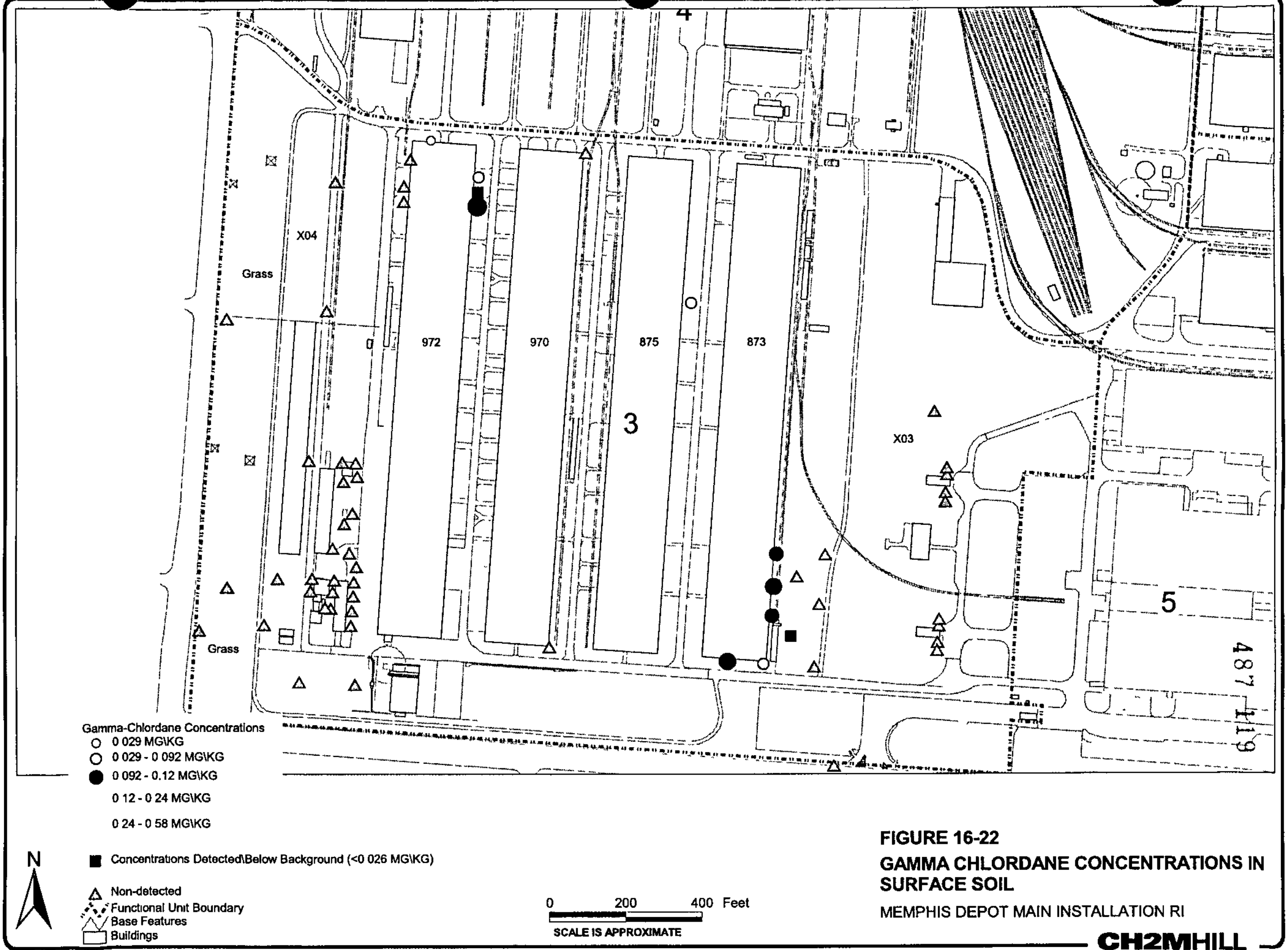

FIGURE 16-22

GAMMA CHLORDANE CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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TAB

Section 17

TAB

17. Fate and Transport for FU3

17.0 Fate and Transport for FU3

The overall fate and transport discussion was included in Section 6.0. This section covers information specific to FU3 and Site 34.

17.1 Fate and Transport for FU3

A summary of site conditions influencing the fate and transport of site contamination is presented in this discussion. Figures 2-16 and 16-1 show the land cover types within FU3.

Source Area Characterization: FU3 is an entirely industrialized area covered mostly with coarse gravel, some grass, paved roads and railroad tracks, and large warehouses (open and closed) Runoff, leaching, and volatilization are anticipated to occur mostly in the open areas without a cover, which is limited to the strips of grass-covered areas around the warehouse buildings. The grassy areas along the western and southern borders, outside the fenced site areas, are not accessible for site operation-related direct releases.

The open area is more than 100 ft wide from the public road intersection, and on the southern boundary, the grassy area is an uphill slope to the public road.

The future redevelopment plans include the removal of all warehouses and other buildings in the area. The surface flow patterns will change in the future with a 4-acre water retention pond built along the western boundary of the Main Installation, between FU3 and FU4. The remainder of FU3 will be used as a light industrial area. The railroad tracks and associated material across the Main Installation, including FU3, will be removed. Thus, many of the PAHs detected along the railroad tracks could be removed during these actions.

Tables 18-1, 18-2, and 18-3 present the COPCs for soil and sump sediment samples within FU3. The COPCs detected in the site media include PAHs, petroleum hydrocarbons, dieldrin, and metals. Of these, only metals such as lead were associated with paint and sandblasting operations in the Parcel 35 area. The PAHs are associated with railroads, asphalt roadways, and vehicular traffic. Dieldrin is associated with routine historical maintenance-related applications.

Potential Contaminant Migration, Persistence, and Exposure Points: The potential migration pathways at FU3 are considered to be surface runoff, dust emission to air, and leachability to groundwater.

The surface runoff pathway is not important because of the lack of significant flow through surface drainage features within this FU; in particular, a direct sheet-flow off-site type of runoff is not a possibility. Stormwater in FU3 is collected through the underground stormwater drainage system and released off-site at a separate discharge point (Site 56). Stormwater in FU3 is routed by drop inlets to the underground drainage pipe system and flow north where it is discharged to Tarrant Branch at Gate 9 in FU4. Tarrant Branch discharges to Nonconnah Creek west of the Depot. Low levels of residual pesticides used in the past were detected at Site 56, but are not specific to FU3; thus, off-site migration is not considered a significant concern for FU3. Dust emission is likely in the gravel-covered areas, although to a limited extent. The grassy areas may dramatically reduce dust emissions off-site. Potential dust emissions were included in the risk estimations using EPA-recommended dust emission assumptions (PEF = 1.3×10^9 m^3/kg).

The surface soil COPCs–PAHs, metals, and dioxin–are not very volatile and are expected to remain bound to the soil; thus, they are likely to be released through dust.

Surface soils (based on 125 surface soil samples) at the site included metals and SVOCs (mostly PAHs; see Table 18-1) as COPCs. Leaching to groundwater is not an issue for any of the surface soil COPCs within FU3, based on their absence in the subsurface soil and regional groundwater. Considering the historical nature of the activities at the Depot, potential migration may have occurred by now. Also, the physio-chemical properties of these chemicals indicate that these COPCs tend to sorb to soil and have a low migration potential. No PAHs or other SVOCs (e g., PCP) exceed the GWP criteria in subsurface soils

The surface soils near the paint booth and sandblasting shops (Sites 31, 32, and 33) have elevated levels of chromium and lead. The subsurface soils do not indicate elevated levels for these metals. The groundwater underneath these sites may have slightly elevated levels of metals in the historical groundwater data (see Table 32-3). However, concentrations of these metals are not elevated in the wells within a short distance from the plating shop or in the downgradient wells. The groundwater in this area moves toward the center of the site, so off-site migration is not a concern. Further details regarding groundwater are provided in Section 33.0.

Fluvial aquifer groundwater beneath FU3 has been affected by VOCs, primarily PCE and TCE, but these chemicals were detected only in isolated surface or subsurface soil samples at FU3 (see Figures 32-2 and 32-3). The detected concentrations were below the groundwater transfer (GWP/SSL) criteria, indicating that soils may not be a continued source of the groundwater contamination. Also, the location of the highest subsurface soil concentration (SB78B and C) did not have significant VOCs in the groundwater, where PZ-03 had 0.007J µg/L TCE and no other CVOCs. Several aromatic VOCs typical of petroleum hydrocarbons, and one CVOC, TCE, at concentrations ranging between 0.002 and 0.013 mg/kg in three subsurface soil samples were reported in soil samples. All aromatic VOCs and TCE were below a groundwater protection-based screening criteria. This finding leads to the conclusion that surface or subsurface soil within FU3 is not a continuing source of groundwater contamination under FU3 within the Main Installation.

The metals exceeding the GWP criteria in subsurface soils were antimony (from 8 to 10 ft bgs) and chromium (total) (from 3 to 20 ft bgs). The mobility of these metals is a function of the soluble fraction (Kd) available for leaching to the groundwater. Considering the low levels of these inorganic constituents in the subsurface soils and the time that has elapsed since the industrial operations at the Depot were discontinued, any leachable fraction is expected to have migrated to deeper soils and eventually to groundwater. Antimony is not elevated in the groundwater underneath this FU (see Section 32.3). Thus, effects on the fluvial aquifer groundwater from this COPC within this FU are anticipated to be negligible.

17.2 Fate and Transport for RI Site 34

The following is a brief summary of the site features that could influence the fate and transport of the contaminants in the site media. Site 34 includes the former locations of USTs near Building 770 that were used to store waste oil from 1960s until their removal in 1989. Building 770 was also used to maintain and store heavy equipment. The site is located west of the major railroad track confluence within the Main Installation. Figure 16-2 shows the surface and subsurface soil sampling locations.

Chemical groups detected in the surface soils (from covered and open areas) included mostly PAHs, with two metals and one SVOC (PCP). Chromium was detected in the subsurface soil at the site.

The CSM for Site 34 is identical to the one for FU3, which is presented on Figure 18-2. Primary release mechanisms include historical spills and leaks of the stored materials. Secondary sources of the contamination are the site soils. Contaminants could be transported through surface runoff, suspension of entrained dust particles, volatilization into ambient air, and infiltration and leaching from soil to shallow groundwater. Potential off-site migration pathways include surface runoff and dust emissions. However, because the site does not have significant drainage features, runoff is not a migration pathway of importance for RI Site 34. Off-site migration via runoff also is limited because the site does not have the significant surface runoff ditches and slopes needed for this pathway to be important, and the soil is shielded by gravel cover (see Figures 2-1 and 2-16). Although COPCs bound to soil particles such as PAHs have been detected in site soils, off-site migration is not likely to have occurred because soils lining the central drainage ditches around the Depot do not indicate the presence of PAHs above background levels. Considering the time that has elapsed since the Depot operations were discontinued, any potential migration would have occurred by now

Because of the presence of gravel and grass cover on the soils, dust generation is not an important emission pathway for COPCs. Evaluation of potential dust generation was included in the risk calculations under conservative dust emission assumptions (EPA's default dust particulate emission factor of 1.32×10^9 m^3/kg). All other migration pathways are negligible at this site, based on the media monitoring information. Potential migration to the subsurface soil is not indicated at this site because of the absence of surface soil constituents in the deeper soil column. Leaching to groundwater is not considered a significant migration pathway for this site because COPCs were not detected in subsurface soil or groundwater. Further details about the COPCs detected in the area groundwater are included in Sections 32.0 and 33.0.

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Section 18

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18. Base line Risk Assessment for FU3

18.0 Baseline Risk Assessment for FU3

18.1 Human Health Evaluation for FU3

A baseline RA was conducted at FU3 using data collected as part of the BRAC Sampling Program (from BRAC Parcels 23, 24, 25, 26, 27, 28, and 35); data from the RI (Sites 27, 32, and 34); and data from Screening Sites 31, 33, 82, 84, and 89. Data were collected from biased locations within known historical site activity areas to evaluate the maximum possible contamination levels within a site and parcel. In general, several surface and subsurface soil samples were collected within each site to assess chemical distributions.

An RA was conducted for FU that includes data collected from the sites and parcels listed above. In lieu of conducting an individual RA at each of the identified parcels and sites, a surrogate approach was implemented to conservatively assess the potential human health risks. The selection of the surrogate site is based on the exposure unit concept and the high-end contamination areas. The selection of the surrogate site and the worst-case representative sample point for the future hypothetical residential evaluations is based on the potential exposure units, designed according to the predicted receptor behavior within an identified area (exposure unit). The surrogate site and FU-wide RAs are based on exposure units where the maintenance worker's exposure unit is the entire area within an FU, and an industrial worker exposure is assumed to be a smaller exposure unit represented by a surrogate site. An exposure unit for a resident is assumed be a 0.5-acre lot, represented by the highest PRE data point within the FU. A figure identifying the exposure units within each FU is included in the human health RA sections. Residential exposure unit evaluation was performed for comparison purposes only. Figure 18-1 presents the various exposure units within FU3. The PRE results used as the basis for the surrogate site and the highest PRE data-point selection are presented in Appendix E. Appendix F provides an analysis of exposure levels for various receptors and provides justification for the selection of the most conservative representative exposure scenario for this RA.

FU3 consists of the four large warehouses (Buildings 873, 875, 970, and 972) and several smaller buildings. The southwestern corner area (Parcel 35) of FU3 included sandblasting and paint operations before the Depot's closure. The sandblasting and paint operations (at Sites 31, 32, 33, and 89) included the removal of the old paint through sand blasting and repainting. Some of the paint operation-related wastes (e.g., lead) also were detected at Site 83 and in Parcel 4 (FU6). Most of the open surface area within FU3 is covered by asphalt for parking lots and roadways, or gravel-covered areas.

The Memphis Depot Redevelopment Plan (The Pathfinders et al., 1997) proposes to demolish all of the buildings within FU3 and to convert FU3 into a stormwater retention basin of about 4 acres, located between FUs 3 and 4. The plans are to develop the remaining portion into a light industrial area.

The surrogate site selected for FU3 is Site 34, which is an old UST near Building 770. The site covers about an acre. The sites associated with the plating shop operations (i.e., Sites 31,

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32, and 33) where metals were detected at elevated concentrations are located in the southwestern corner of FU3, in Parcel 35.

The sediment sample from FU3 was collected from an indoor sump covered with a metal grill located near the plating shop area, at sampling location A(35.3). This sample consisted of sump bottom grit. These are not true sediments and are not easily accessible; it therefore is not realistic to evaluate this medium for potential unlimited exposures. However, for the purposes of site management decision making, assuming that exposure is occurring, a worker exposure was evaluated by selecting COPCs from this sump grit sample.

Data were collected from biased locations within known historical site activity areas to evaluate the maximum possible contamination levels within a site and parcel. When contamination was identified in a sample, the extent of contamination was further defined around that sample in the next phase of sampling. In general, several surface and subsurface soil samples were collected within each site to assess the nature and extent of chemical distributions. A summary of the number of samples collected within an FU and the surrogate site and the frequency of detection for the detected chemicals are included in Tables 18-1 through 18-3.

RI Site 34, the surrogate site for FU3, was selected following the methodology presented in Section 7.1 (see Table 7-1 and Appendix E). This site had the highest PRE ratio in FU3. A separate human health RA was conducted at RI Site 34. A future utility worker exposure was evaluated for this site. The RGOs are to be calculated for COPCs that present risks for an industrial worker, if the risk and HI are above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4} at FU3 and RI Site 34. If no excessive risks are observed, no RGOs will be calculated.

The highest risk area was identified by PRE evaluations (Appendix E), and the future residential scenario was evaluated for the highest risk sampling point from the results of the PRE estimations, (i.e., B(26.2)) to calculate the potential exposure at a future residential lot (assumed to be a 0.5-acre lot).

18.1.1 Selection of COPCs for FU3

A table showing the COPCs selection criteria for FU3, along with human health screening criteria by medium, is provided in Appendix D. A description of the COPC selection methodology was provided in Section 7.0. Chemicals detected above background and the RBCs were selected as COPCs for each of the media (see Tables 18-1, 18-2, and 18-3).

The COPCs for FU3 surface soil are antimony, arsenic, cadmium, chromium (total), lead, mercury, selenium, vanadium, zinc, dieldrin, PAHs, carbazole, PCP, petroleum hydrocarbons and dioxin. The COPCs for FU3 subsurface soil are antimony, chromium (total), copper, and lead. However, for the conservative assessment of risks during excavation types of exposures, all of the surface soil COPCs also were included for subsurface soil, to account for exposure in the zero- to 10-ft soil column by workers. COPCs for FU3 sediment are antimony, barium, cadmium, chromium (total), lead, zinc, 2,4-dimethylphenol, 2-methylnaphthalene, and total petroleum hydrocarbons (TPHs).

The COPCs were selected separately for the FU-wide RA, RI Site 34 (surrogate site), and the single sample point used for the residential RA. A total of 117 surface soil samples, 187 subsurface soil samples, and one sump grit (sediment) sample were used for this FU-wide

RA to evaluate the current and future industrial worker exposure scenarios. Of the detected chemicals in surface soil, PAHs, PCP, dioxins and furans (TCDD equivalents), and nine inorganic chemicals were selected as COPCs for surface soil within FU3. The constituents detected above background in subsurface soil were only four inorganic chemicals (copper, antimony, chromium, and lead). Because future worker populations could be exposed to mixed soils (surface and subsurface) during utility and construction excavation activities, it was assumed that surface and subsurface soils up to 10 ft deep included the same COPCs, although no organic COPCs were detected in subsurface soil. This makes for a conservative risk analysis for future utility worker exposures. The metals detected at elevated concentrations in the sump grit (sediment) sample and TPHs were selected as COPCs.

The COPCs for surface soil at the highest PRE data point, B(26.2), included PAHs only. These COPCs were evaluated for residential exposure-related risk estimations for comparison purposes. The RA for RI Site 34 is discussed in Section 18.3.

18.1.2 Exposure Assessment for FU3

The regional land use within a 3-mile radius of the Depot is presented on Figure 2-15. The historical activities in FU3 can be generalized as packing and repacking hazardous and nonhazardous materials from damaged and leaking containers; storing hazardous and nonhazardous materials; storing antifreeze, petroleum products, paint, pesticides, and solvents; storing waste oil in USTs; applying pesticides, herbicides, and waste oil containing PCP; and sandblasting. Therefore, environmental samples collected from the media within this FU were analyzed for a variety of constituents (e.g., TCL/TAL). In the future, FU3 is likely to remain a light industrial facility, with all of the existing buildings in the area demolished. A small part of FU3 will be converted into a retention pond. Future use for the site is proposed to be as a light industrial center.

18.1.2.1 Conceptual Site Model and Fate and Transport Overview

Figure 18-2 presents the conceptual site (exposure) model for FU3. Each of the components of a conceptual site model is discussed below, including the primary and secondary sources of contamination, primary and secondary release pathways, mechanisms, potential receptors, and routes of exposure.

The primary sources of COPCs in environmental media at FU3 are historical site operations such as the storage of various industrial materials and chemicals. As noted in the fate and transport discussion in Sections 6.0 and 17.0, primary release mechanisms include historical spills and leaks from the storage of chemicals and the surface application of pesticides, herbicides, and waste oil. Some of the chemicals detected in the environmental media could be the result of past paint and sandblast operations and railroad operations. Thus, soils could become secondary sources of the contamination. Over time, surface soils potentially could leach more mobile constituents to subsurface soil and eventually to shallow groundwater, if conditions are favorable. "Favorable conditions" can be described as the presence of shallow groundwater under soils that are very porous, high precipitation conditions at the site, and the presence of very mobile chemicals. Most of these conditions do not exist at the Main Installation. The depth to groundwater averages more than 85 ft bgs, with a maximum depth of 132 ft bgs in the northwestern portion (MW-38) to a minimum depth of more than 55 ft bgs; surficial soils are clayey and relatively impervious and there are no highly mobile organic COPCs.

Generic transport pathways for contaminants could include infiltration and leaching to shallow groundwater, suspension of entrained dust particles, and volatilization into ambient air. On the basis of the COPCs identified, volatilization is not an important migration pathway, because no significant concentrations of volatile constituents were identified in the soils within the FU. Most of the COPCs are naturally occurring inorganic chemicals and semivolatile constituents. Migration of these chemicals could occur via surface runoff and/or dust-borne emissions. Because the potential for leaching of these soil COPCs is low, potential effects on the groundwater from the site are minimal.

Potential exposure points on-site include areas where human activities and/or ecological receptor occurrences are likely and could result in physical contact with one or more contaminated media. Most of the FU is inactive, with human activity limited to areas where property has been leased to private operations. Thus, the current human activity in this area is limited to workers in the recently leased property used by lumberyard (Building 972) and maintenance workers performing routine activities such as lawn mowing and weed cutting. The potential for direct human exposure depends on the presence of exposed contaminated soil and the types of activities within the contaminated areas. Direct human exposure is limited by pavement, gravel, and grass cover (see Figure 16-1). Much of the surface area in FU3 is covered by gravel and pavement, thus limiting potential exposures to soils during maintenance activities. However, for purposes of this risk evaluation, exposures were assumed to be unlimited. Future exposures were evaluated assuming unrestricted land use. Exposures under a future land use are therefore assumed to be maintenance-related work and industrial and residential activities for the entire FU. A utility worker can work anywhere in the FU and therefore can be exposed to the larger exposure unit. However, Site 34 was used as a surrogate, potential RME site to evaluate both the industrial and utility workers' exposures. These theoretical assumptions were included to evaluate the site under conservative exposure assumptions.

On the basis of the nature of the buildings in the area and the planned reuse activities described in the Memphis Depot Redevelopment Plan (The Pathfinders et al., 1997), all existing warehouses and other buildings within FU3 will be removed, and the site will remain a light industrial facility. There are no residents within FU3, and it is not likely to be used for residential purposes in the future. The closest off-site residents are across the fenced property separated by roads both on the southern and western sides of FU3. Potential exposure routes for the maintenance worker include incidental ingestion and dermal contact with surface soil and inhalation of particulate emissions via dust from surface soil. Because of the pavement, concrete, gravel, and grass land cover over FU3, dust generation is expected to be limited.

18.1.2.2 Potentially Exposed Population and Identification of Complete Exposure Pathways

On the basis of occupational duties, it is assumed that a maintenance worker spends an 8-hour workday, once per week (excluding vacation), 50 days per year for 25 years, cutting grass or weeds in the gravel-covered areas. These are conservative assumptions considering the small size of the area in this FU where contamination was detected and surface soil is exposed. Exposure of these workers is assumed to occur via incidental ingestion of soil (50 mg/day); the skin surface area accessible for dermal exposure is assumed to include face, hands, and forearms. About 4 hours of the 8-hour maintenance workday is assumed to

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be spent in contaminated areas of the FU, so half of the total incidentally ingested soil is assumed to come from the contaminated soil. Thus, the FI or ET term of the dose estimates is 0.5. Most of the other exposure factors used are default assumptions from the *Exposure Factors Handbook* (EPA, 1997b). Site-specific factors were used for exposure frequency and duration. Exposure factors and the rationale for their selection are included in tables in Appendix G.

As noted previously, future base redevelopment is expected to focus on light manufacturing and warehouse uses, so site activities will remain industrial. Therefore, future potentially exposed populations are expected to be the same as the current human receptors for the site. However, in the interest of conservatism, it was assumed that the site would be converted to an alternate industrial facility that requires workers to spend more time on the site, with a higher frequency of visits to the contaminated soil areas. This represents the worst-case exposure scenario for industrial land use. Routes of exposure include incidental ingestion, dermal contact, and inhalation of dust from surface soils. Future industrial worker exposures were assumed to occur via the surface soil, and via the subsurface soil in the event that the Depot undergoes construction or excavation and subsurface soils become surface soils. Thus, a future industrial worker's long-term exposure to subsurface soil was evaluated. Exposure factors used were the default values for industrial workers from the *Exposure Factors Handbook* (EPA, 1997b) and other published sources as referenced in Appendix G. Under these assumptions, this hypothetical receptor category would represent the maximum or most conservative degree of exposure that would be associated with this site.

Selected areas of the Depot will be landscaped for aesthetic purposes. Such land use alterations could expose landscaping workers to surface soil (zero to 2 ft bgs) via direct contact and inhalation of particulate emissions during future redevelopment activities. This potential future receptor would be expected to have a short exposure duration (1 year or less). Because this scenario results in relatively lower exposure levels compared to those of a maintenance worker, this scenario was not included for quantitation (see Appendix F for relative exposure comparisons).

On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders, et al., 1997), future residential use of FU3 is unlikely. A hypothetical future residential receptor was evaluated in this baseline RA for comparison purposes only. The nearest residential areas in the vicinity of FU3 are to the south across Ball Road and to the west across Perry Road. The only potentially complete exposure pathway for off-site residents is the inhalation of airborne particulate s from surface soil. However, such exposure is likely to be minimal because of the low potential for dust generation within FU3 due to the paved roadways, the distance separating housing areas from the on-site areas, and the limited amount of outdoor activities observed among the residents in the area. Also, the evaluation of the inhalation pathway for a hypothetical future on-site resident is protective against potential off-site residential exposure because of the dispersion and attenuation of dust due to the travel distance from the on-site to the off-site areas.

The sump sample was used to estimate health risks. The sump is covered with a metal grill and exposure could occur if a worker were to enter it to remove clogs. Therefore, this scenario was used to assess risks to a maintenance worker and an industrial worker using conservative exposure assumptions. The exposure assumptions used for such workers included a sediment ingestion rate of 50 mg/day, with 50 percent (0.5, as fraction) coming from the sump from exposures for 1 hour of the 8-hour workday. Exposure frequency was assumed to be 50 days for an industrial worker and 12 days (once per month) for a maintenance worker. Dermal exposure was assumed to occur to hands and one-half of arms and face for both worker groups. All other assumptions are default values (see Appendix G).

Figure 18-1 presents the exposure units identified within FU3 for the various current and future potential receptors for site contamination. Table 18-4 summarizes potential current and future exposure pathways for FU3 and identifies the pathways that were evaluated quantitatively in this RA. Receptors were conservatively selected to be protective of the relatively lower exposure receptor population for quantitative risk evaluation for this FU. Appendix F compares each potential receptor to the selected representative exposure scenarios to ensure that selected exposure scenarios are protective against all potential current and future exposures. Under these assumed conditions for exposure under current and future land use, the receptor groups that were considered in deriving estimates of exposure and health risk for FU3 were as follows:

- Current on-site maintenance worker;
- Hypothetical future on-site commercial or industrial worker; and
- Hypothetical future on-site resident–adult and child (for comparison purposes only).

The EPCs were the estimated UCL 95% concentrations for surface and subsurface soils. EPCs for a maintenance worker and a future industrial worker are the UCL 95% estimates for the COPCs detected in the surface soil. The EPCs for subsurface soil for the UCL 95% were estimated by combining samples collected from zero- to 10-ft depths (assuming future soil conditions if surface and subsurface soils are mixed during construction and excavation activities). A description of the UCL 95% calculation and the values calculated are provided in Appendix H.

The EPCs for the future hypothetical residential scenario are the maximum PRE sampling location concentrations for all chemicals detected in that particular sample (e.g,. sample B26.2). The estimated EPCs are listed in Tables 18-5, 18-6, 18-7, and 18-8 and in Appendix H. The dose (intake) was estimated for each of the complete exposure pathways (see Appendix I).

18.1.3 Toxicity Assessment for FU3

Table 18-9 presents the toxicity factors for COPCs and the WoE classifications for each. Detailed information regarding the basis for toxicity classification and the uncertainty associated with the listed toxicity factors, based on the EPA toxicity database, is included in the master toxicity tables located in Section 7.0 (Tables 7-7 and 7-8). Because most of the toxicity values are selected from EPA databases, toxicity assessment information was abbreviated here. Technical information provided by EPA Region IV as a basis for the interim toxicity values used is included in Appendix J. Oral CSFs are available for arsenic, eight of the PAH constituents, dieldrin, and PCP. Inhalation CSFs are available for arsenic, dieldrin, and PAHs. The individual CSFs for the PAHs were derived using the TEF compared to the BaP CSF. TEFs are provided in Table 7-9. The oral RfD values are available for 11 of the COPCs, two of which are organic chemicals (dieldrin and PCP); all others are inorganic chemicals. Oral toxicity factors were adjusted by the gastrointestinal ABS_{GI} factors for comparisons with dermal intake estimates. These values were presented in Table 7-10. EPA *RAGS* guidance recommends a discussion of chemicals without toxicity factors. Of the COPCs, only lead did not have toxicity criteria. However, lead was addressed to confirm that high levels do not remain at the Depot. When a lead concentration exceeded the residential screening value for direct exposure, soil target concentrations protective of an adult worker were calculated using EPA's TRW-recommended lead model (EPA, 1996c).

18.1.4 Risk Characterization for FU3

The methodology used for risk and HI calculations is described in Section 7.0, and risk and HI calculations are included in Appendix I. The carcinogenic risks and noncarcinogenic HI results from Appendix I are summarized in Tables 18-10 and 18-11. A set of histograms of the risks and HIs is presented on Figures 18-3 and 18-4.

FU3 was evaluated as one exposure unit. Current and future workers were assumed to have uniform exposures to all areas within FU3. The EPCs were assumed to be distributed at the estimated upper-bound concentration levels (UCL95%) over the entire surface area of the FU. These are conservative assumptions, because most soil is covered by pavement or grass (Figures 2-16 and 16-1), which restricts direct contact with soil. Also, the samples were collected around the suspected contaminated areas; thus, they represent the high-end concentrations in limited areas. The uncontaminated areas are under-represented.

The ELCR from surface soil to a maintenance worker from FU3 is estimated at 1 x 10^{-6}, from BaP, other PAHs, and arsenic. The carcinogenic risks are within the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}). The noncarcinogenic HI for the maintenance worker is estimated at 0.005, which is well below the target value of 1.0. Both carcinogenic and noncarcinogenic risk estimates are within the acceptable limits. Exposures to sediments evaluated for the maintenance worker (although unlikely) resulted in an HI of 0.03. No carcinogenic chemicals were detected in the sediments. Thus, maintenance worker exposure to the site soils and sediment is not a concern, given that the risks and HIs are within acceptable limits.

The estimated ELCR to an industrial worker from surface soil is 9 x 10^{-6}, and subsurface soil mixed with surface soil presents an ELCR of 6 x 10^{-6}, both of which are within the acceptable risk limit range of 10^{-6} to 10^{-4}. The noncarcinogenic hazards from surface soil and from mixed soil (surface and subsurface together) are 0.1 and 0.04, respectively, both of which are well below 1.0. The noncarcinogenic hazard from sediments (no carcinogenic COPCs in sediments) to the industrial worker is 0.6, which is also well below 1.0. This worker scenario assumes a 1-hour exposure during a workday, once a week for 50 weeks (50 days per year), for an exposure period of 25 years. The resulting risks are well within the acceptable limits for cancer risks of 1 to 100 in one million and an HI of 1.0. Thus, the FU3 soils do not pose a health threat to future industrial workers, despite the conservative exposure assumptions used.

Sediment samples included for this assessment are the deposits from the bottom of the drainage in the paint shop area. Although casual contact with the bottom deposits is not likely, such routine constant exposure was assumed for this conservative evaluation. There are no carcinogenic chemicals within these sediment samples. However, several of the metals are significantly elevated above naturally occurring levels for the surface media.

Lead in the sump sample was detected at 3,820 mg/kg, which is above a calculated target value of 1,500 mg/kg (see Table 7-16).

The single point (sample B(26.2) from south of Building 970, next to the railroad tracks) specific risk estimate for the residential receptor resulted in an ELCR of 6×10^{-4}. All of the risks are from PAHs, and no noncarcinogenic chemicals were detected above background levels in this sample. Cancer risks were above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4}. This scenario is included as a hypothetical conservative evaluation scenario, although the site is unlikely to be used for residential purposes.

The inhalation risks from the high-end contamination data point (A(26.2)) are at 2.6E-09, which are below the 1 in one million risk levels for the hypothetical on-site receptors. Risks to any off-site residents from inhalation are likely to be lower than these; thus, dust-borne exposures to off-site residents are not a health concern.

There currently are no groundwater exposures for these receptors, and none are likely in the foreseeable future because of the established water use patterns in the area and because water is provided from the public water supply system. However, a plume of low-level chlorinated solvents is present in the groundwater under FU3. Risk estimates for this plume, combined with the risks from the surface media for industrial and residential receptors, are shown in Table 18-11, using average organic concentrations from Plume A, site-wide inorganic groundwater results, and FU3 soil/sediment results. The total ELCR is 3×10^{-5} and the total HI is 1 for the future industrial worker. Risk drivers for this scenario are arsenic, PCE, and BaP. The total ELCR is 7×10^{-4} and the total HI is 1 for the future hypothetical residential adult. Risk drivers for this scenario are arsenic, PCE, TCE, and PAHs. The total ELCR is.4×10^{-4} and the total HI is 3 for the future hypothetical residential child. Risk drivers for this scenario are arsenic, PCE, and PAHs. Risks and hazards remain acceptable for the maintenance worker, as noted above for surface soil.

Lead was not included in the risk estimations because of the lack of a toxicity factor. However, when compared with a target concentration protective of workers of 1,500 mg/kg, Sites 32, 33, and 89 had excessive lead levels. One sample (A(35.3)) collected from the sump at the paint shop had elevated lead, as listed in Table 18-12. These are all sites identified as paint operation-related areas. Table 18-12 contains a list of sample points that had lead levels above the target concentration. These areas may need further evaluation. Table 6-8 presents a comprehensive list of all of the lead concentrations within the Main Installation.

18.1.4.1 Uncertainty Analysis

Section 7.0 presents the general concepts and sources of uncertainty at a given site. The following are some of the major points pertaining to FU3.

Constituents of Potential Concern. Data were collected from 1996 to 1998. Many of the COPCs, such as PAHs and metals, also were detected in background soils. Several of the PAHs were detected at higher concentrations in the railroad tracks within the Depot. Site operations at several of the sites did not involve PAHs as potential source constituents. Likewise, site-wide data statistical evaluations indicated that the contaminants were similarly distributed in the background samples. Some of the inorganic COPCs were selected based on their exceedances of the GWP criteria. These chemicals are not a direct

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exposure concern. However, their inclusion contributes to the conservatism of the risk estimation.

Subsurface soil organic COPCs are the same as the surface soil COPCs, although most of the organic chemicals were not detected in the deeper soils below 1 ft within FU3 because they tend to remain within the first few inches of the surface. Surface soils in this data set were defined as those from zero to 2 ft, whereas deeper soil was evaluated from zero to 10 ft. EPA defines a "surface soil" as being in the zero- to 1-ft range. Some of the surface soil samples were collected from within the first 1 ft bgs; however, to obtain a large enough data set for statistical evaluations, samples collected from slightly deeper areas were included in the surface soil group. Individual depths of the samples are included in Appendix N.

Exposure Assessment. There are no exposures under current conditions. Most of the area within FU3 is gravel, paved, or grass-covered. There are no human receptors in FU3, except in the building being used as a lumberyard. This site is highly unlikely to be used for residential purposes without significant structural changes to the existing warehouse buildings. Future land use considerations for the Depot include various small industrial uses; thus, land use is likely to remain industrial/commercial.

Exposure assumptions include random access uniformly across the FU3. Exposure point concentrations are based on biased samples from suspected contaminated areas. The uncontaminated areas within the FU3 could be under-represented.

The site, when redeveloped, will undergo extensive restructuring in which a retention pond area will be created, and the rest of FU3 will be light industrial. The railroad tracks and associated material will be removed. This restructuring probably would remove the PAHs detected along the railroad tracks.

A sediment sample was collected from a sump in a building, which has a permanent metal grill that makes it inaccessible for routine work. The exposure assumptions include the constant exposure of a worker. Also, the size of the site does not permit long-term work within the structure. Thus, exposure assumptions are used strictly to assist in site management decisions.

Most of the quantitative exposure values such as EF and ED are assumed values, and true likely exposure of a receptor is not known. Most of the uncertainty within RAs is attributable to this exposure quantitation step.

Toxicity Assessment. The toxicity criteria used are those recommended by EPA through the toxicity databases; therefore, the uncertainty associated with this section is predetermined by the methods used and the studies selected by EPA in calculating these toxicity factors. The quantitative UFs associated with toxicity factors are included in the toxicity factors table (Table 18-9). Some of the primary sources of uncertainty are listed here. Most of the toxicity factors are based on studies from animals extrapolated to humans using arbitrary assumptions (e.g. UF or MF), which introduces a major uncertainty. In extrapolating from carcinogenicity dose to estimate slope factor, no threshold for toxicity is assumed. Some of the metal toxicity factors are based on evidence of toxicity from occupational exposures (e.g., chromium) involving a high level of exposures to fumes and airborne particles. The applicability of these data to environmental exposures requires close scrutiny.

Risk Characterization. As noted previously, the risks and hazards estimated in this assessment are conservative. Several scenarios were evaluated to simulate possible alternative future land uses for FU3. The fact that samples were collected from biased locations within suspected past activity or spill areas near warehouses adds to the conservatism of the estimates. Also, most of the FU3 area is likely to change in configuration during the redevelopment, in which all of the buildings in FU3 will be demolished and the area will be used as a light industrial facility.

The risks within soils are within the 1-in-a-million range for a future industrial worker, primarily from arsenic and BaP. However, arsenic toxicity factors are derived by EPA using mostly epidemiological information from populations exposure to high levels of arsenic in drinking water. The BaP within the Main Installation is mostly from railroad tracks and roadways.

Cumulative risk estimations combining risks from soils and groundwater media are strictly hypothetical, because groundwater contamination is limited in area and is not present in the soil contamination area. The risk drivers in the groundwater are TCE and PCE. The toxicity factors used for risk estimations from the TCE have been withdrawn by EPA. Thus, the areas represented by each sample in the combined assessment at FU3 represent the areas of highest contamination within the site and the FU.

18.1.4.2 Remedial Goal Options

RGOs are the target concentration values for remedial alternatives analysis. Achieving these goals should achieve compliance with state and federal standards and satisfy NCP requirements to ensure protection of human health and the environment at hazardous waste sites. The RGOs calculated for FU3 are in accordance with *RAGS, Part B* (EPA, 1991a) and *EPA Region IV Supplemental Guidance to RAGS* (EPA, 1994b).

The RGOs are developed only for the chemicals that are detected at the site at concentrations above the applicable state or federal standards, or that present risks or HIs above the acceptable levels. "Acceptable" risks are defined as risk levels above 100 in one million (10^{-4}) or HI above 1.0, for either current or future exposure pathways analyzed in the RA. The risk evaluations under future land use conditions included potential exposures of maintenance, industrial, and utility workers within FU3 based on activities observed to be applicable to the site. Hypothetical future scenarios included residential land use.

Exposure of a worker under current land use conditions does not result in excessive risks associated with the soils and other surface media. The estimations of industrial worker exposure also were within the acceptable risk limits. Therefore, no quantitative RGOs were calculated for any of the surface media at the site. There are no human health protection-based ARARs for soils or sediments The target lead concentration, based on the industrial worker exposure, is estimated to be 1,500 mg/kg (see Table 7-16). The surface soil around the paint shop and other associated sites within the area and the sediment sample from the sump indicated that lead levels are above this target concentration. These areas may need further evaluation to prevent excessive lead exposure to future receptors.

The groundwater within the area is addressed as part of the groundwater FU (see Section 34.0). The site groundwater currently is not used within the Depot. Shallow groundwater does not qualify for potable use.

18.2 Environmental Evaluation for FU3

18.2.1 Introduction

An ERA was conducted at FU3 to evaluate whether contaminants detected in surface soil potentially pose adverse ecological effects for terrestrial receptors. FU3 is an entirely industrialized area and contains little, if any, ecological habitat that can be used by terrestrial plants or animals. This FU also will remain an industrial area in the future. EPA's ERA guidance (EPA, 1997d) recommends a screening-level ERA for risk management decisions. Although mowed, grassed areas present within the boundary of FU3 do not provide a significant habitat. Therefore, a screening-level ERA was initiated to aid in risk management decisions.

This ERA was conducted in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (*Process Document*)(EPA, 1997d). Steps 1, 2, and 3 of EPA's ERA model were completed, as summarized in Section 7.8.

18.2.2 Step 1: Screening level Problem Formulation and Effects Evaluation

This is the initial step in the ERA and includes all the elements of a problem formulation and ecological effects analysis, but on a screening level. The results of this step support the exposure estimates and risk calculation in Step 2.

18.2.2.1 Environmental Setting and Contaminants at the Site

The environmental setting at the Depot is described in Section 2.0. An ecological assessment checklist was completed as described in the *Process Document* (EPA, 1997d) and is provided in Appendix S. Site characteristics most relevant to the ERA are discussed in this subsection

FU3 comprises the southwesern corner of the Main Installation. It is entirely an industrial area dominated by four large shed warehouses, other warehouses, a sentry gate station, adjacent railroad tracks, and open storage areas. The groundcover consists predominantly of large expanses of concrete or gravel. The industrial land use of this FU is expected to remain unchanged into the foreseeable future.

Potential ecological habitat is limited to narrow, maintained grassed areas along the western, southern, and southeastern boundaries. There are no trees or shrubs in the grassed areas and no on-site aquatic habitats (e.g., ponds or ditches). A 6-ft chain-link fence with three rows of barbed wire is present along the western and southern property lines, which limits intrusion by off-site wildlife. Potentially occurring plants are limited to a low diversity of landscape grass and other weed species. Potentially occurring wildlife may include tolerant birds such as sparrows, rock doves, grackles, and mockingbirds, and small mammals such as mice, rats, and shrews. There are no wetlands, and no state or federally listed or proposed endangered or threatened species are known to inhabit the area of the site (TDEC, 1996; USFWS, 1996; and Appendix T). Overall, the limited ecological habitat is highly disturbed and of poor quality.

Land use immediately off-site consists of large residential communities to the west and south and the stormwater collection system, which is released to the off-site areas through a drainage ditch at Site 56. This ditch is dry during most of the year and is wet during storm events. Also, overland flows during rain events from FU3 converge in FU4 and flow off-site at Site 56, which will be addressed as part of the Site 56 discussions. The potential for leaching of soil contaminants is low. The shallow groundwater is deeper than the streambeds in the area; therefore, groundwater is not likely to discharge to surface water near the Depot and the potential for migration of contaminants via groundwater from the site to off-site water bodies is minimal. Under periods of high water table, however, the fluvial aquifer may recharge Nonconnah Creek, off-site and southwest of the Main Installation.

The media sampled at FU3 included surface soil, subsurface soil, and groundwater. A single sediment sample was collected from a belowground sump in Building 1086, sample A(35.3); however, this sample was not evaluated for ecological risk because the exposure pathway is incomplete. Surface soil is the only medium to which terrestrial ecological receptors could be exposed and is, therefore, the only medium evaluated in this ERA for FU3. A list of surface soil COPCs at this FU is provided in Section 18.1.1.

18.2.2.2 Contaminant Fate and Transport

An overview of contaminant fate and transport of chemicals detected at FU3 is provided in Section 6.0 and is not repeated here.

18.2.2.3 Complete Exposure Pathways

For a pathway to be complete, a contaminant must travel from the source medium or media to an ecological receptor and be taken up by the receptor via one or more exposure routes. Although ecological habitats are minimal to non-existent at FU3, a conservative assumption was made that a potentially complete exposure pathway may exist for direct contact of terrestrial plants and invertebrates with contaminants detected in surface soil. There are no other potentially complete exposure pathways at this site.

18.2.2.4 Assessment and Measurement Endpoints

Assessment endpoints are expressions of the environmental value(s) to be protected. The assessment endpoint for FU3 is to sustain soil quality and to achieve COPC concentrations that are below adverse effect thresholds for plants and soil invertebrates. Measurement endpoints are measurable ecological characteristics of the assessment endpoint. In this screening level evaluation, the measurement endpoint is the ratio of surface soil maximum concentrations to conservative screening level soil benchmarks. An exceedance of soil COPC concentrations compared to the benchmarks would be a "measure" of a potential effect. If an exceedance occurs, it can be inferred that a possible adverse effect may occur to exposed ecological receptors.

18.2.2.5 Screening level Ecological Effects Evaluation

Conservative thresholds for adverse ecological effects, or screening ecotoxicity values, were used for contaminants detected in surface soil. These values were determined as follows:

- **Surface Soil:** the soil ecological screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from a variety of sources, including the

USFWS, the ORNL, the Canadian Council of Ministers of the Environment, the Netherlands Ministry of Housing, and the RIVM.

See Table 7-14 for the screening soil ecotoxicity values.

18.2.2.6 Uncertainty Assessment

Uncertainty is inherent in each step of the ERA. The following text presents major factors contributing to uncertainty in this assessment.

Exposure point concentrations were assumed to be maximum soil concentrations. This is a highly conservative assumption that may overestimate risk. Under this assumption, the receptor spends 100 percent of its life cycle at the highest concentration area; although this can be true for plants, most terrestrial wildlife receptors are mobile and can be exposed to the complete range of soil concentrations.

The soil criteria used were obtained from various sources in the literature and may not be representative of actual site conditions. Exposure pathways to terrestrial plants and animals were assumed to be potentially complete, even though the maintained grass habitats do not provide suitable habitat in this industrial setting.

18.2.3 Step 2: Screening Level Exposure Estimate and Risk Calculation

This step includes estimating exposure levels and screening for ecological risks as the last two phases of the screening level ERA. At the end of Step 2, an SMDP will be made to assess whether ecological risks are negligible or whether further evaluation is warranted.

18.2.3.1 Screening Level Exposure Estimate

The maximum concentration of all chemicals detected in surface soil at FU3 was used as the EPC for estimating risk to directly exposed terrestrial organisms.

18.2.3.2 Screening Level Risk Characterization

The quantitative screening level risk estimate was conducted using the HQ approach. This approach divides the EPCs (maximum detected soil value) with the soil screening ecotoxicity values.

Table 18-13 summarizes the results of the surface soil screening level risk calculations. Table 18-13 provides information regarding the FOD, range of detection, selected soil criteria, and HQs based on comparison of the maximum concentration to the criteria. An HQ of less than 1.0 indicates that the contaminant is unlikely to cause adverse effects, and therefore, is not considered further in the ERA. Contaminants with HQs greater than or equal to 1.0, or contaminants for which criteria were not available, were identified as COPCs and were carried forward to Step 3.

A total of 22 inorganic and 38 organic compounds were identified as COPCs in surface soil. No screening criteria were available for 4 of the inorganic and 10 of the organic compounds.

18.2.3.3 Scientific Management Decision Point

The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted. The identified COPCs will be carried forward to Step 3.

18.2.4 Step 3: Baseline Risk Assessment Problem Formulation

Step 3 refines the problem formulation developed in the screening level assessment. In this step, the results of the screening level assessment and additional site-specific information are used to evaluate the scope and goals of the baseline ERA.

18.2.4.1 Refinement of COPCs

In Steps 1 and 2, conservative assumptions were used. As a result, some of the COPCs were retained for Step 3, although they pose only negligible risk. Therefore, in this first phase of Step 3, the assumptions used were further evaluated and other site-specific information was considered to refine the list of COPCs. In this refinement phase, the revised assumptions and site-specific considerations used were as follows:

- Arithmetic average contaminant concentrations were considered, along with maximum concentrations, when a comparison to the benchmarks was conducted;
- Arithmetic average and maximum values were compared to background concentrations;
- Contaminant concentrations were compared to background values;
- The FOD was considered; and
- Less conservative (secondary) soil screening values were considered in addition to the more conservative (primary) screening values used in Step 2.

The secondary benchmarks described above were identified to provide a less conservative benchmark for comparison with site contaminant exposure concentrations. The secondary benchmark selection process focused on identifying the next highest benchmark value among the soil literature references used by EPA Region IV. This was a stepwise process in which the first set of toxicological benchmarks considered was from two ORNL studies (Efroymson et al., 1997). These studies established separate screening benchmarks for soil microorganisms, earthworms, and plants. A secondary screening value was chosen from these three data sets that was the next highest value above the primary EPA Region IV screening value. If no values were available, the selection process proceeded to the Netherlands values (MHSPE, 1994). In addition, if the selected value from ORNL was found to be greater than the highest Netherlands value, then the ORNL value was rejected and the process moved forward to the Netherlands values as a conservative measure.

The Netherlands values included optimum values and action values. When this set of data was considered, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark. If a value was not available, the process proceeded to a final set of data as compiled by the USFWS (Beyer, 1990). The values in this data set represent Dutch background, moderate contamination, and cleanup values. As stated above, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark.

In addition, the conservative ecological exposure pathways used in Step 2 were reevaluated based on actual site conditions. All of this information provides a WoE to assess which, if any, contaminants should be recommended for further evaluation in a baseline ERA.

The results of the Step 3 refinement of the COPCs list are summarized in Table 18-14. Table 18-14 presents the maximum and average exposure point concentrations, background concentrations, primary and secondary surface soil screening criteria, range of HQs and background comparisons, and FOD.

On the basis of the WoE presented in Table 18-14, a few of the inorganic and many organic COPCs indicated a potential for adverse effects. These included trivalent chromium, total chromium, selenium, zinc, and several PAHs. These are contaminants for which all HQs were at or above 1.0, and were also above background in all comparisons. Many of the contaminants could be removed from further consideration as a result of some HQs being near or less than 1.0, as being less than background, or as having an FOD at 5 percent or below. Surface soil criteria for a total of 12 contaminants were not available for comparison, so HQs could not be determined; however, 7 of these contaminants were compared to available background concentrations.

The key consideration in this refinement step is the lack of ecological exposure pathways at FU3. As previously discussed, the screening process in Steps 1 and 2 was conducted as a conservative measure, given that EPA guidance recommends minimal or no risk management considerations in a screening-level ERA. FU3 is entirely an industrial area, and this land use is expected to continue into the future. The on-site habitat is limited to small, mowed grassed areas adjacent to warehouses and buildings in the western and southern portions of the FU. There are no on-site or near-site natural habitats that could support significant populations of terrestrial wildlife. Given the industrial nature of FU3 and the lack of suitable on-site habitats, ecological effects are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

18.2.4.2 Scientific Management Decision Point

Although several COPCs were identified in the refinement phase of Step 3 as potentially causing adverse ecological effects, the lack of complete ecological exposure pathways at FU3 indicates that current and future ecological effects are negligible. Therefore, no further assessment of ecological risks to contaminants at FU3 is warranted.

18.3 Human Health Evaluation for RI Site 34

RI Site 34 is the surrogate site for FU3 because it resulted in the highest human health risk ratio during the PRE (see Appendix E). This site was selected based on PREs, ratio estimates that result in risk, and HI ratios (primarily due to PAHs in surface soils) at this site. Elevated metals concentrations were detected at other sites in the southwestern corner of the FU3 near the spray painting and sandblast operations shop. Sites 27 and 32 present a higher HI ratio in the PRE estimations, mostly because of metals.

18.3.1 Selection of COPCs for RI Site 34

Nine surface soil samples (zero to 1 ft deep) were included for analysis of contamination conditions at Site 34. The maximum detected chemical concentration within this data group was compared against background concentrations and the RBCs for direct exposure, as well as the GWP concentrations (SSLs). Six analyses of subsurface soil (>1 to 10 ft) were grouped,

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and maximum detected concentrations were compared with the background concentrations and SSL criteria for COPC selection.

The COPC selection indicated that surface soils at the site had arsenic, chromium, lead, and several PAHs exceeding the background levels and comparison criteria (see Table 18-15). The PRE indicates PAHs as the primary risk drivers (Appendix E) in surface soil. In the deep soil samples group for utility worker exposure evaluations, soils from zero to 10 ft are included. The subsurface soils (>1 ft to water) (see Table 18-16) had a total of 13 single detected concentrations of PAHs that were selected as COPCs. The inorganic chemicals selected as COPCs for subsurface soil include copper and the other metals selected for surface soil (chromium, arsenic, and lead).

18.3.2 Exposure Assessment for RI Site 34

Figure 16-1 depicts the site and its relative location within FU3. RI Site 34 is a former UST site, where the tanks have been removed, and equipment storage area. It is also located adjacent to a major railroad confluence area in the center of the Main Installation. Figure 18-5 presents the conceptual site (exposure) model for RI Site 34.

18.3.2.1 Potentially Exposed Human Population and Identification of Potentially Complete Exposure Pathways

The site (including the Site 34 area) has been inactive since the closure of the Depot. There are no potentially exposed populations under current conditions specific to this site. Maintenance workers for the Depot involved in weed control and other maintenance-related activities could be present for limited periods of time. Maintenance worker exposure at Site 34 was not quantitatively evaluated because of the small area of the site. A maintenance worker exposure scenario was quantified for FU3, including Site 34 data. Other potential receptors evaluated qualitatively for surface soil exposure at this site were landscapers.

Potentially exposed populations under future land use are unknown at this time On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), it is likely that Site 34 will be used in the future for light industrial or commercial operations. Under such a scenario, likely future receptors also are site workers. Future residential use of this former UST site is highly unlikely, because of the site's proximity to major railroad tracks. Hypothetical future residential exposures were evaluated for the worst-case scenario for FU3; a separate evaluation for Site 34, therefore, was not required. A detailed list of exposure factors and the rationale for their selection are included in tables in Appendix G. Off-site subsurface soils were evaluated for direct exposure of a future utility worker and an industrial worker. These scenarios are based on the assumption that, in the future, if the contaminated subsurface soil (zero to 10 ft bgs) is disturbed (e.g., for installation or maintenance of underground utilities), exposure to contaminated subsurface soil for utility workers or future industrial workers in the area could become a complete pathway. A summary of exposure pathways for RI Site 34 is included in Table 18-17.

A UCL 95% concentration was estimated for the EPC for surface soil (zero to 1 ft) and subsurface (zero to 10 ft) data for the COPCs identified. The EPC defaulted to the maximum detected concentrations for both the organic and inorganic COPCs in surface soils, possibly because of the high level of the maximum detected concentration and the relatively small sample size (9 for organic samples and 5 for inorganic samples). For subsurface soils, on the other hand, the lognormal UCL 95% estimates were used for the EPC values for both organic and inorganic COPCs. These values are listed in Tables 18-18 and 18-19, and the estimation methodology is described in Appendix H. The dose (intake) was estimated for each of the complete exposure pathways. The dose estimates are included in Appendix I.

18.3.2.2 Toxicity Assessment for RI Site 34

The COPCs for RI Site 34 are a subset of those previously listed in the FU3 RA section (Section 18.1.1). Table 18-9 presents the toxicity factors for the COPCs identified at RI Site 34. Lead is the only COPC without a toxicity factor for this site.

18.3.2.3 Risk Characterization for RI Site 34

The carcinogenic risks and noncarcinogenic HIs are summarized in Table 18-20. A set of histograms is included in Appendix I. The ELCRs and HIs were estimated for a future industrial worker, utility worker, and hypothetical residential adult and child.

The carcinogenic risks for industrial worker exposures to RI Site 34 surface soil resulted in estimated risks of 4 x 10^{-5} and a noncarcinogenic HI of 0.1. The carcinogenic risks are from arsenic and PAHs. Deeper soil risks are identical to those for surface soil, because these include surface soils and represent carcinogenic COPCs in shallow soils. Because deep soils include surface and subsurface soils, the risks are not additive. Thus, total risks are the higher of the two sets of risks estimated for the industrial worker. This worker scenario assumes a full workday exposure, 250 days per year, for an exposure period of 25 years. The resulting risks are within the acceptable limits for cancer risks of 1 to 100 in one million and the HI of 1.0. Thus, the overall Site 34 soils do not pose a health threat to future industrial workers.

Exposures of a utility worker assume surface and subsurface soil mixed during excavation. Exposure to the utility worker resulted in an ELCR of 6 x 10^{-6} and noncarcinogenic HI of 0.007. Both carcinogenic and noncarcinogenic health risks are within the acceptable limits of 10^{-6} to 10^{-4} and 1.0, respectively. Thus, excavation-type activities do not pose a health threat to these site workers.

The highest lead concentration detected at RI Site 34 was 960 mg/kg, associated with the surface soils. Table 6-8 provides a list of the detected lead concentrations within FU3 above the screening level of 400 mg/kg. The lead levels are below the industrial worker target concentration of 1,50 mg/kg.

Uncertainties associated with this RA are similar to those listed in the FU3 RA section (Section 18.1.4). Because the target risks and HIs were not exceeded, no RGOs were calculated for the site.

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TABLE 18-1

Constituents of Potential Concern in FU3—Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
3	SS	MG/KG	ANTIMONY	119	31	0 18	7 5	0 23	22	2 3	7	3.1	5	Yes	A
3	SS	MG/KG	ARSENIC	125	122	0 15	3 8	0 43	49	10	20	0 43	29	Yes	A
3	SS	MG/KG	BENZO(a)ANTHRACENE	107	43	0 052	15	0 039	40	2 5	0 71	0 87	2	Yes	A
3	SS	MG/KG	BENZO(a)PYRENE	107	42	0 053	15	0 039	37	2 3	0 96	0 087	8	Yes	A
3	SS	MG/KG	BENZO(b)FLUORANTHENE	107	43	0 053	15	0 038	39	2 4	0 9	0 87	5	Yes	A
3	SS	MG/KG	BENZO(k)FLUORANTHENE	107	41	0 053	15	0 043	34	2 6	0 78	8 7	49	Yes	A
3	SS	MG/KG	CADMIUM	125	61	0 0089	1 3	0 08	8 1	1 1	1 4	7 8	8	Yes	A
3	SS	MG/KG	CARBAZOLE	37	7	0 34	15	0 08	10	2 2	0 067	32	0 6	Yes	A
3	SS	MG/KG	CHROMIUM, TOTAL	125	125	0 055	2 5	5 5	915	70	25	10800	38	Yes	A
3	SS	MG/KG	CHRYSENE	107	45	0 052	15	0 043	46	2.7	0 94	87	160	Yes	G
3	SS	MG/KG	DIBENZ(a,h)ANTHRACENE	107	2	0 053	15	0 21	1 2	0 71	0 26	0 087	2	Yes	A
3	SS	MG/KG	DIELDRIN	80	24	0 0036	0 38	0 0012	0 18	0 043	0 086	0 04	0 00	Yes	A
3	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	107	36	0 053	15	0 048	22	1 8	0 7	0 87	14	Yes	A
3	SS	MG/KG	LEAD	125	125	0 11	4 5	2 8	4150	244	30	400		Yes	A
3	SS	MG/KG	MERCURY	125	32	0	0 12	0 015	2 1	0 12	0 4	2 3	2	Yes	A
3	SS	MG/KG	PENTACHLOROPHENOL	37	1	0 17	7 7	0 68	0 68	0 68		5 3	0 03	Yes	A
3	SS	MG/KG	PETROLEUM HYDROCARBONS	4	4	1 8	9 1	26	274	98		34	340	Yes	A
3	SS	MG/KG	SELENIUM	125	36	0 14	3 5	0 29	9 5	1 4	0 8	39	5	Yes	A
3	SS	MG/KG	TCDD Equivalent	6	6	0 001	0 001	0 0000028	0 000013	0 0000072	0 00001	0 0000043	0 005	Yes	A
3	SS	MG/KG	VANADIUM	30	30	0 032	0 2	6 8	77	20	48	55	6000	Yes	A
3	SS	MG/KG	ZINC	125	125	0 072	5	21	4000	257	126	2300	12000	Yes	A

Notes Data evaluated include field duplicates and normal samples (0-2 feet)

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 18-2

Constituents of Potential Concern in FU3—Subsurface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
3	SB	MG/KG	ANTIMONY	103	3	0 18	7 8	0 74	7 8	5 4		5	Yes	A
3	SB	MG/KG	ARSENIC	106	101	0 15	24	2 1	27	10	17	29	Yes	H
3	SB	MG/KG	BENZO(a)ANTHRACENE	89	4	0 052	2 1	0 044	1 2	0 37		2	Yes	H
3	SB	MG/KG	BENZO(a)PYRENE	89	3	0 052	2 1	0 08	1	0 4		8	Yes	H
3	SB	MG/KG	BENZO(b)FLUORANTHENE	89	3	0 052	2 1	0 088	1	0 4		5	Yes	H
3	SB	MG/KG	BENZO(k)FLUORANTHENE	89	3	0 052	2 1	0 081	0 72	0 3		49	Yes	H
3	SB	MG/KG	CADMIUM	106	13	0 0091	1 3	0 07	1 5	0 35	1 4	8	Yes	H
3	SB	MG/KG	CARBAZOLE	45	1	0 38	2 1	0 48	0 48	0 48		0.6	Yes	H
3	SB	MG/KG	CHROMIUM, TOTAL	106	106	0 058	3 1	2 1	102	26	26	38	Yes	A
3	SB	MG/KG	CHRYSENE	89	5	0 052	2 1	0 043	1 2	0 31		160	Yes	H
3	SB	MG/KG	COPPER	106	103	0 1	2 6	2 5	49	20	33		Yes	D
3	SB	MG/KG	DIELDRIN	59	1	0 0038	0 02	0 0049	0 0049	0 0049	0 37	0 0040	Yes	H
3	SB	MG/KG	INDENO(1,2,3-c,d)PYRENE	89	2	0 052	2 1	0 09	0 67	0 38		14	Yes	H
3	SB	MG/KG	LEAD	106	106	0 14	0 78	1 1	282	17	24		Yes	D
3	SB	MG/KG	MERCURY	106	3	0 0074	0 17	0 03	0 05	0 04	0 2	2	Yes	H
3	SB	MG/KG	PETROLEUM HYDROCARBONS	2	1	1 9	2 6	3 2	3 2	3 2		340	Yes	H
3	SB	MG/KG	SELENIUM	106	10	0 16	12	0 36	2 3	1 2	0 6	5	Yes	H
3	SB	MG/KG	TCDD Equivalent	13	13	0 001	0 001	0 00000005	0 0000079	0 0000019	0 000006	0 005	Yes	H
3	SB	MG/KG	VANADIUM	21	21	0 037	0 058	14	38	26	51	6000	Yes	H
3	SB	MG/KG	ZINC	106	106	0 076	5 2	1 7	145	59	114	12000	Yes	H

Notes Data evaluated include field duplicates and normal samples (2 feet and below)

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

TABLE 18-3

Constituents of Potential Concern in FU3 - Sediment

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Sediments	Regulatory Criteria for Leachability	COPC/BASIS	
3	SE	MG/KG	2,4-DIMETHYLPHENOL	1	1	2 7	2 7	16	16	16		160	9	Yes	A
3	SE	MG/KG	2-METHYLNAPHTHALENE	1	1	2 7	2 7	8 2	8 2	8 2		160	6.1	Yes	A
3	SE	MG/KG	ANTIMONY	1	1	0 35	0 35	28	28	28	7 6	3 1	5	Yes	A
3	SE	MG/KG	BARIUM	1	1	0 038	0 038	1120	1120	1120	118	550	1600	Yes	A
3	SE	MG/KG	CADMIUM	1	1	0 038	0 038	84	84	84	29	7 8	8	Yes	A
3	SE	MG/KG	CHROMIUM, TOTAL	1	1	3 3	3 3	1700	1700	1700	20	10800	38	Yes	A
3	SE	MG/KG	LEAD	1	1	0 18	0 18	3820	3820	3820	35	400		Yes	A
3	SE	MG/KG	PETROLEUM HYDROCARBONS	1	1	134	134	5980	5980	5980		34	340	Yes	A
3	SE	MG/KG	ZINC	1	1	0 38	0 38	2550	2550	2550	797	2300	12000	Yes	A

Notes Data evaluated include field duplicates and normal samples

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 18-4
Summary of Exposure Pathways to be Quantified at FU3
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil
Onsite Lumberyard Workers	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Lumberyard worker exposure to surface soil would be limited to less than 2 hours per day Maintenance worker exposure assumptions are protective of lumberyard worker
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Hypothetical future worst-case exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (zero to 10 feet below ground surface)	No	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil This is evaluated as part of the surrogate site exposure unit
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be short exposure duration (less than 1 year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Evaluated for comparison purposes only.

TABLE 18-5

Exposure Point Concentrations for FU3—Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	Antimony	112	31	2	22	3	3	3
MG/KG	Arsenic	117	114	10	49	11	13	13
MG/KG	Cadmium	117	56	0.73	8.1	0.88	1.3	1.3
MG/KG	Chromium (total)	117	117	69	915	88	72	72
MG/KG	Lead	117	117	241	4150	326	311	311
MG/KG	Mercury	117	28	0.06	2.1	0.093	0.062	0.062
MG/KG	Selenium	117	33	0.72	9.5	0.87	0.82	0.82
MG/KG	Vanadium	26	26	21	77	26	26	26
MG/KG	Zinc	117	117	249	4000	321	273	273
MG/KG	Dieldrin	76	21	0.024	0.18	0.032	0.037	0.037
MG/KG	Benzo(a)anthracene	101	44	1.3	40	2.0	1.4	1.4
MG/KG	Benzo(a)pyrene	101	44	1.2	37	1.9	1.3	1.3
MG/KG	Benzo(b)fluoranthene	101	45	1.2	39	2.0	1.4	1.4
MG/KG	Benzo(k)fluoranthene	101	43	1.3	34	2.0	1.4	1.4
MG/KG	Carbazole	35	8	0.63	10	1.1	0.55	0.55
MG/KG	Chrysene	101	47	1.4	46	2.3	1.6	1.6
MG/KG	Dibenz(a,h)anthracene	101	2	0.45	1.2	0.6	0.54	0.54
MG/KG	Indeno(1,2,3-c,d)pyrene	101	38	0.89	22	1.3	1.1	1.1
MG/KG	Pentachlorophenol	35	1	0.26	0.68	0.45	0.24	0.24
MG/KG	Petroleum Hydrocarbons	3	3	118	274	347	90509517	274
MG/KG	TCDD Equivalent	6	6	0.0000072	0.000013	0.000011	0.000019	0.000013

Note

Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation

TABLE 18-6

Exposure Point Concentrations for FU3—Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	Antimony	180	33	2 4	22	2 6	3.5	3.5
MG/KG	Arsenic	187	183	10	49	11	12	12
MG/KG	Cadmium	187	67	0 6	8 1	0.7	0.89	0.89
MG/KG	Chromium (total)	187	187	52	915	65	49	49
MG/KG	Copper	187	185	27	235	30	31	31
MG/KG	Lead	187	187	158	4150	213	143	143
MG/KG	Mercury	187	30	0.057	2 1	0 075	0 056	0 056
MG/KG	Selenium	187	39	0 66	9.50	0 77	0 72	0 72
MG/KG	Vanadium	48	48	24	77	26	27	27
MG/KG	Zinc	187	187	180	4000	226	170	170
MG/KG	Dieldrin	121	22	0 016	0 18	0 021	0 017	0 017
MG/KG	Benzo(a)anthracene	165	48	0 86	40	1 3	0 69	0 69
MG/KG	Benzo(a)pyrene	165	47	0 79	37	1 2	0 65	0 65
MG/KG	Benzo(b)fluoranthene	165	48	0 82	39	1 3	0.68	0.68
MG/KG	Benzo(k)fluoranthene	165	46	0.84	34	1.3	0.69	0.69
MG/KG	Carbazole	68	9	0 43	10	0 69	0 34	0 34
MG/KG	Chrysene	165	52	0 95	46	1 5	0.74	0.74
MG/KG	Dibenz(a,h)anthracene	165	2	0 33	1 2	0.43	0 36	0 36
MG/KG	Indeno(1,2,3-c,d)pyrene	165	40	0 6	22	0.87	0 56	0 56
MG/KG	Pentachlorophenol	68	1	0 19	0 68	0 28	0 16	0 16
MG/KG	Petroleum Hydrocarbons	5	4	72	274	181	9901172	274
MG/KG	TCDD Equivalent	10	10	0 0000062	0 000013	0 0000084	0 00001	0.00001

Notes.

Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within zero to 10 feet

TABLE 18-7

Exposure Point Concentrations for FU3—Sediment

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	Antimony	1	1	28	28	N/A	N/A	28
MG/KG	Barium	1	1	1120	1120	N/A	N/A	1120
MG/KG	Cadmium	1	1	84	84	N/A	N/A	84
MG/KG	Chromium (total)	1	1	1700	1700	N/A	N/A	1700
MG/KG	Lead	1	1	3820	3820	N/A	N/A	3820
MG/KG	Zinc	1	1	2550	2550	N/A	N/A	2550
MG/KG	2,4-Dimethylphenol	1	1	16	16	N/A	N/A	16
MG/KG	2-Methylnaphthalene	1	1	8 2	8 2	N/A	N/A	8 2
MG/KG	Petroleum Hydrocarbons	1	1	5980	5980	N/A	N/A	5980

Note

Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

TABLE 18-8

Exposure Point Concentrations for FU3, Station B(26 2) - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Parameter	EPC (mg/kg)
Benzo(a)pyrene	37
Benzo(b)fluoranthene	39
Benzo(k)fluoranthene	34
Chrysene	46
Indeno(1,2,3-c,d)pyrene	22

Notes:

Data evaluated include normal samples only.

Field duplicates have been dropped from risk evaluation.

EPC values represent the maximum PRE sample within FU3 at location B(26 2).

TABLE 18-9

Toxicity Factors for FU3

Memphis Depot Main Installation RI

Name	Weight-of-Evidence Class	ABS_{GI}	Oral SF kg-day/mg	Dermal SF kg-day/mg	Inhal SF kg-day/mg	C Oral RfD mg/kg-day	Dermal RfD mg/kg-day	C Inhal RfD mg/kg-day
2,3,7,8-Tetrachlorodibenzodioxin (TCDD)	B2	50%	1 50E+05	3 00E+05	1 50E+05			
2,4-Dimethylphenol		65%				2 00E-02	1 30E-02	
2-Methylnaphthalene	D	80%				2 00E-02	1 60E-02	9 00E-04
Antimony	D	2%				4 00E-04	8 00E-06	
Arsenic	A	41%	1.50E+00	3 66E+00	1 51E+01	3 00E-04	1 23E-04	
Barium	D	7%				7 00E-02	4.90E-03	1 43E-04
Benzo(a)anthracene	B2	31%	7 30E-01	2 35E+00	3 10E-01			
Benzo(a)pyrene	B2	31%	7 30E+00	2 35E+01	3 10E+00			
Benzo(b)fluoranthene	B2	31%	7 30E-01	2 35E+00	3 10E-01			
Benzo(k)fluoranthene	B2	31%	7 30E-02	2 35E-01	3.10E-02			
Cadmium	B1	1%			6 30E+00	1 00E-03	1 00E-05	
Carbazole	B2	70%	2 00E-02	2.86E-02				
Chromium (total)	A	2%			4.20E+01	3 00E-03	6 00E-05	2 86E-05
Chrysene	B2	31%	7 30E-03	2 35E-02	3 10E-03			
Copper	D	30%				3 70E-02	1.11E-02	
Dibenz(a,h)anthracene	B2	31%	7 30E+00	2 35E+01	3 10E+00			
Dieldrin	B2	50%	1 60E+01	3 20E+01	1 60E+01	5 00E-05	2 50E-05	
Indeno(1,2,3-c,d)pyrene	B2	31%	7 30E-01	2 35E+00	3 10E-01			
Lead	B2	15%						
Mercury	D	0 01%						8.57E-05
Pentachlorophenol	B2	100%	1 20E-01	1 20E-01		3 00E-02	3.00E-02	
Petroleum Hydrocarbons		50%				4 00E-02	2 00E-02	6 00E-02
Phenanthrene	D	73%						
Selenium	D	44%				5 00E-03	2.20E-03	
Vanadium		1%				7 00E-03	7 00E-05	
Zinc	D	20%				3 00E-01	6 00E-02	

Note

Master list of toxicity factors, with sources and basis, is provided in Section 7 0

TABLE 18-10

Carcinogenic Risks and Noncarcinogenic Hazards of FU3

Memphis Depot Main Installatin RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Surface Soil (zero to 2 ft)		9E-06	0.05	*Arsenic, Benzo(a)pyrene*
	Soil Column (zero to 10ft)[1]		6E-06	0 04	*Arsenic*
	Sediment		0E+00	0.6	
		Total[2]	***9E-06***	***0.6***	***Arsenic, Benzo(a)pyrene***
Maintenance Worker					
	Surface Soil (zero to 2 ft)		1E-06	0 005	
	Sediment		0E+00	0.03	
		Total	***1E-06***	***0.03***	
Residential Adult (age-adjusted)					
	Soil point exposure at B(26 2)		6E-04	0	*PAHs*
		Total	***6E-04***	***0***	***PAHs***
Residential Child[3]					
	Soil point exposure at B(26.2)		4E-04	0	*PAHs*
		Total	***4E-04***	***0***	***PAHs***

Notes:

Residential receptors have been included for comparison purposes only.

[1] *Soil Column includes surface and subsurface soil, and therefore, cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations and may not have been evaluated for all media.*

PAHs = Polynuclear aromatic hydrocarbons

TABLE 18-11

Carcinogenic Risks and Noncarcinogenic Hazards of FU3 Soil and Groundwater

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways	Total ELCR	Total HI	Chemicals of Concern
Industrial Worker				
	Groundwater - Site-wide Inorganics	1E-05	0.5	*Arsenic*
	Groundwater - Plume A Organics (Averages)	8E-06	0.06	*PCE*
	Groundwater Total - Plume A	***2E-05***	***0.5***	***Arsenic, PCE***
	Soils	9E-06	0.05	*Arsenic, B(a)P*
	Sediment	0E+00	0.6	
	Other Media Total[2]	***9E-06***	***0.6***	***Arsenic, B(a)P***
	Totals for All Media (including Groundwater)	***3E-05***	***1***	***Arsenic, PCE, B(a)P***
Maintenance Worker				
	Soils	1E-06	0.005	
	Sediment	0E+00	0.03	
	Other Media Total	***1E-06***	***0.03***	
	(no groundwater exposure for this receptor)			
Residential Adult (age-adjusted)				
	Groundwater - Site-wide Inorganics	5E-05	1	*Arsenic*
	Groundwater - Plume A Organics (Averages)	3E-05	0.2	*PCE, TCE*
	Groundwater Total - Plume A	***9E-05***	***1***	***Arsenic, PCE, TCE***
	Soil point exposure at B(26.2)	6E-04	0	*PAHs*
	Other Media Total	***6E-04***	***0***	***PAHs***
	Totals for All Media (including Groundwater)	***7E-04***	***1***	***Arsenic, PCE, TCE, PAHs***
Residential Child[3]				
	Groundwater - Site-wide Inorganics	2E-05	3	*Arsenic*
	Groundwater - Plume A Organics (Averages)	1E-05	0.4	*PCE*
	Groundwater Total - Plume A	***3E-05***	***3***	***Arsenic, PCE***
	Soil point exposure at B(26.2)	4E-04	0	*PAHs*
	Other Media Total	***4E-04***	***0***	***PAHs***
	Totals for All Media (including Groundwater)	***4E-04***	***3***	***Arsenic, PCE, PAHs***

Notes

Residential receptors have been included for comparison purposes only

[1] *Soil Column includes surface and subsurface soil, and therefore, cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations and may not have been evaluated for all media*

BaP = Benzo(a)pyrene

PAHs = Polynuclea aromatic Hydrocarbons

PCE = Tetrachloroethane

TCE = Trichloroethene

TABLE 18-12
Stations with Elevated Lead Levels in Surface Soil and Sump Sediment in FU3
Memphis Depot Main Installation RI

Functional Unit	Medium	Station ID	Concentration of Lead (mg/kg)
3	Soil	SB32A	4,150
3	Sediment	A(35.3)	3,820
3	Soil	SS89H	2,470
3	Soil	SS89J	2,250
3	Soil	SS33K	1,830
3	Soil	SS32G	1,580

TABLE 18-13
Step 2 Surface Soil Screening Level Risk Calculations for FU3
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection		Range of Detected Values						
	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	30	30	2820	J	13600	=	50	**272**	Y
ANTIMONY	119	31	0 23	J	22 3	=	3 5	**6.4**	Y
ARSENIC	125	122	0 43	J	49 2	=	10	**4.9**	Y
BARIUM	30	30	28 7	=	432	=	165	**2.6**	Y
BERYLLIUM	125	57	0 05	J	2	=	1 1	**1.8**	Y
CADMIUM	125	61	0 08	J	8 1	=	1 6	**5.1**	Y
CHROMIUM III	5	5	13 1	=	403	=	0 4	**1008**	Y
CHROMIUM, HEXAVALENT	5	1	0 12	=	0 12	=	0 4	0.3	N
CHROMIUM, TOTAL	125	125	5 5	J	915	=	0 4	**2288**	Y
COBALT	30	30	0 88	J	8 8	=	20	0.4	N
COPPER	125	123	4 1	=	235	=	40	**5.9**	Y
IRON	30	30	3960	=	51300	=	200	**257**	Y
LEAD	125	125	2 80	=	4150	=	50	**83**	Y
MANGANESE	30	30	60 20	=	634	=	100	**6.3**	Y
MERCURY	125	32	0 015	J	2.1	=	0 1	**21**	Y
NICKEL	125	125	3 2	=	76 3	=	30	**2.5**	Y
SELENIUM	125	36	0 29	=	9 5	J	0 81	**12**	Y
SILVER	125	3	0 31	J	2 5	=	2	**1.3**	Y
VANADIUM	30	30	6.8	=	76.7	=	2	**38**	Y
ZINC	125	125	20 9	=	4000	=	50	**80**	Y
Organics									
1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	6	6	0 000004	J	0 00029	J	0 1	0 0	N
1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	6	2	0 000002	J	0 000003	J	0.1	0 0	N
1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	6	2	0 000004	J	0 000004	J	0 1	0 0	N
1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	6	2	0 000001	J	0 000002	J	0.1	0 0	N
1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	6	1	0 000008	J	0 000008	J	0 1	0 0	N
1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	6	2	0 000005	J	0 000005	J	0 1	0.0	N
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	6	1	0 000003	J	0 000003	J	0 1	0 0	N
2-HEXANONE	80	3	0 001	J	0 008	J		**NA**	Y
2-METHYLNAPHTHALENE	107	2	0 08	J	0 51	=	0 1	**5.1**	Y
ACENAPHTHENE	107	12	0 06	J	5 0	J	20	0 3	N

TABLE 18-13
Step 2 Surface Soil Screening Level Risk Calculations for FU3
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection		Range of Detected Values						
	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
ACENAPHTHYLENE	107	2	0.09	J	0.14	=	0.1	**1.4**	Y
ACETONE	80	34	0.002	J	0.14	=		**NA**	Y
ALPHA-CHLORDANE	80	15	0.0014	J	0.61	=	0.1	**6.1**	Y
ANTHRACENE	107	14	0.07	=	11	J	0.1	**110**	Y
BENZENE	81	3	0.001	J	0.007	J	0.05	0.1	N
BENZO(a)ANTHRACENE	107	43	0.039	J	40	=	0.1	**400**	Y
BENZO(a)PYRENE	107	42	0.039	J	37	=	0.1	**370**	Y
BENZO(b)FLUORANTHENE	107	43	0.038	J	39	=	0.1	**390**	Y
BENZO(g,h,i)PERYLENE	107	35	0.037	J	22	=	0.1	**220**	Y
BENZO(k)FLUORANTHENE	107	41	0.043	J	34	=	0.1	**340**	Y
BENZYL BUTYL PHTHALATE	37	1	0.083	J	0.083	J	0.1	0.8	N
bis(2-ETHYLHEXYL) PHTHALATE	37	11	0.04	J	5.6	=	0.1	**56**	Y
BROMOMETHANE	80	4	0.002	J	0.002	J		**NA**	Y
CARBAZOLE	37	7	0.08	J	10	J		**NA**	Y
CARBON DISULFIDE	80	2	0.002	J	0.002	J		**NA**	Y
CHRYSENE	107	45	0.043	J	46	=	0.1	**460**	Y
DDD	80	4	0.029	J	0.046	=	0.0025	**18**	Y
DDE	80	33	0.0014	J	0.17	J	0.0025	**68**	Y
DDT	80	39	0.002	J	0.41	=	0.0025	**164**	Y
DIBENZ(a,h)ANTHRACENE	107	2	0.21	=	1.2	=	0.1	**12**	Y
DIBENZOFURAN	37	3	0.49	=	2.4	J	0.1	**24**	Y
DIELDRIN	80	24	0.0012	J	0.18	=	0.0005	**360**	Y
DIETHYL PHTHALATE	37	1	0.9	=	0.9	=	0.1	**9.0**	Y
DI-n-BUTYL PHTHALATE	37	1	0.18	J	0.18	J	0.1	**1.8**	Y
FLUORANTHENE	107	50	0.04	J	71	=	0.1	**710**	Y
FLUORENE	107	14	0.056	J	4.8	J	0.1	**48**	Y
GAMMA-CHLORDANE	80	15	0.0017	J	0.58	=	0.1	**5.8**	Y
HEPTACHLOR	80	1	0.035	J	0.04	J	0.1	0.4	N
INDENO(1,2,3-c,d)PYRENE	107	36	0.048	J	22	=	0.1	**220**	Y
METHYL ETHYL KETONE (2-BUTANONE)	80	5	0.002	J	0.044	=		**NA**	Y
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTAN	80	1	0.002	J	0.002	J		**NA**	Y
METHYLENE CHLORIDE	80	28	0.001	J	0.007	J	0.1	0.1	N

TABLE 18-13
Step 2 Surface Soil Screening Level Risk Calculations for FU3
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection Number Analyzed	Number Detected	Range of Detected Values Minimum (mg/kg)	Qual	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
NAPHTHALENE	107	4	0 085	J	0 63	J	0 1	**6.3**	Y
OCTACHLORODIBENZOFURAN	6	6	0 000006	J	0 000697	J	0 1	0.0	N
OCTACHLORODIBENZO-p-DIOXIN	6	6	0 002772	J	0.01025	=	0.1	0 1	N
PENTACHLOROPHENOL	37	1	0 68	=	0 68	=	0 002	**340**	Y
PETROLEUM HYDROCARBONS	4	4	26 3	=	274	=		**NA**	Y
PHENANTHRENE	107	44	0 043	J	52	=	0 1	**520**	Y
PYRENE	107	49	0 043	J	71	=	0 1	**710**	Y
TCDD Equivalent	6	6	0 0000028	=	0.0000103	=		**NA**	Y
TOLUENE	81	5	0 001	J	0 004	J	0 05	0.1	N
Total Xylenes	81	3	0 001	J	0 003	J		**NA**	Y
TRICHLOROETHYLENE (TCE)	80	1	0 001	J	0 001	J	0.001	**1.0**	Y

Notes

Ca, Mg, K, Na were detected, however, these parameters were not evaluated because they are commonly occurring elements

1 = Memorandum; Ecological Risk Assessment at Military Bases Process Consideration, Timing, of Activities, and Inclusion of Stakeholders EPA Region 4, December 22, 1998

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TABLE 18-14

Step 3 Refinement of Surface Soil Preliminary Constituents of Concern for FU3

Ecological Risk Assessment

Memphis Depot Main Installation RI

COPCs	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max. Compared to Primary	Avg Compared to Primary	Max Compared to Secondary	Avg. Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics														
ALUMINUM	13600	6283	23810	50	2	600	3	272	126	23	10	N	N	100
ANTIMONY	22 3	2 3	7	3 5	6	5	2	6	0 7	4	0 5	Y	N,	26
ARSENIC	49 2	10 2	20	10	2	29	4	5	1 0	2	0 4	Y	N	98
BARIUM	432	89 9	234	165	6	500	2	3	0 5	0 9	0 2	Y	N	100
BERYLLIUM	2	0 43	1 1	1 1	6			2	0 4			Y	N	46
CADMIUM	8 1	1 1	1 4	1 6	6	4	2	5	0 7	2	0 3	Y	N	49
CHROMIUM III	403	141 9		0 4	1	1	2	1008	355	403	142	NA	NA	100
CHROMIUM, TOTAL	915	69 5	24 8	0 4	1	1	2	2288	174	915	70	Y	Y	100
COPPER	235	31 2	33 5	40	6	50	2,5	6	0 8	5	0 6	Y	N	98
IRON	51300	15498	37040	200	3			257	77			Y	N	100
LEAD	4150	244	30	50	2 5	500	1	83	5	8	0 5	Y	Y	100
MANGANESE	634	251	1304	100	3	500	2	6	3	1 3	0 5	N	N	100
MERCURY	2 1	0 12	0 4	0 1	1	0 3	2,4	21	1 2	7	0 4	Y	N	26
NICKEL	76 3	18 4	30	30	2	90	3	3	0 6	0 8	0 2	Y	N	100
SELENIUM	9 5	1 4	0 8	0 81	6	1	2	12	2	10	1 4	Y	Y	29
SILVER	2 5	1 5	2	2	2	50	3	1 3	0 7	0 1	0 0	Y	N	2
VANADIUM	76 7	19 6	48 4	2	2	20	3	38	10	4	1 0	Y	N	100
ZINC	4000	257	126	50	2	100	3	80	5	40	3	Y	Y	100
Organics														
2-HEXANONE	0 008	0 003										NA	NA	4
2-METHYLNAPHTHALENE	0 51	0 297		0 1	5	5	7	5	3	0 1	0 1	NA	NA	2
ACENAPHTHYLENE	0 14	0 11	0 19	0 1	5	1	7	1 4	1 1	0 1	0 1	N	N	2
ACETONE	0 14	0 02										NA	NA	43
ALPHA-CHLORDANE	0 61	0 12	0 029	0 1	5	0 5	7	6	1 2	1 2	0 2	Y	Y	19
ANTHRACENE	11	1 6	0 096	0 1	5	10	7	110	16	1 1	0 2	Y	Y	13
BENZO(a)ANTHRACENE	40	2 5	0 71	0 1	5	1	7	400	25	40	2	Y	Y	40
BENZO(a)PYRENE	37	2 3	0 96	0 1	5	1	7	370	23	37	2	Y	Y	39
BENZO(b)FLUORANTHENE	39	2 4	0 9	0 1	5	1	7	390	24	39	2	Y	Y	40
BENZO(g,h,i)PERYLENE	22	1 6	0 82	0 1	5	1	7	220	16	22	2	Y	Y	33
BENZO(k)FLUORANTHENE	34	2 6	0 78	0 1	5	1	7	340	26	34	3	Y	Y	38
bis(2-ETHYLHEXYL) PHTHALATE	5 6	0 8		0 1	4	100	4	56	8	0 1	0 0	NA	NA	30
BROMOMETHANE	0 002	0 002										NA	NA	5
CARBAZOLE	10	2 2	0 067									Y	Y	19
CARBON DISULFIDE	0 002	0 002	0 002									N	N	3
CHRYSENE	46	2 7	0 94	0 1	5	1	7	460	27	46	3	Y	Y	42
DDD	0 046	0 037	0 0067	0 0025	4	4	5	18	15	0 0	0 0	Y	Y	5
DDE	0 17	0 03	0 16	0 0025	4	4	5	68	13	0 0	0 0	Y	N	41

TABLE 18-14

Step 3 Refinement of Surface Soil Preliminary Constituents of Concern for FU3

Ecological Risk Assessment

Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max. Compared to Primary	Avg Compared to Primary	Max. Compared to Secondary	Avg Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
DDT	0 41	0 08	0 074	0 0025	4	4	5	164	32	0 1	0 0	Y	Y	49
DIBENZ(a,h)ANTHRACENE	1 2	0 7	0 26	0 1	5	1	7	12	7	1 2	0 7	Y	Y	2
DIBENZOFURAN	2 4	1 3	0 647	0 1	5	1	7	24	13	2	1 3	Y	Y	8
DIELDRIN	0 18	0 04	0 086	0 0005	4			360	85			Y	N	30
DIETHYL PHTHALATE	0 9	0 9		0 1	4	100	2	9	9	0 0	0 0	NA	NA	3
DI-n-BUTYL PHTHALATE	0 18	0 18		0 1	4	200	2	2	2	0 0	0 0	NA	NA	3
FLUORANTHENE	71	4 2	1 6	0 1	5	10	7	710	42	7	0 4	Y	Y	47
FLUORENE	4 8	1 0		0 1	5	1	7	48	10	5	1 0	NA	NA	13
GAMMA-CHLORDANE	0 58	0 13	0 026	0 1	5	0 5	7	6	1 3	1 2	0 3	Y	Y	19
INDENO(1,2,3-c,d)PYRENE	22	1 8	0 7	0 1	5	1	7	220	18	22	2	Y	Y	34
METHYL ETHYL KETONE (2 BUTANONE)	0 044	0 016	0 002									Y	Y	6
2-PENTANONE)	0 002	0 002										NA	NA	1
NAPHTHALENE	0 63	0 24		0 1	5	5	7	6	2	0 1	0 0	NA	NA	4
PENTACHLOROPHENOL	0 68	0 68		0 002	4	3	2	340	340	0 2	0 2	NA	NA	3
PETROLEUM HYDROCARBONS	274	97 5										NA	NA	100
PHENANTHRENE	52	3 3	0 61	0 1	5	5	7	520	33	10	0 7	Y	Y	41
PYRENE	71	3 6	1 5	0 1	5	10	7	710	36	7	0 4	Y	Y	46
TCDD Equivalent	0 0000131	0 0000072	0 00001	0 1	5	1	7	0 0	0 0	0 0	0 0	Y	N	100
Total Xylenes	0 003	0 002	0 009	0 05	4,5	25	5	0 1	0 0	0 0	0 0	N	N	4
TRICHLOROETHYLENE (TCE)	0 001	0 001		0 001	4	0 1	5	1 0	1 0	0 0	0 0	NA	NA	1

Notes

1 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for earthworms

2 Efroymson, R A et al 1997b Oak Ridge National Laboratory, toxicological banchmarks for plants

3 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for microorganisms

4 Ministry of Housing, Spatial Planning and Environment, 1994 optimum soil quality standards

5 Beyer, W N 1990 US Fish and Wildlife Service Dutch background

6 Commenttuijn, T et al, 1997 RIVM Report No 601501002

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TABLE 18-15

Constituents of Potential Concern in RI Site 34—Surface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
3	34	SS	MG/KG	ARSENIC	5	5	1.6	2.3	1.7	49	15	20	0.43	29	Yes	A
3	34	SS	MG/KG	BENZO(a)ANTHRACENE	9	7	0.11	5.3	0.49	10	3.7	0.71	0.87	2	Yes	A
3	34	SS	MG/KG	BENZO(a)PYRENE	9	7	0.11	5.3	0.48	9.5	3.2	0.96	0.087	8	Yes	A
3	34	SS	MG/KG	BENZO(b)FLUORANTHENE	9	7	0.11	5.3	0.46	9.5	3.1	0.9	0.87	5	Yes	A
3	34	SS	MG/KG	BENZO(k)FLUORANTHENE	9	7	0.11	5.3	0.46	12	3.7	0.78	8.7	49	Yes	A
3	34	SS	MG/KG	CHROMIUM, TOTAL	5	5	0.23	2.3	18.8	124	65	25	10800	38	Yes	A
3	34	SS	MG/KG	DIBENZ(a,h)ANTHRACENE	9	2	0.11	5.3	0.21	1.2	0.71	0.26	0.087	2	Yes	A
3	34	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	9	7	0.11	5.3	0.48	6.2	2.5	0.7	0.87	14	Yes	A
3	34	SS	MG/KG	LEAD	5	5	0.64	1.7	94	960	399	30	400		Yes	A
3	34	SS	MG/KG	CHRYSENE	9	7	0.11	5.3	0.52	12	4.1	0.94	87	160	Yes	G

Notes

Data evaluated include field duplicates and normal samples (0-2 feet)

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 18-16

Constituents of Potential Concern in RI Site 34—Subsurface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC?	Basis?
3	34	SB	MG/KG	CHROMIUM, TOTAL	13	13	0.06	2.6	13	41	25	26	38	Yes	A
3	34	SB	MG/KG	ARSENIC	13	13	0.2	1.3	4.3	13	7.7	17	29	Yes	H
3	34	SB	MG/KG	BENZO(a)ANTHRACENE	13	1	0.062	0.42	0.18	0.18	0.18		2	Yes	H
3	34	SB	MG/KG	BENZO(a)PYRENE	13	1	0.062	0.42	0.13	0.13	0.13		8	Yes	H
3	34	SB	MG/KG	BENZO(b)FLUORANTHENE	13	1	0.062	0.42	0.12	0.12	0.12		5	Yes	H
3	34	SB	MG/KG	BENZO(k)FLUORANTHENE	13	1	0.062	0.42	0.1	0.1	0.1		49	Yes	H
3	34	SB	MG/KG	CHRYSENE	13	1	0.062	0.42	0.15	0.15	0.15		160	Yes	H
3	34	SB	MG/KG	LEAD	13	13	0.24	0.39	6.8	14	10	24		Yes	H

Notes

Data evaluated include field duplicates and normal samples (2 feet and below)

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

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TABLE 18-17
Summary of Exposure Pathways to be Quantified at RI Site 34
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil
Onsite Lumberyard/ Factory Workers	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	No current industrial workers present in this area of the site.
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0-10' bgs)	Yes	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be shorter exposure duration (less than 1 year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper.
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Evaluated for comparison purposes only

TABLE 18-18

Exposure Point Concentrations for RI Site 34 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	Arsenic	5	5	15	49	33	638	49
MG/KG	Chromium (total)	5	5	65	124	110	352	124
MG/KG	Lead	5	5	399	960	785	10041	960
MG/KG	Benzo(a)anthracene	9	7	3 5	10	5 8	19	10
MG/KG	Benzo(a)pyrene	9	7	3 1	10	5	15	10
MG/KG	Benzo(b)fluoranthene	9	7	3	9 5	4 9	14	9 5
MG/KG	Benzo(k)fluoranthene	9	7	3 5	12	6 0	20	12
MG/KG	Chrysene	9	7	3 8	12	6 4	20	12
MG/KG	Dibenz(a,h)anthracene	9	2	1 2	1 2	1 9	8 5	1 2
MG/KG	Indeno(1,2,3-c,d)pyrene	9	7	2 5	6 2	3 8	9 3	6 2

Note

Data evaluated includes normal samples only Field duplicates have been dropped from risk evaluation

TABLE 18-19

Exposure Point Concentrations for RI Site 34 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	Arsenic	11	11	12	49	19	25	25
MG/KG	Chromium (total)	11	11	41	124	61	73	73
MG/KG	Lead	11	11	188	960	366	2831	960
MG/KG	Benzo(a)anthracene	15	8	2 1	10	3 6	56	10
MG/KG	Benzo(a)pyrene	15	8	1 9	9 5	3 2	45	9 5
MG/KG	Benzo(b)fluoranthene	15	8	1 8	9 5	3 1	43	9 5
MG/KG	Benzo(k)fluoranthene	15	8	2 1	12	3 7	56	12
MG/KG	Chrysene	15	8	2 3	12	4	66	12
MG/KG	Dibenz(a,h)anthracene	15	2	0 72	1 2	1 2	5 6	1 2
MG/KG	Indeno(1,2,3-c,d)pyrene	15	7	1 5	6 2	2 5	37	6 2

Notes

Data evaluated includes normal samples only Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

TABLE 18-20

Carcinogenic Risks and Noncarcinogenic Hazards of RI Site 34

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Surface Soil (0-2ft)		4E-05	0 1	*Arsenic, PAHs*
	Soil Column (0-10ft)[1]		4E-05	0 06	*Arsenic, PAHs*
		Total[2]	***4E-05***	***0.1***	***Arsenic, PAHs***
Utility Worker					
	Soil Column (0-10ft)		6E-06	0 007	*B(a)P*
		Total	***6E-06***	***0.007***	***B(a)P***

Notes

[1] *Soil Column includes surface and subsurface soil, and therefore, cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

BaP = Benzo(a)pyrene

PAHs = Polynuclear aromatic hydrocarbons

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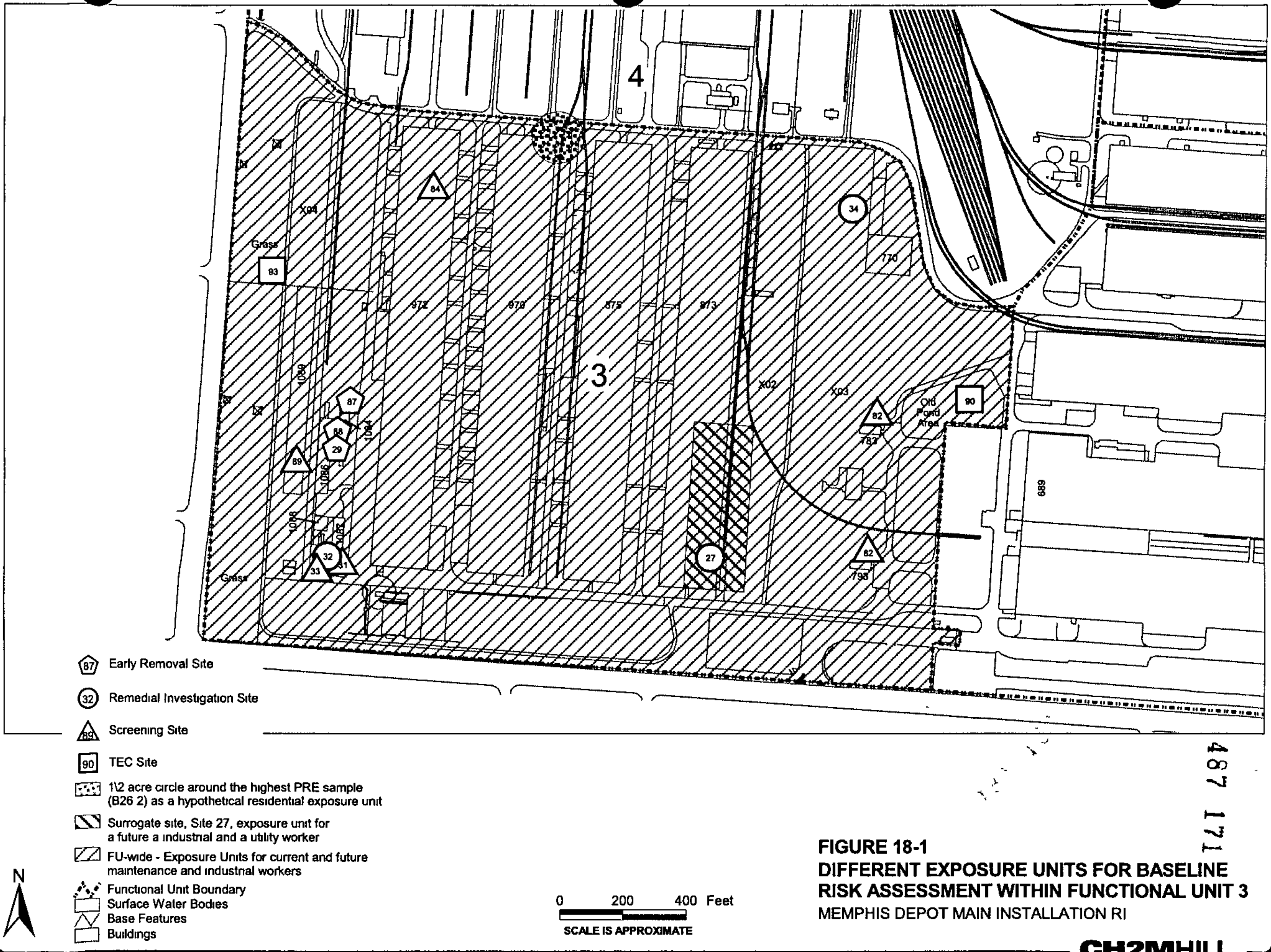

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FIGURE 18-1
DIFFERENT EXPOSURE UNITS FOR BASELINE RISK ASSESSMENT WITHIN FUNCTIONAL UNIT 3
MEMPHIS DEPOT MAIN INSTALLATION RI

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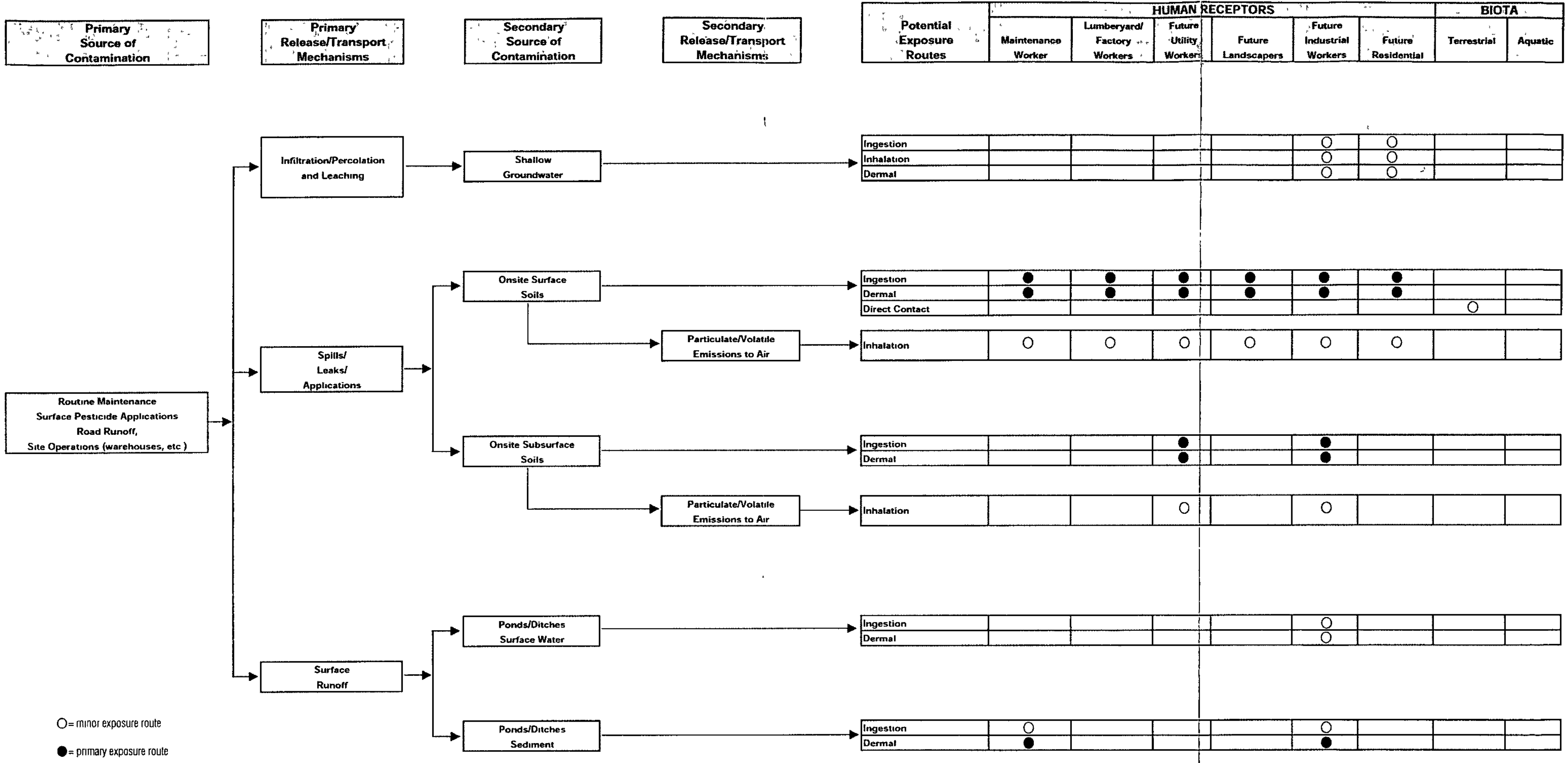

Potential Exposure Routes	HUMAN RECEPTORS						BIOTA	
	Maintenance Worker	Lumberyard/ Factory Workers	Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Ingestion					○	○		
Inhalation					○	○		
Dermal					○	○		
Ingestion	●	●	●	●	●	●		
Dermal	●	●	●	●	●	●		
Direct Contact							○	
Inhalation	○	○	○	○	○	○		
Ingestion			●		●			
Dermal			●		●			
Inhalation			○		○			
Ingestion					○			
Dermal					○			
Ingestion	○				○			
Dermal	●				●			

○ = minor exposure route

● = primary exposure route

FIGURE 18-2
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: FUNCTIONAL UNIT 3
MEMPHIS DEPOT MAIN INSTALLATION RI

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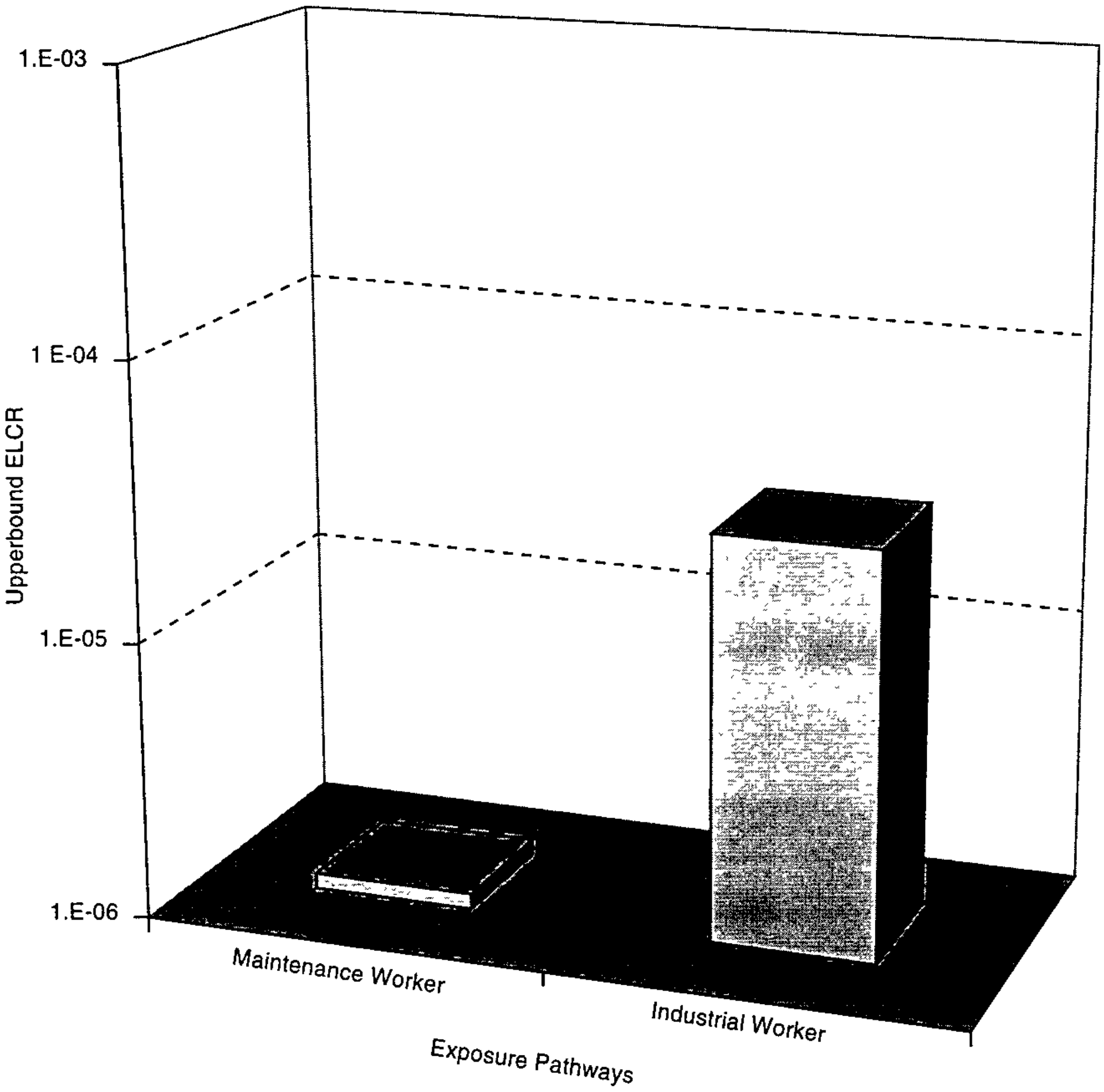

☐ Total ELCR (accepted range of 10-4 to 10-6)

Note

ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 18-3
TOTAL EXCESS LIFETIME CANCER RISKS FOR TOTAL SOIL & GROUNDWATER EXPOSURE AT FU3
MEMPHIS DEPOT MAIN INSTALLATION RI

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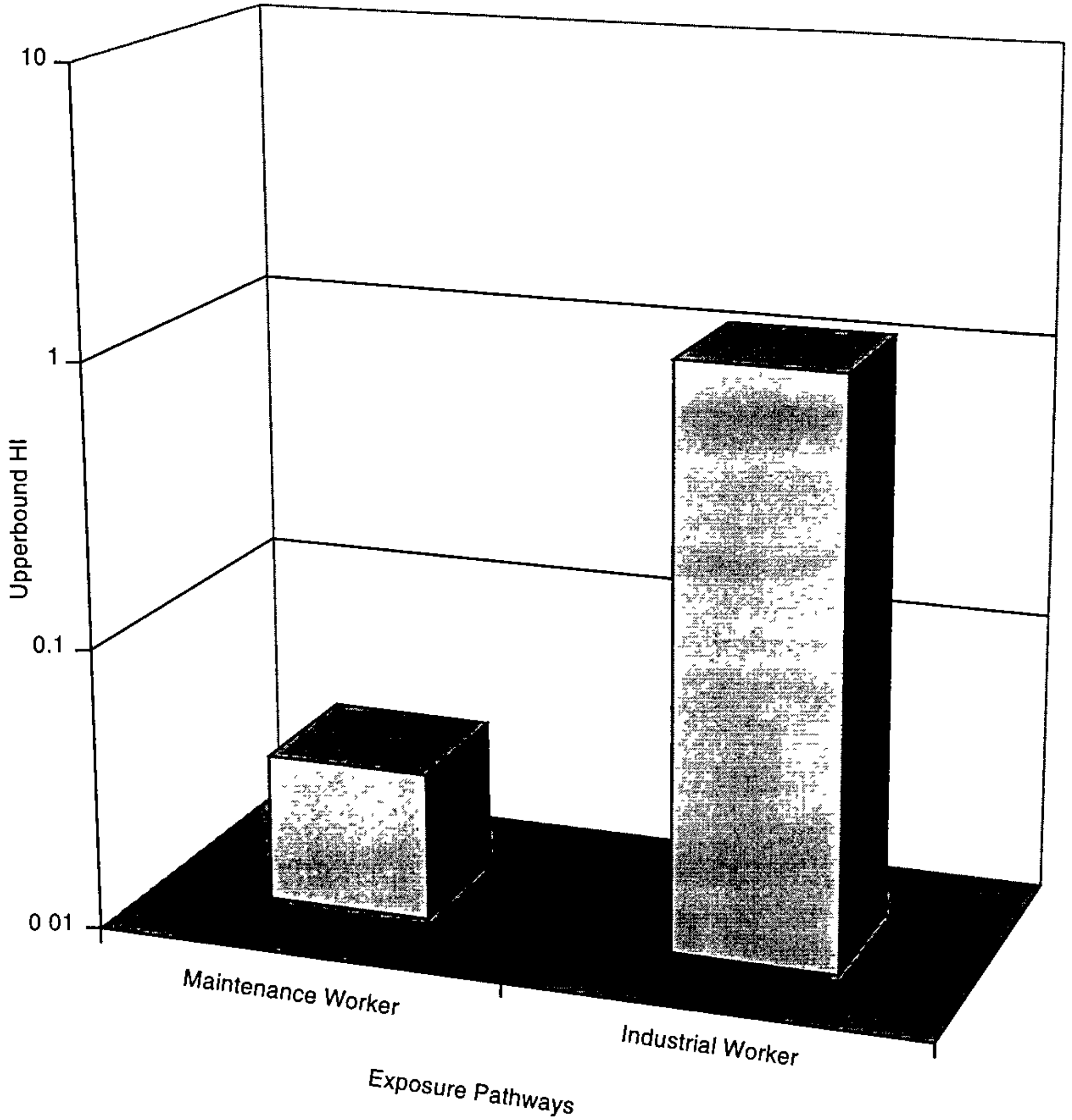

☐ Total HI (threshold of 1.0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 18-4
TOTAL HAZARD INDICES FOR TOTAL SOIL & GROUNDWATER EXPOSURE AT FU3

MEMPHIS DEPOT MAIN INSTALLATION RI

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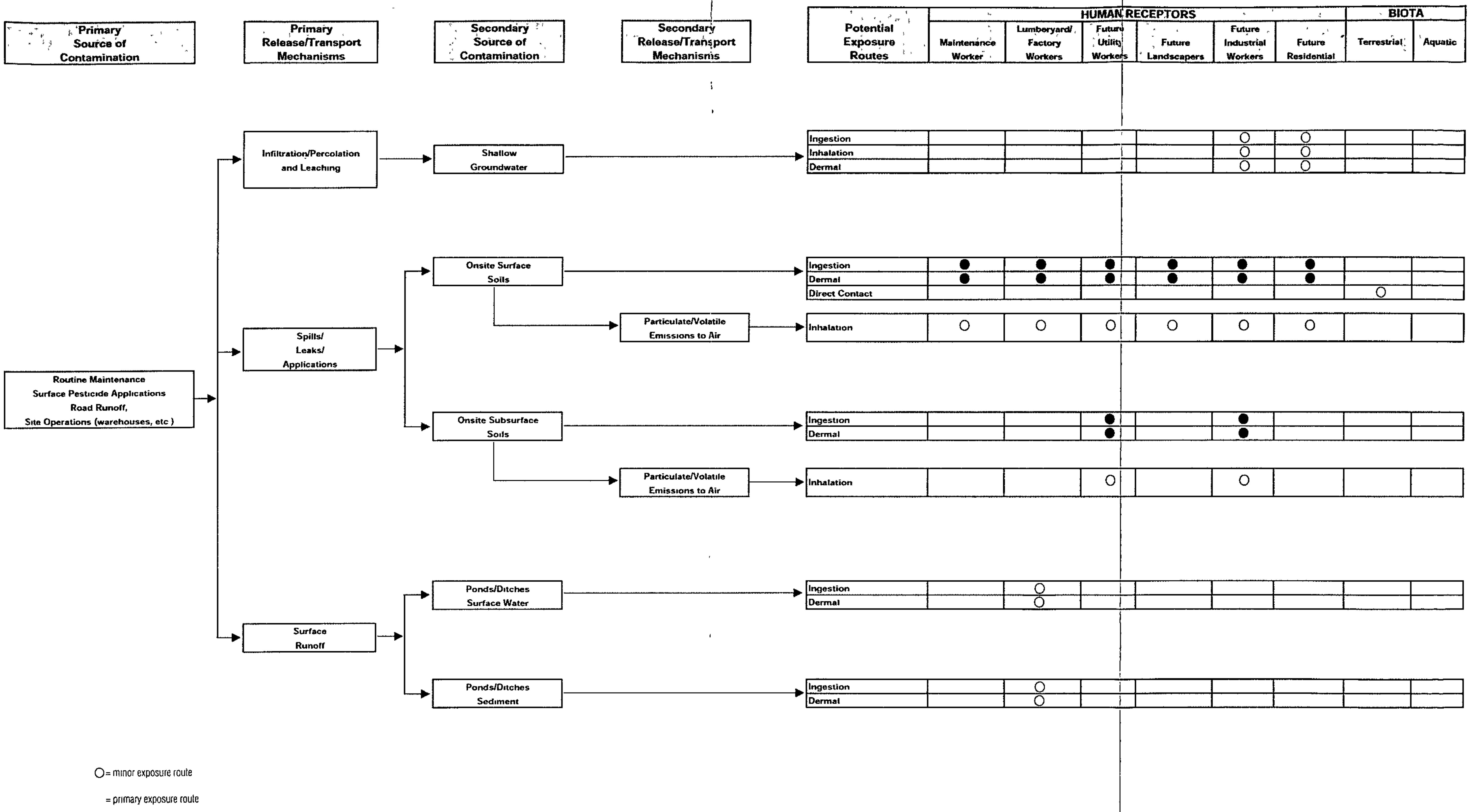

Potential Exposure Routes	HUMAN RECEPTORS						BIOTA	
	Maintenance Worker	Lumberyard/ Factory Workers	Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Ingestion					○	○		
Inhalation					○	○		
Dermal					○	○		
Ingestion	●	●	●	●	●	●		
Dermal	●	●	●	●	●	●		
Direct Contact							○	
Inhalation	○	○	○	○	○	○		
Ingestion			●		●			
Dermal			●		●			
Inhalation			○		○			
Ingestion		○						
Dermal		○						
Ingestion		○						
Dermal		○						

FIGURE 18-5
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: RI SITE 34
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 19

TAB

19. Summary and Conclusions for EU3

19.0 Summary and Conclusions for FU3

19.1 Summary

19.1.1 Nature and Extent of Contamination

RI data were collected for surface and subsurface soil to assess the nature and extent of contamination at FU3.

19.1.1.1 Soil

Metals, PAHs, pesticides, VOCs, and dioxins were detected in the soils across FU3. Some of these contaminants were detected at elevated concentrations (concentrations above background values) in areas that may have contributed to contamination based on past operations. The following data interpretation associates the detected contamination with the historical site operations:

- The southwestern section of FU3 for metals, pesticides, and VOCs–at the former paint booth and sandblasting waste drum accumulation and storage area (near Buildings 1087 and 1088) and at the acids storage area (the southern end of Building 1089);
- The northwestern section of FU3 for pesticides and VOCs–near the flammables, solvents, and waste oil storage area at the northern end of Building 972;
- The southeastern section of FU3 for pesticides, PAHs, and VOCs–near the former recoupment area at the southeastern section of Building 873; and
- The eastern section of FU3 for VOCs, PAHs, dioxins, and metals–at the old pond area, the former UST area near Building 770, and the flammables storage area at Building 783.

In addition, the elevated concentrations typically were detected in the surface soils. Contaminants detected in the subsurface soil were generally below (or near) background values, with the exception of chromium.

Metals. Arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc are the commonly detected metals of concern throughout FU3. These constituents exceed background values in surface soil at a number of areas throughout FU3. However, most of the highest concentrations of these contaminants, with the exception of arsenic, were detected near Building 1088 (the sandblasting waste area), Building 1087 (the paint booth), and Building 1089 (acids storage area). Arsenic was detected in concentrations just above background levels throughout the Depot because of site-wide pesticide management activities.

Chromium was the only metal that appears to have infiltrated to the subsurface soil However, 39 of the 42 chromium samples that exceeded the background value were collected at depths less than 15 ft. Other metals detected in the subsurface soil, such as arsenic and lead, appear to be attributable to natural soil formations rather than to surface infiltration. Concentrations of these contaminants were at or just above established background levels in the subsurface soil.

Pesticides. Most of the samples analyzed for pesticides within FU3 indicate *no detections* or *detections below background concentrations*. DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin were the only pesticides detected above background levels in surface soil at FU3. The pesticides were detected in three areas of FU3: the southwestern, northwestern, and southeastern corners.

Because the pesticides are distributed throughout FU3, their detection probably is attributable to site-wide application rather than to site-specific activity related releases at these specific waste management sites. DDE and dieldrin were the only pesticides detected in the subsurface soil above background. These detected concentrations were located in grassy areas on the eastern side of FU3.

SVOCs. The primary SVOCs of concern in the surface soil at FU3 were PAH compounds. PAHs were detected throughout the Main Installation, with the highest concentrations in proximity to the railroad tracks. PAH compounds can originate from the seepage of creosote from railroad ties, from historical railcar leaks, or from PCP/used-oil mixtures historically applied for weed control along the tracks. At RI Site 34, where the highest levels of PAH compounds were detected, the elevated concentrations probably resulted from the management and handling of waste oils.

SVOCs, including PAHs, were not detected frequently in the subsurface soils. SVOC concentrations detected in the subsurface soil were normally at the zero- 4-ft interval. There were no elevated concentrations detected at the 8- 10-ft interval.

VOCs and Other Organics. The majority of the surface and subsurface soil sampling results for VOCs within FU3 indicate *no detections*. However, there are three isolated areas where elevated concentrations of VOCs were detected in the surface soil within FU3:

- MEK, 2-Hexanone, benzene, bromomethane, and MIBK were detected at elevated concentrations on the northwestern corner of Building 972;
- MEK, benzene, and toluene were detected at elevated concentrations in the gravel area just east of the concrete pad between Buildings 1087 and 1088 where sandblasting and waste operations took place; and
- TCE was detected near the southeastern corner of Building 873.

Probably because of volatilization at the surface, detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations. These areas are identified below:

- MEK, toluene, total xylenes, bromomethane, benzene, carbon disulfide, and 2-Hexanone were detected in the subsurface soil at the old pond area;
- TCE was detected in the subsurface soil on the northwestern corner of Building 972 and just west of Building 770; and
- MEK was detected in the subsurface soil on the northwestern and northeastern corners of Building 972.

None of the detected VOC concentrations in the subsurface soil exceeded the GWP values. Low levels of MEK were detected in deep soils (9 to 11 ft); however, MEK was not detected in the groundwater.

Other Organics. Concentrations of petroleum hydrocarbons were detected in the surface and subsurface soil at depths of zero to 4 ft. Background values were not established for petroleum hydrocarbons, but the detected concentrations in three surface soil samples at Parcel 35 near Building 1084 exceed the Region III RBC direct exposure value of 34 mg/kg. The GWP value of 340 mg/kg was not exceeded in the subsurface soil sample detection at the location of a former gasoline spill.

A total of 37 surface soil samples and 45 subsurface soil samples were analyzed for dibenzofurans. A total of 6 surface soil samples and 13 subsurface soil samples were analyzed for dioxins. Detected concentrations of these compounds in surface and subsurface soil samples were similar to background concentrations.

19.1.1.2 Sediment

One BRAC sediment sample was collected from the sump in Building 1086, which houses a spray paint booth. Contaminants detected in the sump sediment included metals (antimony, cadmium, copper, lead, nickel, and zinc) and an SVOC (naphthalene). The sediments are beneath a metal grill and are not subject to direct surface water runoff because they are within an enclosed building.

19.1.2 Fate and Transport

19.1.2.1 Migration Pathways

FU3 is an entirely industrialized area, covered mostly with coarse gravel, some grass, paved roads, railroad tracks, and large warehouses (open and closed) (see Figure 2-19). Potential pathways for migration at FU3 are surface runoff, leaching, and dust emission. Because of the present ground cover, significant leaching and volatization are not anticipated.

Surface runoff will migrate from concrete-, asphalt-, and gravel-covered areas around the warehouse buildings and the grassy areas located near the FU boundaries. Leaching will occur and dust emissions will be generated from the grass- and gravel-covered areas within FU3. However, dust emissions will be dramatically reduced based on the types of ground cover within FU3.

There are no drainage ditches or bodies of water in the area. Surface water runoff within FU3 flows in a northerly direction based on surface topography. The runoff is routed through a stormwater drainage system that discharges into a drainage ditch outside of the Main Installation perimeter fence at FU4 (Screening Site 56), just north of G Street and Gate No. 9. The area most affected by contaminants at FU3 is the area where sandblasting and painting operations occurred, near Buildings 1086, 1087, and 1088. Surface runoff from this area flows northeasterly or southerly into storm drains that eventually flow north and connect to a 60-inch drain pipe that discharges all of the FU3 runoff to the drainage ditch outside of FU4. Contaminants detected in this drainage ditch are discussed in Section 20.0, "Nature and Extent of Contamination at FU4."

The western and southern boundaries of FU3 are also the Main Installation site boundaries, which are fenced and covered with grass. The grassy areas outside of the fenced areas were not accessible to site operations related to direct releases, although there is more than 100 ft between the fence and public roads. Furthermore, the grassy area on the southern boundary of the Main Installation-site is an uphill slope to the public road.

19.1.2.2 Contaminant Persistence and Migration

Metals and PAHs were the most frequently detected contaminants at FU3. Metals are persistent in the environment, but they are not volatile. Emissions of metals to the ambient air would be in the form of particulate emissions. PAHs are not very volatile and are expected to remain bound to the soil; thus, they are likely to be released through dust.

Leaching to groundwater is unlikely for any of the surface soil organic constituents within FU3, based on their absence or low concentration in the subsurface soil and the regional groundwater. Also, the physio-chemical properties of these chemicals indicate that these COPCs tend to sorb to soil and have a low migration potential. Effects on the regional groundwater at this FU are anticipated to be negligible.

19.1.3 Risk Assessment

19.1.3.1 Summary and Conclusions of Risk Assessment for FU3

The human health RA for FU3 included all of the data collected within this physical unit. The primary conclusions of this RA are as follows:

- Overall human health risks and noncarcinogenic hazards to workers in FU3 are within acceptable risk limits. Potential risks from the surrogate site (RI Site 34) are negligible. The COPCs identified are a subset of those found in FU3. No subsurface COPCs were identified at this site. Overall risks to various receptors were within acceptable levels;

- Overall human health risks and noncarcinogenic hazards to residents in FU3 also are within acceptable risk limits. The risks under a hypothetical residential scenario estimated for a single data point were above the upperbound acceptable limits for carcinogenic risk of the 1 in 10,000 (10^{-4}) level, primarily from the PAHs detected in the sample. The sample was collected from Parcel 26, adjacent to the railroad tracks;

- Some inorganic chemicals were detected in surface soils above background and RBC values, and therefore, were included as COPCs. Surface soils also had PAHs, dieldrin, and PCP;

- Only two inorganic chemicals were included as COPCs for subsurface soils. For the evaluation of the exposures to subsurface soils, the COPCs detected in the surface soil were used to account for potential future mixing of surface soil with subsurface soil during excavations;

- High concentrations of lead, chromium, and cadmium were detected in sump bottom grit sample (sediment).These concentrations present excessive noncarcinogenic hazards, if exposure were to occur to industrial workers under conservative exposure assumptions; and

19.1.3.2 Summary and Conclusions of Environmental Evaluation for FU 3

A screening-level ERA was conducted for the entire FU3 to evaluate whether constituent concentrations potentially could adversely affect ecological receptors. Although ecological habitat at FU3 is limited to a few maintained grassed areas, the ERA was conducted in accordance with EPA guidance, which recommends little or no risk management input in the screening assessment. The screening assessment (Steps 1 and 2) identified a number of COPCs for consideration in Step 3. The refinement process in Step 3 reduced the number of COPCs; however, further consideration of site-specific ecological exposure pathways indicated that current and future exposure pathways at this site are incomplete. Therefore, there is adequate information to conclude that ecological risk at FU3 is negligible, and there is no need for remediation based on ecological risk.

19.1.3.3 Summary and Conclusions for Remedial Investigation at Site 34

Conclusions specific to the surrogate site RA performed at Site 34 are presented below:

- RI Site 34 is selected as the surrogate site to represent the worst-case potential risk areas within FU3, based on the results of the evaluation presented in Section 7.0;
- A human health RA also was conducted for this site because it represents the worst-case exposures to human receptors. An ERA was not conducted at this site because it is an industrial site and not a suitable habitat for terrestrial receptors;
- Surface soil samples indicated the presence of several PAH compounds, two metals (iron and vanadium), and one SVOC (PCP) above screening criteria and/or background values; these were selected as COPCs;
- Deep soil risk evaluations included the soil column from the surface to a 10-ft depth. Nine surface soil (zero to 1 ft) and six deeper samples (>1 to 10 ft) were included in this data set;
- Risks and noncarcinogenic hazards estimated for workers under various exposure scenarios represent risks within the 1 to 100 in a million range (10^{-6} to 10^{-4}) and HIs below a target value of 1.0. The total risks are represented by the higher of the surface and deeper soil risk estimates; and
- RI Site 34 does not pose a significant human health concern for future industrial land use at FU3, even under high-end exposure assumptions.

19.2 Conclusions

19.2.1 Data Limitations and Recommendations for Future Work

The nature and extent of the chemical constituents in surface and subsurface soil have been defined both vertically and horizontally in FU3. In general, surface soil samples with concentrations attributable to source areas within FU3 were surrounded by sampling locations with concentrations more representative of background levels. Similarly, subsurface soil samples with elevated concentrations generally were located in borings that contained deeper samples with concentrations below background values. As a result, no data limitations exist with respect to the surface or subsurface soil samples collected in FU3 Therefore, no additional future work is recommended for FU3.

19.2.2 Recommended Remedial Action Objectives

As shown in the baseline RA detailed in Section 18.0, overall human health risks and noncarcinogenic hazards associated with exposure to soil and sediment are within acceptable risk limits. Groundwater risks are further discussed in Section 34.0. However, some areas within FU3 require remedial action to facilitate the transfer of property. An EE/CA of the paint spray booth area, located in the southwestern portion of FU3 (BRAC Parcels 28 and 35) was performed to identify surficial soils requiring removal to achieve risk-based criteria. Elevated concentrations of metals, primarily lead, exceeding the target concentration value of 2,720 mg/kg, require the removal of soils to reduce industrial exposures potentially resulting from future operations within the former paint spraying facility.

The EE/CA contains the basis for the evaluation and selection of a preferred remedial alternative to address chemical contamination from the former paint shop and maintenance area located in the parcels. Removal of the sump sediments also is included as part of the EE/CA preferred alternative. This evaluation was performed to facilitate the transfer of BRAC Parcels 28 and 35 to the City of Memphis. No additional soil remedial actions are recommended for FU3.

TAB

Section 20

TAB

20. Nature and Extent of Contamination
at FU4

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20.0 Nature and Extent of Contamination at FU4

This section addresses the nature and extent of contamination in FU4, the Northern and Open Area. The subsections below provide a description of how FU4 was defined, discuss the probable sources of contamination that exist within FU4, and identify the nature and extent of contamination at FU4 by identifying the distribution and location of widespread contaminants in the surface and subsurface soil, surface water, and sediment of the FU. Groundwater contamination beneath FU4 is addressed in Section 32.0.

As described in the following subsections, FU4 contains CERCLA sites identified in the original RI activities prior to 1990, as well as screening sites and TEC sites identified by CH2M HILL. These sites were investigated as possible sources of contaminant releases to the environment. Sampling of areas not associated with a specific site occurred as part of the BRAC characterization program. This section discusses the nature and extent of contamination within the entire FU area by evaluating the combined CERCLA and BRAC data.

20.1 Functional Unit Background

20.1.1 FU4 Description

FU4 is the Northern and Open Area, consisting of BRAC Parcels 13, 14, 15, 29, 30, 31, 32, and 33 (see Figure 1-1). As discussed in Section 1.1, FU4 was established based on similar operational activities in the northern, central, and western portion of the Main Installation, including open and closed storage of various items such as waste materials, hazardous waste, PCB and non-PCB containing transformers, petroleum products, hazardous materials, flammable materials, fuels, steel bar stock, and PVC pipes.

20.1.2 FU4 History

Most of the land cover within FU4 consists of open storage areas lined with gravel or asphalt, railroad tracks, and administrative, maintenance, and general purpose warehouse buildings. The western half of this FU was mostly used for open storage. Figure 20-1 shows the open storage area locations and buildings within FU4. All open storage areas within FU4 have the potential to have stored hazardous materials, fuels, or petroleum products in the past (USATHAMA, 1981). Open storage areas, X17, X19, X20, X21, X23, X25, X27, and X30 were used to store steel and PVC pipe, as well as petroleum products and fuels. A portion of the open storage area X23 was used as a hazardous material re-pouring and repackaging area; other storage included non-PCB-containing transformers. Open storage areas X10, X12, X13, and X15 also were used to store petroleum products, fuels, and miscellaneous nonhazardous materials. Open storage areas X05, X06, X07, and X08 were used to store petroleum products, equipment, and transformers. Finally, open storage area X11 contained drums that stored flammables.

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A number of large warehouses and buildings are located in this FU. Building 209 stored waste materials to be sold or disposed of by the DRMO. Building 835 stored a variety of hazardous materials including pesticides, herbicides, corrosives, oxidizers, reactives, and flammables. Building 925 stored flammable materials such as MEK, acetone, and xylene. Building 949, a fabric-tension structure, was used to store a variety of materials including steel and tents awaiting storage space in another of the warehouses. Building 865 was used as a hazardous materials recoupment facility. In summary, a number of other buildings are located in this FU that were used to store various materials.

20.2 Summary of Remedial Investigations at FU4

20.2.1 Historical Remedial Investigations

Initial sampling of surface and subsurface soil occurred at FU4 as part of the 1990 RI conducted by Law Environmental (Law Environmental, 1990a) in six different areas. One surface soil sample was collected at Screening Site 35 (DRMO Building T-308); one surface soil sample was collected at Screening Site 43 (the former Underground PCP Storage Tank Area); one surface soil sample was collected at Screening Site 80 (Fuel and Cleaners Dispensing at Building 720); and one surface soil sample was collected at Screening Site 83 (the Dried Paint Disposal Area, also known as POL Areas X13, X15, and X25). One boring was drilled at Screening Site 46 (the Pallet Drying Area), and surface water and sediment samples were collected from Screening Site 56 (the West Gate Stormwater Drainage Canal).

20.2.1.1 DRMO Building T-308: Hazardous Waste Storage (Screening Site 35)

According to the *Remedial Investigation at DDMT, Final Report* (Law Environmental, 1990a), a surface soil sample (SS4) was collected southwest of Building T-308. In Sample SS4, methylene chloride and acetone were the only VOCs that were detected. However, acetone was detected at concentrations less than sample quantitation limits and methylene chloride was detected in the laboratory method blank. These are common laboratory contaminants. No SVOCs were detected at concentrations greater than sample quantitation limits.

Dieldrin was the only pesticide detected in surface soil at Screening Site 35 during the 1989 site work. Several inorganic compounds commonly found in soil also were detected.

20.2.1.2 Former PCP Dip Vat Area and Former Underground PCP Tank Area (Screening Sites 42 and 43)

Screening Site 43 is located near the center of the Main Installation south of Building 737. It contained a UST that stored PCP. Pesticides were used extensively in the area of the tank. During 1985, OHM conducted the tank removal and subsequently conducted soil sampling around the excavated tank; these activities are detailed in the *Summary Report, On-site Remedial Activities at the Defense Depot Memphis* (OHM, 1986). The structural integrity of the tank was determined to be sound. However, leaking was discovered at six joints between the pump house and tank, and between the pump house and dipping vat. The tank was removed and soils were removed until the excavation pit was approximately 15 ft deep, 20 ft wide, and 22 ft long.

Subsurface soils with total dioxin and furan concentrations exceeding 200 ppb associated with the tank were replaced with clean soils (OHM, 1986). Samples that contained more than 200 ppb total dioxins and furans were packed in roll-off containment vessels; 39 roll-off vessels were stored north of former Building 737 and covered with tarps for weather protection. The roll-offs subsequently were removed from the facility. The excavation was then filled with 650 cubic ft of native soil and 489 tons of crushed stone.

20.2.1.3 Fuel and Cleaners Dispensing, Building 720 (Screening Site 80)

Screening Site 80 is located approximately 2,000 ft east of the western boundary and 700 ft south of the northern boundary of the Main Installation. Cleaners and fuel were stored and dispensed in Building 720. According to the *Remedial Investigations at DDMT, Final Report* (Law Environmental, 1990a), one surface soil sample indicated the presence of VOCs, PAHs, DDT, and metals.

20.2.1.4 Dried Paint Disposal Area/POL Areas X13, X15, and X25 (Screening Site 83)

According to the *Remedial Investigations at DDMT, Final Report* (Law Environmental, 1990a), one surface soil sample (SS20) was collected at Screening Site 83 in 1989. This sample detected metals, pesticides, VOCs, and SVOCs. In Sample SS20, methylene chloride, total xylenes, toluene, and acetone were the VOCs detected. However, methylene chloride, a common laboratory contaminant, and toluene were detected at concentrations greater than sample quantitation limits, and methylene chloride was qualified as having been found in the method blank. BEHP and 2-Methylnaphthalene (reported in Sample SS20 at 2,300 µg/kg and 2,600 µg/kg, respectively) were the SVOCs detected in surface soil at the site at concentrations less than the sample quantitation limits.

DDE and DDT were the only two pesticides detected in surface soil at Screening Site 83. Several inorganic compounds commonly found in soil also were detected at elevated concentrations in Sample SS20. Among these inorganic compounds were lead (7,680 µg/kg), barium (5,640 µg/kg), chromium (16,200 µg/kg), and zinc (28,200 µg/kg).

20.2.1.5 Pallet Drying Area (Screening Site 46)

Screening Site 46 is located near the center of the Main Installation, 115 ft south of Building 720 and 125 ft west of 6th Street. This site was used to dry pallets after the PCP-treating operation that occurred at Screening Sites 42 and 43. Soils at this screening site had detectable concentrations of 2-Butanone.

20.2.1.6 West Gate Stormwater Drainage Canal (Screening Site 56)

According to the *Remedial Investigations at DDMT, Final Report* (Law Environmental, 1990a), two surface water samples were collected at Screening Site 56 in 1989. In addition, according to the *Defense Distribution Depot Memphis, Tennessee Sediment Sampling Program; Sediment Sampling Analysis Report* (EDRW, Inc., 1996), one sediment sample (SD19) was collected at Screening Site 56 during the 1995 sediment sampling program.

Benzoic acid and BEHP were the only SVOCs detected in the surface water. However, no SVOC concentrations were detected at greater than the sample quantitation limits

Endosulfan-I was the only pesticide found in surface water samples. This datum, however, was reported with a qualifier stating that it was not positively identified because of matrix interference. Several inorganic compounds common in soil also were detected in surface water.

Carbon tetrachloride (the only VOC detected above the sample quantitation limit) was detected in the sediment Sample SD19 at a concentration of 78 µg/kg. Several SVOCs were detected in Sample SD19, but no concentrations were detected at greater than the sample quantitation limit. Although several dioxin concentrations were estimated at levels below the sample quantitation limits, only total heptachlorinated dibenzofuran (HPCDF) (detected in sample SD19 at 0.01 µg/kg) was detected at a quantifiable concentration. Several inorganic compounds common in soil also were detected in sediment.

20.2.2 Summary of Key Findings from Past Remedial Investigations

The results of the previous sample data collected during the 1990 RI investigation indicated that most samples contained detectable concentrations of pesticides, dioxins and furans, VOCs, SVOCs, metals, and PAHs, based on past operational activities.

On the basis of the fate and transport analysis, Law Environmental concluded that metals and organic compounds were capable of migration. Pesticides and PCBs were not determined to be very mobile, and it was concluded that these compounds were detected at locations proximate to their original sources of contamination.

The extent of contamination from the constituents detected was not defined by Law Environmental. Results from the Law 1990 RI were used to evaluate potential problem areas within FU4 and provided the basis for additional sampling. Additional sampling was conducted for areas where data gaps existed and where sampling and analyses were required to characterize the nature and extent of contaminants from past activities of the site.

20.2.3 Current Remedial Investigations

The areas of most concern within this FU (including screening sites and BRAC parcels) initially were investigated by CH2M HILL from December 1996 through January 1997. At that time, the surface soil was sampled to assess the nature and horizontal extent of contamination at these sites, and the subsurface soil was sampled at most of these sites to assess the vertical extent of contamination. Surface water and sediment samples were collected from the northern, eastern, and western stormwater drainage ditches after rainfall events to evaluate surface water runoff and sediment.

Additional investigations of the screening sites were conducted from September 1998 through October 1998. Additional surface soil, subsurface soil, sediment, and surface water data were needed to accomplish the following:

- Further characterize the nature and extent of contamination;
- Collect a sufficient number of data points to perform an RA;
- Confirm the absence of contamination at some screening sites based on initial (1996-1997) screening results;

- Assess the groundwater contamination; and
- Collect feasibility samples where remedial activities are likely.

The sites investigated within FU4 and the sampling rationale for each site are presented in Table 20-1. Figure 20-1 shows the location of these sites. The basis for the 1996 sampling rationale was the same for each site identified at the time: 1) to collect soil samples that were representative of site conditions; 2) to compare the detected concentrations to background and screening levels; and 3) to develop appropriate recommendations. The 1998 sampling rationale was developed so that the recommendations made from the 1996-1997 sampling event could be accomplished. Information regarding specific activities that occurred at the FU4 areas is discussed in Section 20.3.

Some areas of FU4 shown on Figure 20-2 have a relative scarcity of sampling points compared to other areas. One such area is Open Storage Area X30. This storage area was not extensively sampled because, after years of investigations and interviews, nothing has turned up to warrant a specific investigation of this particular storage area. There is not a specific CERCLA site near X30, and therefore no additional sampling was proposed.

20.3 Potential Sources of Contamination

Because hazardous materials were handled and stored at a number of buildings within FU4, there was a potential for hazardous materials spills to soil surrounding the buildings Other areas of concern within FU4 (and also throughout the Main Installation) include releases associated with transport along railroad tracks and pesticide/herbicide applications in grassy areas. Table 20-1 lists the sites of most concern at FU4, Figure 20-1 presents the locations of these sites, and the following paragraphs provide a description of operations that have taken place at these sites, plus other areas of concern within FU4.

20.3.1 DRMO Building T-308: Hazardous Waste Storage (Screening Site 35)

Building T-308 is a roofed, tin-sided shed with a concrete floor located in the northeastern corner of the Main Installation, south of Dunn Avenue. It has a 2-ft-high concrete berm and foundation on all four sides, with 3-inch concrete or asphalt dikes at the entrances. Wastes were segregated and stored on pallets in this building. The hazardous waste storage area at Building T-308 is identified as Screening Site 35.

20.3.2 DRMO Drum Storage at Open Storage Areas (Screening Sites 36-39)

Drums containing hazardous materials and waste were stored at open storage areas located in the northeastern section of the Main Installation. The open storage area was approximately 2.5 acres. The drums remained in the storage area until shipment to a licensed hazardous waste disposal facility occurred. Some areas were used to store empty, damaged drums that might contain hazardous waste and POL residues. The open storage areas are identified as Screening Sites 36 through 39. The specific function of each site was as follows:

- Screening Site 36–DRMO Hazardous Waste Concrete Storage Pad
- Screening Site 37–DRMO Hazardous Waste Gravel Storage Pad

- Screening Site 38–DRMO Damaged/Empty Hazardous Materials Drum Storage Area
- Screening Site 39–DRMO Damaged/Empty Lubricant Container Area

For investigation purposes, these sites are hereafter referred to as Screening Sites 36-39, the DRMO Drum Storage area.

20.3.3 DRMO East Stormwater Runoff Canal (Screening Site 54)

The DRMO East Stormwater Runoff Canal is located near the northeastern part of the Main Installation and is approximately 930 ft long. The canal, identified as Screening Site 54, collects the stormwater runoff from the DRMO yard (and associated sites) and other Depot facilities.

20.3.4 DRMO North Stormwater Runoff Area (Screening Site 55)

Screening Site 55 is located at the northern end of the Main Installation adjacent to Perimeter Road (Figure 20-1). It consists of the stormwater drain that collects runoff from the DRMO yard. Sample locations were selected at the inlet of the stormwater drain that carries runoff across the northern Depot boundary.

20.3.5 Waste Oil (PDO Yard) Surface Application for Dust Control (Screening Site 72)

Waste oils mixed with PCP were applied to the soil surface in the Property Disposal Office (PDO) Yard for dust and weed control purposes. The PDO yard is in the northern section of the Main Installation and is north of B Street. Surface samples were selected based on the fact that waste oil has been applied directly to the surface soils, and therefore, surface soil contamination is probable. The area is identified as Screening Site 72 (see Figure 20-1).

20.3.6 Flammables and Toxics (West End Building 319) (Screening Site 74)

The western end of Building 319, off of C Street, historically has been used for the storage of flammable and toxic materials. Sampling locations were selected based on activities conducted at the storage area such as loading and unloading areas and on surface water drainage pathways. Twenty-ft soil borings were selected because shallow and surface soil contamination is probable. The area is identified as Screening Site 74.

20.3.7 Fuels, Miscellaneous Liquids, Wood, and Paper (Screening Site 79)

The area adjacent to Building 702, approximately 2,400 ft from the western boundary and 200 ft from the northern boundary of the Main Installation, has been used to store fuels, miscellaneous liquids, wood, and paper. Sample locations at this site were selected based on activities conducted at the building such as waste loading, unloading, and storage areas. Twenty-ft soil borings were selected to investigate potential leaching and percolation releases to surface soil. The area is identified as Screening Site 79. Building 702 was also used as a hobby shop.

20.3.8 West Gate Stormwater Drainage Canal (Screening Site 56)

Screening Site 56 (see Figure 20-1) is on the western side of the Main Installation, adjacent to Perry Road and north of Gate 9. This site collects the stormwater runoff from the former PCP tank areas and the western portion of the Main Installation.

20.3.9 Dried Paint Disposal Area (Screening Site 83)

The area adjacent to the southern side of Building 949 apparently was used as an outdoor spray paint site, which would account for dried paint residues accumulating on the surface. No records indicate that paint wastes were transported here for disposal. The area is identified as Screening Site 83.

20.3.10 Recoupment Area–Building 865 (Screening Site 28)

The hazardous materials and waste handling area is identified as Screening Site 28. The area, which is used to transfer materials from damaged or leaking containers into undamaged containers, began operating in 1986. The area north of Building 865 historically has been used as an open storage area.

Screening Site 28 is situated 75 ft north of G Street and south of Building 835. Building 865 is constructed of concrete block with a poured concrete floor that has a chemical-resistant coating. The materials are placed in separate bays for segregation; bays are bermed to contain spills during repackaging or from leaking containers.

20.3.11 Former PCP Dip Vat Area, Former Underground PCP Tank Area, and Pallet Drying Area (Screening Sites 42, 43, and 46)

The area located near Building 737 and 275 ft west of 6th Street was used to hold PCP for treating wood pallets (Screening Site 42). It was mixed with waste oil and applied to the ground surface for dust control purposes. The area also contained a PCP UST (Screening Site 43). PCP inherently contains small amounts of dioxins as a by-product of manufacturing. During 1985, OHM removed the PCP dip vat, associated PCP underground tank, and 39 roll-off containers of PCP-contaminated soil. The tank was removed, and soils were removed until the excavation pit was approximately 15 ft deep, 20 ft wide, and 22 ft long.

The pallet drying area (identified as Screening Site 46) is located near the center of the Main Installation, 115 ft south of Building 720 and 125 ft west of 6th Street (Figure 20-1). This site was a gravel area used to dry pallets after the PCP-treating operation that occurred at Screening Sites 42 and 43.

20.3.12 Fuel and Cleaners Dispensing, Building 720 (Screening Site 80)

Building 720 was used to store cleaners (used in train engine maintenance), to dispense fuel, and to repair and maintain train engines. The building is located approximately 2,000 ft east of the western boundary and 700 ft south of the northern boundary of the Main Installation and is identified as Screening Site 80.

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20.3.13 Fuel Oil Building 765 (Screening Site 81)

Building 765 formerly was a fuel oil aboveground storage tank (AST). The AST was located approximately 2,200 ft east of the western boundary and 1,350 ft south of the northern boundary of the installation (shown on Figure 20-1). The former AST is identified as Screening Site 81.

20.3.14 Railroad Tracks (Screening Site 70/71)

Railroad operations were the main means of transporting materials to the warehouses for storage. A number of the railroad tracks are located in FU4. Throughout the Main Installation, railroad tracks historically were sprayed with pesticides, herbicides, and waste oil containing PCP. Surface and subsurface soil sampling investigations along the railroad tracks detected elevated concentrations of PAHs. Surface soil samples from railroad track cross ties and asphalt were collected in FU1 to further assess the presence of PAH compounds in surface soil. The analyses from these samples are discussed in Section 8.4.2

20.3.15 All Grassed Areas (Screening Site 73)

Grassed areas throughout the Main Installation were treated as one screening site during the investigation. The historical application of pesticides such as dieldrin on grassy areas was cause to consider areas as a potential source of contamination.

20.3.16 BRAC Parcels

Environmental sampling was performed at BRAC property parcels to assess whether the property was suitable for transfer or lease. Sampling was conducted to assess whether chemicals existed in the surface and subsurface soils in concentrations that might present a concern for industrial, and in some portions of the Main Installation, residential uses.

20.4 Nature and Extent of Soil and Subsurface Soil Contamination

To characterize the nature and extent of contaminants within FU4, surface and subsurface soil samples were collected and analyzed for VOCs, SVOCs, metals, petroleum hydrocarbons, and the TCL/TAL parameters (organochlorine pesticides and herbicides). Figure 20-2 shows the sample locations for FU4, and Table 20-2 lists the parameters analyzed for at each site. Appendix O provides a list of all detected parameters in the surface and subsurface soil samples collected at FU4 and compares them to screening and background values. The nature and extent of the contaminants detected above background values at the FU are discussed below.

20.4.1 Nature and Extent of Metal Contamination

Several metals were detected throughout FU4 at concentrations above background values. The results of the analyses are provided in Table 20-3. The metals that exceeded background values were divided into three categories based on the number of sample concentrations that exceeded background values and the relative importance of the metal as a potential contaminant. Each metal that exceeded a background value was classified as a primary metal of concern, a distributed metal, or a naturally occurring metal:

- Primary metals of concern were detected above background values in a significant number of samples and may indicate a release from source areas in FU4;
- Distributed metals were detected above background values in a relatively small and insignificant number of samples; and
- Naturally occurring metals were metals associated with the natural soil conditions that were detected above background levels.

20.4.1.1 Primary Metals of Concern

On the basis of the results of the surface and subsurface soil sampling, arsenic, total chromium, copper, lead, nickel, selenium, and zinc were designated as the primary metals of concern throughout FU4. The soil samples that exceeded the background values for these constituents are shown on Figures 20-3 through 20-12. These constituents were designated as primary metals of concern primarily because they exceeded background levels in a number of areas throughout FU4.

Arsenic. Twenty-six of the 149 surface soil samples (including 21 duplicates) analyzed for arsenic contained an arsenic concentration that exceeded the background value of 20 mg/kg. As shown on Figure 20-3, these samples were scattered throughout FU4, but mostly were concentrated in the northeastern section of FU4. The elevated concentrations of arsenic in the northeastern portion of FU4 do not indicate a release from a specific source Only one surface soil arsenic concentration exceeded two times the background limit. BRAC sample SS14A contained an arsenic concentration of 66.3 mg/kg. The remaining arsenic concentrations were relatively close to the background value of 20 mg/kg, ranging from 1.1 mg/kg to 37.7 mg/kg.

Arsenic was detected in all 157 subsurface soil samples (including 7 duplicates) analyzed for arsenic. Forty-two samples contained arsenic concentrations that slightly exceeded the background value of 17 mg/kg. The highest arsenic concentration was 34.2 mg/kg (4- to 6-ft interval of SB79C). Only 7 arsenic concentrations from samples collected between the 3- to 5-ft interval exceeded the background value. The majority of the samples that exceeded the background value for arsenic occurred between the 4- to 10-ft interval. There were no elevated arsenic concentrations deeper than the 11-ft interval. These factors indicate that the intermediate subsurface arsenic concentrations may occur as a result of natural soil formations and not as a result of surface infiltration.

As described above, the arsenic samples that exceeded the background values in both the surface and subsurface were broadcast throughout FU4. In most cases, the concentrations of arsenic did not significantly exceed the background value. The highest surface or subsurface concentration of arsenic was only 66.3 mg/kg, and the next highest concentration was only 37.7 mg/kg. Arsenic is present in low concentrations throughout the Memphis Depot, probably because of site-wide pesticide management activities and naturally elevated background levels in soil that may be misinterpreted as specific source areas in FU4.

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Total Chromium. Chromium was detected in all 144 samples (including 20 duplicates). Sixty-eight total chromium concentrations exceeded the background value of 24.8 mg/kg. The detected concentrations of chromium ranged from 5J mg/kg to 4,385 mg/kg. As shown on Figure 20-4 and Table 20-3, elevated chromium was concentrated in four main areas:

- The dried paint area just south of Building 949 (Screening Site 83);
- The waste loading and unloading area adjacent to Building 702 (Screening Site 79);
- The recoupment area at Building 865 (Screening Site 28); and
- The DRMO Drum Storage Area (Screening Sites 36-39).

Concentrations as high as 4,385 mg/kg, 1,750 mg/kg, and 1,310 mg/kg were observed at Screening Site 83. Screening Sites 79, 28, and 36 had highs of 112.95 mg/kg, 30.8 mg/kg, and 33.5 mg/kg, respectively. Elevated chromium concentrations also were detected at the Stormwater Drainage Canal (Screening Site 56). Surface soil samples from Screening Site 56 contained an elevated chromium concentration of 71.6 mg/kg.

Most elevated chromium concentrations were significantly less than those concentrations observed at Screening Site 83. The next highest concentrations at Screening Site 83 were 610 mg/kg, 598 mg/kg, and 313 mg/kg. The highest concentration detected among all the other sites was only 113 mg/kg. Most elevated concentrations were within two times the background value of 24.8 mg/kg.

Chromium concentrations in 57 of the 154 subsurface soil samples, including 7 duplicates, exceeded the background value of 26.4 mg/kg. As shown on Figures 20-5 through 20-7, the elevated chromium concentrations were dispersed throughout FU4 at depths of 4 to 6 ft, 8 to 10 ft, and 18 to 20 ft. The detected concentrations ranged from 1.8 mg/kg to 140 mg/kg. With the exception of the detected concentration in sample SB79C (140 mg/kg), the elevated chromium concentrations did not greatly exceed the background value. At boring SB79C, chromium was detected at 140 mg/kg (18- to 20-ft depth), 39.1 mg/kg (4- to 6-ft depth), and 24.2 mg/kg (8- to 10-ft depth). At Screening Site 83, where surface soil was greatly contaminated with total chromium, the highest concentration detected was 45.6 mg/kg in boring SB83B at the 4- to 6.5-ft interval. The next highest concentration at this site was barely above background, which was 26.8 mg/kg at the same boring. Other detected concentrations in the subsurface soil at this site were below background.

In summary, chromium was present in surface soil samples at concentrations that significantly exceeded the background value. The highest chromium values were concentrated near the dried paint disposal area, the waste loading and unloading area at Building 702, the recoupment area at Building 865, and the DRMO Drum Storage Area. The south-central portion of FU4 near the railroad tracks was free of chromium. Elevated chromium concentrations in the subsurface soil appear to be a result of surface infiltration (Screening Site 79), as well as of natural formation in soil.

Lead. Of the 150 surface soil samples analyzed for lead (including 21 duplicates), 82 samples contained lead concentrations that exceeded the background value of 30 mg/kg. As shown on Figure 20-8, the elevated lead values were broadcast throughout FU4. The highest detected concentrations were at the dried paint disposal area (Screening Site 83) and the waste loading and unloading area adjacent to Building 702 (Screening Site 79). The three highest concentrations at SS83 were 2,800 mg/kg (sample SS83C), 2,430 mg/kg (sample

SB83B), and 1,720 mg/kg (sample SS83B). The three highest detected concentrations at SS79 were 1,060 mg/kg (sample SS79A), 702 mg/kg (sample FS79B), and 506 mg/kg (sample SS79E). Detected concentrations above background at other sites (Screening Sites 56, 54, 36, 35, 28, 43, and 72) were not as high as these concentrations, normally ranging from 31 mg/kg to about 300 mg/kg.

An elevated lead concentration of 308 mg/kg was detected at the western stormwater drainage canal (Screening Site 56) in Sample SS56B and an elevated concentration of 213 mg/kg was detected at the eastern stormwater drainage canal (Screening Site 54) in Sample SB54B. The other detected concentrations of lead at these sites were either near or below background. In most cases at other sites, there would be one significant detected concentration above background and the remaining detected concentrations would exceed background by less than three times the background value. The majority of lead concentrations detected at the DRMO Drum Storage Area (Screening Sites 36-39) were below background. The only significant lead concentrations were detected in sample SB36H (131 mg/kg) and in sample SS36B (142 mg/kg), which were collected from locations just north and just south, respectively, of the concrete pad in the area. The highest concentrations detected at Screening Site 72, the PDO yard, were located near Screening Site 79.

Lead concentrations in 30 of the 157 subsurface soil samples, including 7 duplicates, exceeded the background value of 23.9 mg/kg. The elevated lead concentrations normally were detected in the 3- to 5-ft and 8- to 10-ft intervals. The highest lead concentration detected in the borings at FU4 was 38.4 mg/kg at boring SB79C at the 4- to 6-ft interval Only one boring (SB35B) had an elevated lead concentration in the 18- to 20-ft interval, which was only 30.6 mg/kg. All other samples collected from deeper intervals within the borings at FU4 contained lead concentrations that were below the background limit.

Overall, lead was detected in significant concentrations near the dried paint waste disposal area at the southwestern corner of FU4 and near the waste loading and unloading area adjacent to Building 702. Many of these lead concentrations greatly exceeded the background value. However, lead does not appear to be leaching to the subsurface. Throughout FU4, the highest lead concentration in the subsurface soil did not exceed 38.4 mg/kg in the subsurface, which is not greatly above the background value of 23.9 mg/kg. Additionally, the concentrations in the subsurface soil were significantly lower than those concentrations detected in the surface soil.

Copper. Copper concentrations in 36 of the 150 surface soil samples (including 21 duplicates) exceeded the background value of 33.5 mg/kg. As shown on Figure 20-9, the elevated copper values were concentrated near the DRMO Hazardous Waste Storage Area at Building 308 (Screening Site 35), the DRMO Drum Storage Area (Screening Sites 36-39), and the PDO yard area (Screening Site 72). However, the copper concentrations remained relatively low. Only three surface soil copper concentrations exceeded 100 mg/kg. Sample SS35C contained a copper concentration of 1,400 mg/kg, SS35D contained a copper concentration of 119 mg/kg, and SS72K contained a copper concentration of 227 mg/kg. In addition, only 8 of the 150 copper concentrations detected exceeded twice the background limit.

Of the 157 subsurface soil samples analyzed for copper (including 7 duplicates), 39 samples contained copper concentrations that exceeded the background value of 32.7 mg/kg. The elevated copper concentrations were scattered throughout the borings and normally were concentrated at depths of 4 to 6 ft and 8 to 10 ft. In addition, the copper concentrations were not significantly higher than the background value of 32.7 mg/kg. The highest detected copper concentration in the subsurface of 56.8 mg/kg occurred at the 4- to 6-ft interval of SB79C. The next highest concentration of 47.2 mg/kg occurred at the 4- to 6-ft interval of SB79A.

Copper concentrations that exceeded the background value were concentrated near the DRMO hazardous waste storage area at Building 308 (Screening Site 35), the DRMO Drum Storage Area (Screening Sites 36-39), and the PDO yard (Screening Site 72). The elevated copper concentrations did not consistently greatly exceed background values in the surface and subsurface soil.

Nickel. Thirty-two nickel concentrations exceeded the background value of 30 mg/kg in the 150 surface soil samples analyzed for nickel at FU4. As shown on Figure 20-10, the samples collected near the DRMO Drum Storage Area (Screening Sites 36-39), and the PDO yard (Screening Site 72) contained the majority of the nickel concentrations that exceeded the background value. However, the nickel concentrations did not significantly exceed the background limit. None of the detected concentrations were greater than two times the background value of 30 mg/kg.

Thirty-eight of 157 subsurface soil samples (including 7 duplicates) contained nickel concentrations that exceeded the background value of 36.6 mg/kg. The elevated nickel concentrations were located near the DRMO Drum Storage Area (Screening Sites 36-39), the flammables and toxics storage area on the western end of Building 319 (Screening Site 74), the waste loading and unloading area adjacent to Building 702 (Screening Site 79), and Building 720 (Screening Site 80). However, the concentrations that exceeded the background value of 36.6 mg/kg at these sites only ranged from 36.7 mg/kg to 64.8 mg/kg. The elevated nickel concentrations detected were concentrated at the 4- to 6-ft and 8- to 10-ft intervals. The 3- to 5-ft interval just below the surface soil and the lower depths of 18 to 20 ft normally contained detected concentrations below background. The highest concentration of 64.8 mg/kg was detected at boring SB79C (4- to 6-ft depth), located at Screening Site 79. The next two highest concentrations of 59.3 mg/kg and 50 mg/kg were detected at boring SB79A (8- to 10-ft depth and 4- to 6-ft depth).

The DRMO drum storage area, the flammables and toxics storage area on the western end of Building 319, the waste loading and unloading area adjacent to Building 702, and the area surrounding Building 720 appear to have concentrated nickel values that exceeded the background limit in the surface and subsurface soil. The elevated nickel concentrations in the subsurface soil were slightly higher than those concentrations detected in the surface soil However, neither the nickel concentrations in the surface nor the subsurface significantly exceeded the background values.

Zinc. Zinc was detected in 149 out of 150 surface soil samples analyzed for zinc (including 21 duplicates). Forty-eight of the detected zinc concentrations exceeded the background value of 126 mg/kg. As shown on Figure 20-11, the elevated zinc values were concentrated near the dried paint disposal area just south of Building 949 (Screening Site 83), the recoupment area (Screening Site 28), the DRMO drum storage area (Screening Sites 36-39), the PDO yard (Screening Site 72), the waste loading and unloading area at Building 702 (Screening Site 79), and the fuel-dispensing area at Building 720 (Screening Site 80). The highest zinc concentrations were located in Screening Site 83, Screening Site 28, and Screening Site 79. At Screening Site 83, high individual zinc concentrations were encountered at sample FS83T (9,915J mg/kg), SB83B (3,030 mg/kg), SS83B (2,630 mg/kg), and SS83C (1,000 mg/kg). At Screening Site 28, an elevated zinc concentration was detected in sample SS28A at 1,530 mg/kg. The other four detected concentrations at Screening Site 28 were below the background value of 126 mg/kg. At Screening Site 79, zinc was detected in sample SS79A at 331 mg/kg. There were three more detected concentrations above background at Screening Site 79 that were 160.6 mg/kg, 175.5 mg/kg, and 177 mg/kg. The other 10 detected concentrations at Screening Site 79 were below background. Elevated zinc concentrations detected at the other sites (Screening Sites 35, 36-39, 54, 56, 72, and 80) ranged from 127 mg/kg to 308 mg/kg.

Zinc concentrations in 48 of 150 subsurface soil samples (including 7 duplicates) exceeded the background value of 114 mg/kg. The elevated zinc concentrations were located near the recoupment area (Screening Site 28), the DRMO hazardous waste storage area at Building 308 (Screening Site 35), the DRMO drum storage area (Screening Sites 36-39), the western stormwater drainage canal (Screening Site 56), the flammables and toxics storage area on the western end of Building 319 (Screening Site 74), the waste loading and unloading area adjacent to Building 702 (Screening Site 79), the fuel dispensing area at Building 720 (Screening Site 80), and the dried paint disposal area just south of Building 949 (Screening Site 83). The zinc concentrations in the subsurface did not significantly exceed the background limit. In fact, most of the zinc concentrations that exceeded the background limit of 114 mg/kg only ranged from 120 mg/kg to 145 mg/kg. In addition, the elevated zinc concentrations were widely dispersed and not concentrated in one boring or strata. Only 8 of the 38 detected concentrations were more than 145 mg/kg, with the highest of the 8 detected concentrations being 223 mg/kg at boring SB79C (4- to 6-ft depth) and 182 mg/kg and 177 mg/kg at boring SB79A (4- to 6-ft and 8- to 10-ft depths). These borings located at Screening Site 79 typically contain very high metals concentrations at the 4- to 6-ft and 8- to 10-ft depths.

Overall, elevated zinc concentrations were observed at the dried paint disposal area just south of Building 949, the recoupment area at Building 865, the DRMO drum storage area, the PDO yard, the waste loading and unloading area at Building 702, and the fuel-dispensing area at Building 720. Some of these surface soil concentrations significantly exceeded the background limit–especially at the dried paint disposal area. Zinc was not detected in significant quantities in the subsurface, but was detected throughout FU4, mostly at depths of 4 to 6 ft and 8 to 10 ft. Concentrations in the subsurface soil were slightly lower than those detected in the surface soil.

Selenium. Selenium was detected in 36 of 150 surface soil samples (including 21 duplicates) analyzed for selenium. Twenty-nine of the detected concentrations exceeded the background value of 0.8 mg/kg. As shown on Figure 20-12, the elevated selenium concentrations are concentrated in the central portion of FU4 where BRAC samples were collected, near the DRMO drum storage area (Screening Sites 36-39), the dried paint disposal area (Screening Site 83), and the PDO yard (Screening Site 72). The highest concentrations

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were detected at samples SB36F at 14.5 mg/kg, FS83T at 12.8 mg/kg, C(33.9) at 11.2 mg/kg, E(33.9) at 7.7 mg/kg, and B(29.2) at 6.3 mg/kg. Unlike other metals, selenium was detected above background in most of the samples within the gravel and grassy areas, including the open gravel area in the central portion of FU4.

Selenium was only detected 8 times out of 150 subsurface soil samples (including 7 duplicates). Seven of these detected concentrations exceeded the background value of 0.6 mg/kg. The elevated selenium concentrations were detected at depths of 4 to 6 ft and 8 to 10 ft. In addition, the elevated concentrations only ranged from 1.3 to 2 mg/kg. Selenium concentrations in the 3- to 5-ft interval did not exceed background values or were not detected, and selenium was not detected in the 18- to 20-ft-depth interval.

20.4.1.2 Distributed Metals

Antimony, barium, beryllium, cadmium, cobalt, mercury, and vanadium were detected at concentrations that exceeded background values. However, the elevated concentrations for these constituents occurred infrequently (see Table 20-3) and were widely dispersed. As a result, the elevated concentrations of these constituents were not considered indicative of a release from a source area in FU4, and these constituents were classified as distributed metals.

Antimony. Antimony was detected in 46 out of 147 samples analyzed for antimony. Antimony concentrations in 8 of the 147 surface soil samples exceeded the background value of 7 mg/kg. These 8 surface soil samples were located near the dried paint disposal area south of Building 949 (Screening Site 83), the southern end of Building 925, the DRMO drum storage area (Screening Sites 36-39), and the DRMO hazardous waste storage area at Building 308 (Screening Site 35). The detected elevated concentrations ranged from 7.3 mg/kg to 27.5 mg/kg. Only nine antimony concentrations were detected in 154 subsurface soil samples. No background value was established for the subsurface antimony concentrations.

Barium. Two of the 43 surface soil samples contained barium concentrations that exceeded the background value of 234 mg/kg. These two surface soil samples were located at the western stormwater drainage canal and the dried paint disposal area at concentrations of 238 mg/kg (SS56C) and 366 mg/kg (SS83B), respectively. Each of the 43 surface soil samples collected contained a detected barium concentration. The detected concentrations ranged from 6.7J mg/kg to 366 mg/kg. Only one of the 57 subsurface soil samples contained a barium concentration that exceeded the background concentration of 300 mg/kg. This detection was at the western stormwater drainage canal in boring SB56A (5- to 7-ft depth) at a concentration of 422 mg/kg.

Beryllium. The background value of 1.1 mg/kg for beryllium was exceeded in one surface soil sample. This elevated concentration was detected near the dried paint disposal area in sample SS83B at only 1.6 mg/kg. Beryllium was analyzed in 150 surface soil samples (including 21 duplicates) and detected in 80 surface soil samples. The detected concentrations ranged from 0.02J mg/kg to 1.6 mg/kg.

Beryllium concentrations in 3 subsurface soil samples exceeded the background value of 1.2 mg/kg. However, the beryllium concentrations that exceeded the background value ranged from 1.4 mg/kg to 1.8 mg/kg. In addition, the elevated beryllium subsurface concentrations were scattered throughout the soil borings and not concentrated in any one area. Beryllium was detected in 71 of the 157 subsurface soil samples, including 7 duplicates.

Cadmium. Cadmium was detected in 66 out of 150 samples analyzed for cadmium. Cadmium concentrations in 12 of the 66 surface soil detections exceeded the background value of 1.4 mg/kg. These 12 surface soil samples were located near the dried paint disposal area south of Building 949 (Screening Site 83), the DRMO drum storage area (Screening Sites 36-39), the DRMO hazardous waste storage area at Building 308 (Screening Site 35), the recoupment area at Building 865 (Screening Site 28), the eastern stormwater runoff canal (Screening Site 54), the waste loading and unloading area at Building 702 (Screening Site 79), and Building 720 (Screening Site 80). The detected elevated concentrations ranged from 1.6 mg/kg to 4.8 mg/kg. Only 18 cadmium concentrations were detected in 157 subsurface soil samples. One detection exceeded the background value of 1.4 mg/kg. The elevated concentration of 1.8 mg/kg was detected at sample SB36H at the 18- to 20-ft interval.

Cobalt. Cobalt concentrations in one surface soil sample exceeded the background value of 18.3 mg/kg. This sample was located near the western stormwater drainage canal (Screening Site 56) in sample SB56A at a concentration of 18.9 mg/kg. Cobalt was detected in all 43 surface soil samples and all 157 subsurface soil samples. Two cobalt concentrations in the subsurface soil exceeded the background value of 20.4 mg/kg. These samples were also located at the western stormwater drainage canal in boring SB56A (5- to 7-ft and 8- to 10-ft depths) at concentrations of 28 mg/kg and 23.4 mg/kg, respectively.

Mercury. Mercury was detected in 44 out of 150 surface soil samples at concentrations below the background value of 0.4 mg/kg. Mercury was analyzed in 157 subsurface soil samples, but was detected in only 3 subsurface soil samples. Two mercury concentrations of 0.37 mg/kg detected in the subsurface soil exceeded the background value of 0.2 mg/kg The samples were located in the open gravel area in the central portion of FU4.

Vanadium. Vanadium concentrations in one surface soil sample exceeded the background value of 48.4 mg/kg. This sample was located near the western stormwater drainage canal (Screening Site 56) in sample SS56C at a concentration of 50.9 mg/kg. Vanadium was detected in all 43 surface soil samples and all 57 subsurface soil samples. One vanadium concentration in a subsurface sample exceeded the background value of 51.3 mg/kg. This sample also was located at the western stormwater drainage canal in boring SB56A (8- to 10-ft depth) at a concentration of 65.1 mg/kg.

20.4.1.3 Naturally Occurring Metals

Various samples collected throughout FU4 contained concentrations of aluminum, calcium, iron, magnesium, manganese, and potassium that exceeded background values. However, these metals frequently occur in the natural clay soils beneath the site. Specifically, almost every soil sample analyzed for these constituents at FU4 contained a detected concentration of aluminum, calcium, iron, magnesium, manganese, and potassium. In addition, these metals do not pose significant health risks and generally are not indicative of a release from source areas in FU4. Therefore, the following constituents were classified as naturally occurring metals.

Aluminum. Aluminum concentrations in 1 surface soil sample exceeded the background value of 23,800 mg/kg. The elevated concentration was detected near the western stormwater drainage canal in boring SB56A at 27,600 mg/kg. Aluminum was detected in all 43 surface soil samples including five duplicates and all 57 subsurface soil samples, including three duplicates. Only 1 of the 57 subsurface soil samples contained an aluminum concentration that exceeded the background concentration of 21,829 mg/kg. This detection also was at the western stormwater drainage canal in boring SB56A (5- to 7-ft depth) at a concentration of 26,800 mg/kg.

Calcium. Calcium concentrations in 19 surface soil samples exceeded the background value of 5,840 mg/kg. The surface soil samples with elevated calcium concentrations were broadcast throughout FU4, and ranged from 6,160 mg/kg to 306,000 mg/kg. Calcium concentrations in two subsurface soil samples exceeded the background value of 2,432 mg/kg. The two subsurface soil samples were located near the western stormwater drainage canal in boring SB56A at 2,540 mg/kg (at 5 to 7 ft) and 5,670 mg/kg (at 8 to 10 ft). Calcium was detected in 41 out of 43 surface soil samples, including 5 duplicates, and in 56 out of 57 subsurface soil samples, including 3 duplicates.

Iron. Iron was detected in all 43 surface soil samples, including 2 duplicates, and all 57 subsurface soil samples, including two duplicates. Iron concentrations in two surface soil samples exceeded the background value of 37,040 mg/kg. The elevated iron concentrations were detected at the western stormwater drainage canal (Screening Site 56) and at the dried paint disposal area (Screening Site 83). One iron concentration in the subsurface exceeded the background value of 38,480 mg/kg. This concentration was detected at the western stormwater drainage canal in boring SB56A.

Magnesium. The background value of 4,600 mg/kg for magnesium was exceeded in four surface soil samples. The elevated concentrations ranged from 5,360 mg/kg to 7,060 mg/kg. Magnesium concentrations in 2 subsurface soil samples exceeded the background value of 4,900 mg/kg. The elevated concentrations were detected at 84,200 mg/kg in sample A (24.2) (zero to 4 ft) and at 410 mg/kg in sample SB56A (8 to 10 ft). Magnesium was detected in all 43 surface soil samples, including 5 duplicates, and in all 57 subsurface soil samples, including 3 duplicates.

Manganese. The background value of 1,304 mg/kg for manganese was exceeded in three surface soil samples. The elevated concentrations ranged from 1,400 mg/kg to 2,260 mg/kg. A manganese concentration in 1 subsurface soil sample exceeded the background value of 4,900 mg/kg. The elevated concentration was detected at 2,960 mg/kg in sample SB56A (5 to 7 ft). Manganese was detected in all 43 surface soil samples, including 5 duplicates, and in all 57 subsurface soil samples, including 3 duplicates.

Potassium. Potassium concentrations in 10 surface soil samples exceeded the background value of 1,820 mg/kg. These elevated potassium concentrations were detected throughout FU4 and ranged from 1,910 mg/kg to 3,140 mg/kg. Potassium concentrations in 19 subsurface soil samples exceeded the background value of 1,800 mg/kg. Most of the elevated potassium concentrations were located near the railroad tracks in the central portion of FU4. Potassium was detected in 42 of the 43 surface soil samples, including 5 duplicates, and in 55 of the 57 subsurface soil samples.

20.4.1.4 Metals below Background Values

Silver, sodium, and thallium were detected infrequently in surface and subsurface soil samples analyzed for these constituents. However, no concentrations of these constituents exceeded the background values, if available.

20.4.2 Nature and Extent of SVOC Contamination

20.4.2.1 Surface Soil

On the basis of soil sample results for FU4, the primary SVOCs of concern in the surface soil were determined to be PAHs. As shown on Figure 20-13 and in Table 20-4, 56 out of 129 surface sample locations contained detectable concentrations of total PAHs. The total PAH concentrations were detected throughout FU4 in all of the screening sites. The detected total PAH concentrations ranged from 0.050 mg/kg to 79.4 mg/kg. The highest total PAH concentrations (79.5 mg/kg and 63.2 mg/kg) were observed in B(30.2) and SS43F, respectively. Sample B(30.2) was taken near the southwestern corner of Building 925 near the railroad track. Sample SS43F was taken in the open gravel area on the eastern portion of FU4, just northwest of Building 737. Other PAH detected concentrations were less than 40 mg/kg.

PAHs are observed throughout the Main Installation, generally from surface soil samples in proximity to railroad tracks and those not adjacent to railroad tracks. PAH compounds can generate from creosote seepage that comes from railroad track cross ties, from historical railcar leaks to the surface, or from the application of a PCP/used-oil mixture that historically was applied for weed control along the tracks. PAH compounds also can be generated as a result of engine exhaust from trucks, automobiles, and trains. To further assess the presence of PAH compounds in surface soil from railroad track cross ties and asphalt, two samples (RR57A and RR65A) were collected from the cross ties and two samples were collected from asphalt (RD57A and RD65A) and analyzed for PAHs. These samples were collected in FU1.

As shown in Table 20-5, high concentrations of the following PAHs were detected in the railroad cross tie samples, indicating potential source contamination from railroad tracks: benzo(a)anthracene, chrysene, flouranthene, naphthalene, phenanthrene, and pyrene.

The relationship between detected PAHs in surface soil and asphalt could not be evaluated because of the difficulty of analyzing the asphalt samples (Table 20-5). Excessive matrix interference caused unusually high dilution factors, which resulted in elevated reporting limits (matrix interference was anticipated before analysis, and therefore, only 6 grams of sample rather than the typical 30 grams were analyzed). Therefore, PAHs at the requested reporting limits were masked by the sample matrix.

The SVOC carbazole was detected 12 out of 99 times it was analyzed for and exceeded the background value of 0.067 mg/kg 9 times. As shown on Figure 20-14, the highest concentrations of carbazole were found along the southwestern corner of Building 925 (1.8 mg/kg), the northwestern corner of Building 209 (1.1 mg/kg), and the northwestern corner of Building 972 (1.0 mg/kg). Other isolated detected concentrations of carbazole were just above background.

Concentrations of other SVOCs (BEHP, diethyl phthalate, di-n-butyl phthalate, di-n-octyphthalate, and PCP) were detected in surface soil samples. However, no concentration of these constituents exceeded a background value. In some cases, no background value was available. Benzyl butyl phthalate, a common laboratory contaminant, was detected in 1 out of 3 samples above its background value of 0.645 mg/kg, at 0.700 mg/kg.

In summary, the primary SVOCs of concern in the surface soil are PAH compounds. In the western portion of FU4, where the highest levels of PAH compounds were detected, the elevated concentrations probably result from railroad ties. Other detected concentrations of SVOCs normally were below background, or the SVOC was determined to be a laboratory contaminant.

20.4.2.2 Subsurface Soil

As shown in Table 20-4, PAHs were not frequently detected in subsurface soil samples. Total PAH concentrations were detected in only 6 out of 157 subsurface soil samples. The concentrations ranged from 0.094 mg/kg to 2.59 mg/kg.

The PAHs fluoranthene and pyrene exceeded background values in five subsurface soil samples. The five detected fluoranthene concentrations ranged from 0.050 mg/kg to 0.540 mg/kg, exceeding the background value of 0.045 mg/kg. The five detected pyrene concentrations ranged from 0.044J mg/kg to 0.370J mg/kg, exceeding the background value of 0.042 mg/kg. Concentrations of most PAHs were detected only 2 or 3 times out of the 157 samples analyzed for these constituents (see Table 20-4).

In summary, SVOCs generally were not detected in the subsurface soils. Only the SVOCs BEHP and di-n-butyl phthalate, which are common laboratory contaminants, were detected in a number of the subsurface soil samples.

20.4.3 Nature and Extent of Pesticide Contamination

A total of 6 pesticides were detected in 108 pesticide surface soil samples at FU4. The pesticides are DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin. Table 20-6 lists these pesticides, the number of times they were analyzed, and the minimum and maximum concentrations detected.

There are two general areas in which elevated concentrations of pesticides were detected within FU4:

- West-central portion of FU4 (just north of Building 737 in the open gravel area; and
- The far eastern portion of FU4 (just west of Building 209 and Building 210 in the grassy areas and the grassy areas surrounding these buildings).

As presented on Figures 20-15 through 20-16, elevated concentrations of DDE and DDT were detected above background in the open gravel area just north of Building 737 (Screening Sites 43 and 46), and some isolated detected concentrations were around Buildings 209, 210, and 949. DDE was detected in 34 sample locations, with 8 detected concentrations above its background value of 0.16 mg/kg (see Table 20-7). The highest concentrations of DDE were detected at Screening Site 43 at 3 mg/kg in sample SS43F and at

Screening Site 46 at 1.6 mg/kg in sample SS46E. Both of these samples are located in the open gravel area north of Building 737. Pesticides were used extensively in this area.

DDT was detected in 48 sample locations, with 13 detected concentrations above its background value of 0.074 mg/kg. The highest concentrations of DDT were detected in the same locations as DDE. DDT was detected at Screening Site 43 at 13 mg/kg in sample SS43F and at Screening Site 46 at 3.1 mg/kg in sample SS46E. The constituent DDD was only detected once out of 108 samples in sample SS43C at 0.033J mg/kg. The detected concentration exceeded the background value of 0.0067mg/kg.

Dieldrin was detected throughout the Main Installation and is not associated with known sources of contamination at FU4. It was sprayed routinely on grassy areas and around warehouses. Within FU4, dieldrin was detected 44 out of 108 samples analyzed for dieldrin Dieldrin exceeded its background concentration in 20 of the samples, which were taken in grassy areas (see Figure 20-17 for detection points and Figure 2-16 for land cover).

Alpha-chlordane and gamma-chlordane were detected at elevated concentrations in sample SS46E, as well, at concentrations of 3.4 mg/kg and 3.3 mg/kg, respectively (see Figures 20-18 and 20-19). In all, alpha-chlordane was detected in 22 samples, in which 6 of the detected concentrations exceeded the background value of 0.029 mg/kg. Gamma-chlordane was detected in 22 samples, in which 8 of the detected concentrations exceeded the background value of 0.087 mg/kg.

In summary, the pesticides detected in the surface soil were normally just north of Building 737 in the open gravel area and in the grassy areas surrounding Buildings 209 and 210. The detected pesticide concentrations probably cab be attributed to site-wide application rather than to site-specific releases.

20.4.3.1 Pesticides in Subsurface Soil

A total of 144 subsurface soil samples were analyzed for pesticides. Pesticides normally were not detected in the subsurface soils. The minimal detected concentrations of pesticides in the subsurface soil were normally at the 8- to 10-ft depth. Dieldrin was detected at the 8- to 10-ft depth in 6 out of 7 of its detected concentrations. None of the dieldrin concentrations exceeded the background value of 0.37 mg/kg.

DDE was detected only 5 times out of 144 subsurface soil samples and exceeded its background value of 0.0015 mg/kg in all detected concentrations. Elevated concentrations of DDE ranged from 0.002J mg/kg to 0.024 mg/kg. DDT was detected 8 times out of 144 samples and exceeded its background value of 0.0072 mg/kg in 3 of the detected concentrations. Elevated concentrations of DDT ranged from 0.0033J mg/kg to 0.019 mg/kg. The elevated concentrations of DDE and DDT were detected at Screening Site 35, Screening Site 54, Screening Site 74, and Screening Site 79, normally at the 8- to 10-ft depth, and normally in only one boring located at the site.

DDT was the most common pesticide detected in the subsurface soil above background. However, all pesticide detections in subsurface soil were infrequently located throughout FU4, normally at the 8- to 10-ft depth, and are possibly associated with sampling artifacts.

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20.4.4 Nature and Extent of Dioxin and Furan Contamination

20.4.4.1 Dioxins and Furans in the Surface Soil

Dioxins are ubiquitous in the urban environment and have been detected in the background samples. Dioxins were analyzed for in surface soil and subsurface soil at Screening Site 42 (the former PCP dip vat area), Screening Site 43 (the former underground PCP tank area), Screening Site 46 (the pallet drying area), Screening Site 54 (the DRMO east stormwater runoff canal), Screening Site 55 (the DRMO north stormwater runoff area) and Screening Site 56 (the western stormwater drainage canal). Table 20-7 presents the number of times that dioxins and furans were detected, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected. As shown in Table 20-7, estimated concentrations of CDD equivalents exceeded background TCDD equivalent values in surface soil samples. Concentrations of dioxins and furans normally were detected in the same areas, in the PCP dip vat area and along the eastern stormwater drainage canal (see Figure 20-20).

Normally, detected concentrations of TCDD indicate that the observed concentrations probably are a result of atmospheric deposition that results from waste incineration and burning activities. However, the former PCP dip vat area and PCP storage tank area within FU4 previously were contaminated with dioxins and furans, based on past practices. Correspondence with facility personnel by OHM and AHEA representatives revealed that PCP liquid had been mixed with waste oil in past years and sprayed on the grounds in the PCP dip vat area for dust control. Areas suspected of receiving this mixture are located in the area between the cluster of railroad track trunklines and 6th Street extending 450 ft to the southeast and 1,000 ft to the northwest, and are identified as Screening Sites 42, 43, and 46 (see Figure 20-1). Previous soil samples indicated that the area had been contaminated with PCP and dioxin. The soil in the PCP dip vat area was removed and backfilled with clean material, and gravel was used to cover some of the areas that had higher dioxin concentrations (OHM, 1986). The PCP UST and soil surrounding the tank were removed, as well. The extent of contamination remaining in the area surface soil, as well as throughout FU4, is discussed in the paragraphs below. When surface soils were taken as part of the recent investigation, the gravel was removed by shovel or pick and the soil beneath was sampled as the "true" surface soil (Section 4.1.1).

Of the different isomers of dioxins and furans, the higher chlorinated isomers such as octa-isomers are the most persistent. Octachlorodibenzofuran was detected above its background value of 0.00039 mg/kg in 18 out of 25 detected sample concentrations. Thirteen of the elevated detected concentrations occurred at Screening Sites 42, 43, and 46. However, the highest detection was noted in the DRMO eastern stormwater drainage canal (Screening Site 54). Surface soil samples SB54A, SS46E, and SS54A contained the highest octachlorodibenzofuran concentrations–0.039746 mg/kg, 0.03227 mg/kg, and 0.017604 mg/kg, respectively.

Octachlorodibenzo-p-dioxin was detected above its background value of 0.0097 mg/kg in 10 out of 24 sample detected concentrations. Six of the elevated concentrations occurred at Screening Sites 42, 43, and 46. Three of the elevated concentrations were detected at the eastern stormwater drainage canal (Screening Site 54) and one elevated concentration was detected at the northern stormwater drainage canal (Screening Site 55). The highest concentration was detected in sample SS43B at 0.072 mg/kg. The next highest concentrations were detected at the eastern stormwater drainage canal in samples SB54B and SS54A at 0.056 mg/kg and 0.054 mg/kg, respectively.

20.4.4.2 Dioxins and Furans in the Subsurface Soil

The samples analyzed for dioxins and furans indicated elevated concentrations of TCDD equivalent in the subsurface soil at the PCP dip vat area (Screening Site 42), the pallet drying area (Screening Site 43), and the eastern stormwater drainage canal (Screening Site 54). Most of the observed TCDD equivalent values are similar in the site samples and the background value of 0.000006 mg/kg, with the exception of the concentration detected in boring SB42A at 0.0056 mg/kg (8- to 10-ft depth). Octachlorodibenzo-p-dioxin also was detected in boring SB42A at elevated concentrations. Octachlorodibenzo-p-dioxin was detected in boring SB42A at 3.25J mg/kg (8 to 10 ft) and 0.062 mg/kg (28 to 30 ft). These concentrations exceeded the background value of 0.0094 mg/kg. Concentrations of TCDD equivalent and octachlorodibenzo-p-dioxin did not exceed background values in boring SB42A at depths greater than 30 ft.

All of the surface and subsurface samples analyzed for dioxins and furans had detectable levels of dioxins and furans, mostly the hepta- and octa- isomers. Concentrations of dioxins and furans were detected in the PCP dip vat area and along the east stormwater drainage canal. The soil around the former PCP dip vat area and storage tank area previously was contaminated with dioxins and furans, based on past practices. The area was remediated in 1986 for possible PCP and dioxin contamination in the surface soil. However, the highest dioxin concentrations are now detected at the east stormwater drainage canal; the source of these contaminants in this location is not known. However, background samples indicated dioxins and furans at similar concentrations.

20.4.5 Nature and Extent of VOC and Other Organic Contamination in Surface and Subsurface Soil

20.4.5.1 VOCs in Surface Soil

A total of 14 VOCs were detected in the 105 surface soil samples analyzed for VOCs throughout FU4. The VOCs are 1,1,2,2-Tetrachloroethane, 2-Hexanone, acetone, benzene, bromomethane, carbon disulfide, chloromethane, ethyl benzene, MEK, methylene chloride, PCE, toluene, total xylenes, and TCE. Table 20-8 presents a list of these compounds, the number of times they were detected, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected.

Most of the surface soil sample results for VOCs within FU4 indicated *no detected concentrations*. The VOCs that were detected were located throughout FU4. MEK was one of the most common VOCs detected, with exception of two laboratory contaminants, acetone and methylene chloride. MEK was detected in 8 out of 105 surface soil samples. The MEK concentrations detected ranged from 0.006J mg/kg to 0.044 mg/kg, in which all detected concentrations exceeded the background value of 0.002 mg/kg. As shown on Figure 20-21, the highest elevated concentrations of MEK were detected at the following locations:

- On the northwestern corner of Building 209 at sample point SS14A–this detection could have resulted from past general purpose warehouse storage;

- On the northwestern corner of Building 210 at sample point SS13A–this detection could have resulted from the storage of waste solvents, empty product containers, and solvent rags; and
- Just south of the concrete pad located west of Building 309 in Samples SS36B and SS36C–these detected concentrations could have resulted from the former hazardous waste storage in this area.

Other elevated concentrations of VOCs were detected at Building 720 (total xylenes), at the open storage area west of Building 835 (toluene), and at the DRMO drum storage area (1,1,2,2-Tetrachloroethane).

The majority of the surface soil sampling results for VOCs in FU4 indicated no detections. MEK was one of the most common VOCs detected, with the exception of the laboratory contaminants.

20.4.5.2 VOCs in Subsurface Soil

A total of 155 subsurface soil samples were analyzed for VOCs. Table 20-8 presents a list of VOCs detected in the subsurface soil. Most subsurface soil results showed no detected concentrations, with the exception of the laboratory contaminants. Background values for most VOC constituents that were detected have not been established in the subsurface soil. 1,1,2,2-Tetrachloroethane and TCE were the only VOCs in the subsurface soil detected at concentrations that exceeded the GWP values.

Most of the VOCs in the subsurface soil were detected at the DRMO drum storage area (Screening Sites 36-39). The two CVOCs–1,1,2,2-Tetrachloroethane and TCE–were the only VOCs detected at concentrations that exceeded the GWP values. These VOC concentrations above the GWP values were detected at the lowest sample depth of 18 to 20 ft. TCE was detected in the groundwater just north of this site in MW-53.

In boring SB36K, 1,1,2,2-Tetrachloroethane was detected above the GWP value at depths of 4 to 6 ft, 8 to 10 ft, and 18 to 20 ft. TCE was detected in borings SB36K and SB36I at the 18- to 20-ft depth at concentrations that exceeded the GWP values, as well. It does not appear that the vertical extent of VOC contamination has been bounded at Screening Sites 36-39, because VOC concentrations detected above the GWP values were detected at the lowest sample depth of 18 to 20 ft. The subsurface soil beneath the drum storage area in FU4 appears to be a potential continuing source of contamination to groundwater.

20.4.5.3 Other Organics

Petroleum hydrocarbons were analyzed for in three locations, including one duplicate, in the area east and southeast of Building 770 (located in FU3) at sample locations A(24.2) and B(24.2). Concentrations of petroleum hydrocarbons in the surface and subsurface soil were detected in Sample A(24.2), located east of Building 770 at the FU3 and FU4 border. Two concentrations of petroleum were detected in the surface soil at depths of zero to 1 ft; and two concentrations of petroleum were detected in the subsurface soils at depths of zero to 4 ft and 7 to 10 ft. Concentrations of petroleum hydrocarbons were not detected at sample interval depths lower than 7 to 10 ft.

Background values were not established for petroleum hydrocarbons, but the detected concentrations in the two surface soil samples (1,300 mg/kg to 1,570 mg/kg) exceeded the Region III RBC direct exposure value of 34 mg/kg and the GWP value of 340 mg/kg The concentrations in the subsurface soil did not exceed the GWP value of 340 mg/kg.

20.5 Nature and Extent of Surface Water Contamination

Stormwater west of 6th Street in FU4 flows to either concrete-lined ditches or the underground drainage pipe system (Black & Veatch, 1999). Both discharge off-site to Tarrant Branch at Gate 9 (Outfall 5). Stormwater in the northern portion of FU4 that is bisected by B Street largely travels by sheet flow until it reaches the concrete-lined ditch north of Building T416 or through drop inlets to the underground pipe system parallel to C Street. The ditch curves to the north and the underground pipe empties into it before discharging off-site (Outfalls 8 and 7, respectively) to the city's stormwater drainage system at Dunn Avenue. Stormwater in the northern portion of FU4 north of B Street is collected by drainage pipes and is discharged to the city's stormwater drainage system at Dunn Avenue.

20.5.1 Nature and Extent of Metal Contamination

Total and dissolved metals were analyzed in the surface water of FU4. Only one primary metal, dissolved arsenic, was detected in FU4 at concentrations above background values. The results of the analyses are presented in Table 20-9. Lead and dissolved selenium were identified as distributed metals. Dissolved iron was the only naturally occurring metal that had exceedances above background. No background values were established for dissolved copper, dissolved silver, and dissolved vanadium. The remaining metals were all detected below their background values.

20.5.1.1 Arsenic

Total and dissolved arsenic were analyzed in surface water samples in FU4. Total arsenic was analyzed eight times and detected five times, with no concentrations above the background value (0.018 mg/L). The detected values below background ranged from 0.0046J to 0.0125 mg/L.

Dissolved arsenic was detected in five of the eight samples analyzed. The background value of 0.012 mg/L was exceeded twice. SW54C had a concentration of 0.0121 mg/L and SW56B had a concentration of 0.0892 mg/L.

20.5.1.2 Lead

Total and dissolved lead were analyzed in surface water samples in FU4. Total lead was detected in seven of the eight surface water samples. One concentration exceeded the background value of 0.0186 mg/L. SW55A contained a concentration of 0.0387 mg/L. The concentrations below the background value ranged from 0.0026J to 0.0114 mg/L.

Dissolved lead also was analyzed in eight surface water samples, but no concentration exceeded the background value of 0.0226 mg/L. The two concentrations detected below the background value were 0.0028 mg/L (SW56B) and 0.0071 mg/L (SW55A).

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20.5.1.3 Selenium

Total selenium was analyzed in eight surface water samples, but was not detected.

Dissolved selenium was analyzed in eight samples and detected once. This concentration, 0.0101 mg/L (SW56B), exceeded the background value of 0.003 mg/L.

20.5.1.4 Iron

Dissolved iron was detected in each of the five samples in which it was analyzed, with three samples exceeding background values of 0.12 mg/L. One sample with an elevated concentration was a duplicate. These exceedances were found at SW55A (0.445J mg/L) and SW56C (0.223J mg/L).

Total iron was detected in each of the five samples, but no detected concentration exceeded the background value.

20.5.1.5 Remaining Metals

Several other metals were analyzed for both dissolved and total fractions, and although frequently detected, had no detected concentrations that exceeded the background values. These metals include aluminum (total), barium (total and dissolved), calcium (total and dissolved), chromium (total and dissolved), magnesium (total and dissolved), manganese (total and dissolved), nickel, potassium (total and dissolved), sodium (dissolved and total), vanadium (total and dissolved), and zinc (total and dissolved).

20.5.2 Nature and Extent of SVOC Contamination

Surface water samples were analyzed for SVOCs, and the only concentrations detected were BEHP and PCP (Table 20-10). BEHP was analyzed for in eight samples and was detected once at a concentration of 0.019 mg/L at SW56C. The results of the DQE (Section 5.0) established that the detection of BEHP can be attributed to field sampling and laboratory contamination rather than to environmental conditions at the site. PCP was detected in three of the eight samples, with concentrations of 0.006, 0.007, and 0.013 mg/L in samples SW54B, SW54A, and SW55A, respectively. No background values were established for either parameter in the surface water of FU4.

Total PAHs were analyzed for in eight samples of the surface water of FU4. No detected concentrations were found.

20.5.3 Nature and Extent of Pesticide Contamination

Two pesticides were detected in the surface water in FU4 (Table 20-11). Dieldrin was the most commonly detected, at five times out of eight samples. DDT was detected in four of the eight samples. No background values were established for these constituents in surface water.

Dieldrin concentrations of 0.00024 and 0.00023 mg/L were detected at SW54A and SW54B, respectively. SW56A, SW56B, and SW56C contained concentrations of 0.00016, 0.000057J, and 0.000034J mg/L. Each dieldrin concentration exceeded the ecological criterion value of 0.0000019 mg/L.

DDT concentrations of 0.000068J, 0.000066J, and 0.000086J mg/L were detected in SW54A, SW54B, and SW54C, respectively. SW55A contained a concentration of 0.00022 mg/L.

20.5.4 Nature and Extent of Dioxin and Furan Contamination

Six dioxins were detected in the surface water at FU4 (Table 20-12). Octachlorodibenzo-p-dioxin and TCDD equivalent were the only two whose concentrations exceeded a background value. The four remaining dioxins did not have a background value for comparison.

Octachlorodibenzo-p-dioxin was detected in all eight surface water samples, including one duplicate, and exceeded the background value of 0.00000123 mg/L in six of those samples. Concentrations detected above the background value ranged from 0.000002019J to 0.000027148J mg/L.

TCDD equivalent was detected in all eight surface water samples, including one duplicate, and exceeded the background value of 0.000000018 mg/L in five of those samples (see Figure 20-22). A high concentration of 0.000000028449 mg/L was detected in SW55A.

20.5.5 Nature and Extent of VOC Contamination

Eight samples, including one duplicate, of surface water in FU4 were analyzed for the standard suite of VOC parameters. No detected compounds were noted in any of the samples.

20.6 Nature and Extent of Sediment Contamination

To characterize the nature and extent of contamination within FU4, sediment samples were collected and analyzed for dioxins, VOCs, SVOCs, metals, pesticides/PCBs, herbicides, and PAHs. Figure 20-2 shows the sample locations for FU4, and Table 20-2 lists the parameters analyzed for at each site. Appendix O provides a list of all detected parameters in the sediment samples collected at FU4 and compares them to screening and background values. The nature and extent of the contaminants detected above background values at FU4 are discussed below.

The three screening sites that apply to the sediment in FU4 are Screening Sites 54, 55, and 56. All three sites discharge into the City's collection system. Screening Site 54 (DRMO East Stormwater Runoff Canal) is a concrete-lined drainage canal that collects runoff from the DRMO yard and other Depot facilities and directs it toward Dunn Avenue. The canal is approximately 930 ft long. Sample locations SE54A and SE54B are located in this site.

Screening Site 55 (DRMO North Stormwater Runoff Area) consists of the stormwater drain that collects runoff from the DRMO yard. It consists of sample location SE55A.

Screening Site 56 (West Gate Stormwater Drainage Canal) is a drainage canal that collects runoff from the PCP tank areas and the western portion of the Main Installation. Sample locations SE56A, B, and C are located within this site.

20.6.1 Nature and Extent of Metal Contamination

Metals were analyzed in the sediments of FU4 and only two primary metals (total chromium and lead) were detected in FU4 at concentrations above background values. The results of the analyses are presented in Table 20-9. No distributed metals were identified in the sediment samples. Calcium and magnesium were the only naturally occurring metals with exceedances above background. The remaining metals were all detected below background values.

20.6.1.1 Primary Metals in Sediments

Chromium. Total chromium was detected in all 11 sediment samples, including two duplicates, and exceeded the background value of 20.0 mg/kg in five samples (including one duplicate–see Figure 20-23). The five concentrations above the background value were observed in four sample locations. M-SD14 contained concentrations of 36.2 and 28 mg/kg (duplicate). SE54A contained a concentration of 68.5J mg/kg. SE56B contained a concentration of 26.5J mg/kg. SE56C contained concentrations of 16.7J mg/kg and 28.1J mg/kg in the duplicate sample.

Lead. Lead was detected in all 11 samples, including 2 duplicates, in which it was analyzed and exceeded the background value of 35.2 mg/kg in 4 of the samples (Table 20-9 and Figure 20-24). The 4 concentrations above the background value were observed in three sample locations. M-SD14 contained concentrations of 484 and 285 mg/kg (duplicate). SE54B contained a concentration of 63.9J mg/kg. SE56C contained a concentration of 23.6J mg/kg, and contained 66.9J mg/kg in the duplicate sample.

20.6.1.2 Naturally Occurring Metals in Sediment

Calcium and magnesium were detected in each of the eight samples, including two duplicates. The background value for calcium (14,900 mg/kg) was exceeded eight times, including two duplicates. Magnesium concentrations exceeded the background value of 2,440 mg/kg in three of the samples. However, because these metals are naturally occurring, the background value exceedances are not considered significant.

20.6.1.3 Other Metals in Sediment

Several other metals were detected in some or all of the samples in which they were analyzed, but because the detected concentrations never exceeded the background values, the occurrence of these metals is not considered significant. The metals in sediments falling into this category include aluminum, antimony, arsenic, barium, beryllium, cadmium, cobalt, copper, iron, manganese, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc. Their occurrences are summarized in Table 20-9.

20.6.2 Nature and Extent of SVOC Contamination

On the basis of the sediment sample results for FU4, the primary SVOCs of concern in the sediments were determined to be PAHs. As shown in Table 20-10 and presented on Figure 20-25, each of the 11 sediment sample locations contained detectable concentrations of total PAHs.

Thirteen individual PAHs exceeded their background values at least once in the 11 times PAHs were analyzed in FU4. Eleven exceeded twice; two exceeded once.

Other SVOCs detected in FU2 at concentrations that exceeded background values include BEHP and carbazole (Table 20-10). Detected concentrations of BEHP are attributable to laboratory contamination (Section 5.0). Carbazole was detected five times, with two concentrations exceeding the background value of 1.1 mg/kg. The elevated carbazole concentrations were detected in the 1995 sediment sampling event at one sample location, Sample SD-14 and its field duplicate, at 2.4 mg/kg and 2.1 mg/kg, respectively (see Figure 20-26).

20.6.3 Nature and Extent of Pesticide Contamination

Nine pesticides were detected in 11 sediment samples at FU4: alpha endosulfan, alpha-chlordane, DDD, DDE, DDT, dieldrin, endrin, endrin aldehyde, and gamma-chlordane. Four of these pesticides were detected above background values: dieldrin, DDD, DDE, and alpha-chlordane (see Table 20-11). Background values were not available for alpha endosulfan, DDT, endrin, and endrin aldehyde in sediments.

20.6.3.1 Dieldrin

Dieldrin was detected in 8 out of 11 samples, including 20 duplicates. Each detected concentration exceeded the background value of 0.011 mg/kg, ranging from 0.038J mg/kg (SE56C) to 0.31 mg/kg (M-SD14). Figure 20-27 shows the locations of the dieldrin detections.

20.6.3.2 DDD

DDD was detected 7 times out of 11 samples, including 1 duplicate. Each detected concentration exceeded the background value of 0.0061 mg/kg, with concentrations ranging from 0.03J mg/kg (SE55A) to 0.99J mg/kg (SE54B). Figure 20-28 shows the locations of the DDD detections,

20.6.3.3 DDE

DDE was detected 7 times out of 11 samples, including 1 duplicate. Each detected concentration exceeded the background value of 0.0072 mg/kg, with concentrations ranging from 0.015J mg/kg (SE54A) to 0.25J mg/kg (SE54C). See Figure 20-29 for the locations of the DDE detections.

20.6.3.4 Alpha-Chlordane

Alpha-chlordane was detected in 5 out of 11 samples, in which 4 of the detected concentrations, including 1 duplicate, exceeded the background value of 0.0052 mg/kg. The elevated concentrations of alpha-chlordane ranged from 0.032J mg/kg (SE56B) to 0.53J mg/kg (SE54B). Figure 20-30 shows the locations of the alpha-chlordane detections.

20.6.4 Nature and Extent of Dioxin and Furan Contamination

Dioxins are ubiquitous in the urban environment and have been detected in the background samples. Twelve dioxins were detected in the sediment samples from FU4. Background values were established for only three of these contaminants, and each value was exceeded.

Sample SE54B generally contained the highest concentrations of each detected contaminant. SE54B is located in the northernmost section of the canal in FU4, just south of Dunn Avenue.

TCDD equivalent was detected in all 11 samples, including 2 duplicates (see Table 20-12 and Figure 20-31). Elevated concentrations (those above the background value of 0.000009 mg/kg) were observed in nine of those samples, including the two duplicates. SE54B had the highest reported concentration at 0.000129119 mg/kg. The elevated concentrations ranged from the value at SE54B to 0.000018757 mg/kg (SE55A). The duplicate taken at SE56C contained an elevated concentration of 0.000030386 mg/kg, although the primary sample was below the background value.

Of the different isomers of dioxins and furans, the higher chlorinated isomers such as octa-isomers are the most persistent and are commonly detected in the general environment (ATSDR, 1998). Octachlorodibenzo-p-dioxin was detected 11 times, including the 2 duplicates, and exceeded the background value of 0.00856 mg/kg in 7 samples. SE54B had the highest reported concentration at 0.014863J mg/kg. The elevated concentrations ranged from the value at SE54B to 0.016838 mg/kg (SE54C). The duplicate taken at SE56C contained an elevated concentration of 0.029301 mg/kg, although the primary sample was below the background value.

1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin was detected 8 out of 11 times, including 1 duplicate, and exceeded the background value of 0.000583 mg/kg 6 times, including 1 duplicate. SE54B had the highest reported concentration at 0.0238 mg/kg. The elevated concentrations ranged from the value at SE54B to 0.001253J mg/kg (SE54A).

The remaining dioxins that were detected did not have background values. 1,2,3,4,6,7,8-Heptachlorodibenzofuran and octachlorodibenzofuran were detected 10 out of 11 times. 1,2,3,6,7,8-Hexachlorodibenzofuran and 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin were detected 5 out of 11 times. 1,2,3,4,7,8-Hexachlorodibenzofuran and 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin were detected 4 out of 11 times. 1,2,3,4,7,8,9-Heptachlorodibenzofuran and 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin were detected 3 out of 11 times. 2,3,4,6,7,8-Hexachlorodibenzofuran was detected 1 out of 11 times.

20.6.5 Nature and Extent of VOC Contamination in Sediments

A total of five VOCs were detected in the 11 sediment samples analyzed for VOCs throughout FU4 (Table 20-13). They include acetone, carbon tetrachloride, MEK, methylene chloride, and total xylenes. Of these, acetone and methylene chloride may be eliminated from further discussion, because they were determined to be laboratory contaminants (Section 5.7).

Of the remaining VOCs, the most frequently detected was total xylene, which was detected twice (including one duplicate). The higher of the two concentrations was 0.036J mg/kg, below the GWP value of 0.2 mg/kg. Background values were not established for total xylenes in the sediment of FU4.

MEK (2-Butanone) was detected once in the duplicate sample of SE56C. The concentration (0.014J mg/kg) exceeded the background value of 0.01 mg/kg.

Carbon tetrachloride was detected once at a concentration of 0.078 mg/kg in M-SD19. No background value was established, but the GWP value of 0.07 mg/kg was exceeded.

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TABLE 20-1
Sampling Rationale at FU4
Memphis Depot Main installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media*
Screening Site 28 Recoupment Area, Building 865	Evaluate whether releases have occurred to surface and subsurface soils.	No additional sampling was conducted	5 Surface Soil 6 Subsurface Soil
Screening Site 35 Defense Reutilization Marketing Office (DRMO) Building T-308: Hazardous Waste Storage	Evaluate whether releases have occurred to surface and subsurface soils.	Confirm presence of elevated arsenic reported in historical sample Surface Soil4 and evaluate extent of contamination, provide a consistent data set for risk analysis.	7 Surface Soil 9 Subsurface Soil
Screening Site 36-39 DRMO Drum Storage Area	Evaluate whether releases have occurred to subsurface soils.	Confirm presence of high levels of lead, chromium, and SVOCs at historical sample Surface Soil5 Delineate the horizontal contamination of metals in surface soils	17 Surface Soil 42 Subsurface Soil
Screening Site 42 Former PCP Dip Vat Area	Evaluate whether former contaminants remain at the site beneath the previous dip vat location	Assess the horizontal contamination of metals, PAHs, and pesticides to provide a consistent data set	8 Surface Soil 8 Subsurface Soil
Screening Site 43 Former Underground PCP Tank Area	Evaluate whether potential contaminants exist at the site from the PCP UST	Need to analyze all related compounds for further site characterization	7 Surface Soil 8 Subsurface Soil
Screening Site 46 Pallet Drying Area	Evaluate whether potential contaminants exist at the site	Need to analyze for all related compounds for further site characterization	7 Surface Soil 8 Subsurface Soil
Screening Site 54 DRMO East Storm Water Runoff Canal	Assess characteristics of the storm water runoff in the eastern portion of the Main Installation	No additional sampling was conducted	3 Surface Soil 4 Subsurface Soil 4 Sediment 6 Surface Water
Screening Site 55 DRMO North Storm Water Runoff Area	Assess characteristics of the storm water runoff in the northern portion of the Main Installation.	No additional sampling was conducted	1 Surface Soil 2 Subsurface Soil 1 Sediment 2 Surface Water
Screening Site 56 West Gate Storm Water Drainage Canal	Assess characteristics of the storm water runoff in the western portion of the Main Installation	No additional sampling was conducted	4 Surface Soil 2 Subsurface Soil 4 Sediment 6 Surface Water
Screening Site 70/71 All Railroad Tracks	Evaluate whether releases have occurred to surface soils and subsurface soils	Further delineate PAH contamination in surface soils based on previous sampling	25 Surface Soil 20 Subsurface Soil

TABLE 20-1
Sampling Rationale at FU4
Memphis Depot Main installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media*
Screening Site 72 Waste Oil Surface Application for Dust Control (PDO Yard)	Evaluate whether releases have occurred to surface soils and subsurface soils	Delineate horizontal contamination of lead and chromium and provide a consistent data set.	1 Surface Soil
Screening Site 73 All Grassed Areas	Evaluate whether releases have occurred to surface soil from past pesticide use	No additional environmental sampling was necessary	7 Surface Soil
Screening Site 74 Flammables and Toxics (West End Building 319)	Evaluate whether releases have occurred to surface and subsurface soils	No additional sampling was conducted	3 Surface Soil 9 Subsurface Soil
Screening Site 79 Fuels, Miscellaneous Liquids, Wood, and Paper	Evaluate whether releases have occurred to surface and subsurface soils.	Confirm the presence of chemicals of concern detected in the 1996-1997 sampling event, and delineate the horizontal extent of contamination, assess surface soil depth distribution of contamination to evaluate quantities for remediation	12 Surface Soil 12 Subsurface Soil
Screening Site 80 Fuel and Cleaner Dispensing (Building 720)	Evaluate whether potential contaminants exist at the site in the surface and subsurface soil	Confirm and assess the lateral extent of metals, PCB, and PAH contamination in surface soil.	11 Surface Soil 6 Subsurface Soil
Screening Site 81 Fuel Oil (Building 765)	Evaluate whether potential contaminants exist at the site in the surface and subsurface soil	No additional sampling was conducted.	4 Surface Soil 3 Subsurface Soil
Screening Site 83 Dried Paint Disposal Area/POL Areas X13, X15, and X25	Evaluate whether releases have occurred to surface soils and subsurface soils	Assess the lateral extent of surface soil contamination, assess surface soil depth distribution of contamination to evaluate quantities for remediation, evaluate whether groundwater is affected by metals	22 Surface Soil 4 Subsurface Soil
BRAC-Parcels 13, 14, 15, 29, 30, 31, 32 and 33	Assess the environmental condition of soil in Parcels 13, 1,4 15, 29, 30, 31, 32, and 33	Assess the presence of contaminants (other than pesticides and PCBs) to further characterize the soils in these parcels	34 Surface Soil 35 Subsurface Soil

Notes
DRMO–Defense Reutilization and Marketing Office
PCP–Pentachlorophenol
Surface Soil–Surface soil sample
SVOC–Semivolatile organic compound
UST–Underground storage tank
BRAC–Baseline Realignment and Closure site
PAH–Polynuclear aromatic hydrocarbon
Subsurface Soil–Subsurface Soil Samples
Sediment–Sediment Sample
Surface Water–Surface Water Sample
* Groundwater samples were collected throughout the Main Installation and are identified under FU7, which is discussed in Section 32

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TABLE 20-2
Analytes Investigated for FU4
Memphis Depot Main Installation RI

Functional Unit	Site	Matrix[1]	Event	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	Pesticides	Pesticides, TCLP	Pesticides/PCBs	PAHs	Pet_ Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
4		SB	DO4				X			X			X				X		X
4	28	SB	SS							X			X				X		X
4	28	SS	SS							X			X				X		X
4	35	SB	SS							X			X				X		X
4	35	SS	MAINRIFS							X									
4	35	SS	SS							X			X				X		X
4	36	SB	SS							X			X				X		X
4	36	SS	MAINRIFS							X	X			X			X		X
4	36	SS	SS							X			X				X		X
4	42	SB	SS	X												X			
4	42	SS	MAINRIFS							X	X			X			X		X
4	42	SS	SS	X						X			X				X		X
4	43	SB	SS	X												X			
4	43	SS	MAINRIFS								X			X					
4	43	SS	SS	X						X			X				X		X
4	46	SB	SS	X												X			X
4	46	SS	MAINRIFS								X			X					
4	46	SS	SS	X						X			X				X		X
4	54	SB	SS	X						X			X				X		X
4	54	SE	SS	X	X					X			X				X		X
4	54	SS	SS	X						X			X				X		X
4	54	WS	SS	X				X		X			X				X		X
4	55	SB	SS	X						X			X				X		X
4	55	SE	SS	X						X			X				X		X
4	55	SS	SS	X						X			X				X		X
4	55	WS	SS	X				X		X			X				X		X
4	56	SB	SS	X						X			X				X		X
4	56	SE	SS	X	X					X			X				X		X
4	56	SS	SS	X						X			X				X		X
4	56	WS	SS	X				X		X			X				X		X
4	70	SB	SS							X			X				X		X
4	72	SS	MAINRIFS							X									
4	72	SS	SS							X			X	X			X		X
4	74	SB	SS							X			X				X		X
4	74	SS	SS							X			X				X		X
4	79	SB	MAINRIFS							X									
4	79	SB	SS							X			X				X		X
4	79	SS	MAINRIFS		X	X			X	X				X					
4	79	SS	SS							X			X				X		X
4	80	SB	SS							X				X					X
4	80	SS	MAINRIFS							X	X			X					

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TABLE 20-2
Analytes Investigated for FU4
Memphis Depot Main Installation RI

Functional Unit	Site	Matrix[1]	Event	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	Pesticides	Pesticides, TCLP	Pesticides/PCBs	PAHs	Pet_ Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
4	80	SS	SS							X			X	X			X		X
4	81	SB	SS											X			X		
4	81	SS	SS							X			X	X			X		X
4	83	SB	SS							X							X		X
4	83	SS	MAINRIFS		X	X			X	X									
4	83	SS	SS							X			X				X		X
4	BRAC	SB	BRAC							X			X		X		X		X
4	BRAC	SS	BRAC							X			X		X		X		X
4	BRAC	SS	MAINRIFS							X	X			X			X		X

Notes

[1]Matrix	GW-groundwater, SB-subsurface soil, SS-surface soil, SE-sump sediment
[2]GW	Groundwater sampled in March 1996, March 1997, September 1997, June 1998, and October 1998
[3]MAINRIFS	Additional samples for RI, BRAC and Screening Sites (and initial investigations for TEC sites) collected in September and October 1998
[4]RI	RI Sites sampled in December 1996 and January 1997
[5]SS	Screening Sites sampled in December 1996 and January 1999
BRAC	Base Realignment and Closure

TABLE 20-3

Frequency of Metals Detection in Surface and Subsurface Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALKALINITY, TOTAL (AS CaCO3)	3	3	8.05E+02	=	4.65E+05	=		
SS	ALUMINUM	43	43	6.74E+02	=	2.76E+04	=	2.38E+04	1
SS	ANTIMONY	147	46	3.70E-01	J	2.75E+01	J	7.00E+00	8
SS	ARSENIC	150	147	1.10E+00	J	6.63E+01	=	2.00E+01	27
SS	BARIUM	43	43	6.70E+00	J	3.66E+02	=	2.34E+02	2
SS	BERYLLIUM	150	80	2.00E-02	J	1.60E+00	=	1.10E+00	1
SS	CADMIUM	150	66	1.20E-01	J	4.80E+00	=	1.40E+00	12
SS	CALCIUM	43	41	4.79E+02	J	3.06E+05	=	5.84E+03	19
SS	Chromium, TCLP	4	1	1.49E+01	=	1.49E+01	=		
SS	CHROMIUM, TOTAL	150	150	5.00E+00	J	4.39E+03	=	2.48E+01	73
SS	COBALT	43	43	2.50E-01	J	1.89E+01	=	1.83E+01	1
SS	COPPER	150	150	1.40E+00	J	1.40E+03	=	3.35E+01	36
SS	IRON	43	43	1.36E+03	=	6.61E+04	=	3.70E+04	2
SS	LEAD	150	150	5.00E+00	J	2.80E+03	=	3.00E+01	82
SS	Lead, TCLP	4	1	7.96E-02	J	7.96E-02	J		
SS	MAGNESIUM	43	43	1.22E+02	J	7.06E+03	=	4.60E+03	4
SS	MANGANESE	43	43	3.43E+01	J	2.26E+03	=	1.30E+03	3
SS	MERCURY	150	44	1.00E-02	J	1.10E-01	=	4.00E-01	0
SS	Mercury, TCLP	4	3	1.70E-04	J	2.10E-04	=		
SS	NICKEL	150	150	2.30E+00	J	4.38E+01	=	3.00E+01	32
SS	pH	3	3	6.20E+00	=	8.40E+00	=		
SS	POTASSIUM	43	42	8.87E+01	J	3.14E+03	J	1.82E+03	10
SS	SELENIUM	150	36	2.80E-01	J	1.45E+01	=	8.00E-01	29
SS	SILVER	150	18	4.50E-02	J	6.30E-01	J	2.00E+00	0
SS	SODIUM	43	10	1.04E+02	J	1.08E+03	J		
SS	THALLIUM	150	2	2.80E+00	=	6.50E+00	J		
SS	VANADIUM	43	43	3.40E+00	J	5.09E+01	=	4.84E+01	1
SS	ZINC	150	149	9.50E+00	J	9.92E+03	J	1.26E+02	48
SS	Zinc, TCLP	4	3	1.49E-01	=	3.51E+01	=		
Subsurface Soil									
SB	ALUMINUM	57	57	1.80E+03	J	2.68E+04	=	2.18E+04	1
SB	ANTIMONY	154	9	5.10E-01	J	8.70E+00	=		
SB	ARSENIC	157	157	1.30E+00	=	3.42E+01	=	1.70E+01	42
SB	BARIUM	57	57	6.70E+00	J	4.22E+02	=	3.00E+02	1
SB	BERYLLIUM	157	71	3.30E-01	J	1.80E+00	=	1.20E+00	3
SB	CADMIUM	157	18	3.00E-02	J	1.80E+00	=	1.40E+00	1
SB	CALCIUM	57	56	3.77E+02	J	5.67E+03	=	2.43E+03	2
SB	CHROMIUM, TOTAL	157	157	1.80E+00	J	1.40E+02	=	2.64E+01	57
SB	COBALT	57	57	1.10E+00	J	2.80E+01	=	2.04E+01	2
SB	COPPER	157	157	3.00E+00	J	5.68E+01	=	3.27E+01	39
SB	IRON	57	57	3.45E+03	J	4.08E+04	=	3.85E+04	1
SB	LEAD	157	156	1.80E+00	=	3.84E+01	=	2.39E+01	30
SB	MAGNESIUM	57	57	2.95E+02	J	8.42E+04	=	4.90E+03	2
SB	MANGANESE	57	57	3.91E+01	=	2.96E+03	=	1.54E+03	1
SB	MERCURY	157	3	4.00E-02	J	3.70E-01	=	2.00E-01	2
SB	NICKEL	157	157	3.30E+00	J	6.48E+01	=	3.66E+01	38
SB	POTASSIUM	57	55	2.36E+02	J	3.71E+03	J	1.80E+03	19
SB	SELENIUM	157	8	5.70E-01	J	2.00E+00	=	6.00E-01	7
SB	SILVER	157	9	9.00E-02	J	2.50E-01	J	1.00E+00	0
SB	SODIUM	57	3	1.10E+02	J	4.51E+02	=		
SB	THALLIUM	157	2	3.50E+00	=	4.70E+00	=		
SB	VANADIUM	57	57	5.10E+00	J	6.51E+01	=	5.13E+01	1
SB	ZINC	157	156	9.90E+00	J	2.23E+02	=	1.14E+02	38

Note

All units are mg/kg

TABLE 20-4

Frequency of SVOCs Detection in Surface and Subsurface Soil at FU4

Memphis Depot Main Installation RI

Matrix	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil										
SS	PAH	Total Polynuclear Aromatic Hydrocarbons	129	56	5 00E-02	J	7 94E+01	=		
SS	PAH	CARBAZOLE	99	12	3 50E-02	J	1 80E+00	=	6 70E-02	9
SS	PAH	FLUORENE	129	8	4 00E-02	J	7 70E-01	J		
SS	PAH	INDENO(1,2,3-c,d)PYRENE	129	37	4 20E-02	J	4 10E+00	=	7 00E-01	7
SS	PAH	NAPHTHALENE	129	4	4 50E-02	J	3 80E-01	J		
SS	PAH	PHENANTHRENE	129	47	3 80E-02	J	9 70E+00	=	6 10E-01	11
SS	PAH	PYRENE	129	53	5 00E-02	J	1 20E+01	=	1 50E+00	9
SS	SVOC	BENZYL BUTYL PHTHALATE	99	3	1 10E-01	J	7 00E-01	=	6 45E-01	1
SS	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	99	43	3 80E-02	J	3 00E+00	=		
SS	SVOC	DIETHYL PHTHALATE	99	1	1 80E-01	J	1 80E-01	J		
SS	SVOC	DI-n-BUTYL PHTHALATE	99	12	4 10E-02	J	1 50E-01	J		
SS	SVOC	DI-n-OCTYLPHTHALATE	99	1	1 20E-01	J	1 20E-01	J		
SS	SVOC	PENTACHLOROPHENOL	99	8	4 80E-02	J	3 00E 01	=		
Subsurface Soil										
SB	PAH	Total Polynuclear Aromatic Hydrocarbons	157	6	9 40E-02	J	2 59E+00	=		
SB	PAH	ANTHRACENE	157	2	5 40E-02	J	2 00E-01	J		
SB	PAH	BENZO(a)ANTHRACENE	157	3	4 20E-02	J	1 80E-01	J		
SB	PAH	BENZO(a)PYRENE	157	3	4 90E-02	J	1 60E-01	J		
SB	PAH	BENZO(b)FLUORANTHENE	157	3	5 70E-02	J	2 10E-01	J		
SB	PAH	BENZO(g h i)PERYLENE	157	2	4 40E 02	J	1 40E-01	J		
SB	PAH	BENZO(k)FLUORANTHENE	157	2	3 90E 02	J	1 80E-01	J		
SB	PAH	CARBAZOLE	151	1	7 00E-02	J	7 00E-02	J		
SB	PAH	CHRYSENE	157	3	6 60E-02	J	2 70E-01	J		
SB	PAH	FLUORANTHENE	157	5	5 00E-02	J	5 40E-01	=	4 50E-02	5
SB	PAH	INDENO(1,2 3-c d)PYRENE	157	1	1 40E-01	J	1 40E-01	J		
SB	PAH	PHENANTHRENE	157	4	4 90E-02	J	3 50E-01	J		
SB	PAH	PYRENE	157	5	4 40E-02	J	3 70E-01	J	4 20E-02	5
SB	SVOC	BENZYL BUTYL PHTHALATE	151	3	8 60E-02	J	4 30E-01	=		
SB	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	150	43	4 20E-02	J	1 80E+02	=		
SB	SVOC	DIMETHYL PHTHALATE	151	1	1 80E 01	J	1 80E 01	J		
SB	SVOC	DI n-BUTYL PHTHALATE	151	23	4 10E 02	J	7 40E-01	=		
SB	SVOC	N NITROSODIPHENYLAMINE	151	1	1 40E-01	J	1 40E-01	J		
SB	SVOC	PENTACHLOROPHENOL	154	1	4 70E+02	J	4 70E+02	J		

Notes

PAHs are a subcategory of SVOCs

All units are mg/kg

TABLE 20-5
PAH Detections from Asphalt and Railroad Track Samples
Memphis Depot Main Installation RI

Analyzed PAH Compound	Roadway Asphalt Samples				Railroad Tie Samples			
	Station RD57A		Station RD65A		Station RR57A		Station RR65A	
	Result	Q	Result	Q	Result	Q	Result	Q
1-METHYLNAPHTHALENE	250	U	250	U	760	U	51	U
2-METHYLNAPHTHALENE	250	U	250	U	380	J	51	U
ACENAPHTHENE	250	U	250	U	**880**	=	41	J
ACENAPHTHYLENE	250	U	250	U	760	U	51	U
ANTHRACENE	250	U	250	U	300	J	38	J
BENZO(a)ANTHRACENE	250	U	250	U	760	U	**66**	=
BENZO(a)PYRENE	250	U	250	U	760	U	51	U
BENZO(b)FLUORANTHENE	250	U	250	U	760	U	51	U
BENZO(g,h,i)PERYLENE	250	U	250	U	760	U	51	U
BENZO(k)FLUORANTHENE	250	U	250	U	760	U	51	U
CHRYSENE	250	U	250	U	760	U	**78**	=
DIBENZ(a,h)ANTHRACENE	250	U	250	U	760	U	51	U
FLUORANTHENE	250	U	250	U	**830**	=	**290**	=
FLUORENE	250	U	250	U	740	J	39	J
INDENO(1,2,3-c,d)PYRENE	250	U	250	U	760	U	51	U
NAPHTHALENE	250	U	250	U	**1000**	=	51	U
PHENANTHRENE	250	U	250	U	**2600**	=	**270**	=
PYRENE	250	U	250	U	630	J	**220**	=

Note All units are mg/kg

TABLE 20-6

Frequency of Pesticides Detection in Surface and Subsurface Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALPHA-CHLORDANE	108	22	7 50E-04	J	3 40E+00	=	2 90E-02	6
SS	DDD	108	1	3 30E-02	J	3 30E-02	J	6 70E-03	1
SS	DDE	108	34	1 30E-03	J	3 00E+00	=	1 60E-01	8
SS	DDT	108	48	2 40E-03	J	1 30E+01	=	7 40E-02	13
SS	DIELDRIN	108	44	1 20E-03	J	5 60E+00	J	8 60E-02	20
SS	GAMMA-CHLORDANE	108	22	9 70E-04	J	3 30E+00	=	2 60E-02	8
Subsurface Soil									
SB	ALDRIN	144	1	3 10E-03	=	3 10E-03	=		
SB	ALPHA-CHLORDANE	144	1	2 20E-02	=	2 20E-02	=	2 60E-03	1
SB	DDE	144	5	2 00E-03	J	2 40E-02	=	1 50E-03	5
SB	DDT	144	8	3 30E-03	J	1 90E-02	=	7 20E-03	3
SB	DIELDRIN	144	7	1 40E-03	J	3 90E-02	=	3 70E-01	0
SB	GAMMA-CHLORDANE	144	1	2 40E-02	=	2 40E-02	=	2 20E-03	1

Note
All units are mg/kg

TABLE 20-7

Frequency of Dioxins Detection in Surface and Subsurface Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	1,2,3,4 6,7,8-HEPTACHLORODIBENZOFURAN	27	25	3 00E-06	J	1 20E-02	=		
SS	1,2,3,4,6,7,8-HEPTACHLORODIBENZO-p-DIOXIN	26	23	1 80E-05	J	2 34E-02	=	3 90E-04	18
SS	1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	27	8	9 00E-06	J	1 80E-04	J		
SS	1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	27	11	9 00E-06	J	4 01E-04	J		
SS	1,2,3,4,7,8-HEXACHLORODIBENZO-p-DIOXIN	27	6	6 00E-06	J	1 31E-04	J		
SS	1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	27	9	5 00E-06	J	1 35E-04	J		
SS	1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	27	17	1 20E-05	J	1 32E-03	J		
SS	1,2,3,7,8,9-HEXACHLORODIBENZOFURAN	27	1	1 20E-05	J	1 20E-05	J		
SS	1,2,3,7,8 9-HEXACHLORODIBENZO-P-DIOXIN	27	9	6 00E-06	J	2 92E-04	J		
SS	1,2,3 7,8-PENTACHLORODIBENZOFURAN	27	1	1 20E-05	J	1 20E-05	J		
SS	1,2,3,7,8-PENTACHLORODIBENZO-p-DIOXIN	27	2	1 20E-05	J	5 50E-05	J		
SS	2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	27	8	8 00E-06	J	4 14E-04	J		
SS	2 3 4 7,8-PENTACHLORODIBENZOFURAN	27	1	1 40E-05	J	1 40E-05	J		
SS	DIBENZOFURAN	99	4	5 00E-02	J	4 40E-01	J	6 47E-01	0
SS	OCTACHLORODIBENZOFURAN	27	25	3 00E-06	J	3 97E-02	=	3 93E-04	18
SS	OCTACHLORODIBENZO-p-DIOXIN	24	24	2 39E-04	J	7 21E-02	=	9 72E-03	10
SS	**TCDD Equivalent**	**27**	**27**	**1 04E-06**	**=**	**4 66E-04**	**=**	**1 00E-05**	**19**
Subsurface Soil									
SB	1,2,3 4,6,7,8-HEPTACHLORODIBENZOFURAN	35	17	2 00E-06	J	1 05E-01	J		
SB	1,2,3,4,6,7,8-HEPTACHLORODIBENZO-p-DIOXIN	35	15	6 00E-06	J	4 88E-01	J		
SB	1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	35	5	1 20E-05	J	6 64E-03	=		
SB	1,2 3 4,7 8-HEXACHLORODIBENZOFURAN	35	5	1 00E-05	J	1 70E-03	J		
SB	1,2,3,4,7,8-HEXACHLORODIBENZO-p-DIOXIN	35	2	6 00E-06	J	3 90E-05	J		
SB	1 2 3 6 7 8-HEXACHLORODIBENZOFURAN	35	6	2 00E-06	J	5 04E-04	J		
SB	1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	35	7	4 00E-06	J	6 61E-03	=		
SB	1 2,3,7 8,9-HEXACHLORODIBENZOFURAN	35	4	1 20E-05	J	1 33E-04	J		
SB	1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	35	7	3 00E-06	J	4 96E-04	J		
SB	1 2 3 7,8 PENTACHLORODIBENZOFURAN	35	2	9 00E-06	J	1 90E-05	J		
SB	1,2 3 7 8-PENTACHLORODIBENZO-p-DIOXIN	35	1	7 00E-06	J	7 00E-06	J		
SB	2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	35	22	2 00E-06	J	3 44E-04	J		
SB	2,3,4,7,8-PENTACHLORODIBENZOFURAN	35	2	6 00E-06	J	3 80E-05	J		
SB	2,3,7,8-TETRACHLORODIBENZOFURAN	35	1	8 00E-06	J	8 00E-06	J		
SB	2,3,7,8-TETRACHLORODIBENZO-p-DIOXIN	35	1	1 70E-05	J	1 70E-05	J	6 00E-06	1
SB	OCTACHLORODIBENZOFURAN	35	18	2 00E-06	J	2 31E+00	J		
SB	OCTACHLORODIBENZO-p-DIOXIN	35	31	1 40E-05	J	3 25E+00	J	9 44E-03	3
SB	**TCDD Equivalent**	**35**	**32**	**4 50E-08**	**=**	**1 25E-02**	**=**	**6 00E-06**	**9**

Note

All units are mg/kg

TABLE 20-8
Frequency of VOC and Other Organics Detection in Surface and Subsurface Soil at FU4
Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	1,1,2,2-TETRACHLOROETHANE	105	3	4 00E-03	J	7 00E-03	J		
SS	2-HEXANONE	105	2	1 00E-03	J	1 00E-03	J		
SS	ACETONE	105	33	2 00E-03	J	3 10E-01	=		
SS	BENZENE	105	1	2 00E-03	J	2 00E-03	J		
SS	BROMOMETHANE	105	2	1 00E-03	J	3 00E-03	J		
SS	CARBON DISULFIDE	105	2	1 00E-03	J	1 00E-03	J	2 00E-03	0
SS	CHLOROMETHANE	105	1	1 00E-03	J	1 00E-03	J		
SS	ETHYLBENZENE	105	1	8 00E-03	J	8 00E-03	J		
SS	METHYL ETHYL KETONE (2-BUTANONE)	105	8	6 00E-03	J	4 40E-02	=	2 00E-03	8
SS	METHYLENE CHLORIDE	105	21	1 00E-03	J	1 00E-02	J		
SS	PETROLEUM HYDROCARBONS	3	2	1 30E+03	=	1 57E+03	=		
SS	TETRACHLOROETHYLENE(PCE)	105	1	8 00E-03	J	8 00E-03	J		
SS	TOLUENE	105	4	2 00E-03	J	1 70E-02	=	2 00E-03	2
SS	Total Xylenes	105	4	1 00E-03	J	2 00E-03	J	9 00E-03	0
SS	TRICHLOROETHYLENE (TCE)	105	1	5 00E-03	J	5 00E-03	J		
Subsurface Soil									
SB	1,1,2,2-TETRACHLOROETHANE	157	5	5 00E-03	J	2 00E-02	=		
SB	1,1-DICHLOROETHENE	157	1	9 00E-03	J	9 00E-03	J		
SB	ACETONE	157	55	3 00E-03	J	1 60E-01	=		
SB	BENZENE	157	1	1 00E-03	J	1 00E-03	J		
SB	BROMOMETHANE	157	2	1 00E-03	J	2 00E-03	J		
SB	CHLOROMETHANE	157	2	1 00E-03	J	2 00E-03	J		
SB	METHYL ETHYL KETONE (2-BUTANONE)	157	11	1 00E-03	J	2 40E-02	=		
SB	METHYLENE CHLORIDE	157	25	1 00E-03	J	8 00E-03	J		
SB	PETROLEUM HYDROCARBONS	5	2	1 85E+01	=	1 98E+01	=		
SB	TETRACHLOROETHYLENE(PCE)	157	2	4 00E-03	J	6 00E-03	J		
SB	TOLUENE	157	1	2 00E-03	J	2 00E-03	J		
SB	TOTAL 1,2-DICHLOROETHENE	157	4	6 00E-03	J	1 10E-01	=		
SB	Total Xylenes	157	1	2 00E-03	J	2 00E-03	J	2 00E-03	0
SB	TRICHLOROETHYLENE (TCE)	157	10	1 00E-03	J	3 20E-01	=		

Note
All units are mg/kg

TABLE 20-9

Frequency of Metals Detection in Surface Water and Sediment Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Water									
SW	ALUMINUM	5	5	2 28E-01	=	1 70E+00	=	5 08E+00	0
SW	Aluminum Dissolved	5	1	3 20E-01	=	3 20E-01	=	4 71E-01	0
SW	ARSENIC	8	5	4 60E-03	J	1 25E-02	=	1 80E-02	0
SW	Arsenic, Dissolved	8	5	4 20E-03	J	8 92E-02	=	1 20E-02	2
SW	BARIUM	5	5	2 03E-02	J	3 39E-02	J	1 25E-01	0
SW	Barium Dissolved	5	5	1 89E-02	J	2 88E-02	J	8 76E-01	0
SW	CALCIUM	5	5	6 19E+00	=	3 03E+01	=	3 18E+01	0
SW	Calcium Dissolved	5	5	7 28E+00	=	2 44E+01	=	3 02E+01	0
SW	Chromium Dissolved	8	2	2 20E-03	J	4 00E-03	J	3 34E-02	0
SW	CHROMIUM, TOTAL	8	4	2 90E-03	J	8 20E-03	J	3 61E-02	0
SW	COPPER	8	1	5 93E-02	=	5 93E-02	=	7 46E-02	0
SW	Copper, Dissolved	8	1	2 97E-02	=	2 97E-02	=		
SW	IRON	5	5	3 12E-01	=	2 52E+00	=	6 10E+00	0
SW	Iron Dissolved	5	5	7 19E-02	J	4 45E-01	J	1 20E-01	3
SW	LEAD	8	7	2 60E-03	J	3 87E-02	=	1 86E-02	1
SW	Lead, Dissolved	8	2	2 80E-03	J	7 10E-03	=	2 26E-02	0
SW	MAGNESIUM	5	5	1 46E+00	J	2 41E+00	J	7 70E+00	0
SW	Magnesium Dissolved	5	5	1 63E+00	J	2 20E+00	J	6 86E+00	0
SW	MANGANESE	5	5	1 08E-02	J	4 92E-02	=	6 56E-01	0
SW	Manganese, Dissolved	5	5	3 10E-03	J	1 02E-02	J	3 52E-01	0
SW	NICKEL	8	6	6 00E-03	J	1 21E-02	J	2 28E-01	0
SW	POTASSIUM	5	5	1 53E+00	J	3 02E+00	J	7 28E+00	0
SW	Potassium, Dissolved	5	5	1 53E+00	J	2 80E+00	J	6 72E+00	0
SW	Selenium, Dissolved	8	1	1 01E-02	=	1 01E-02	=	3 00E-03	1
SW	Silver Dissolved	8	1	2 30E-03	J	2 30E-03	J		
SW	SODIUM	5	5	5 84E-01	J	2 07E+00	J	2 14E+01	0
SW	Sodium Dissolved	5	5	5 70E-01	J	2 11E+00	J	2 16E+01	0
SW	VANADIUM	5	2	3 20E-03	J	4 00E-03	J	3 90E-02	0
SW	Vanadium Dissolved	5	2	1 80E-03	J	9 30E-03	J		
SW	ZINC	8	8	2 51E-02	J	7 02E-02	J	2 87E-01	0
SW	Zinc Dissolved	8	3	1 88E-02	J	6 40E-02	=	4 10E-01	0
Sediment Soil									
SE	ALUMINUM	8	8	2 03E+02	=	3 45E+03	=	1 01E+04	0
SE	ANTIMONY	11	2	1 30E+00	J	1 40E+00	J	7 60E+00	0
SE	ARSENIC	11	10	2 60E-01	J	1 01E+01	=	1 20E+01	0
SE	BARIUM	8	8	5 80E+00	J	7 86E+01	=	1 18E+02	0
SE	BERYLLIUM	11	7	4 00E-02	J	3 50E-01	J	1 30E+00	0
SE	CADMIUM	11	4	1 30E+00	=	3 00E+00	=	2 89E+01	0
SE	CALCIUM	8	8	2 48E+04	=	2 43E+05	=	1 49E+04	8
SE	CHROMIUM, TOTAL	11	11	3 70E+00	=	6 85E+01	J	2 00E+01	5
SE	COBALT	8	8	1 50E+00	J	1 08E+01	J	1 36E+01	0
SE	COPPER	11	11	2 90E+00	J	5 65E+01	=	5 80E+01	0
SE	IRON	8	8	2 96E+03	=	1 22E+04	=	2 31E+04	0
SE	LEAD	11	11	1 80E+00	=	4 84E+02	=	3 52E+01	4
SE	MAGNESIUM	8	8	1 62E+03	=	7 78E+03	=	2 44E+03	3
SE	MANGANESE	8	8	3 73E+01	J	3 41E+02	J	8 71E+02	0
SE	MERCURY	11	2	1 00E-01	=	1 20E-01	=	4 00E+00	0
SE	NICKEL	11	10	3 00E+00	J	1 91E+01	=	3 05E+01	0
SE	POTASSIUM	8	8	7 60E+01	J	4 19E+02	J	1 56E+03	0
SE	SELENIUM	11	2	8 70E-01	J	1 10E+00	J	1 70E+00	0
SE	SODIUM	8	6	6 33E+01	J	1 58E+02	J	2 40E+02	0
SE	VANADIUM	8	8	2 10E+00	J	1 75E+01	=	3 00E+01	0
SE	ZINC	11	11	1 62E+01	J	2 88E+02	=	7 97E+02	0

Notes

All units are mg/kg or mg/L (surface water)

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TABLE 20-10

Frequency of SVOCs Detection in Surface Water and Sediment Soil at FU4

Memphis Depot Main Installation RI

Matrix	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Water										
WS	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	8	1	1 90E-02	=	1 90E-02	=		
WS	SVOC	PENTACHLOROPHENOL	8	3	6 00E-03	=	1 30E-02	=		
Sediment Soil										
SE	PAH	2-METHYLNAPHTHALENE	11	3	2 60E-02	J	1 00E+01	J		
SE	PAH	ACENAPHTHENE	11	1	6 10E-02	J	6 10E-02	J	7 70E-01	0
SE	PAH	ACENAPHTHYLENE	11	1	3 80E-02	J	3 80E-02	J		
SE	PAH	ANTHRACENE	11	5	9 40E-02	J	6 90E+00	J	1 60E+00	2
SE	PAH	BENZO(a)ANTHRACENE	11	10	6 00E-02	J	2 00E+01	J	2 90E+00	2
SE	PAH	BENZO(a)PYRENE	11	10	8 50E-02	J	1 90E+01	J	2 50E+00	2
SE	PAH	BENZO(b)FLUORANTHENE	11	10	1 80E-01	J	2 60E+01	J	2 22E+00	2
SE	PAH	BENZO(g,h,i)PERYLENE	11	8	9 50E-02	J	9 50E+00	J	1 80E+00	1
SE	PAH	BENZO(k)FLUORANTHENE	11	10	1 20E-01	J	2 50E+01	J	2 30E+00	2
SE	PAH	CARBAZOLE	11	5	1 00E-01	J	2 40E+00	J	1 10E+00	2
SE	PAH	CHRYSENE	11	10	1 60E-01	J	3 00E+01	J	3 20E+00	2
SE	PAH	DIBENZ(a,h)ANTHRACENE	11	1	9 00E-02	J	9 00E-02	J	7 00E-01	0
SE	PAH	FLUORANTHENE	11	10	1 60E-01	J	3 20E+01	J	7 10E+00	2
SE	PAH	FLUORENE	11	3	6 60E-02	J	7 20E+00	J	8 70E-01	2
SE	PAH	INDENO(1,2,3-c,d)PYRENE	11	8	1 00E-01	J	9 10E+00	J	1 70E+00	1
SE	PAH	PHENANTHRENE	11	10	2 00E-02	J	3 30E+01	J	6 90E+00	2
SE	PAH	PYRENE	11	10	1 30E-01	J	5 50E+01	J	2 88E+00	2
SE	PAH	Total Polynuclear Aromatic Hydrocarbons	11	11	4 60E-02	J	2 62E+02	J		
SE	SVOC	4-METHYLPHENOL (p-CRESOL)	11	1	1 70E-01	J	1 70E-01	J		
SE	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	11	2	7 40E-02	J	1 50E+00	J	4 80E-01	1
SE	SVOC	DIETHYL PHTHALATE	11	1	7 70E+00	J	7 70E+00	J		
SE	SVOC	DI-n-BUTYL PHTHALATE	11	1	3 40E-02	J	3 40E-02	J		
SE	SVOC	PENTACHLOROPHENOL	11	2	8 00E-02	J	2 60E-01	=		

Note

All units are mg/kg or mg/L (surface water)

TABLE 20-11

Frequency of Pesticide Detection in Surface Water and Sediment Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Water									
SW	DDT	8	4	6 60E-05	J	2 20E-04	=		
SW	DIELDRIN	8	5	3 40E-05	J	2 40E-04	=		
Sediment Soil									
SE	ALPHA ENDOSULFAN	11	1	3 20E-02	J	3 20E-02	J		
SE	ALPHA-CHLORDANE	11	5	3 20E-03	J	5 30E-01	J	5 20E-03	4
SE	DDD	11	7	3 00E-02	=	9 90E-01	J	6 10E-03	7
SE	DDE	11	7	1 50E-02	J	2 50E-01	J	7 20E-03	7
SE	DDT	11	10	2 20E-02	=	2 70E-01	J		
SE	DIELDRIN	11	8	3 80E-02	J	3 10E-01	J	1 10E-02	8
SE	ENDRIN	11	2	4 50E-02	J	4 80E-02	J		
SE	ENDRIN ALDEHYDE	11	2	2 90E-02	J	4 30E-02	J		
SE	GAMMA-CHLORDANE	11	5	3 80E-03	J	6 50E-01	J	2 00E+00	0

Note

All units are mg/kg or mg/L (surface water)

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TABLE 20-12

Frequency of Dioxins Detection in Surface Water and Sediment Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Water									
SW	1 2 3 4 6 7 8-HEPTACHLORODIBENZOFURAN	8	4	7 10E-08	J	7 07E-07	J		
SW	1 2,3,7 8 9-HEXACHLORODIBENZOFURAN	8	4	6 00E-08	J	2 60E-07	J		
SW	2 3 4,6 7 8-HEXACHLORODIBENZOFURAN	8	5	1 53E-06	J	5 07E-06	J		
SW	OCTACHLORODIBENZOFURAN	8	6	8 10E-08	J	1 30E-06	J		
SW	OCTACHLORODIBENZO-p-DIOXIN	8	8	1 63E-07	J	2 71E-05	J	1 23E-06	6
SW	TCDD Equivalent	8	8	1 63E-10	=	Z 8449E-08	=	1 80E-08	5
Sediment Soil									
SE	1,2,3 4 6 7,8-HEPTACHLORODIBENZOFURAN	11	10	6 90E-06	J	6 99E-03	=		
SE	1 2 3 4 6 7 8-HEPTACHLORODIBENZO-p-DIOXIN	11	8	1 80E-04	J	2 38E-02	=	5 83E-04	6
SE	1 2 3 4 7 8 9-HEPTACHLORODIBENZOFURAN	11	3	2 10E-05	J	1 10E-04	J		
SE	1 2 3 4 7 8-HEXACHLORODIBENZOFURAN	11	4	1 00E-05	J	7 40E-05	J		
SE	1 2,3 4,7 8-HEXACHLORODIBENZO-p-DIOXIN	11	3	8 00E-06	J	1 40E-05	J		
SE	1 2 3 6 7 8 HEXACHLORODIBENZOFURAN	11	5	4 00E-06	J	7 90E-05	J		
SE	1 2 3 6 7 8 HEXACHLORODIBENZO-P-DIOXIN	11	5	7 00E-06	J	2 60E-04	J		
SE	1 2 3 7 8 9-HEXACHLORODIBENZO-P-DIOXIN	11	4	1 50E-05	J	1 50E-04	J		
SE	2 3 4 6 7 8-HEXACHLORODIBENZOFURAN	11	1	2 20E-05	J	2 20E-05	J		
SE	OCTACHLORODIBENZOFURAN	11	10	2 43E-05	J	1 49E-02	J		
SE	OCTACHLORODIBENZO-p-DIOXIN	11	11	2 07E-04	J	1 14E-01	J	8 56E-03	7
SE	TCDD Equivalent	11	11	3 00E-07	=	4 94E-04	=	9 00E-06	9

Note

All units are mg/kg or mg/L (surface water)

Table 20-13

Frequency of VOC and Other Organics Detection in Sediment Soil at FU4

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Sediment Soil									
SE	ACETONE	11	1	2 50E-02	J	2 50E-02	J		
SE	CARBON TETRACHLORIDE	11	1	7 80E-02	=	7 80E-02	=		
SE	METHYL ETHYL KETONE (2-BUTANONE)	11	1	1 40E-02	J	1 40E-02	J	1 00E-02	1
SE	METHYLENE CHLORIDE	11	2	3 20E-02	=	4 50E-02	=		
SE	Total Xylenes	11	2	1 80E-02	J	3 60E-02	J		

Note

All units are mg/kg

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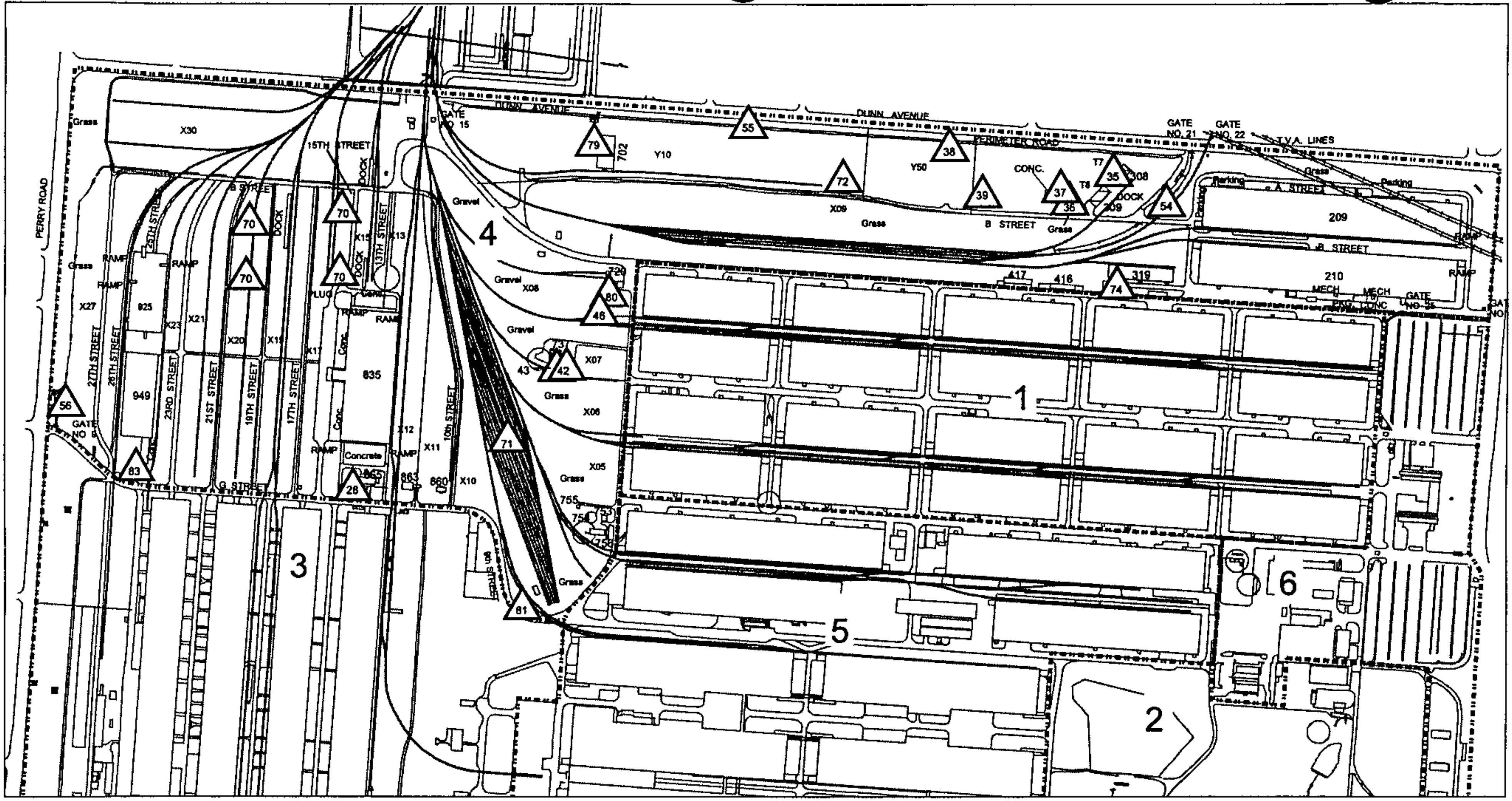

FIGURE 20-1
FU4 LAND COVER AND SITE LOCATIONS
MEMPHIS DEPOT MAIN INSTALLATION RI

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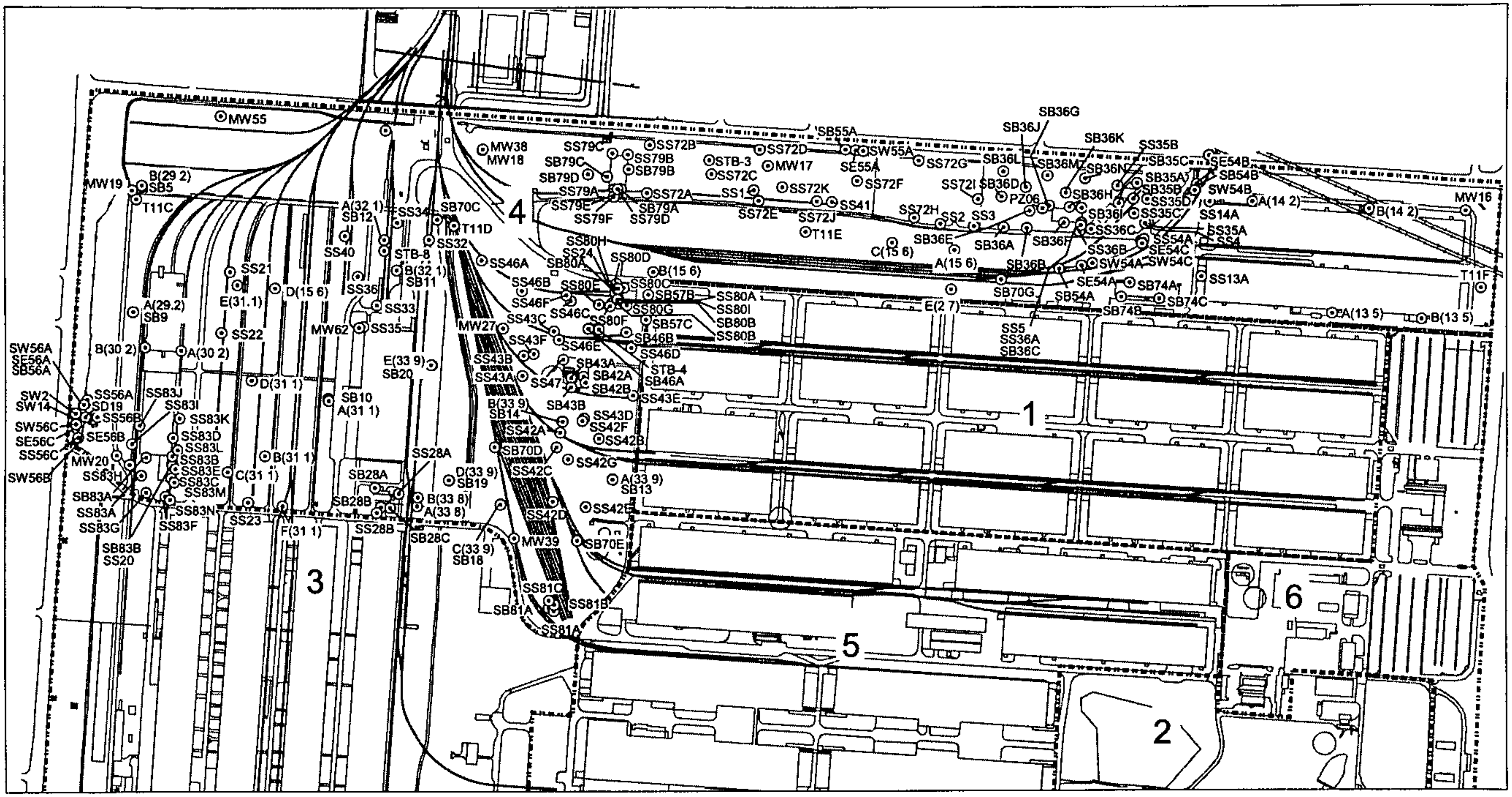

FIGURE 20-2
SAMPLE LOCATIONS IN FU4
MEMPHIS DEPOT MAIN INSTALLATION RI

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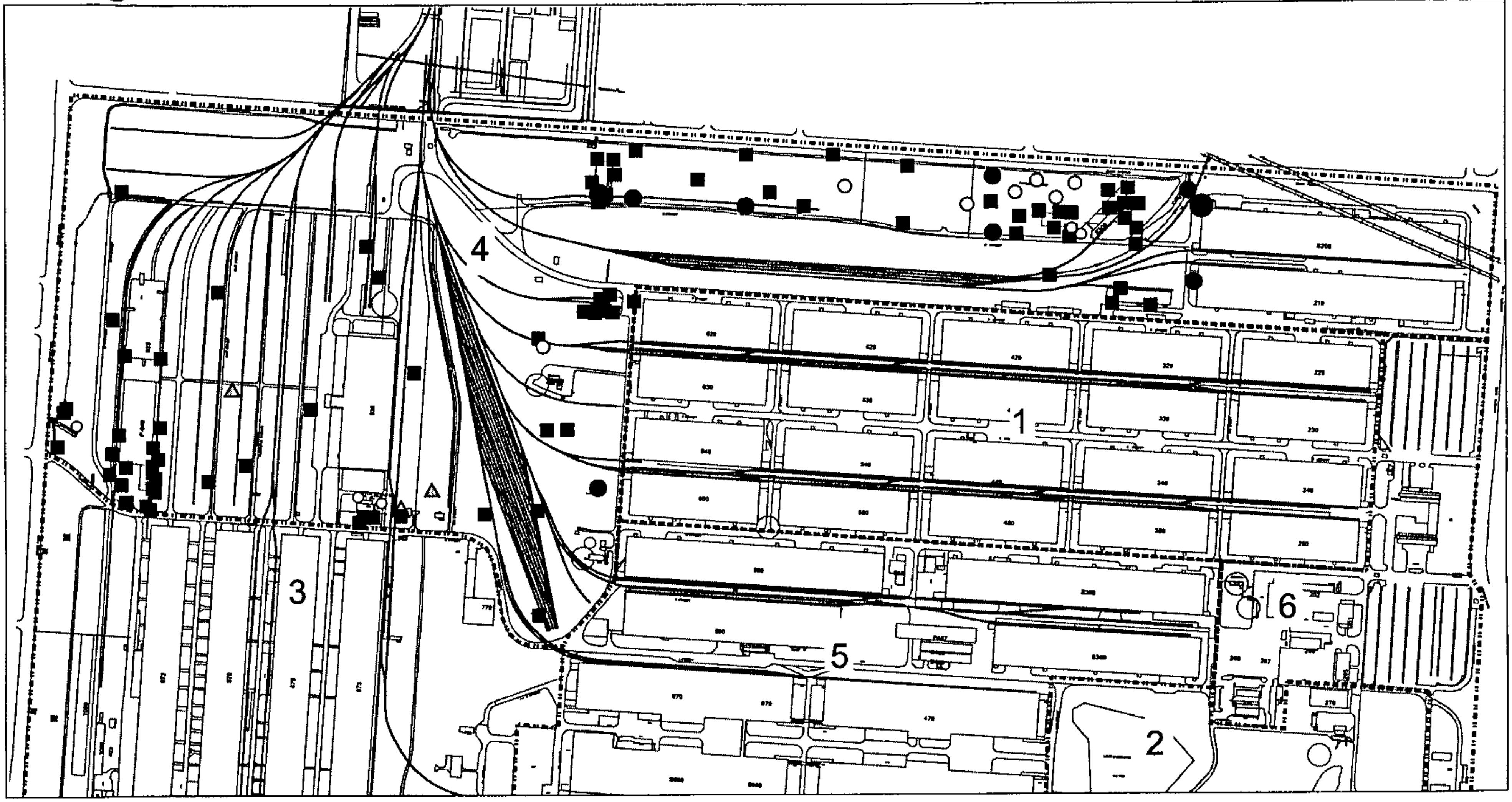

FIGURE 20-3
ARSENIC CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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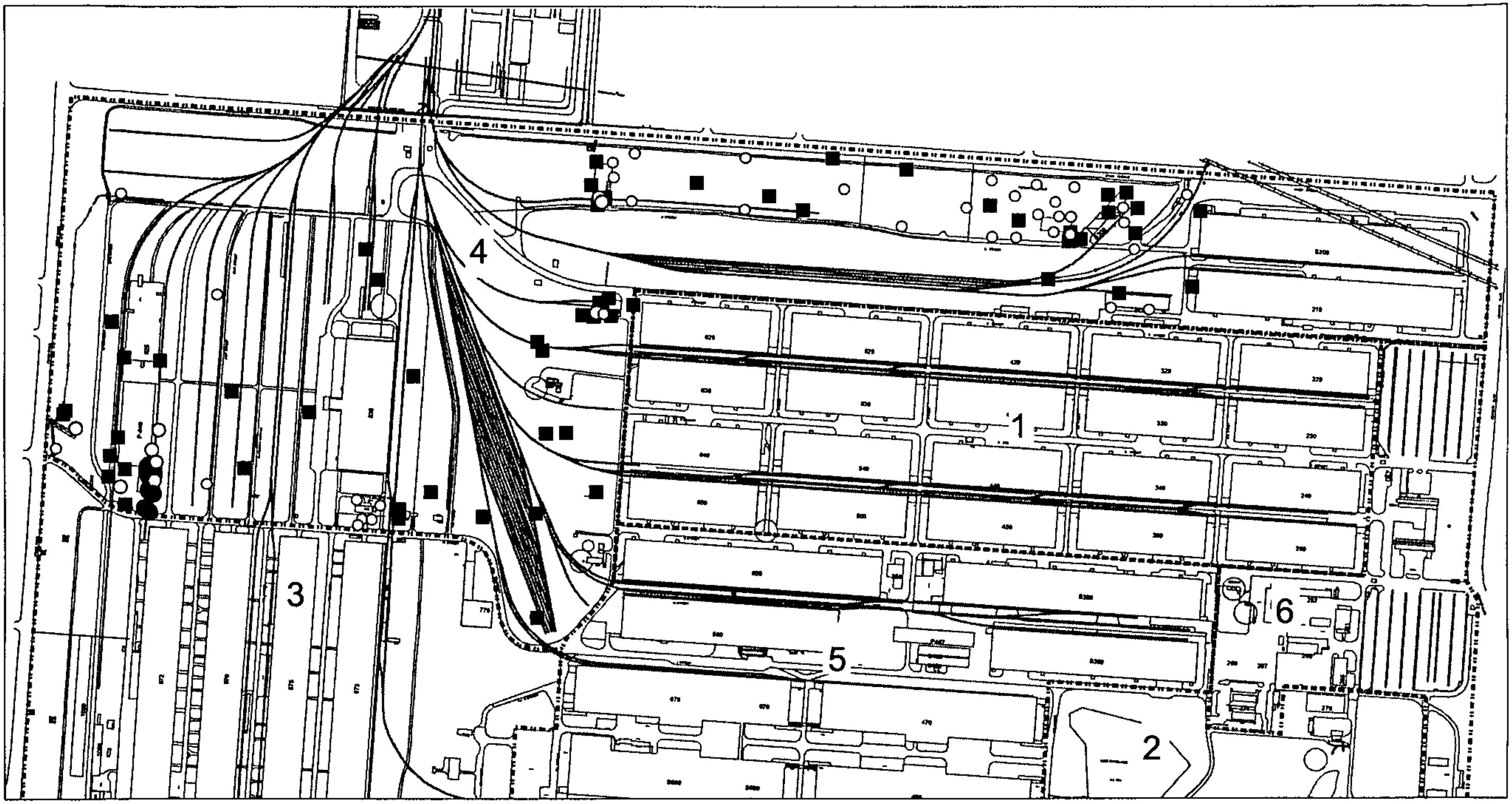

FIGURE 20-4
TOTAL CHROMIUM CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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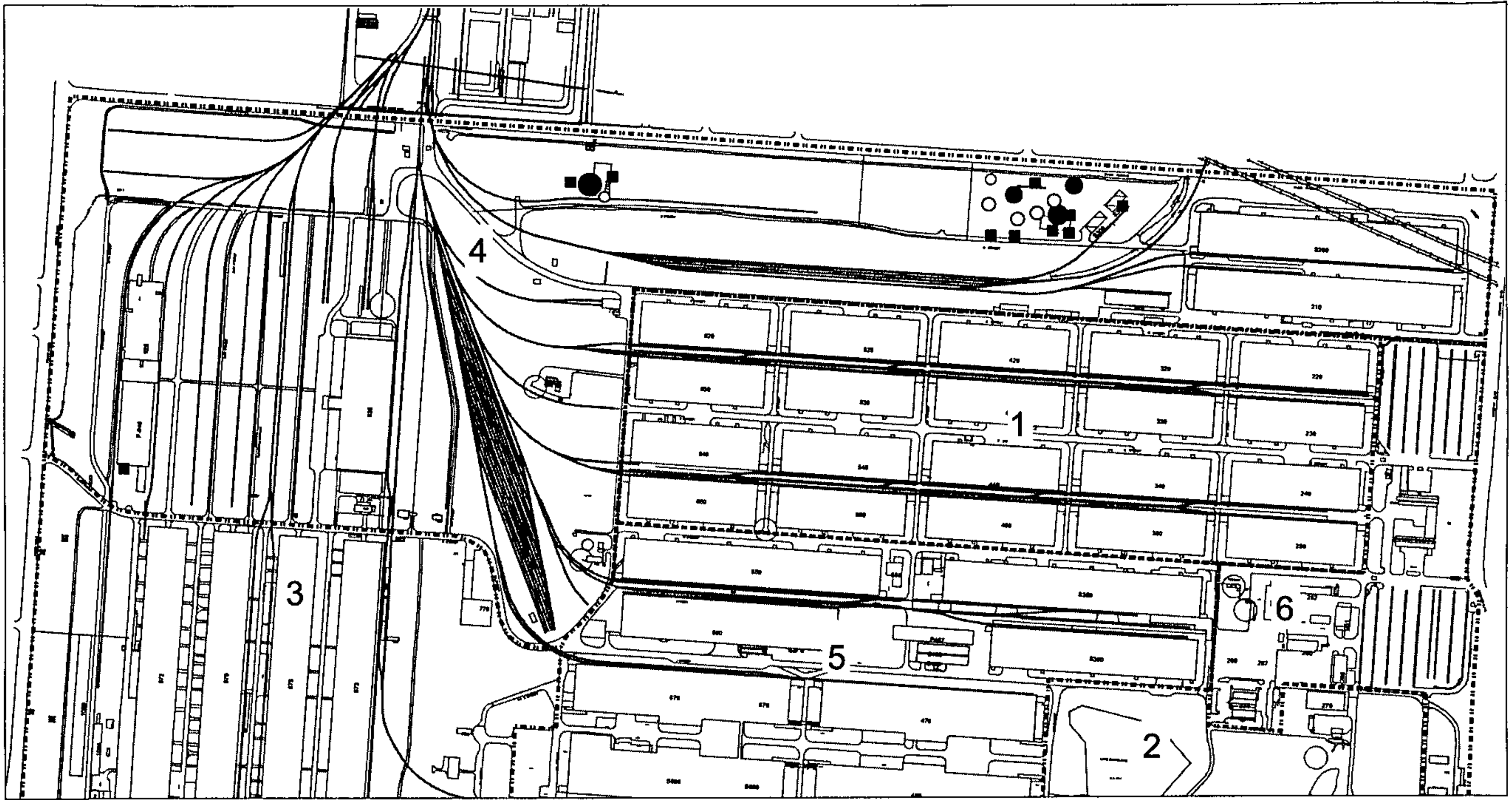

Total Chromium Concentrations In Depths 4 - 6 Feet

- ○ 27 1 - 27 4 MG\KG
- ○ 27 4 - 28 9 MG\KG
- ● 28 9 - 30 5 MG\KG
- 30 5 - 31 8 MG\KG
- 31 8 - 39 1 MG\KG

- ■ Concentrations Detected\Below Background (<26 4 MG\KG)
- Text Building Numbers
- Functional Unit Boundary
- Base Features
- ☐ Buildings

N

0 400 800 Feet

SCALE IS APPROXIMATE

FIGURE 20-5
TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-6 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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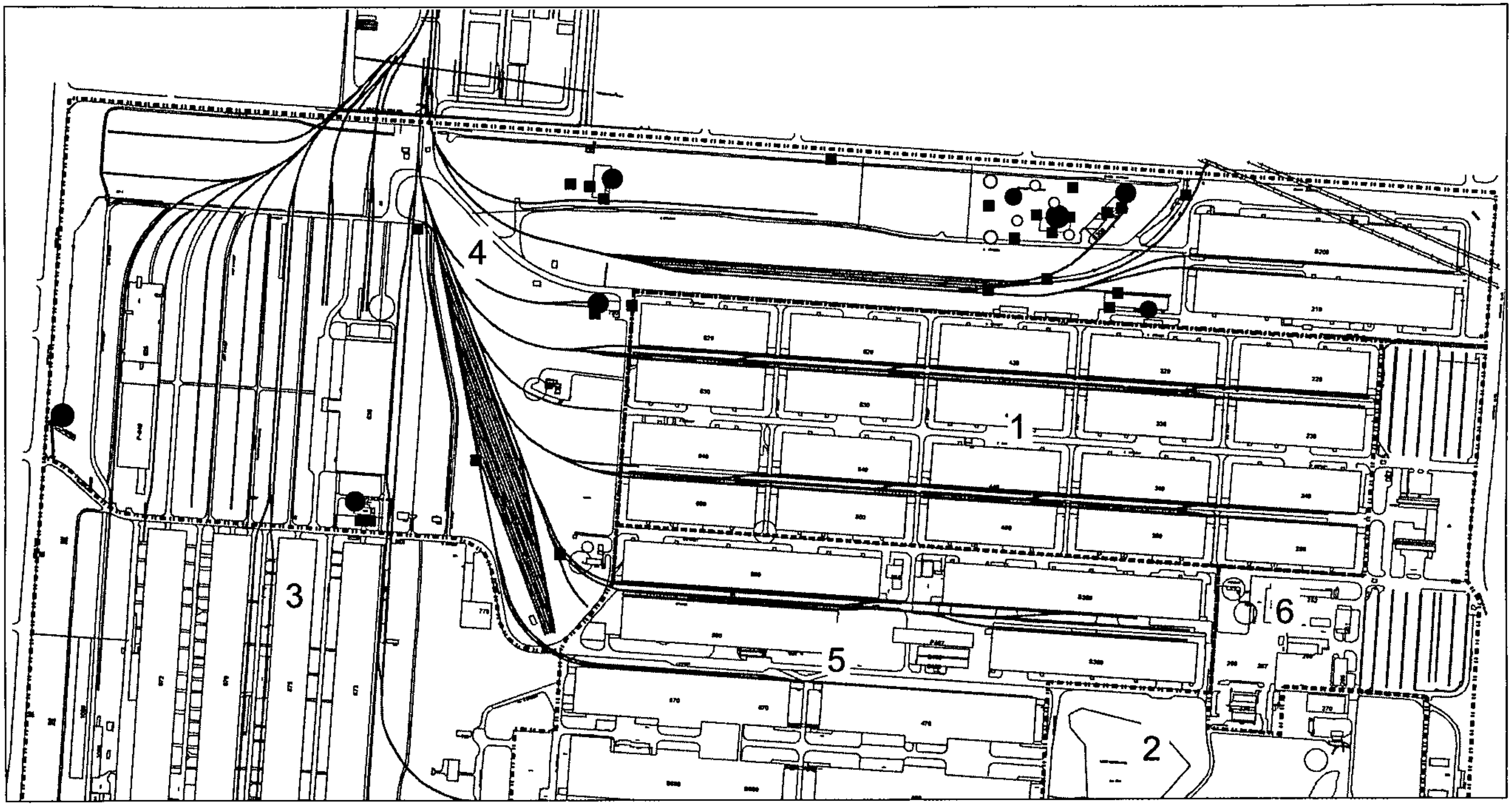

FIGURE 20-6
TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 8-10 FEET
MEMPHIS DEPOT MAIN INSTALLATION RI

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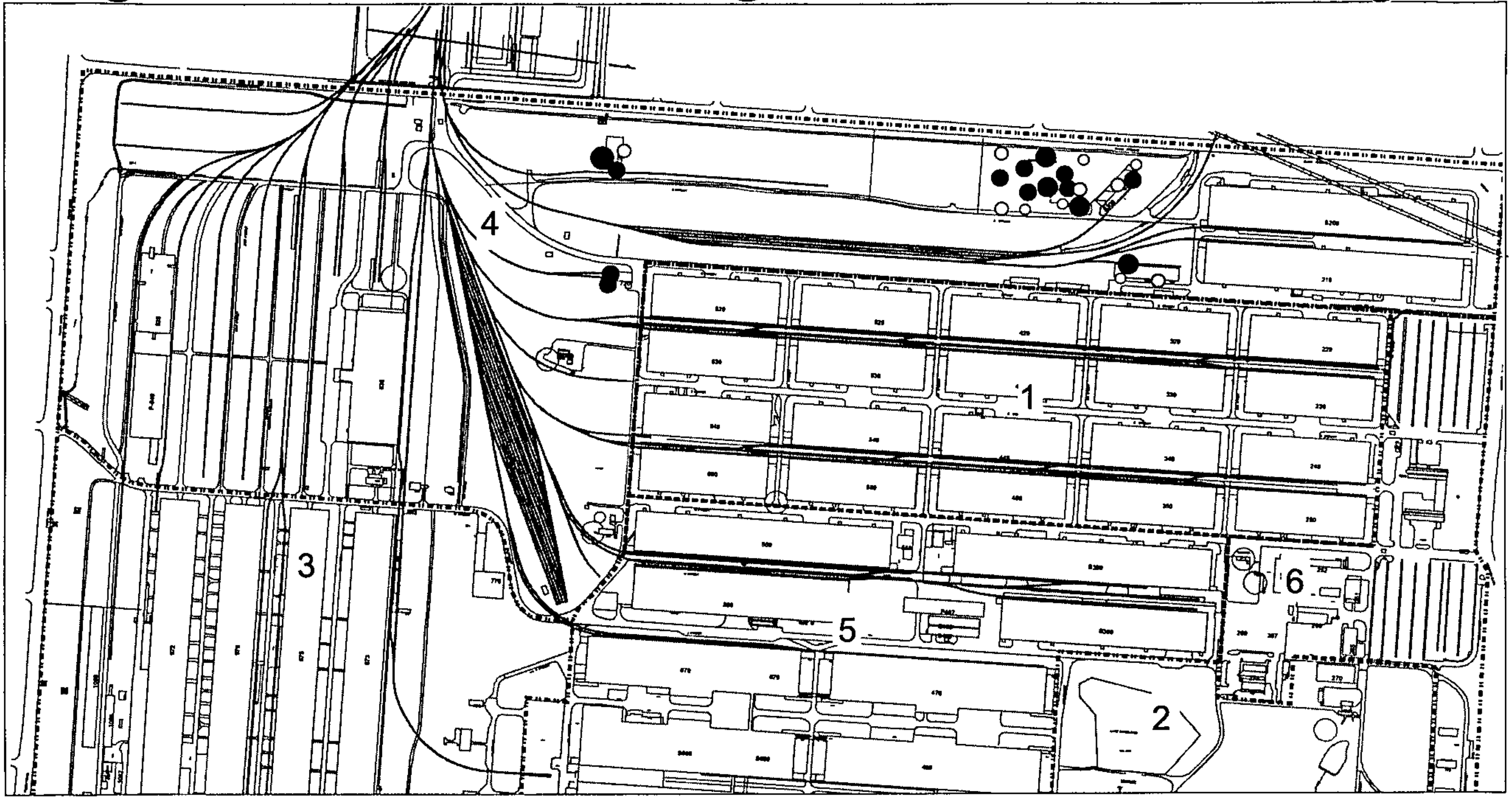

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FIGURE 20-7
TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 18-20 FEET
MEMPHIS DEPOT MAIN INSTALLATION RI

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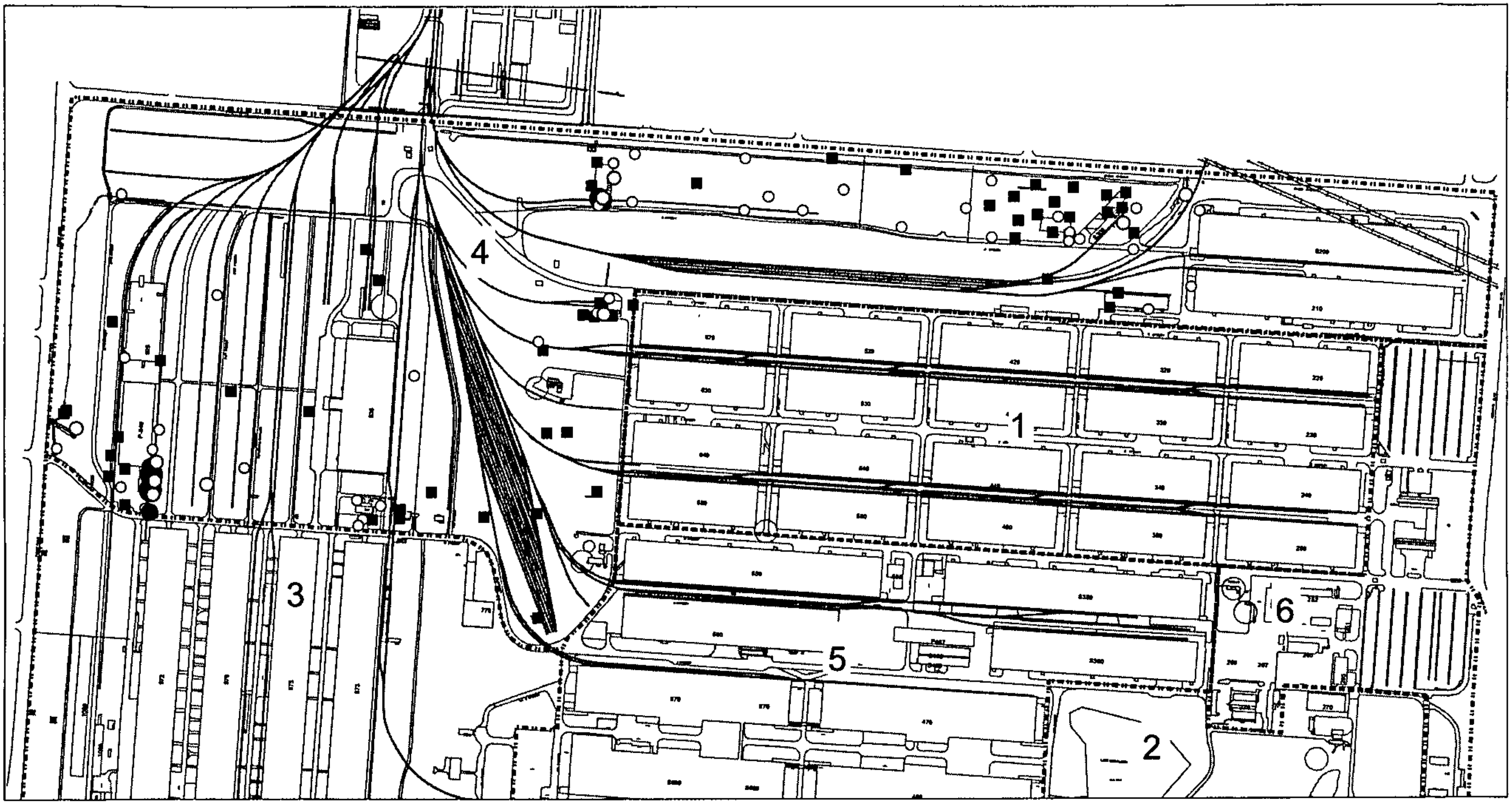

FIGURE 20-8
LEAD CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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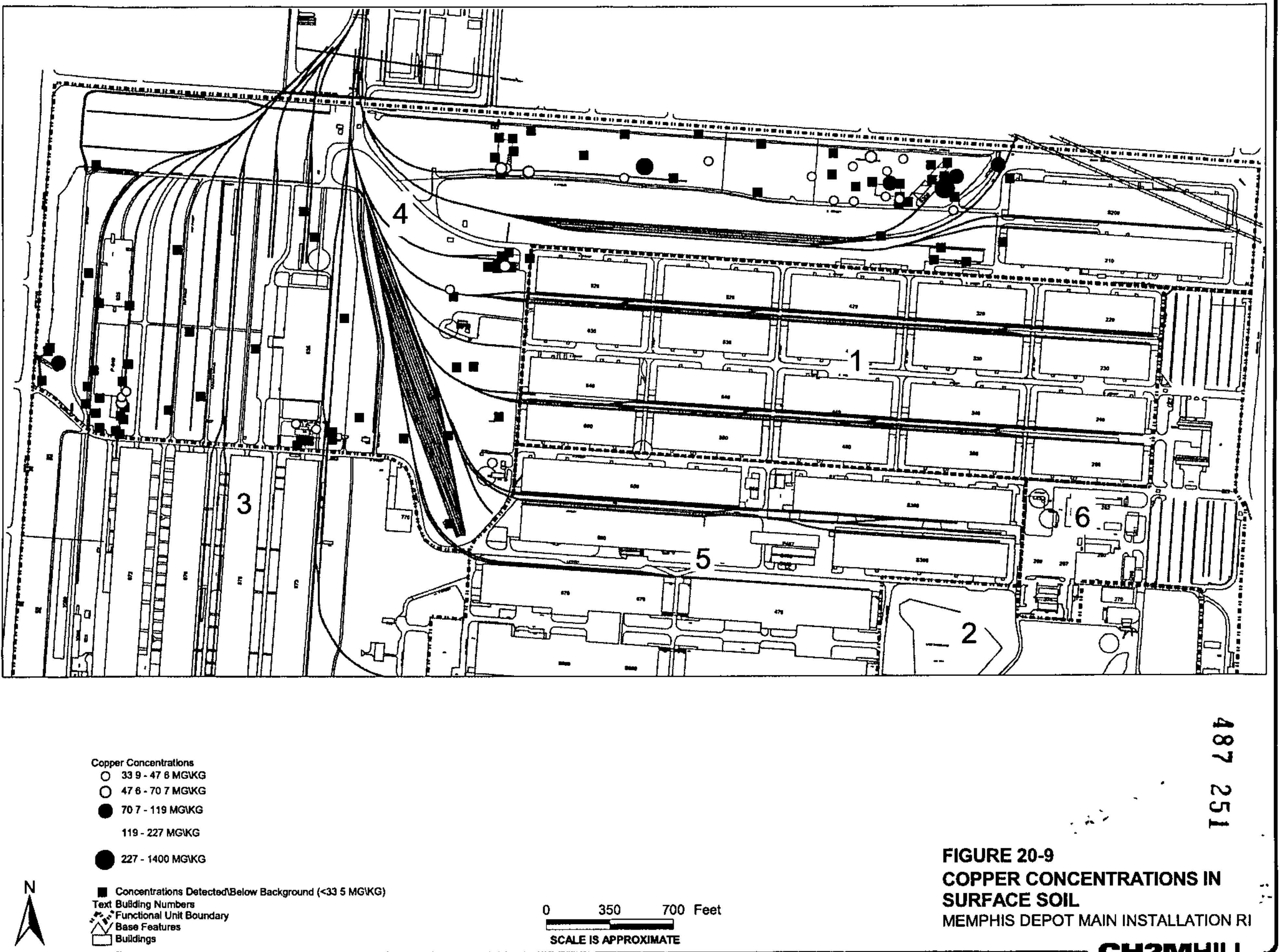

FIGURE 20-9
COPPER CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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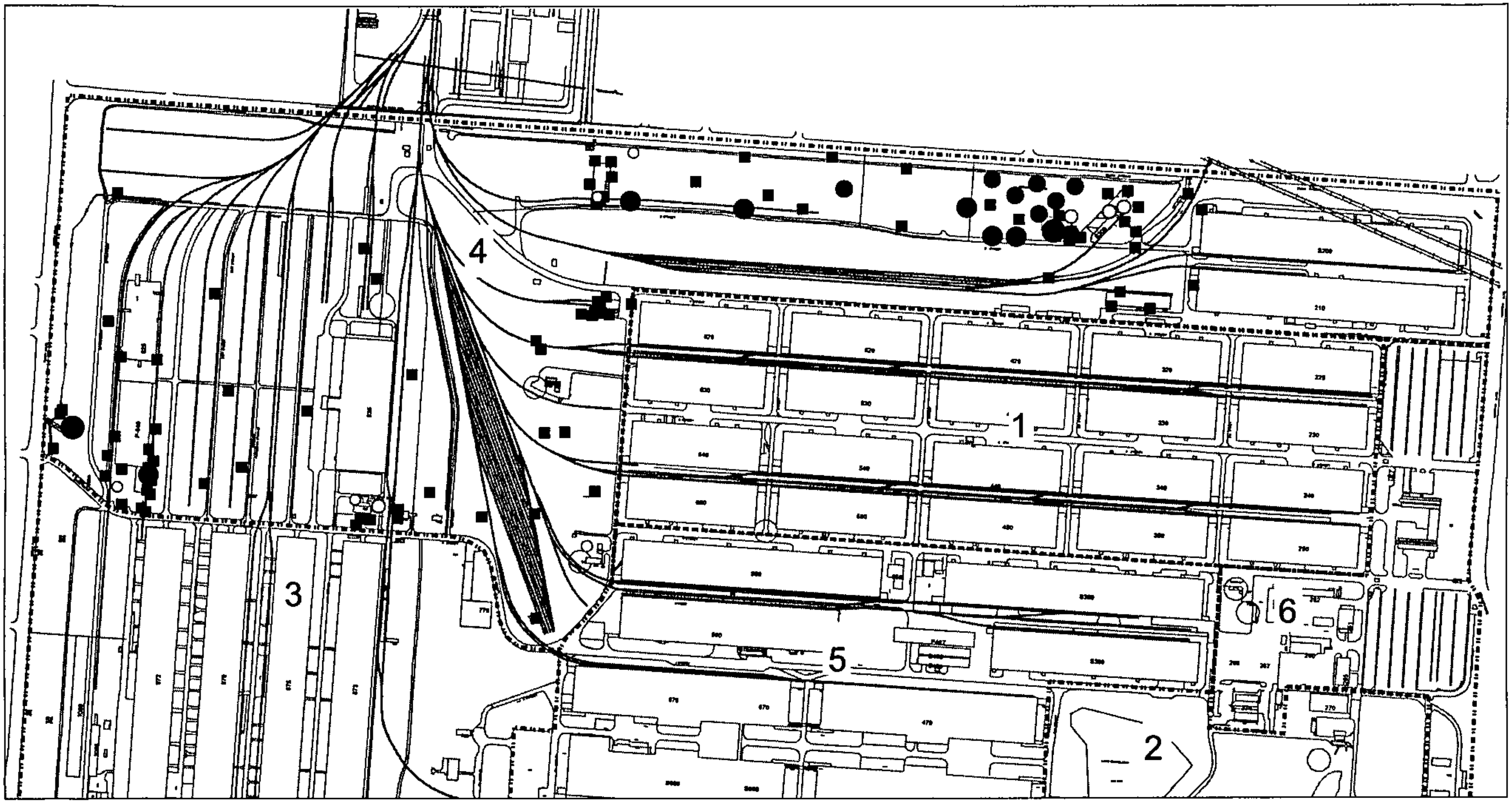

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FIGURE 20-10
NICKEL CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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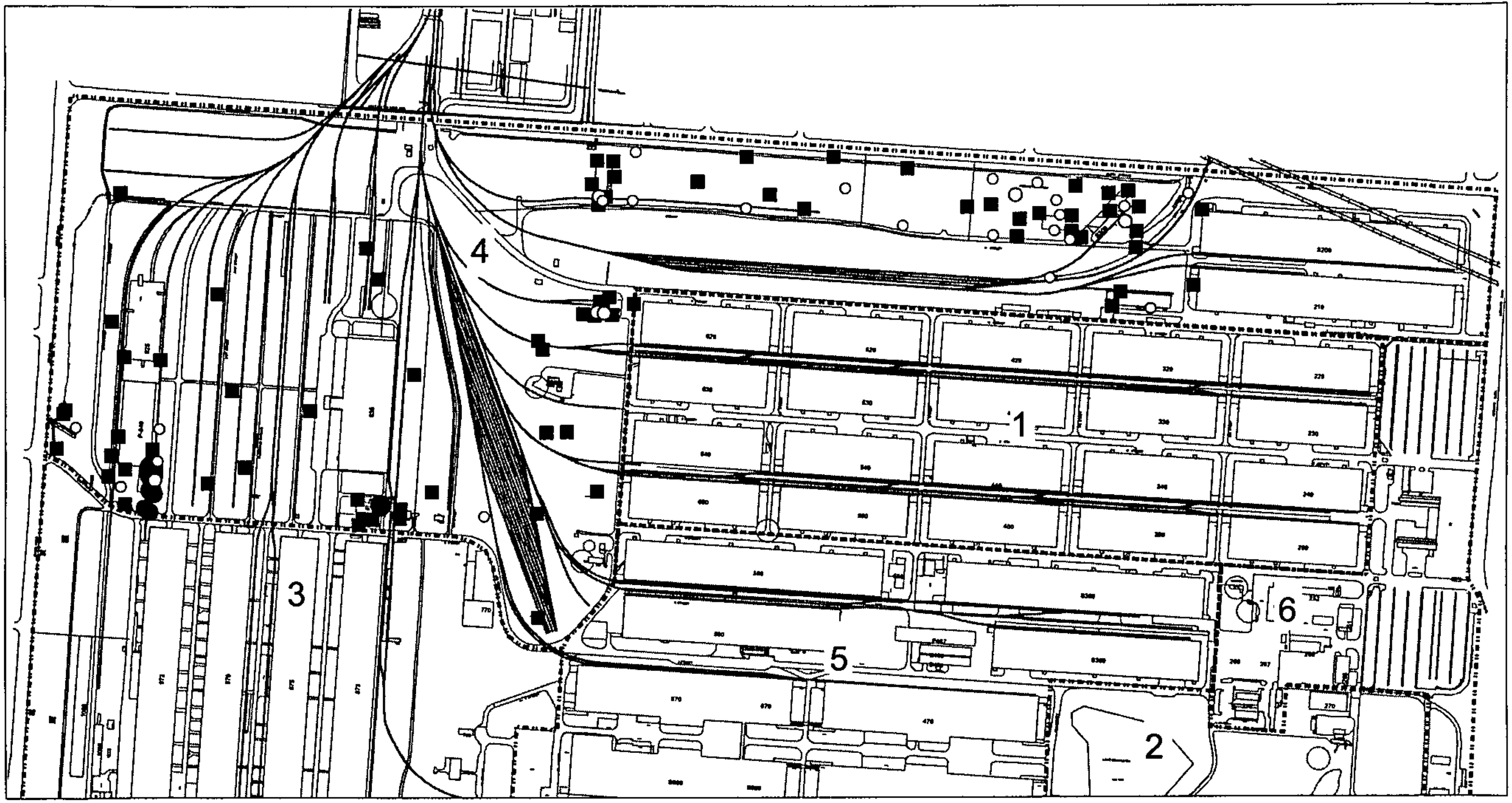

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FIGURE 20-11
ZINC CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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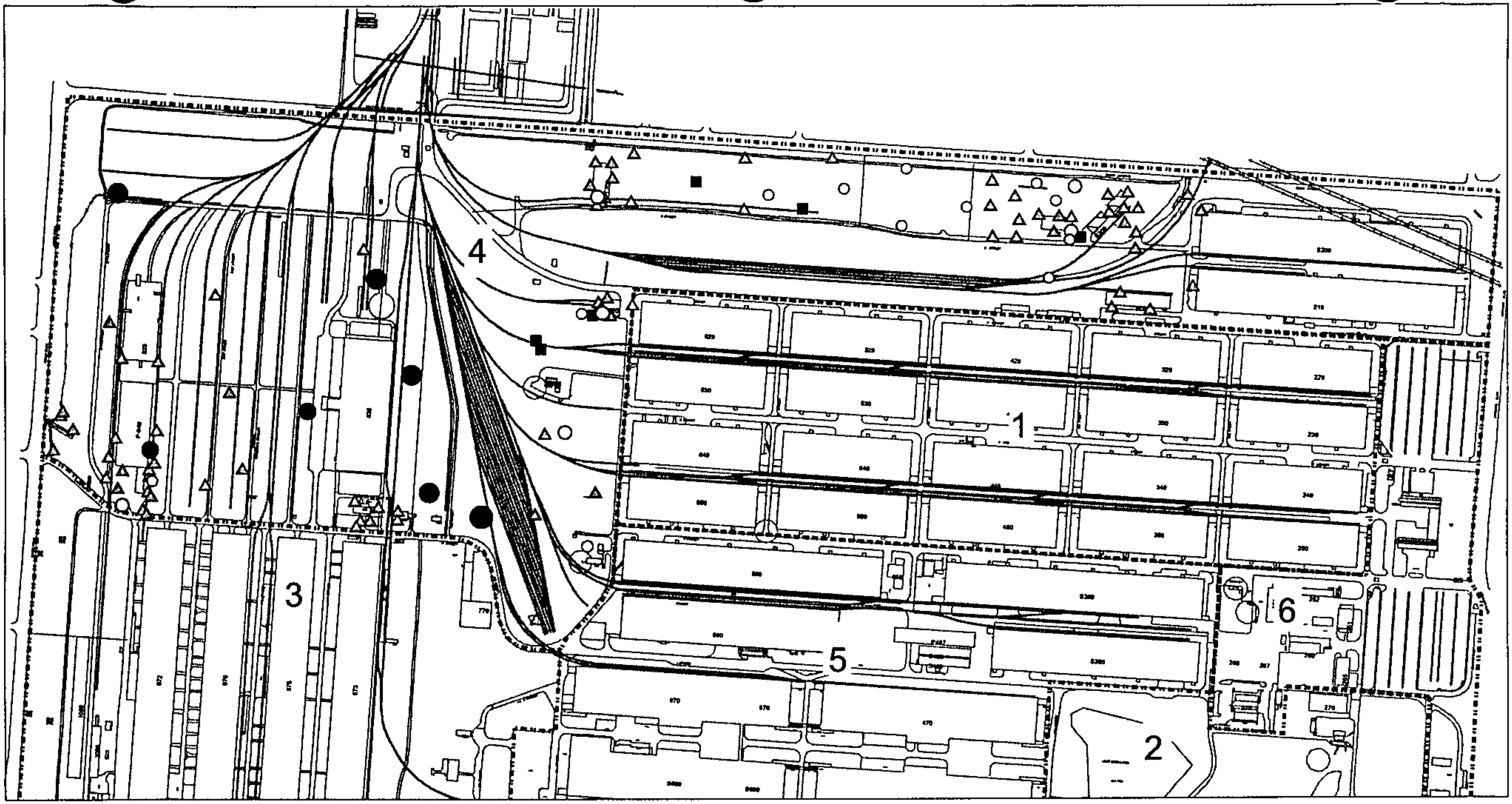

Selenium Concentrations
- ○ 0 92 - 1 5 MG\KG
- ○ 1.5 - 2.3 MG\KG
- 2 3 - 3 3 MG\KG
- 3 3 - 7 7 MG\KG
- 7 7 - 11 2 MG\KG

■ Concentrations Detected\Below Background (<0 8 MG\KG)

△ Non-detected
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

487 257

FIGURE 20-12
SELENIUM CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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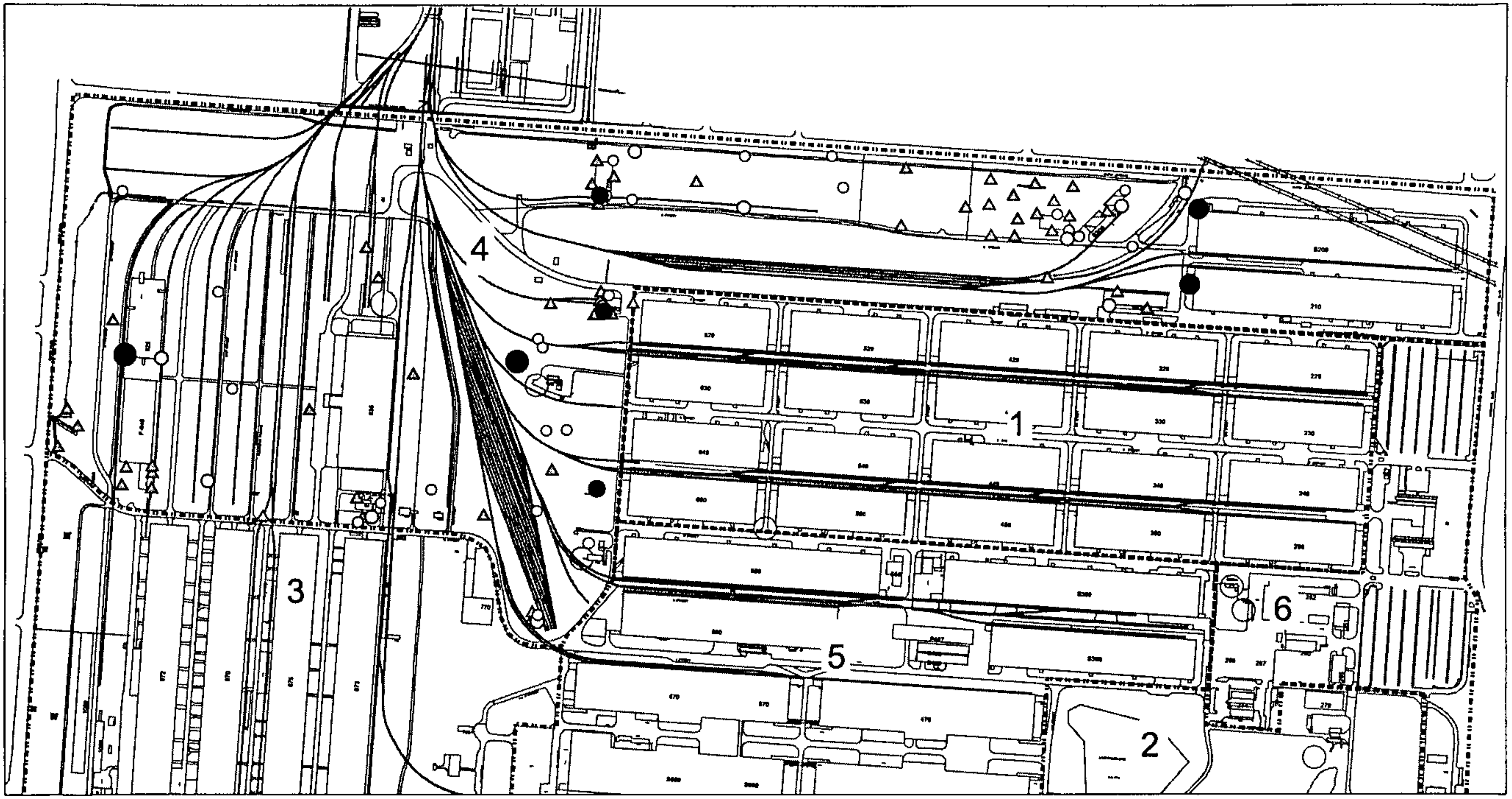

Total PAH Concentrations
○ 0 05 - 1 617 MG\KG
○ 1 617 - 4 13 MG\KG
4 13 - 13 3 MG\KG
● 13 3 - 37 83 MG\KG
37 83 - 79 35 MG\KG

△ Non-detected
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet

SCALE IS APPROXIMATE

487 259

FIGURE 20-13
TOTAL PAH CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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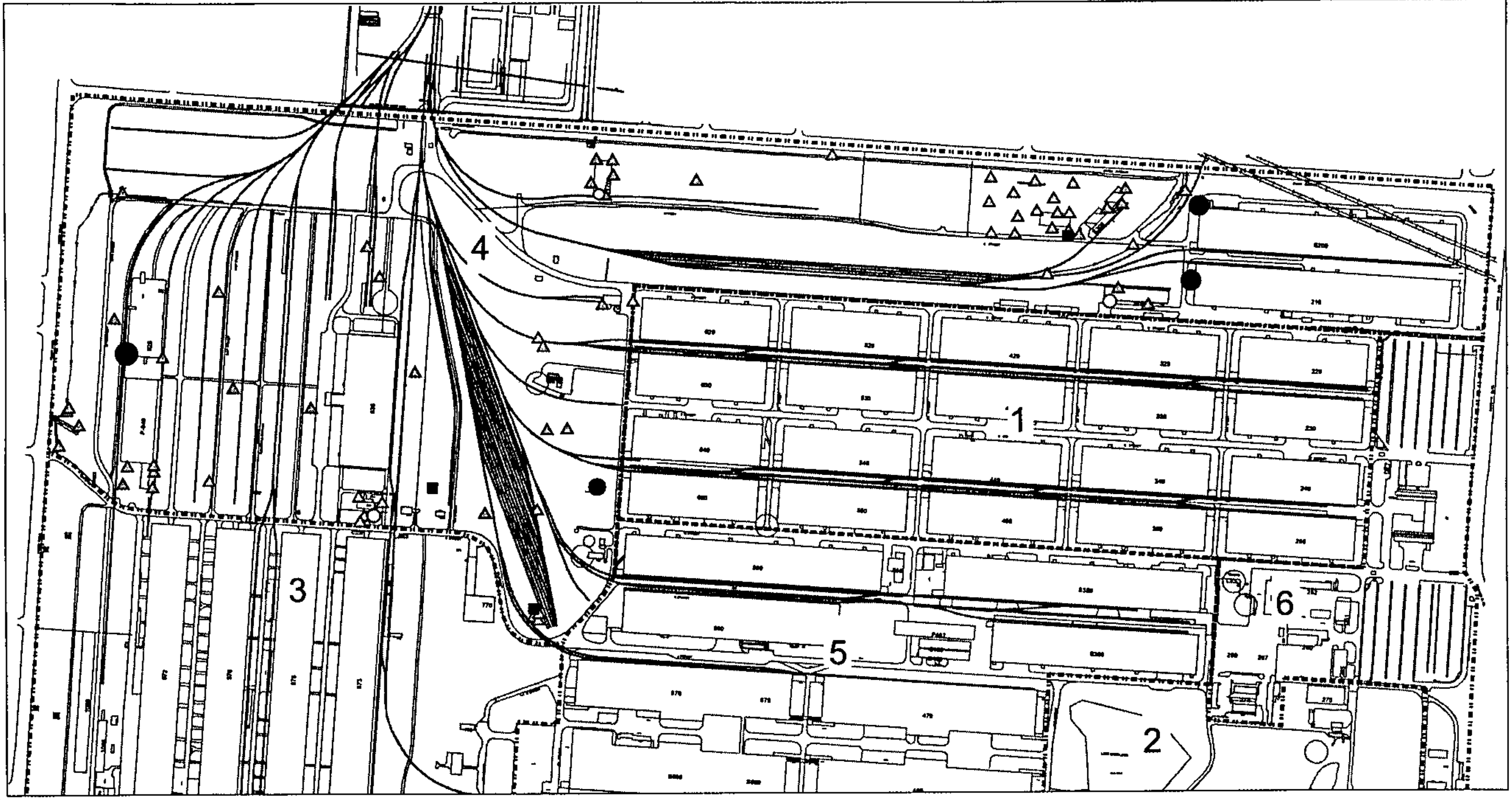

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FIGURE 20-14
CARBAZOLE CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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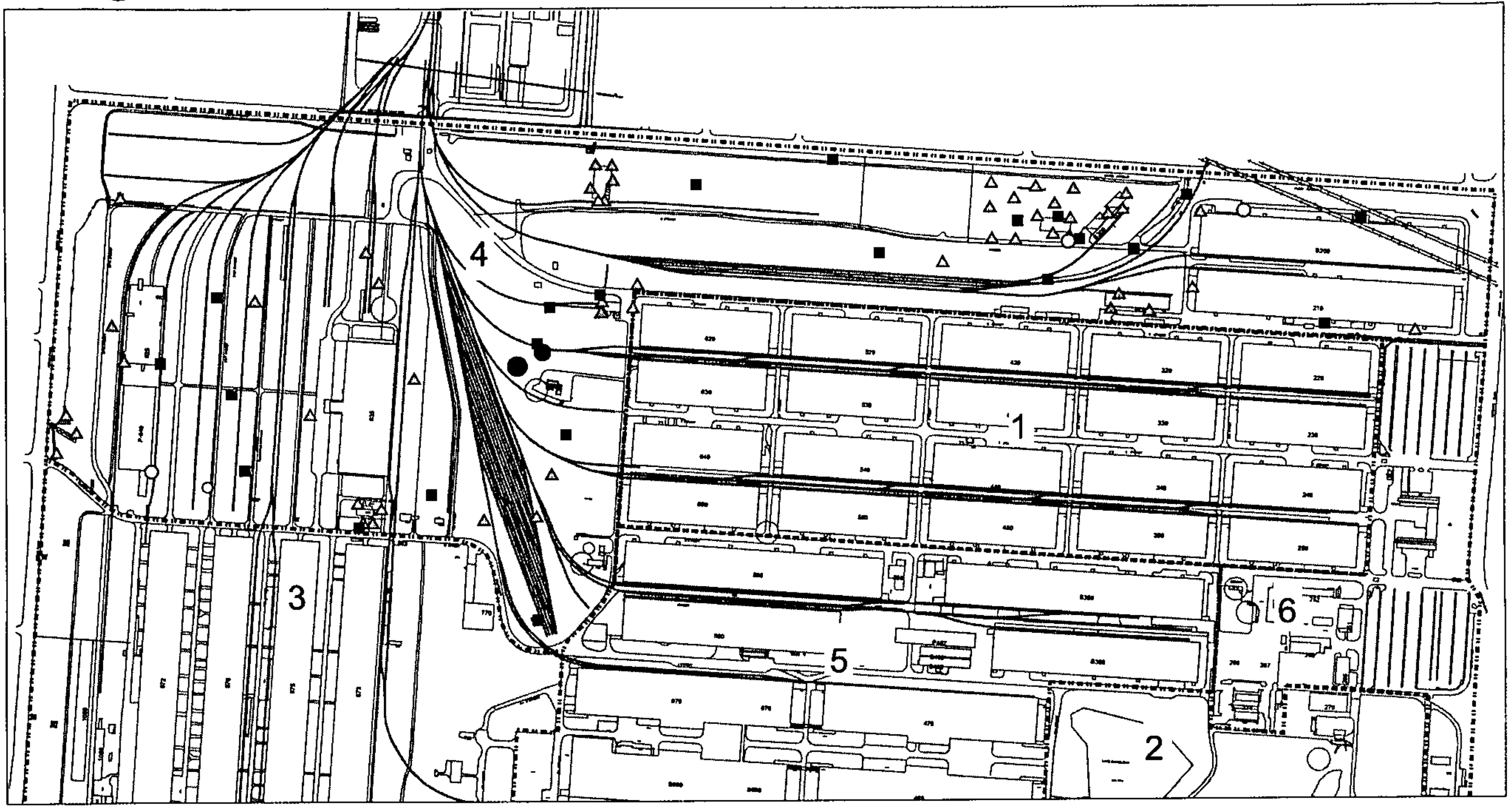

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DDE Concentrations
○ 0 3 MG\KG
○ 0.3 - 0 44 MG\KG
0 44 - 1 6 MG\KG
1 6 - 3 MG\KG

■ Concentrations Detected\Below Background (<0 16 MG\KG)

N

△ Non-detected
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-15
DDE CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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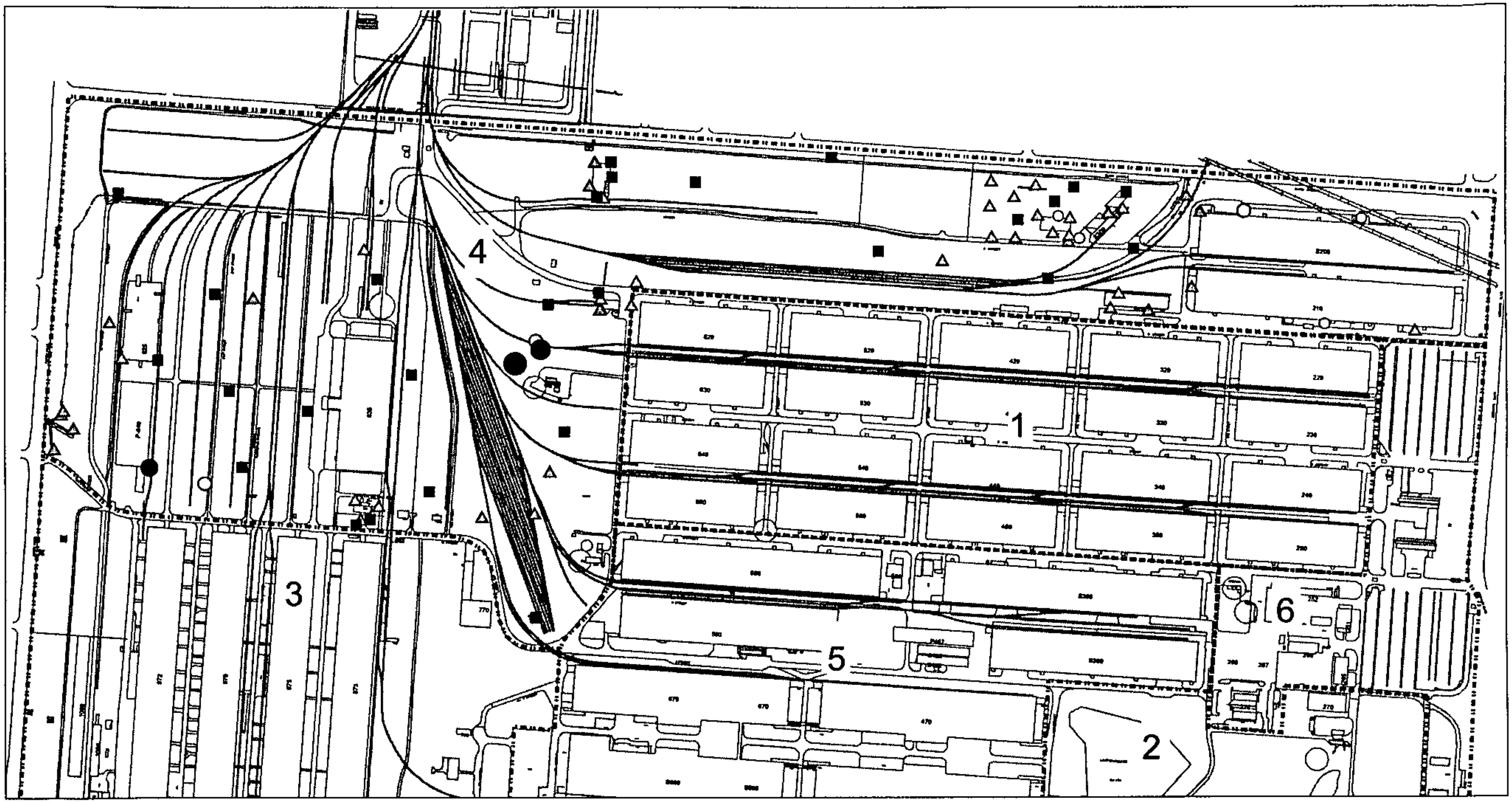

FIGURE 20-16
DDT CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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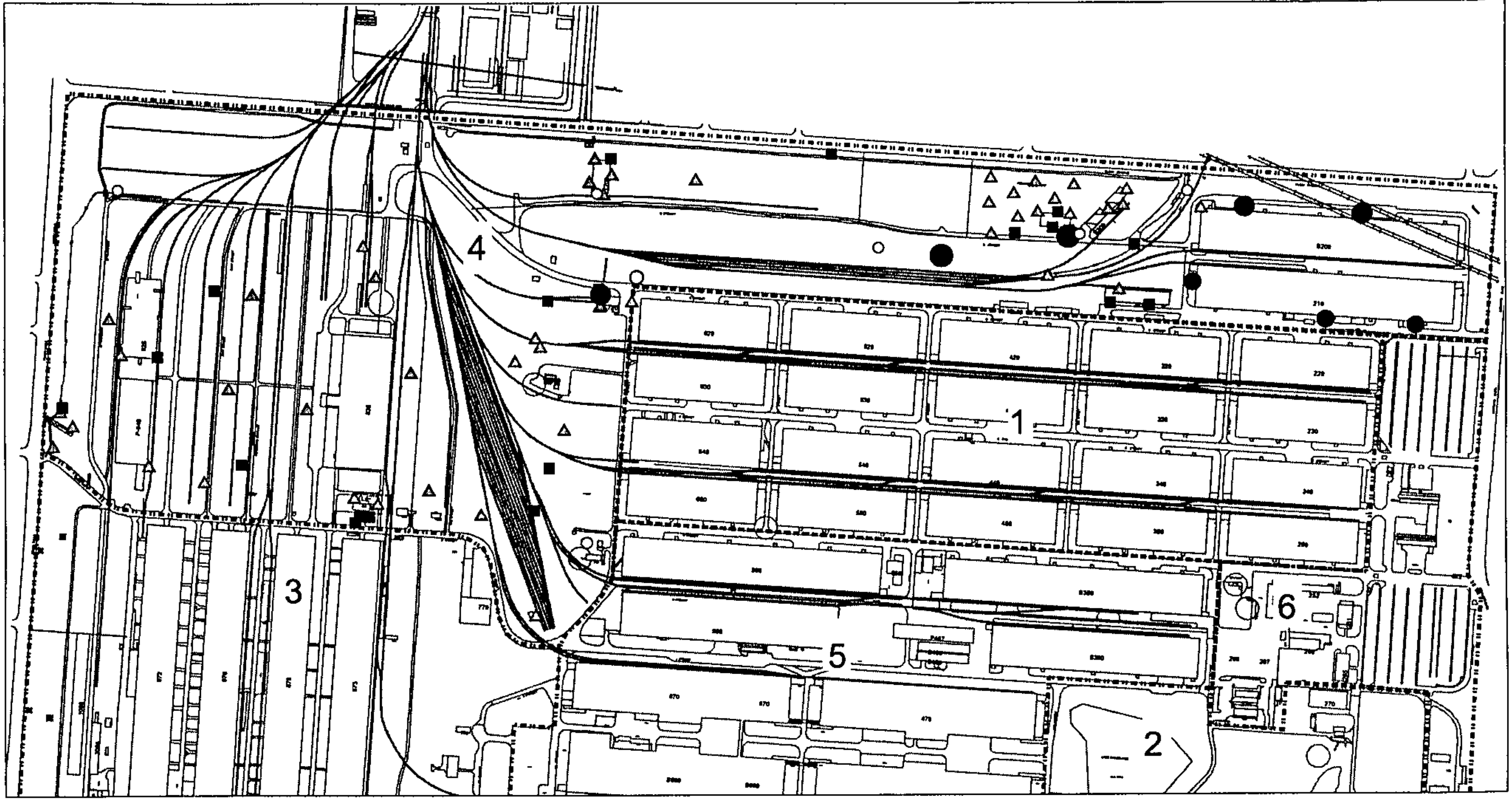

FIGURE 20-17
DIELDRIN CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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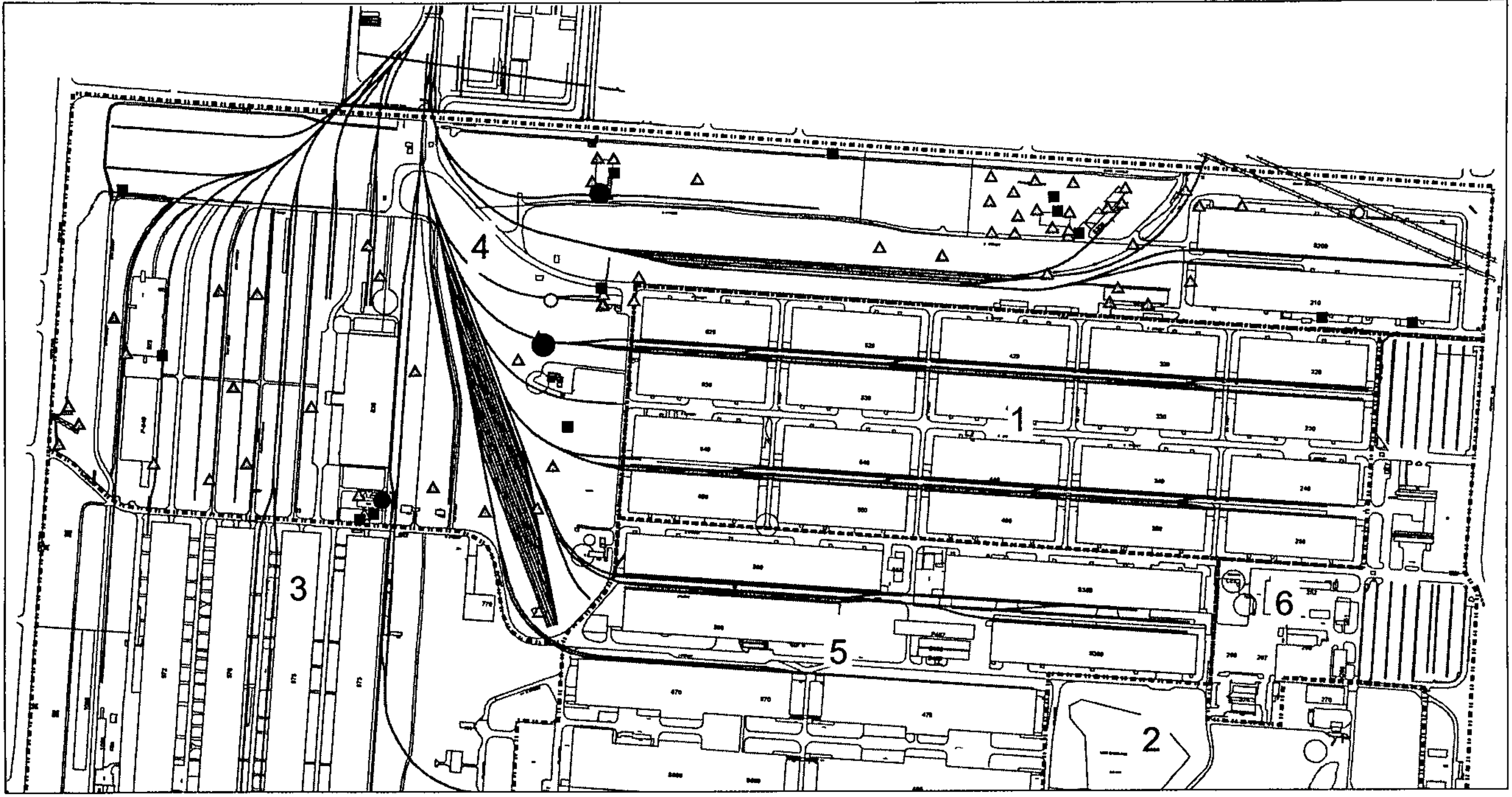

FIGURE 20-18
ALPHA-CHLORDANE CONCENTRATIONS.
IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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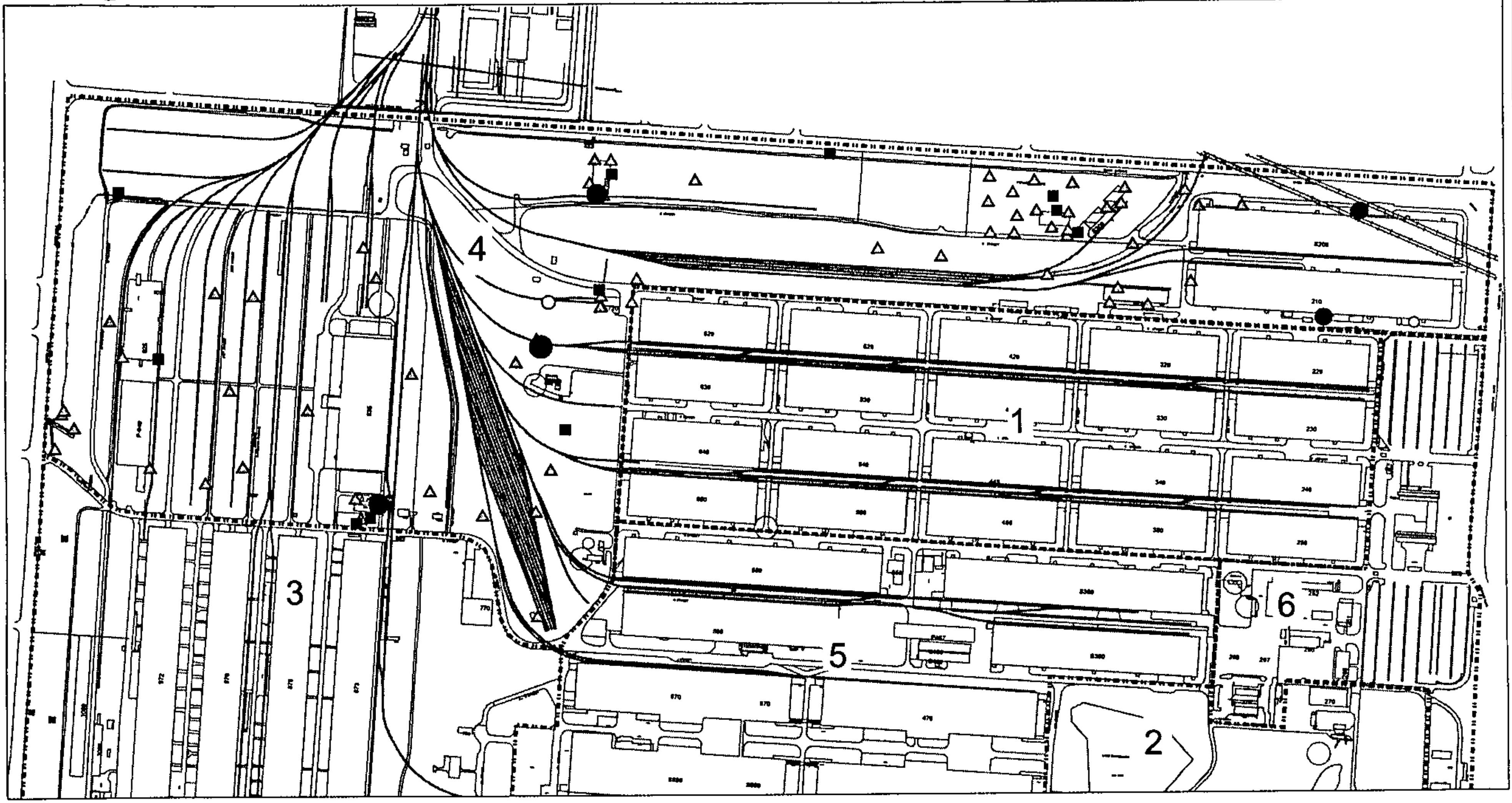

FIGURE 20-19
GAMMA-CHLORDANE CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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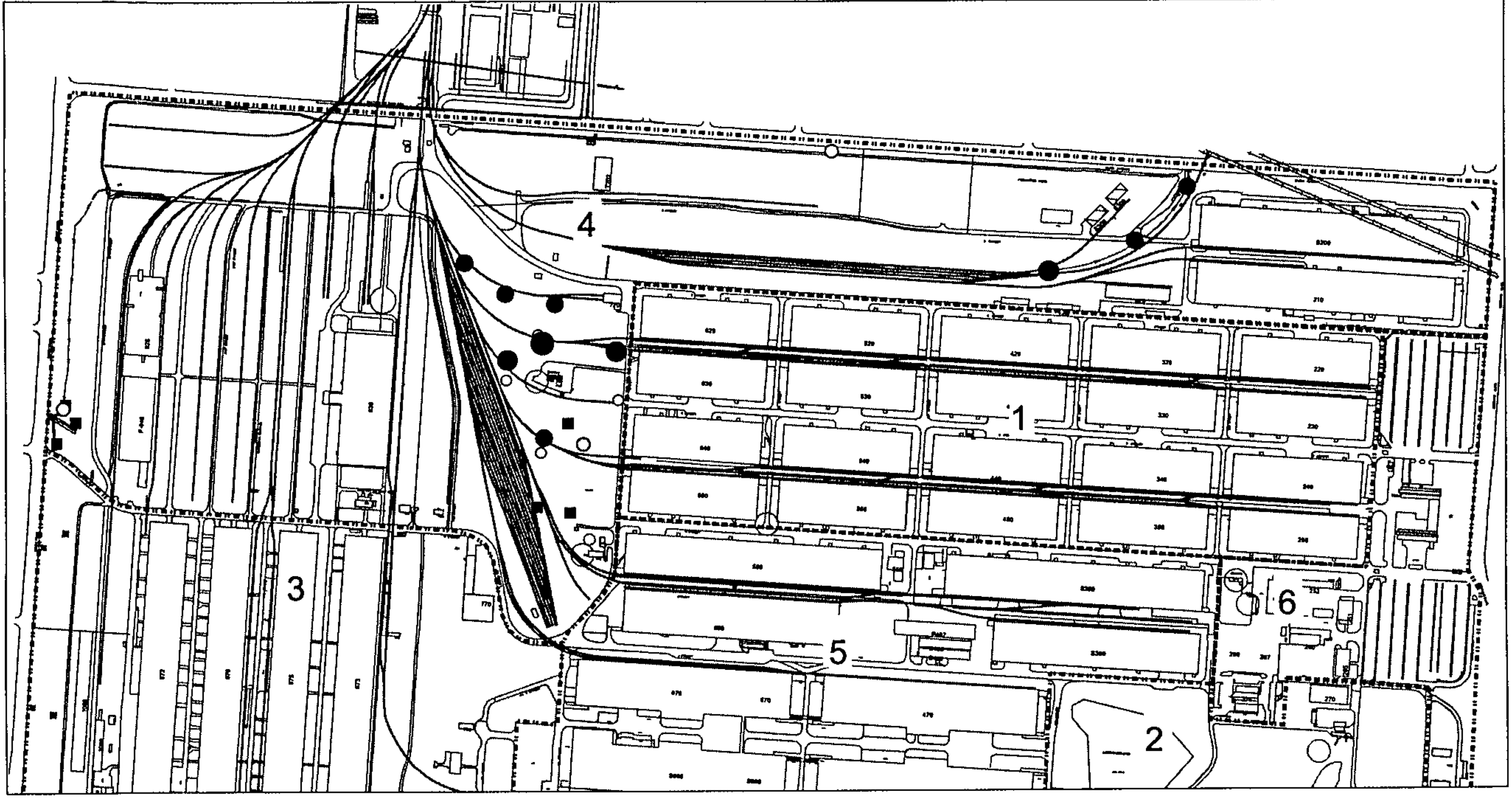

TCDD Equivalent Concentrations
○ 0 000014 - 0 000022 MG\KG
○ 0 000022 - 0 000047 MG\KG
0 000047 - 0 000174 MG\KG
0 000174 - 0 00035 MG\KG
0 00035 - 0 000466 MG\KG

■ Concentrations Detected\Below Background (< 0 00001 MG\KG)
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-20
TCDD EQUIVALENT CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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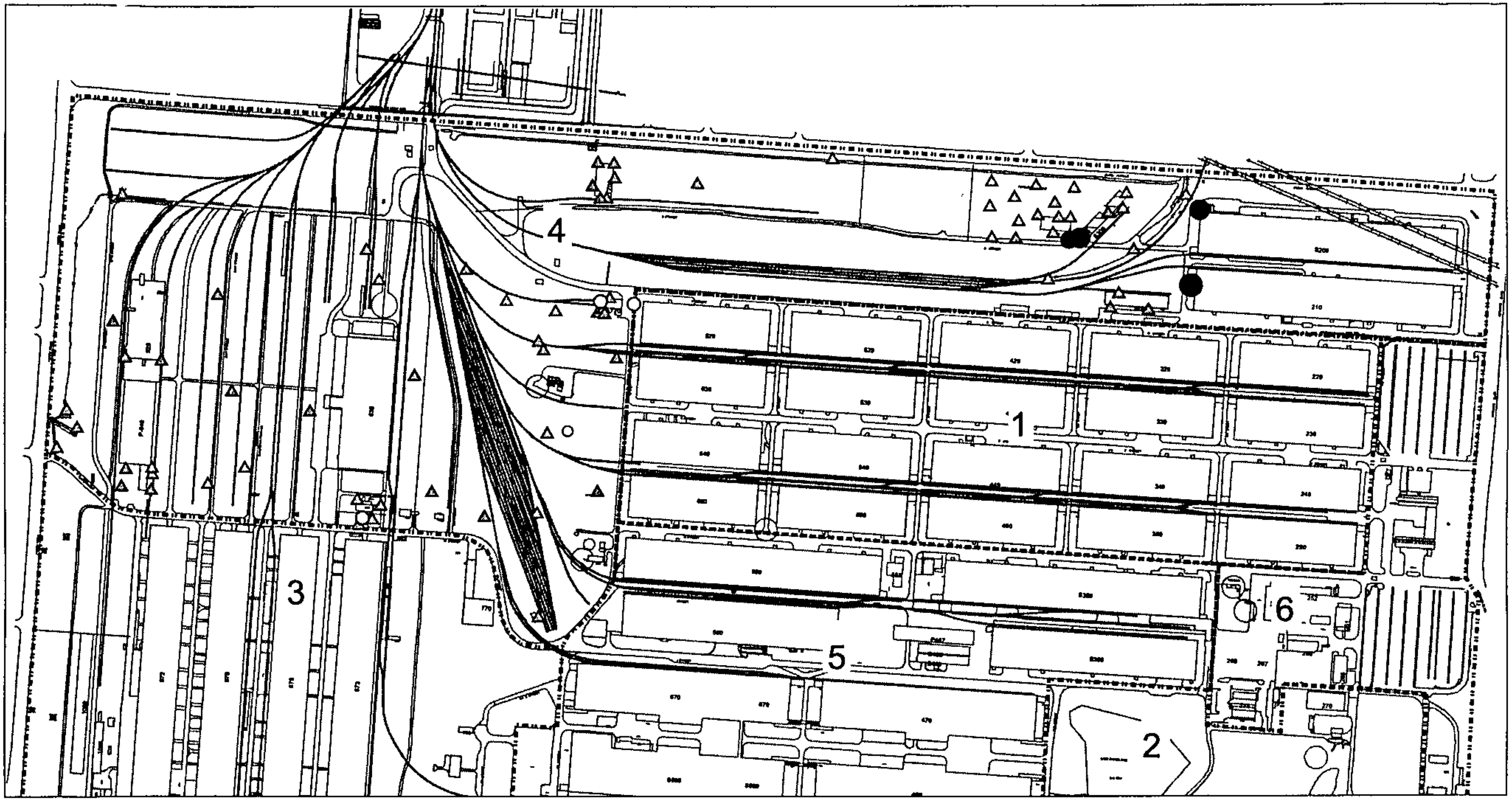

FIGURE 20-21
METHYL ETHYL KETONE CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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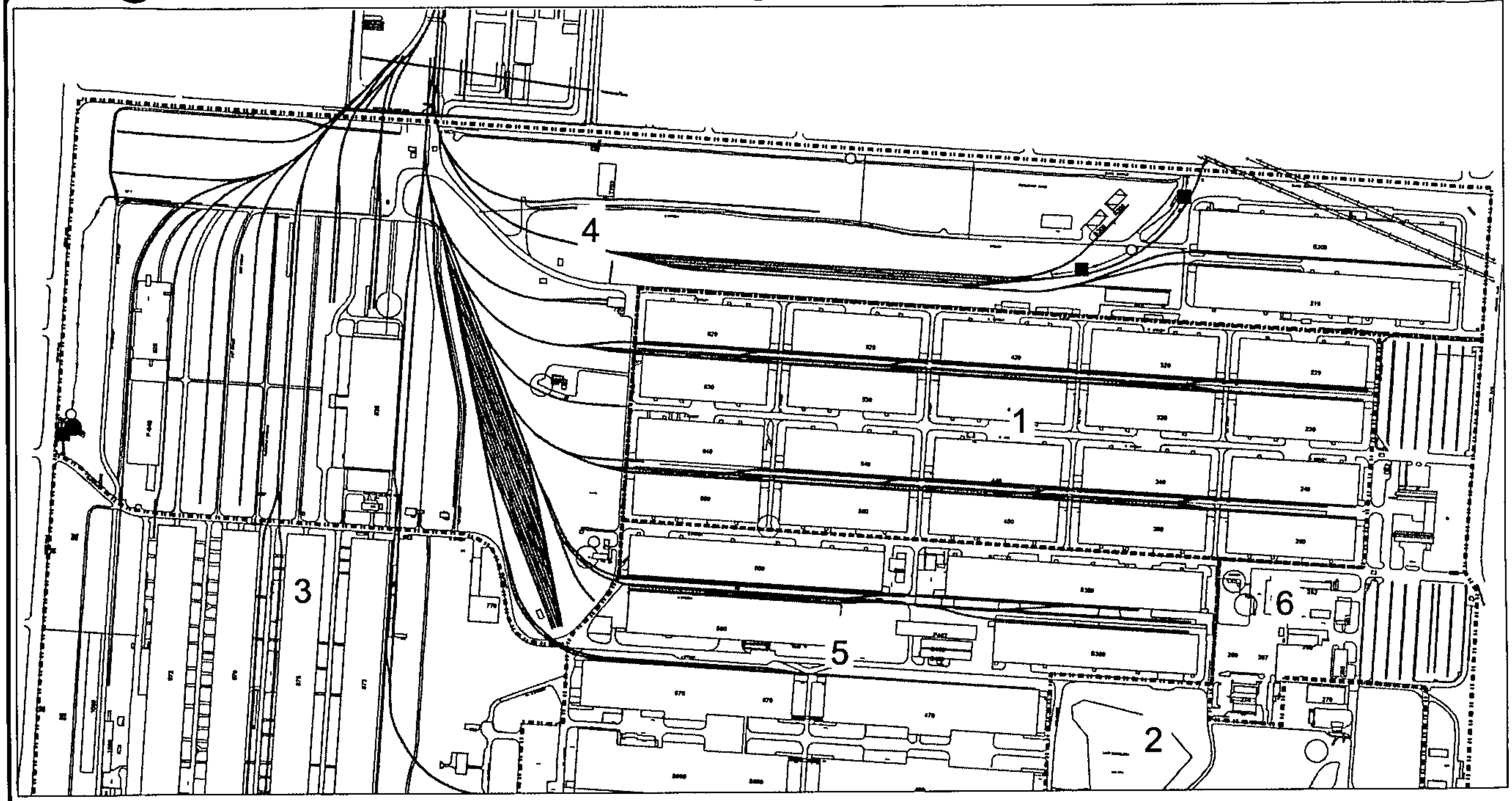

TCDD Equivalent Concentrations
○ 0 000000 MG\L
0 000001 MG\L

■ Concentrations Detected\Below Background (< 0 000000 MG\L)
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-22
TCDD EQUIVALENT CONCENTRATIONS IN SURFACE WATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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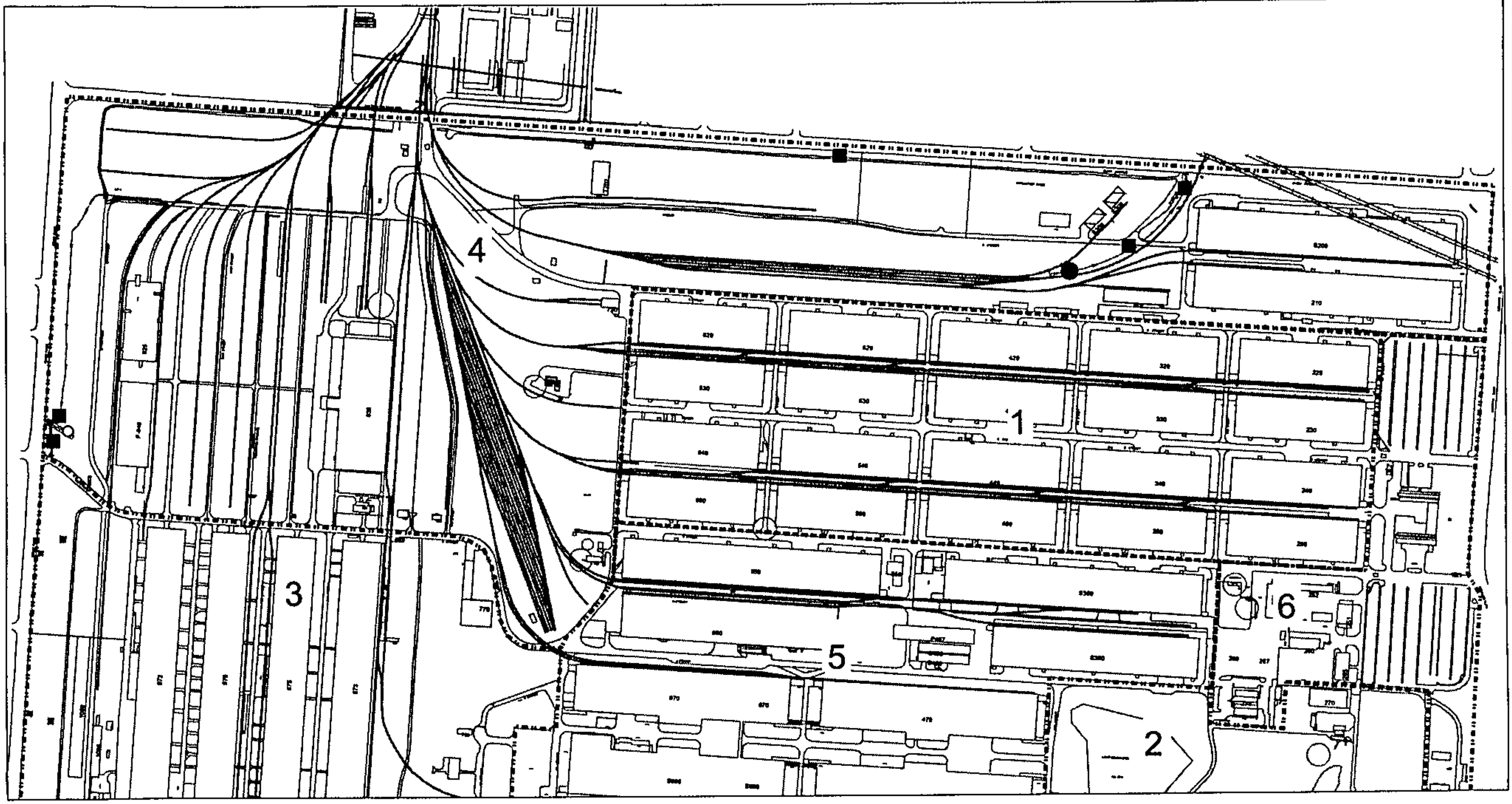

Total Chromium Concentrations
○ 26 5 MG\KG
68 5 MG\KG

■ Concentrations Detected\Below Background (<20 0 MG\KG)
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-23
TOTAL CHROMIUM CONCENTRATIONS
IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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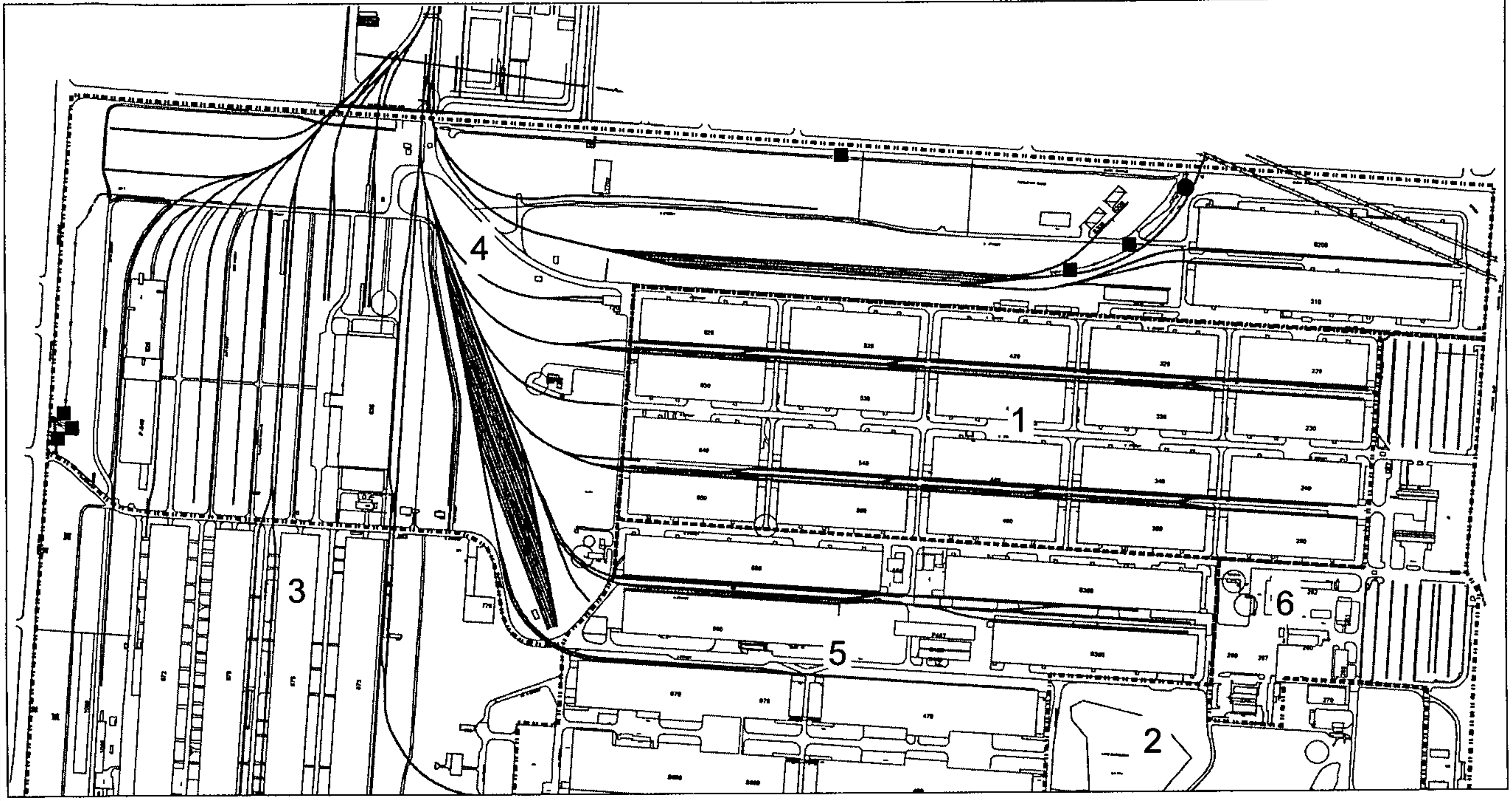

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FIGURE 20-24
LEAD CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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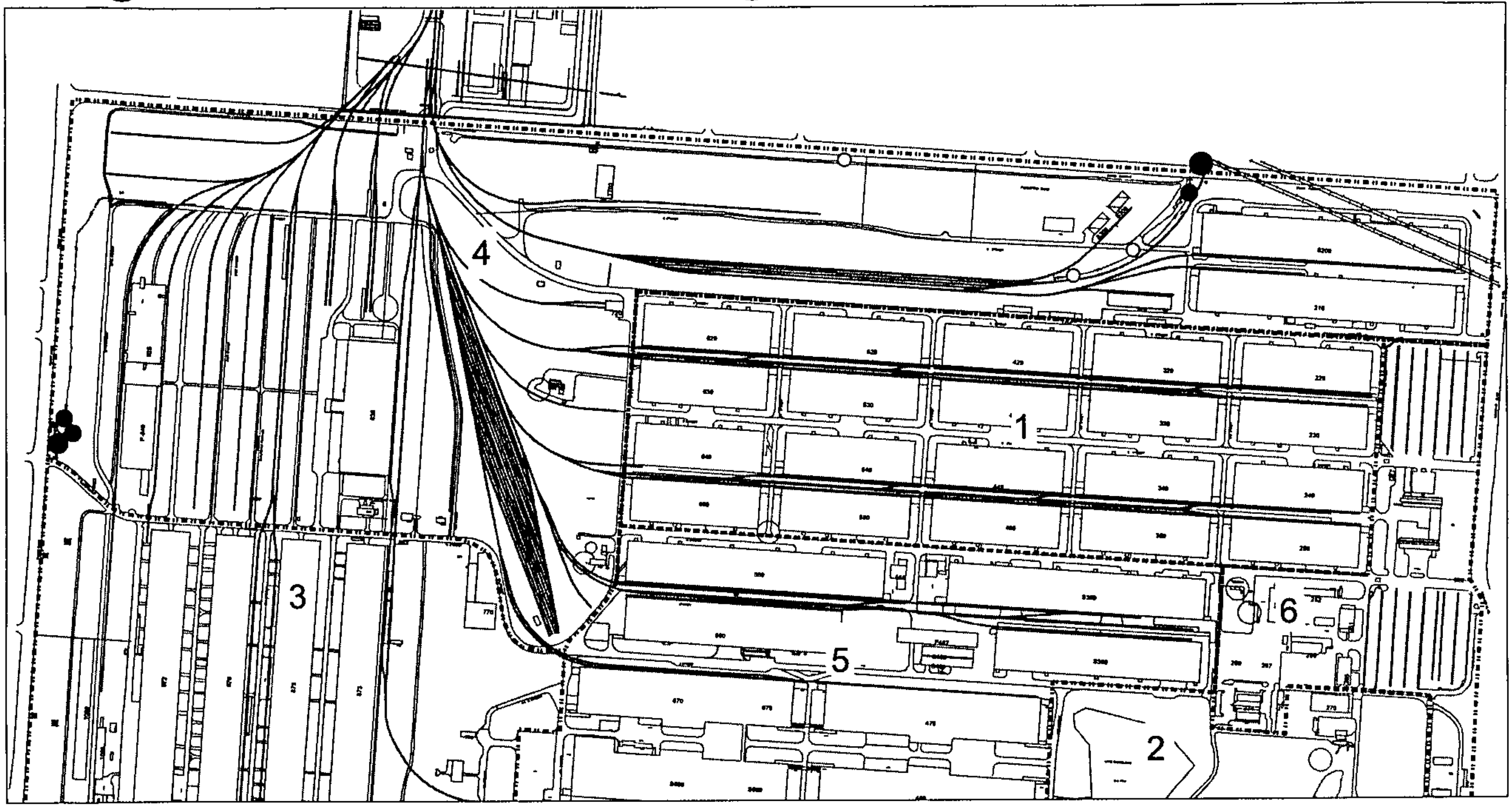

Total PAH Concentrations
○ 0 046 - 1 MG\KG
○ 1 001 - 2.155 MG\KG
2.155 - 6 532 MG\KG
6 532 - 12 27 MG\KG
262 1 MG\KG
Text Building Numbers
Functional Unit Boundary
Base Features
☐ Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-25
TOTAL PAH CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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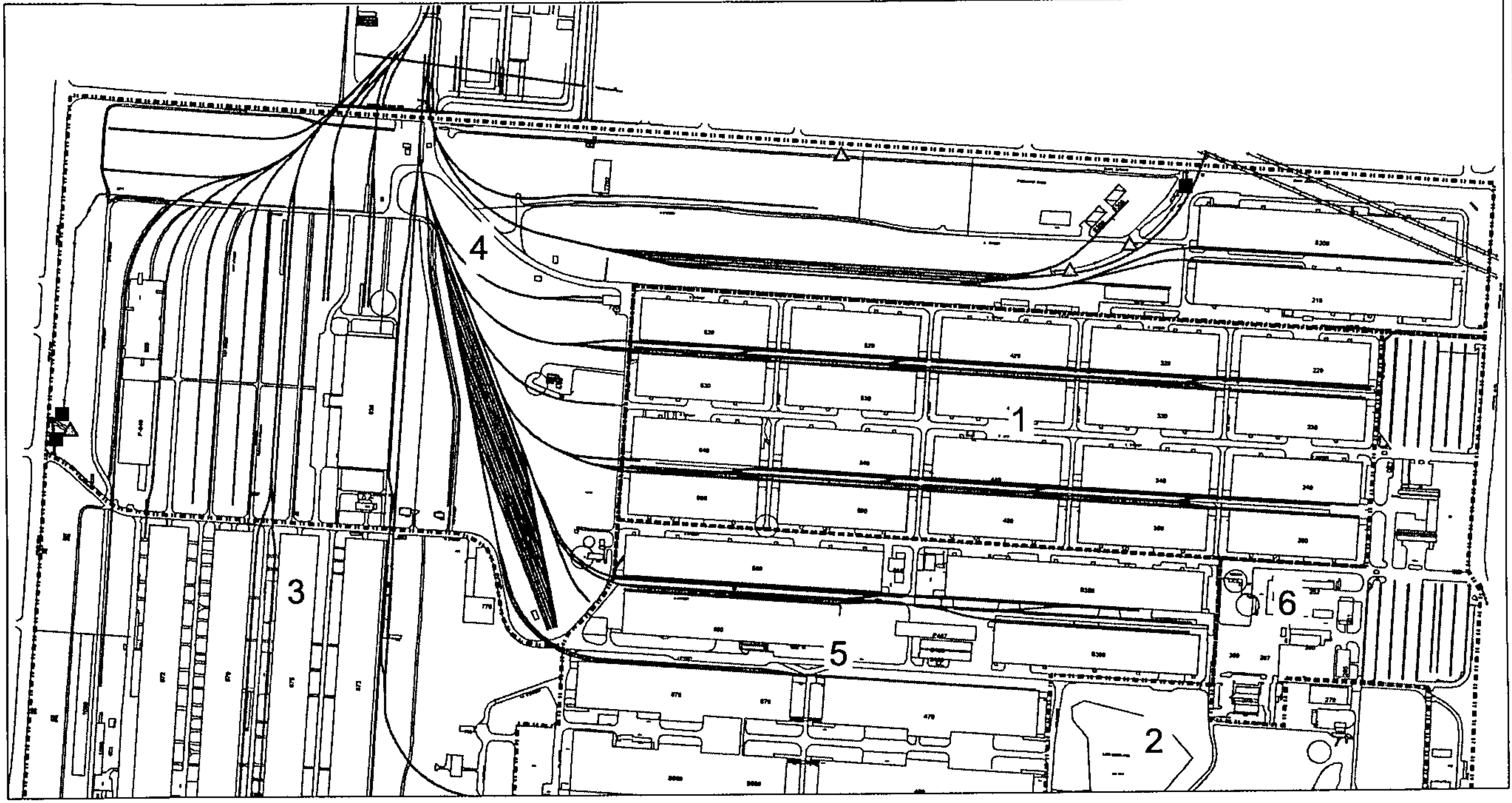

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FIGURE 20-26
CARBAZOLE CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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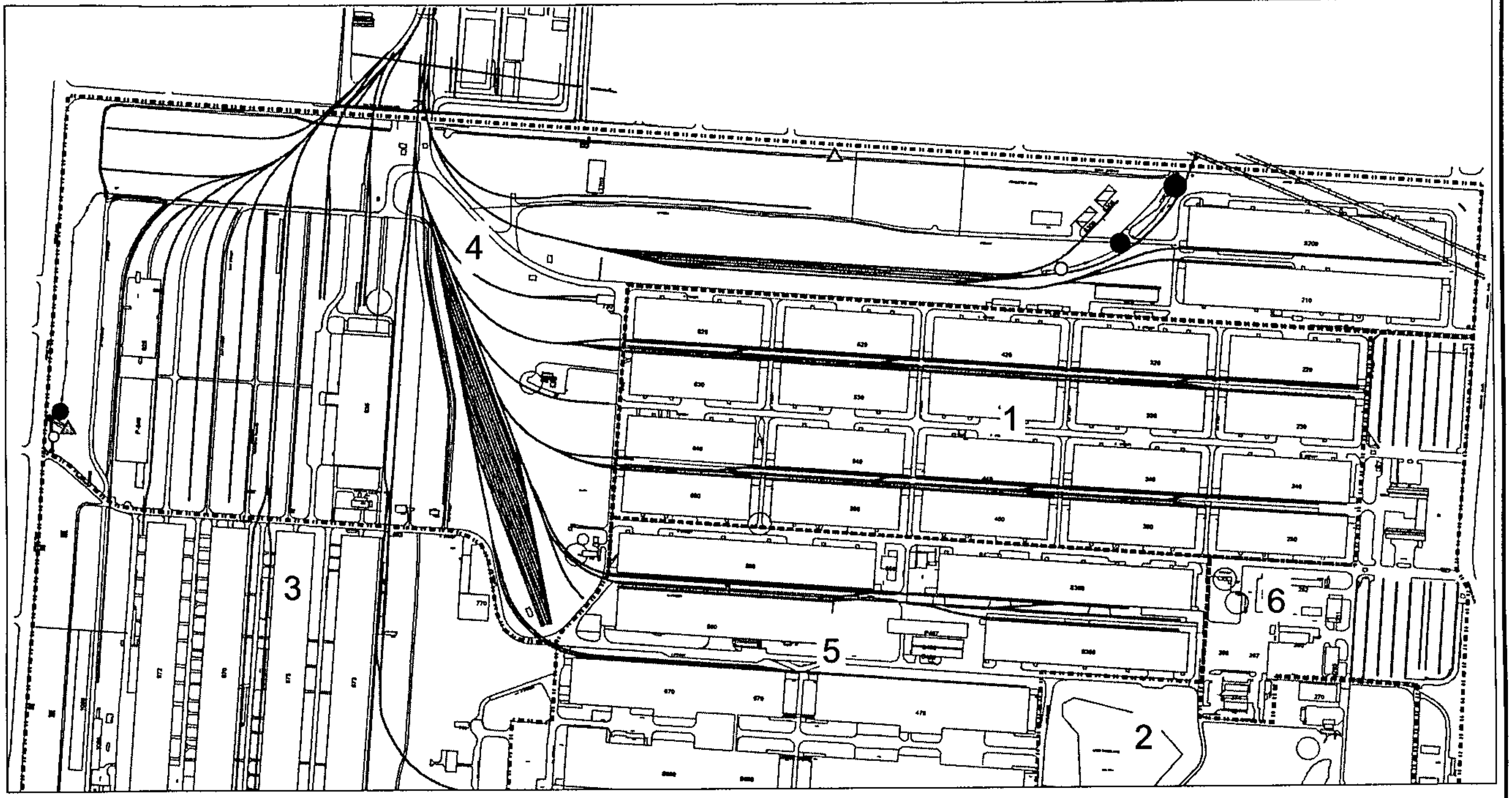

FIGURE 20-27
DIELDRIN CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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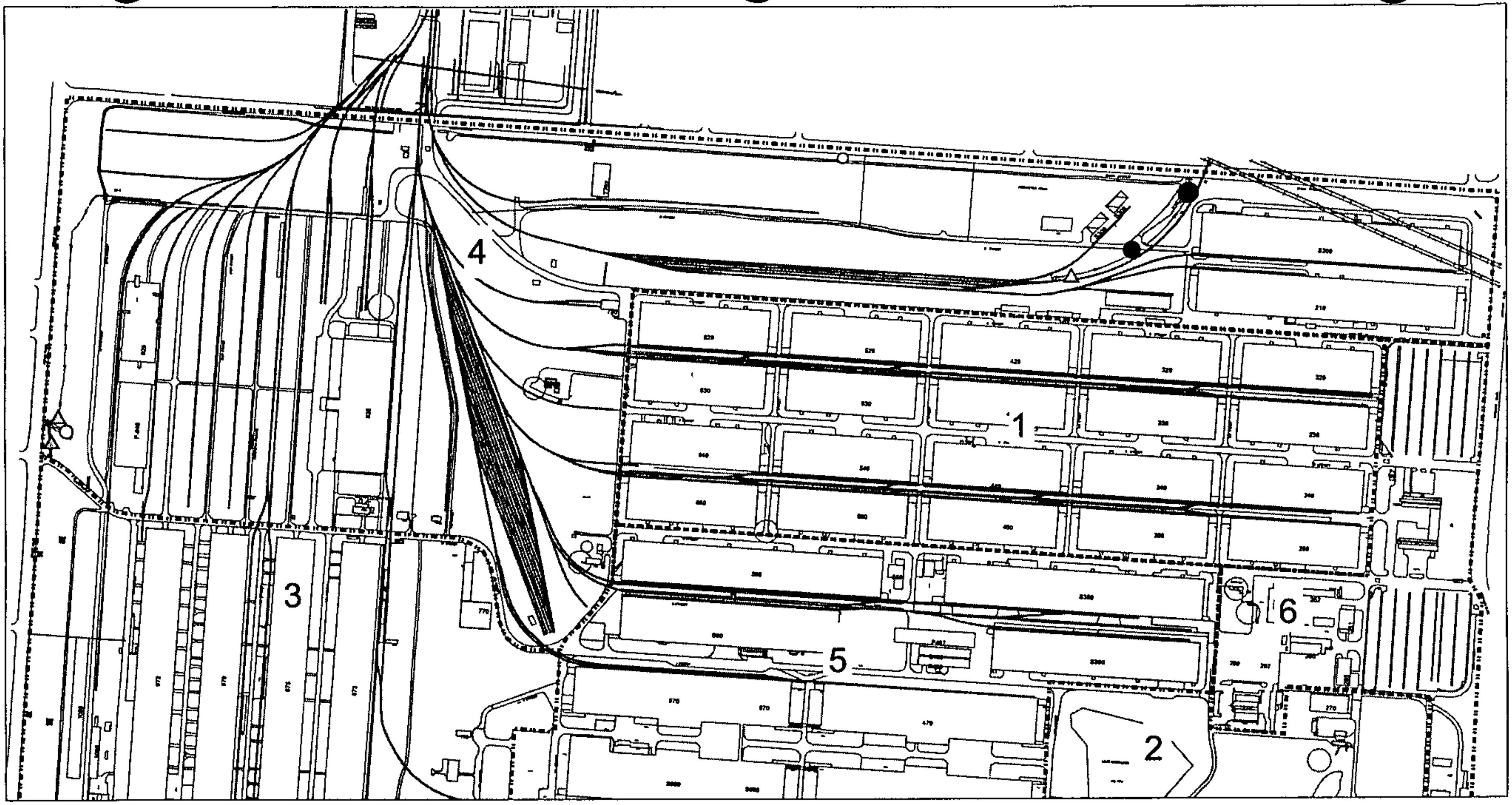

DDD Concentrations
○ 0 03 MG\KG
○ 0 061 MG\KG
0 089 MG\KG
● 0 99 MG\KG

△ Non-detected
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

FIGURE 20-28
DDD CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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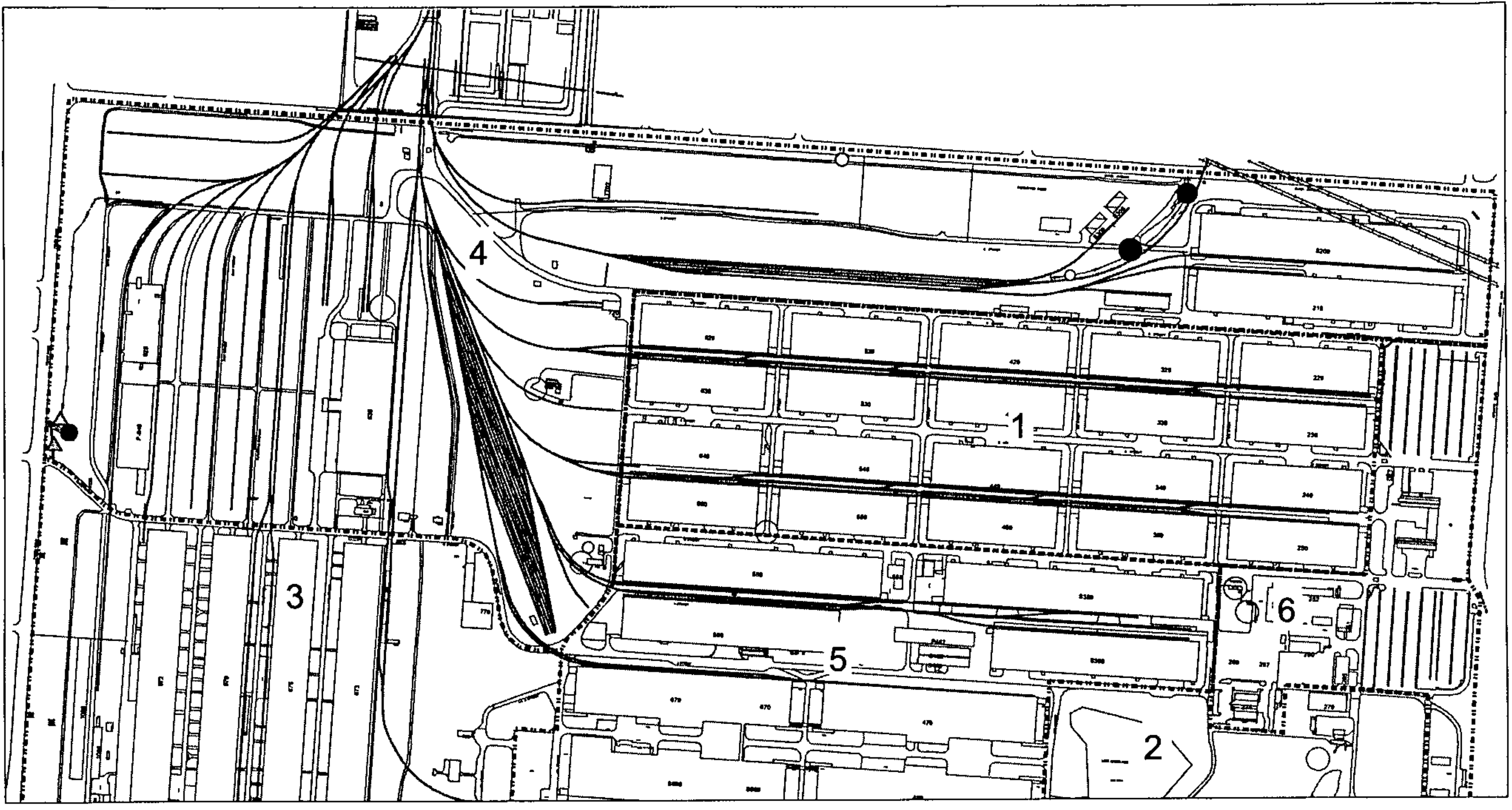

FIGURE 20-29
DDE CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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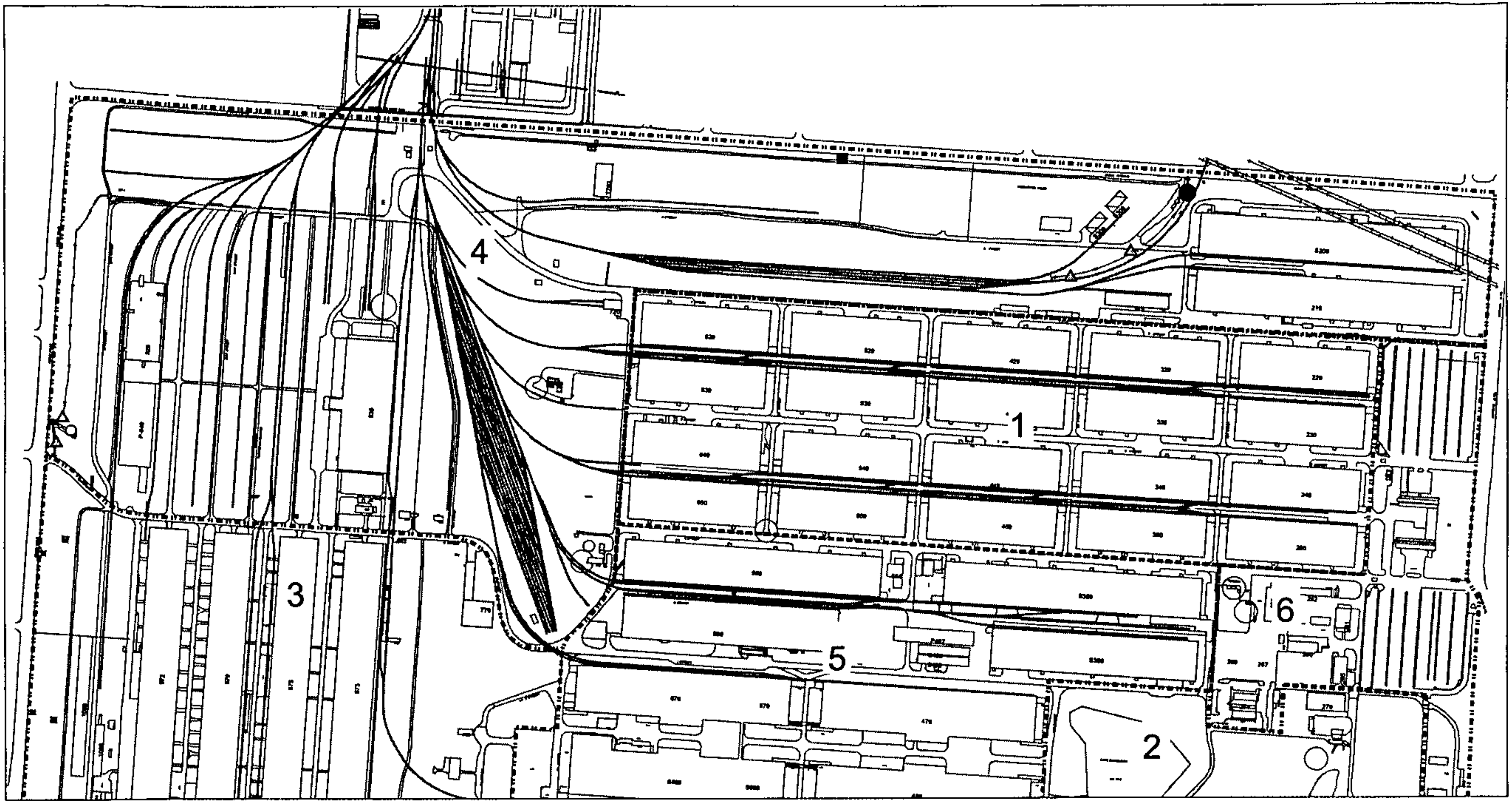

Alpha-Chlordane Concentrations
○ 0 032 MG\KG
● 0 53 MG\KG

■ Concentrations Detected\Below Background (<0 005 MG\KG)

△ Non-detected
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet

SCALE IS APPROXIMATE

FIGURE 20-30
ALPHA-CHLORDANE CONCENTRATIONS
IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

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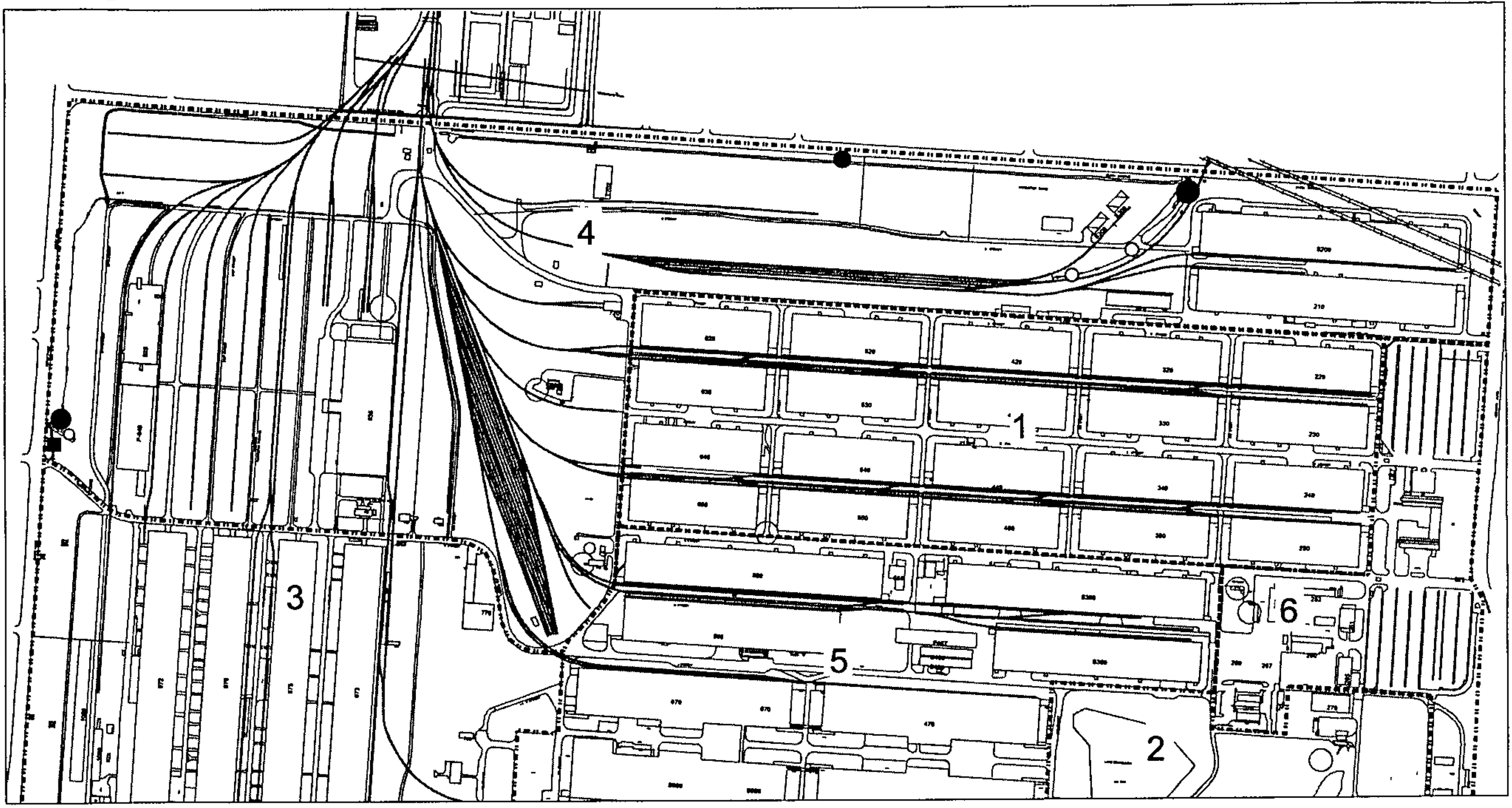

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TCDD Equivalent Concentrations
○ 0 00001 MG\KG
○ 0 00001 - 0 000038 MG\KG
● 0 000038 - 0 000049 MG\KG
0 000049 - 0 00017 MG\KG
0 00017 - 0 000494 MG\KG

■ Concentrations Detected\Below Background (< 0 00001 MG\KG)
Text Building Numbers
Functional Unit Boundary
Base Features
Buildings

N

0 350 700 Feet
SCALE IS APPROXIMATE

FIGURE 20-31
TCDD EQUIVALENT CONCENTRATIONS IN SEDIMENTS
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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TAB

Section 21

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TAB

21. Fate and Transport for FU4

21.0 Fate and Transport for FU4

The overall fate and transport discussion was included in Section 6.0. This section covers information specific to FU4 and Site 36. The CSM for FU4 is presented on Figure 22-2.

21.1 Fate and Transport for FU4

A summary of site conditions influencing the fate and transport of site contamination is presented in this discussion. Figures 2-16 and 19-1 show the land cover types within FU4.

Source Area Characterization: FU4 is the largest of the FUs within the Main Installation, consisting of 20 screening sites (Sites 28, 35, 36, 37, 38, 39, 42, 43, 46, 54, 55, 56, 70, 71, 72, 73, 74, 79, 80, and 83) and 8 BRAC parcels (13, 14, 15, 29, 30, 31, 32, and 33). Several small buildings and three relatively large buildings (Buildings 209, 210, and 835) are located in this FU. There are no RI sites within this FU. A large portion of the Depot's railroad tracks (Site 70) is located within this FU, which will be removed as part of the Depot redevelopment planned for Year 2003 to 2006 (The Pathfinders et al., 1997). The majority of the Depot operations in this FU consisted of open storage yards and areas used for wood pallet preservation treatment with PCP (Sites 42 and 43), which have been remediated (OHM, 1986). The storage drums of various hazardous and nonhazardous materials were removed and properly disposed of during remediation (OHM, 1986). Sampling was implemented to analyze for dioxins in the drainage ditches and at sites with past PCP-related operations in this area.

Surface water runoff within FU4 travels to the north in the northern portion of FU4 (Parcels 13, 14, and 15) through concrete-lined drainage ditches at Sites 54 and 55, and to the west through the drainage ditch at Site 56. Drainage through Sites 54 and 55 is routed to the enclosed pipes of the City of Memphis collection system along Dunn Road. Runoff not collected by the ditch associated with Site 56 is collected by the enclosed pipes of the City of Memphis collection system along Perry Road. The stormwater runoff from the northwestern, central, and western parts of FU4 that drains through Site 56 is routed to Tarrent Branch, which is an open concrete-lined ditch that eventually reaches Nonconnah Creek. These drainage ditches are dry under normal conditions. Sampling from Sites 54 and 55 and the drainage confluence at Site 56 indicated the presence of naturally occurring inorganic chemicals and chlorinated pesticides (i.e., DDT and DDE) at concentrations lower than those detected in the Depot surface soils. All of the detected sediment and surface water constituents were included in the RA for the potential direct exposure-related risk estimates, as well as for potential indirect effects on the groundwater.

Tables 6-4 and 22-1 list the COPCs for FU4 surface soils, which were aluminum, antimony, arsenic, chromium (total), copper, manganese, selenium, thallium, zinc, PAHs, DDE, DDT, dieldrin, chlordanes (alpha/gamma-), Aroclor-1260, PCP, petroleum hydrocarbons, 1,1,2,2-Tetrachloroethane, and TCDD equivalent. The maximum concentrations detected for metals predominantly were found in Sites 36, 56, and 83 and Parcel 14. The PAHs were detected mostly along the asphalt roads or along the railroad tracks at concentrations

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[illegible]

similar to those detected across the Depot. The maximum concentrations of PAHs were detected at B(30.2), at the railroad tracks next to Building 925. Several samples also had residual chlorinated organic pesticides, presumably from historical applications, at concentrations similar to those detected at other areas of the Depot.

Subsurface soils at the site had the same COPCs as surface soil, plus cobalt, 1,2-DCE (total), and TCE, which were detected at low concentrations in a few locations. Arsenic, chromium, copper, and lead were detected in practically all 150 surface and 157 subsurface soil samples analyzed for inorganic constituents.

Sediment and rainwater data were recorded from the drainage ditches that collect stormwater runoff at Sites 54, 55, and 56. These drainage ditches extend off-site at Gates 9, 21, and 22. The drainage ditch samples were analyzed for dioxins and furans, which are commonly present in the urban environment. The COPCs for FU4 sediment are chromium (total), PAHs, dieldrin, PCP, 2-Methylnapthalene, 4-Methylphenol, carbon tetrachloride, methylene chloride, and TCDD equivalent. COPCs for FU4 surface water, based on data from samples collected during a storm event, included DDT, dieldrin, TCDD equivalent, and PCP, possibly from the suspended sediments in the rainwater. The surface runoff from previous dip vat operations and wooden pallet-related operations flows westward through the concrete-lined drainage ditch at Site 56, and is not likely to reach the ditches in the north (Sites 54 and 55).

Potential Contaminant Migration, Persistence, and Exposure Points: The potential transport and migration pathways at FU4 are considered to be surface runoff, percolation/leaching, and dust emission/volatilization. These pathways are likely to occur mostly in the areas without an impervious cover, which are limited to the strips of grass- and gravel-covered areas around the warehouse buildings.

Surface Runoff Pathway: Surface runoff may have occurred during historical operations in open areas such as the open storage facilities and the pallet drying areas near Sites 42 and 43. The sediments in the drainage ditches at the property boundary had pesticides, PCP, and dioxins/furans. The concentrations observed are low; however, to be conservative in the RA, these constituents were included. Most of the surface soils within FU4 have COPCs similar to those elsewhere within the Depot. The chlorinated hydrocarbons such as pesticides and TCDD-related compounds degrade slowly in the environment and are likely to remain bound to the soil/sediments. Because no new or significant contaminant sources were identified within the site, detected concentrations are not likely to increase. There are no human or ecological receptors within the ditches. However, conservative human health RAs and ERAs were conducted to evaluate future potential effects from direct exposures. The downstream locations at Site 56 had only trace levels of site-related contamination.

Air/Dust Emission Pathway: The surface soil COPCs are likely to remain bound to the soil, so dust-borne air emissions are relatively unimportant. 1,1,2,2-Tetrachloroethane was detected in 3 of the 105 samples for which it was analyzed, at concentrations near detection limits (maximum concentration of 0.0007 mg/kg) and was not detected in subsurface soils at the site. Therefore, though this is a volatile constituent, because of the low and infrequent concentrations detected, this chemical is not likely to emit significant air concentrations. Nonetheless, direct inhalation exposures to this chemical were assumed in the risk estimations. Exposure via inhalation of dust-borne particle-bound COPCs was evaluated in the RAs using EPA-recommended dust emission assumptions (PEF = 1.3×10^9 m^3/kg).

The subsurface soils had 1,2-DCE (total) and TCE, which could become air-borne through volatilization from subsurface soil or during excavation activities. Thus, exposure to airborne volatiles from shallower subsurface soil is a potential migration and exposure pathway. The VOCs therefore were included for inhalation exposure through volatilization using conservative exposure assumptions (see Section 22.0 and Appendix G).

Migration to Groundwater Pathway: Leaching to groundwater is not an issue for surface soil COPCs within FU4, except for 1,1,2,2-Tetrachloroethane. The low concentrations of this chemical detected in surface soil and its absence in subsurface soils indicate that it is degrading and not reaching the subsurface soils or groundwater at measurable levels. COPCs–TCE, and 1,2 DCE–detected in the subsurface soil are very soluble, are considered mobile, and could reach the groundwater, although they are not distributed widely (4 to 10 concentrations detected of the 157 samples analyzed for these constituents). The groundwater underneath FU4 does have detectable levels of chlorinated solvent contamination.

Figure 32-9 presents the subsurface soil VOC concentrations at different soil boring locations. Two of the 10 detected concentrations of TCE in subsurface soils (with a maximum of 0.32 mg/kg) exceeded groundwater transfer (GWP/SSL) criteria, indicating that soils within FU4 may be a continuing source of groundwater contamination. These higher concentrations were recorded in samples collected from 18 to 20 ft bgs at Site 36. Most of the detected concentrations of TCE were from samples collected at Site 36. 1,2-DCE (total) was detected at a maximum concentration of 0.11 mg/kg, which is below a GWP criteria of 0.4 to 0.7 mg/kg (*cis* vs. *trans* – isomers) in subsurface soils (4 of 157 samples analyzed for these constituents); thus, this compound may not be reaching the groundwater. Groundwater monitoring samples from PZ06 and MW53 did not have CVOCs.

Fluvial aquifer groundwater beneath the Depot in general has been affected by VOCs, primarily TCE and PCE. Groundwater at FU4 flows to the west and southwest to the central trough within the Depot, so potential groundwater contaminants are likely to flow onto the site. The potential effects on the groundwater are addressed as part of FU7 in Sections 32 0 through 35.0.

21.2 Fate and Transport for Screening Site 36

The following is a brief summary of the site features that could influence the fate and transport of the contaminants in the site media. Screening Site 36 is located within a concrete pad that is part of the DRMO Hazardous Waste Concrete Storage Pad measuring 300 ft by 60 ft, in the northern portion of FU4 and the Depot. Hazardous wastes were stored in this area until shipment to a licensed hazardous waste disposal facility (CH2M HILL, 1998).

On the basis of this historical use, constituents expected to be present at this site are metals and chlorinated solvents. Figure 20-2 shows the surface and subsurface soil sampling locations.

The surface soil COPCs included antimony, arsenic, selenium, dieldrin, PCP, and 1,1,2,2-Tetrachloroethane. The same compounds plus chromium (total), copper, 1,2-DCE (total), and TCE were selected as COPCs in subsurface soil.

The CSM for Site 36 is identical to the one for FU4, and is presented on Figure 22-5. Primary release mechanisms include historical spills and leaks during storage. The metals and VOCs may have contaminated the soils from spills on or along the concrete pad. The pesticides detected at low concentrations appear to be from historical applications along the grassy areas and buildings.

Contaminants could be transported through surface runoff, suspension of entrained dust particles, volatilization into ambient air, and infiltration and leaching from soil to shallow groundwater. Potential off-site migration pathways include surface runoff and dust emissions.

Surface Runoff Pathway: The site is located near the drainage ditch at Site 54, and potential runoff may reach this concrete-lined ditch flowing along B Street. The ditch at Site 54 also receives overland flow from other areas within FU4. There are no direct surface flow features, except the stormwater runoff potential for Screening Site 36. The surrounding area is gravel-covered on three sides and is covered by grass on the southern side of the concrete pad. The COPCs detected in the surface soil at Site 36 are similar to those found across the Depot and are not expected to be a surface runoff concern to off-site areas.

Dust/Air Pathway: Because of the presence of asphalt cover on the soils, dust generation is not an important emission pathway for the site COPCs. However, for conservative risk estimation purposes, assumptions were made that the site consists of open area and that the soil COPCs could become airborne. The risk calculations used EPA's default dust emission assumptions (PEF of 1.3×10^9 m^3/kg).

Groundwater Migration Pathway: Two of the detected COPCs (TCE and DCE) could be associated with site storage activities and may have resulted from accidental historical releases. They were not detected in the surface soils. These compounds were detected in the subsurface soils at relatively low levels; they are highly mobile, and thus, could continue to leach to groundwater (see Table 6-2). The groundwater in the area had trace levels of TCE (MW53 at 0.001J µg/L). The groundwater quality and the fate and transport of the CVOCs in the groundwater are further addressed in FU7 (Sections 32.0 through 35.0).

TAB

Section 22

TAB

22. Baseline Risk Assessment for FU4

22.0 Baseline Risk Assessment for FU4

22.1 Human Health Evaluation for FU4

A baseline RA was conducted at FU4, which covers the largest surface area of all FUs within the Main Installation. Specifically, FU4 consists of Screening Sites 28, 35, 36, 37, 38, 39, 42, 43, 46, 54, 55, 56, 70, 71, 72, 73, 74, 79, 80, 81, and 83 and BRAC Parcels 13, 14, 15, 29, 30, 31, 32, and 33. Several small buildings and three relatively large buildings (Buildings 209, 210, and 835) are present in this FU. There are no RI sites within this FU. A large portion of the Depot's railroad tracks (Site 70) is located within this FU, which will be removed as part of the Depot redevelopment planned for Year 2003 to 2006 (The Pathfinders et al., 1997). The majority of the Depot operations in this FU consisted of open storage yards and areas used for wood pallet preservation treatment with PCP (Sites 42, 43, 46 and 80). The areas of contamination related to PCP use were remediated by excavating soils from the dipping vat, storage tank, and surrounding areas (OHM, 1986). The storage drums of various hazardous and nonhazardous materials were removed and properly disposed of during remediation (OHM, 1986).

The RA was conducted using data collected as part of the BRAC sampling program (from BRAC parcels), and data from the screening site investigations. Data were collected from biased locations within known historical site activity areas to evaluate maximum possible contamination levels within a site and parcel. Once contamination was detected in a sample, the extent of that contamination was further defined in the area around that sample in the next phase of sampling. In general, several surface and subsurface soil samples were collected within each site to assess the nature and extent of chemical distributions. Currently, the FU is not being used. To make the site more accessible for future light industrial uses, the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997) proposes to remove all of the railroad tracks, to build new public access roads, and to demolish buildings in poor condition. The future demolition plan includes removal of most of the small buildings (Buildings 308, 309, 319, 416, 417, T702, 720, 737, 860, 863, 865, and 949) and the two larger warehouses (Buildings 209 and 210). Buildings T702 and 209 were demolished during the period of this report preparation. The only buildings planned to be retained are Buildings 835, 925, and the complex that includes Buildings 753, 754, 755, and 756. The main off-site truck access is a public road planned for the Gate No. 15 area. This public road will be connected with other planned public roads within the Main Installation. Most of Parcel 15 will be used as a parking area and will be landscaped with new ornamental plants. The northeastern corner area warehouse Building 210, will be used as a light industrial facility (The Pathfinders et al., 1997).

As with the other FUs within the Main Installation, a surrogate approach was implemented to conservatively assess potential human health risks. The surrogate approach is used in lieu of an individual RA at each of the identified parcels and sites. The approach was presented in Section 7.1 and Table 7-1. Selection of the surrogate site and the worst-case representative sample point for the future hypothetical residential evaluations was based on exposure units designed according to predicted receptor behavior within an identified area (exposure unit). Three exposure units were identified to represent conservative exposure scenarios. First, the FU-wide exposure unit assumes that a maintenance worker has equal and random access to the entire area within FU4. Therefore, all the data collected in the FU were used to calculate the EPC. Second, maintenance workers and industrial workers were assumed to be exposed to a smaller exposure unit represented by a surrogate site (Site 36). Because Site 36 had the highest PRE ranking, estimating exposure and risk at this site provides a conservative surrogate for maintenance worker or industrial worker exposure at all the other sites within FU4. Finally, a resident was assumed to be exposed to soils from a 0.5-acre lot. This exposure unit was represented by the sample location that generated the highest PRE estimates within FU4. Figure 22-1 presents the various hypothetical exposure units within FU4. The residential scenario is included for comparison purposes only. The PRE results used as the basis for the surrogate site and the highest PRE data-point selection are presented in Appendix E.

RGOs were not calculated for FU4 because there were no risks above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4}, and there were no HQs or HIs above 1.0.

Some discrete areas within FU4 may have unique exposure scenarios that differ from the scenarios quantified in this RA. In an attempt to limit the number of quantified exposure scenarios, yet to ensure a conservative approach, relative exposure levels to several different receptor populations were compared (Appendix F). On the basis of the comparison, the most conservative representative exposure scenario for an industrial setting was used in the risk estimations for FU4.

22.1.1 Selection of COPCs for FU4

As noted previously, data collected from parcels and from the screening sites were used for this RA at FU4. The media of interest are soils (surface and subsurface), sediments, and surface water. Soil COPC selection was based on soil samples collected from the gravel or grass strips along the railroad tracks, warehouses, and grassed areas adjacent to paved roadways or alongside warehouses. COPCs in sediments were selected from samples collected from drainage ditches within FU4. The drainage ditches are dry for most of the year. The surface water and sediment samples were collected during a storm event, and are not representative of normal site conditions. Also, the drainage ditches (Screening Site 54 and part of 55 and 56) are concrete-lined and do not have typical sediment accumulation. Therefore, surface water samples were not included for quantitative RA. Sediments were included for RA, because workers involved in maintenance at FU4 could be exposed to these dry ditch linings.

The soil samples were analyzed for the TCL/TAL compounds in most, but not in all, of the samples. As a result, the number of samples analyzed differed between various chemical groups. The total number of samples included in the RA ranged between 27 to 150 for surface soil samples and 35 to 157 for subsurface soil samples for this FU-wide RA. A total of 11 sediment samples from Sites 54, 55, and 56 were included for RA. The stormwater (surface water) samples were not included in the RA. The soil and sediment data were used to select COPCs to evaluate the current and future industrial worker exposure scenarios.

Section 7.0 provides a description of the COPC selection methodology. The COPCs for FU4 were selected by comparing the detected chemical maximum concentration with background and health-based criteria (RBCs), as presented in Tables 22-1, 22-2, 22-3, and

22-4. Chemicals detected above background and the RBCs were selected as COPCs for surface soil and subsurface soil. The surface and subsurface soil sampling results also were compared with leachability to groundwater-based RBCs. This method of comparison conservatively selects the COPCs. A table showing human health screening criteria by medium and the results of the COPC selection screening is provided in Appendix D.

Dioxins and furans were analyzed in samples collected from soils and sediments from selected sites (Sites 42, 43, 46, 54, 55, 56, and 80) because of PCP use as a wood preservative in railroad ties and wooden pallets. Soils at Sites 42 and 43 were remediated in 1986 (OHM, 1986). TCDD equivalents were detected in all the analyzed samples, as well as in all the background samples. Of the detected dioxins and furans, the higher chlorinated, more persistent hepta- and octa-chlorinated isomers were the most commonly detected of this group of compounds.

COPCs were selected separately for the FU-wide RA, Site 36 (surrogate site), and the single sample point (SS14A) used for the residential RA:

- COPCs for FU4 surface soil include inorganic, PCBs, organo-chlorine pesticides, and SVOCs (including PAHs);
- Surface soil had several inorganic chemicals as COPCs, of which chromium and lead may be associated with the past paint chip area south of Building 949. However, paint chip disposal-related inorganic chemicals, lead and chromium, were not detected in the subsurface soils;
- The SVOCs selected as COPCs in surface soil are PAHs, PCP, and petroleum hydrocarbons;
- The surface soil pesticide/PCB group COPCs are DDE, DDT, dieldrin, chlordanes (alpha/gamma-), Aroclor-1260, and TCDD equivalent;
- Of the CVOCs, 1,1,2,2-Tetrachloroethane is the only COPC in surface soil, and it was detected in subsurface soil also; and
- The COPCs for FU4 subsurface soil included the same ones as surface soil, with the addition of cobalt, 1,2-DCE (total), and TCE.

For conservative assessment of risks during excavation-type exposures, all of the surface soil COPCs were included for subsurface soil, to account for exposure to the excavated soils up to zero- to 10-ft depths by utility or industrial workers. COPCs for FU4 sediment are chromium (total), PAHs, dieldrin, carbazole, PCP, 2-Methylnapthalene, 4-Methylphenol, carbon tetrachloride, methylene chloride, and TCDD equivalent. COPCs for surface soil at data point SS14A evaluated for residential exposure-related risk estimations are benzo(a)anthracene, BaP, chrysene, carbazole, and PCP.

22.1.2 Exposure Assessment for FU4

Regional land use within a 3-mile radius of the Depot is presented on Figure 2-15. Historically, operations in FU4 included open storage of materials in the DRMO yards, wooden pallet preservation treatment and drying, and indoor storage in warehouses. Therefore, environmental samples collected from this medium within FU4 were analyzed for a variety of constituents (such as the TCL/TAL). The areas with historical PCP operations were remediated in 1986, as indicated above.

22.1.2.1 Conceptual Site Model and Fate and Transport Overview

Figure 22-2 presents the exposure CSM for FU4. Each of the components of a CSM are discussed below, including the primary and secondary sources of contamination, primary and secondary release pathways and mechanisms, potential receptors, and routes of exposure.

The primary sources of COPCs in the soil at FU4 are suspected to be historical site operations involving storage of various industrial materials and chemicals, as well as wood treatment and paint chip disposal. As noted in the fate and transport discussion in Section 6.0, primary release mechanisms include historical spills and leaks from storage of chemicals and surface application of pesticides, herbicides, and waste oil. Some of the chemicals detected in the environmental media could be the result of past railroad operations. Thus, soils could become secondary sources of contamination. Over time, surface soils could leach more mobile constituents to subsurface soil and eventually to shallow groundwater if conditions are favorable. "Favorable conditions" include the presence of shallow groundwater under soils that are very porous, high precipitation conditions at the site, and the presence of very mobile chemicals in the open soils. Most of these conditions do not exist at the Main Installation and FU4. The depth to groundwater averages more than 85 ft bgs, with the maximum depth of 132 ft bgs in the northwestern portion (MW-38) to the minimum depth of more than 5 ft bgs. Surficial soils are clayey and relatively impervious and there are no highly mobile organic COPCs.

Other potential migration pathways for contaminants could include surface runoff, suspension of entrained dust particles, and chemical volatilization into ambient air. Most of the COPCs are naturally occurring inorganic chemicals and semivolatile or chlorinated organic constituents. Migration of these chemicals could occur via surface runoff or dust-borne emissions. On the basis of the COPCs identified, volatilization is not an important migration pathway because no significant concentrations of volatile constituents were identified in the soils within FU4.

Low levels of three CVOCs were detected in subsurface soil within FU4, but these are not expected to produce a significant source of chemical vapors in the ambient air. Concentrations were near detection limits in 2 to 8 samples of 208 analyzed. There is a potential for leachability of these constituents. Groundwater underneath the Main Installation has CVOCs, which are addressed as part of FU7. Soils under FU4 were not identified as potential sources of groundwater contamination (see Sections 32.0 through 35.0).

Potential exposure points on-site include areas where human activities or ecological receptor occurrences are likely and could result in physical contact with one or more contaminated media. Most of the FU is inactive, with human activity limited to property maintenance in grass- and gravel-covered areas. The potential for direct human exposure depends on the presence of exposed contaminated soil and the types of activities within the contaminated areas. Direct human exposure is limited by pavement, gravel, and grass cover (see Figure 2-16). Much of the surface area at FU4 is covered by grass, gravel, and asphalt pavement in the roadways. However, for the purposes of this risk evaluation, exposures were assumed to be unlimited. Future exposures were evaluated assuming unrestricted land use. Exposures under a future land use therefore are assumed to be maintenance-related work and industrial and residential activities for the entire FU. Sampling location SS14A is from the northeastern corner of FU4, along the northwestern corner of Building 209. This building was demolished recently. This area is not likely to be used as residential area and thus provides a worst-case scenario for future residents. The utility worker can work anywhere in FU4 and therefore can be exposed to the larger exposure unit. Screening Site 36 was used as a surrogate to evaluate the potential RME to both the industrial and utility workers. These theoretical exposure scenarios were included to evaluate the site under conservative exposure assumptions.

On the basis of the good functional condition of the warehouse buildings in the area and the planned reuse activities described in the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), the site is likely to remain industrial. Future land use plans indicate a need to demolish some of the older buildings to provide adequate parking space for future industrial use. Also, the railroad tracks and associated material will be removed; thus, some of the surface soil sampling locations may be removed and replaced. Potential exposure routes for the maintenance worker include incidental ingestion and dermal contact with surface soil and inhalation of particulate emissions via dust from surface soil. Because of the presence of pavement, concrete, gravel, and grassy land cover over FU4, dust generation is anticipated to be limited.

The ecological receptors of interest are discussed below in the ERA section. The following text identifies the human receptors and the potentially complete exposure pathways.

22.1.2.2 Potentially Exposed Population and Identification of Complete Exposure Pathways

Currently, the warehouses in FU4 are not used and the facility is inactive. Maintenance workers occasionally cut the grass between the warehouses, but this is the only potentially exposed population under current conditions. The overgrowth of the grass and weeds observed in some of the areas during the site visit indicates that the site may not be under a regular maintenance program. However, if the site is to be reused, routine maintenance is likely to resume.

Under foreseeable future conditions, potentially exposed receptors could include maintenance workers, similar to those identified under current land use. The site is not likely to be used for residential land use because of its physical attributes and historical use; in addition, the site conditions indicate that the warehouses and the surrounding Depot property could be used for light industrial purposes that provide economic benefits to the surrounding community. Therefore, current and future potentially exposed populations are likely to be industrial workers.

For conservative risk estimation purposes, future workers are assumed to contact soils around warehouses routinely on a daily basis over a 25-year exposure duration. A general description of activities to be performed by a maintenance worker within the Depot is provided in Section 7.0. On the basis of occupational duties, it is assumed that a maintenance worker spends half-a-day (4 hours) out of an 8-hour workday, once per week (excluding vacation), 50 days per year for 25 years, cutting grass or weeds around the gravel-covered areas. These are conservative assumptions considering the small size of the grass- and gravel-covered surface soil area in FU4. Exposure of these workers is assumed to occur via incidental ingestion of soil (50 mg/day). The skin surface area accessible for dermal exposure is assumed to include the face (1/2 of head area), hands, and forearms. About 4 hours of the 8-hour maintenance workday is assumed to be spent in contaminated areas of FU4, so half of the total incidentally ingested soil is assumed to come from the contaminated soil. Thus, the FI or ET term of the dose estimates is 0.5. The adherence factors used are estimated as documented in Appendix G. Most of the other exposure factors used are default assumptions from the *Exposure Factors Handbook* (EPA, 1997b). Site-specific factors used for EF and ED, as discussed above (½ workday), are based on best professional judgment. The exposure factors and the rationale for their selection are included in tables in Appendix G.

As noted previously, future base redevelopment is expected to focus on light manufacturing and warehouse uses, so site activities are expected to remain industrial. Therefore, future potentially exposed populations are expected to be the same as the current human receptors for the site. However, in the interest of conservatism in risk estimations, it was assumed that the site would be converted to an alternate industrial facility that requires workers to spend more time on-site, with a higher frequency of visits to the contaminated soil areas. This represents the RME scenario for industrial land use. Routes of exposure are identical to those for a maintenance worker, which include incidental ingestion, dermal contact, and inhalation of dust from surface soils. Future industrial worker exposures were assumed to occur from the surface soil and from subsurface soil in the event the Depot undergoes construction or excavation and subsurface soils become surface soils. Thus, a future industrial worker's long-term exposure to subsurface soil was evaluated. Exposure factors used were the default values for industrial workers from the *Exposure Factors Handbook* (EPA, 1997b) and other published sources, as referenced in Appendix G. Under these assumptions, this hypothetical receptor category would represent the maximum or most conservative degree of exposure that would be associated with this site.

Selected areas of the Depot will be landscaped for aesthetic purposes. Such land use alterations could expose landscaping workers to surface soil (zero to 2 ft bgs) via direct contact and inhalation of particulate emissions during future redevelopment activities. This potential future receptor would be expected to have a short ED (1 year or less). Because this scenario results in relatively lower exposure levels compared to those of a maintenance worker, this scenario was not included for quantitation (see Appendix F for relative exposure comparisons).

On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders, et al., 1997), future residential use of FU4 is unlikely. A hypothetical future residential receptor was evaluated in this baseline RA for comparison purposes only. There are no residents within the Main Installation under current land use conditions. The nearest residential areas in the vicinity of FU4 are located to the north along Dunn Road and to the west across Perry Road. The Depot property is separated from surrounding areas by a chain-link fence, which limits access to off-site residents. Thus, there are no direct exposure pathways for the off-site residents to the on-site contamination. The only potentially complete exposure pathway for off-site residents is inhalation of particulate emissions (dust) from on-site surface soil. The potential for exposure of off-site residents is considered negligible, because there are no dust-generating activities within on-site areas, and contamination is limited to COPCs that are detected everywhere else within the Main Installation. The off-site dust inhalation exposures are likely to be lower than the on-site dust inhalation scenarios because of the dilution and attenuation processes natural to the airborne dust. Thus, the on-site residential scenario is assumed to conservatively represent an off-site resident's exposure.

The on-site hypothetical residential scenario evaluated the ingestion, dermal, and inhalation pathways. Hypothetical exposure units are presented on Figure 22-1. Table 22-5 summarizes potential current and future exposure pathways for FU4 and identifies the pathways that were evaluated quantitatively in this RA. Under these assumed conditions for exposure under current and future land use, the receptor groups considered in deriving estimates of exposure and health risk for FU4 were as follows:

- Current on-site maintenance worker;
- Hypothetical future on-site commercial or industrial worker; and
- Hypothetical future on-site resident–adult and child (for comparison purposes only).

A description of the UCL 95% calculation is provided in Appendix H. The EPCs were the estimated UCL 95% concentrations for surface soils, subsurface soils, and sediments. EPCs for a maintenance worker and a future industrial worker are either the UCL 95% estimates or maximum detects for the COPCs detected in the surface soil. All of the sediment COPCs defaulted to the maximum concentration despite the relatively large number of samples in the data sets, because of data distributions that do not fit normal or lognormal distribution curves. Therefore, the risk estimates are overly conservative for the sediment medium, because the entire ditch system was assumed to be covered with maximum contaminant levels. The sampling results indicate that most contamination in the areas of the ditches is at lower concentrations. The EPCs for subsurface soil for the UCL 95% were estimated by combining samples collected from zero- to 10-ft depths (assuming future soil conditions if surface and subsurface soils are mixed during construction and excavation activities).

The EPCs for the future residential scenario are the maximum PRE sampling location concentrations for all chemicals detected in that particular sample (sample SS14A). The estimated EPCs are listed in Tables 22-6, 22-7, 22-8, and 22-9. The dose (intake) was estimated for each of the complete exposure pathways (see Appendix I).

22.1.3 Toxicity Assessment for FU4

Table 22-10 presents the toxicity factors for COPCs and the WoE classifications for each Detailed information about the basis for toxicity classification and the uncertainty associated with the listed toxicity factors based on the EPA toxicity database are listed in the master toxicity tables located in Section 7.0, Tables 7-7 and 7-8.

The detected carcinogenic chemicals in site soils and sediments were Class A, B2, or C carcinogens (see Table 30-8). Oral CSFs are available for 17 of the COPCs, and inhalation CSFs are available for 15 of the COPCs. The individual CSFs for the PAHs were derived using the TEF compared to the BaP CSF. TEFs are provided in Table 7-9. The oral RfD values are available for 15 of the COPCs. The inhalation RfD values are available for six COPCs. Oral toxicity factors were adjusted by the gastrointestinal ABS_{GI} factors for comparisons with dermal intake estimates. These values were presented in Table 7-10.

Lead was detected in soils at a maximum concentration of 2,800 mg/kg and a mean concentration of 153 mg/kg. There is no toxicity factor for lead. Therefore, it is compared with a target concentration calculated for the protection of workers in the risk characterization subsection below.

22.1.4 Risk Characterization for FU4

Section 7.0 describes the methodology used to calculate risks and HIs and Appendix I provides the actual risk and HI calculations for FU4. Carcinogenic risks and noncarcinogenic HI results from Appendix I are summarized in Table 22-11. A set of histograms of the risks and HIs is presented on Figures 22-3 and 22-4. FU4 was evaluated as one exposure unit. Workers and residents were assumed to have uniform exposures, and the EPCs were assumed to be present over the entire surface area of the FU. These are conservative assumptions, because most soil is covered with gravel and requires limited maintenance work (see Figures 2-16 and 22-1), thus reducing direct contact with soil.

The ELCR from surface soil to a maintenance worker at FU4 is estimated at 3 x 10^{-6}, primarily because of TCDD. The carcinogenic risks are within the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}). However, the exposure assumptions used are considered to be overly conservative for a maintenance worker's exposure to surface soils at this site. The noncarcinogenic HI for the maintenance worker is estimated at 0.01, which is below the target value of 1.0. Both carcinogenic and noncarcinogenic risk estimates are within the acceptable limits. Thus, maintenance worker exposure to the site soils is not a concern, given that the risks and HIs are within acceptable limits. The estimated ELCR to a maintenance worker from drainage ditch sediments is 4 x 10^{-6}. The cancer risks in sediment were from BaP. The ELCR for sediment is within the acceptable risk range of 10^{-6} to 10^{-4}. The noncarcinogenic hazard is 0.001 for sediment exposure, which is below the acceptable threshold of 1.0

Combined risks from soil and sediment exposure pathways for the maintenance worker resulted in a total ELCR of 7 x 10^{-6} and a total HI of 0.01. The cumulative surface media exposure is within the acceptable limits.

The estimated ELCR to an industrial worker from surface soil is 3 x 10^{-5} and subsurface soil mixed with surface soil presents an ELCR of 3x 10^{-5}, both of which are within the acceptable risk range of 10^{-6} to 10^{-4}. However, the exposure assumptions used are considered to be overly conservative for a maintenance worker's exposure to surface soils at this site. Cancer risks were due to arsenic, dieldrin, and Aroclor-1260 for both surface and subsurface soil estimates. The noncarcinogenic hazards from surface soil and from the soil column (surface and subsurface together) are 0.1 and 0.08, respectively, both of which are below the target value of 1.0. Thus, the FU4 soils do not pose a health threat to future industrial workers, despite the conservative exposure assumptions used.

The estimated ELCR to an industrial worker from drainage ditch sediments is 1 x 10^{-5}. Cancer risks in sediment were due to TCDD and PAHs. The ELCR for sediment is within the acceptable risk limit range of 10^{-6} to 10^{-4}. The noncarcinogenic hazard is 0.003 for sediment exposure, which is below the target value of 1.0.

Combined risks from soil and sediment exposure pathways for the industrial worker resulted in a total ELCR of 4 x 10^{-5} and a total HI of 0.1. The cumulative surface media exposure is within the acceptable limits.

The single point (sample SS14A) specific risk estimate for the hypothetical future residential receptor resulted in an ELCR of 3 x 10^{-5}. Cancer risks were within the acceptable risk range of 10^{-6} to 10^{-4}. Noncarcinogenic hazards were below the standard of 1.0 for both adult and child receptors. This hypothetical worst-case scenario is included for comparison purposes only, because the site is unlikely to be used for residential purposes. The inhalation risks for an on-site hypothetical resident are estimated to be 1.9 x 10^{-10} (see Appendix I, Table I5-4b), which is below 1 in a million. Thus, extrapolating this risk to an off-site resident who is likely to receive average concentrations of the attenuated dust, the risks are likely to be much lower. Thus, there are no health concerns for off-site residents from exposures to on-site contamination at FU4.

22.1.4.1 Combined Risks with Groundwater at FU4

There are currently no groundwater exposures for these receptors and none are likely in the foreseeable future because of the established water use patterns in the area and the fact that residents are provided with water from the public water supply system. However, a plume of low-level chlorinated solvents is present in the groundwater under FU4. Groundwater wells identified in the vicinity of FU4 have been associated with Plume C (see Section 34.0). Risk estimates of the combined inorganic and average organic concentrations for Plume C are detailed in Section 34.0 (Table 34-5).

The hypothetical cumulative risks from groundwater and all other media combined within FU4 for industrial workers and residential adults and children are presented in Table 22-12 and in Appendix I. This cumulative summary merges the average organic concentrations from Plume C, the site-wide inorganic groundwater results, and FU4 soils and sediment results. An industrial worker exposed to site soils, sediments, and groundwater simultaneously may have a total ELCR of 5 x 10^{-5} and total HI of 0.6, for the combined exposure routes. These results indicate that, despite the conservative assumptions used, risks are within the acceptable limits for a future worker. The total ELCR is 1 x 10^{-4} and the total HI is 1.0 for the future hypothetical residential adult for the combined pathways. The total ELCR is 5 x 10^{-5} and the total HI is 3.0 for the future hypothetical residential child for the combined pathways. Most of the risks were from groundwater, which also were addressed as part of Section 34.0. The residential scenario is included for comparison purposes, although the site is unlikely to be used for residential purposes and, even if it were, water probably would be supplied from a public system. The groundwater at the Depot is recognized to flow to the center of the site into a central trough, and thus, direct downgradient migration to off-site areas is not a concern (see Sections 32.0 through 35.0). The groundwater currently is not being used.

The site-specific risk evaluations under current land use conditions do not present excess risks or HIs. Future potential use of FU4 for industrial purposes does not pose a human health risk concern. Therefore, RGOs were not developed for FU4 because industrial worker risks were not excessive.

22.1.4.2 Lead in FU4 Soils

Lead was detected in all 150 surface soil samples and in 156 out of 157 subsurface soil samples. The range of concentrations in surface soil samples was 5 mg/kg to 2,800 mg/kg. The highest detected concentrations were associated with Building 949 in the southwestern corner of FU4, where former paint stripping operations wastes were disposed. Lead in subsurface soils ranged between 1.8 and 38.4 mg/kg, compared to a background value of 23.9 mg/kg. The subsurface soils do not appear to have lead at elevated levels.

The target concentration estimated using TRW's adult lead model (EPA, 1996) was 1,530 mg/kg, which is protective of a worker (see Table 7-16). The maximum detected concentration in the surface soil is slightly above this target level; however, the mean concentration is below the target lead concentration.

Lead was not detected above background levels in the drainage, indicating that off-site migration is not occurring.

22.1.4.3 Uncertainty Analysis

Section 7.0 presents the general concepts and sources of uncertainty at a given site. The following are some of the major points pertaining to FU4.

Constituents of Potential Concern. Data were collected from 1996 to 1998. Many of the COPCs such as PAHs and metals also were detected in background soils. Several of the PAHs were detected at higher concentrations along the railroad tracks within the Depot. Site operations at several of the sites did not involve PAHs as potential source constituents. Pesticides and waste oils tainted with PCB (Aroclor-1260) were not used in the storage-related operations; however, they were applied during routine maintenance of the storage facilities and are not directly related to the site operations. Likewise, site-wide statistical evaluations indicate that the contaminants were distributed similarly in the background samples. Some of the inorganic COPCs were selected based on their exceedances of the GWP criteria. These chemicals are not a direct exposure concern. However, their inclusion contributes to the conservatism of the risk estimation.

The majority of the contamination (PAHs and PCP) is associated with the railroad tracks distributed abundantly across FU4. The future redevelopment plans probably will remove these tracks. Some of the highest contamination data points may not exist after removal of the railroad tracks and ties.

Subsurface soil organic COPCs are the same as those for surface soil, although most of the organic chemicals were not detected in the soils below 1 ft within FU4. Surface soils in this data set were defined as zero to 2 ft, whereas deeper soil was evaluated from zero to 10 ft. EPA defines a surface soil as being in the zero- to 1-ft range. Most of the contaminants at this site have been located in the first 6 inches of the soil. Therefore, there is some added uncertainty in the actual concentration of contaminants evaluated because the 2-ft interval was analyzed.

Exposure Assessment. There are no exposures under current conditions. Most of the area within FU4 is paved or covered with gravel or grass. Some of the samples collected were from paved areas, which were assumed to be readily available for exposure. There are no human receptors in FU4, as mentioned previously. This site is highly unlikely to be used for residential purposes without significant structural changes to the existing warehouse buildings. Future land use plans for the Depot include various small industrial uses; thus, land use is likely to remain industrial/commercial. Under future land use, also, indoor warehouse workers would rarely come into contact with the grass strips around the warehouses. Much of the direct exposure would be limited because of the presence of paved roads and walkways around the buildings. Utility and future industrial worker

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exposure to subsurface soil that might become surface soil is a conservative risk estimation scenario.

Most of the quantitative exposure values such as EF and ED are assumed values, and the true likely exposure of a receptor is not known. Most of the site-related uncertainty within the RAs is attributable to this exposure quantitation step.

Toxicity Assessment. The toxicity criteria used are those recommended by EPA through the toxicity databases; therefore, the uncertainty associated with the toxicity factors is predetermined by the methods used and the studies selected by EPA in calculating these toxicity factors. The quantitative UFs associated with toxicity factors are included in the master toxicity factors tables (Section 7.0, Tables 7-7 and 7-8). Some of the primary sources of uncertainty are listed there. Most of the toxicity factors are based on studies from animals extrapolated to humans using arbitrary assumptions (UF, or MF), which introduces a major uncertainty. In extrapolating from carcinogenic dose for the slope factor estimation, no threshold for toxicity is assumed. Some of the metal toxicity factors are based on evidence of toxicity from occupational exposures (chromium) involving a high level of exposures to fumes and airborne particles. The applicability of data from high occupational exposures to relatively low environmental exposures adds uncertainty to the RA and probably produces overestimates of risk.

Risk Characterization. As noted previously, the risks and hazards estimated in this assessment are conservative. Several scenarios were evaluated to simulate possible alternative future land uses for FU4. The fact that samples were collected from biased locations within suspected past activity and spill areas near warehouses adds to the conservatism of the estimates. As a result, the areas represented by each sample in the combined assessment at the FU4 level represent the areas of highest contamination within the site and FU4.

22.1.4.4 Remedial Goal Options

RGOs were not calculated for any of the surface media for industrial exposure at the site. Exposure of a worker under current land use conditions did not result in excessive risks associated with the soils and other surface media. The estimations of industrial worker exposure also were within the acceptable risk limits. However, there were some risks at the acceptable boundaries for residential exposure. There are no human health protection-based ARARs for soils. A general list of RGOs for some of the primary COPCs detected across the Depot is included in Section 7.0. The target lead concentration based on the industrial worker exposure is estimated to be 1,530 mg/kg (Section 7.0, Table 7-17).

RGOs are developed only for the chemicals that are either detected at the site at concentrations above the applicable state or federal standards or that present risks or HIs above the acceptable levels. "Acceptable" risks are defined as risk levels below 100 in one million (10^{-4}) or an HI below 1.0, for either current or future exposure pathways analyzed in the RA. The risk evaluations under future land use conditions included potential exposures of maintenance, industrial, and utility workers within FU4 based on activities observed to be applicable to the site. Hypothetical future scenarios included residential land use.

The groundwater within the area is addressed as part of the groundwater FU (see Section 34.0). The site groundwater currently is not used in the Depot. Shallow

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groundwater does not qualify for potable use. However, because the shallow aquifer is contaminated with CVOCs (Sections 32.0, 33.0, and 34.0), it is unfit for potable use. However, such a use is highly unlikely for several reasons related to poor yield, set water use patterns in the area, flow to the center of the property, degradation and attenuation before off-site release, and lack of groundwater use in the area.

22.2 Environmental Evaluation for FU4

22.2.1 Introduction

An ERA was conducted at FU4, the Northern and Central Open Areas, to evaluate whether contaminants detected in surface soil, surface water, and sediment potentially pose adverse ecological effects to terrestrial or aquatic receptors. FU4 is a large (approximately 200-acre) area (see Figure 20-1) that consists primarily of open storage areas lined with gravel or asphalt; railroad tracks; and administrative, maintenance, and general purpose warehouse buildings. FU4 is entirely industrialized and contains a few mowed grass areas among the railroad tracks and gravel areas that provide little, if any, ecological habitat for plants or animals. There are no water bodies on-site; however, drainage swales, which direct stormwater to the perimeter of the facility, contain water only during occasional storm events. The current land use in this FU is expected to remain unchanged in the future. EPA ERA guidance (EPA, 1997d) recommends a screening level ERA for risk management decisions. Although FU4 does not provide significant habitat, a screening level ERA was initiated to aid in risk management decisions.

This ERA was conducted in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (*Process Document*)(EPA, 1997d). Steps 1, 2, and 3 of the EPA ERA model were completed, as summarized in Section 7.8.

22.2.1.1 Step 1: Screening Level Problem Formulation and Effects Evaluation

This is the initial step in the ERA and includes all of the elements of a problem formulation and ecological effects analysis, but on a screening level. The results of this step support the exposure estimates and risk calculation in Step 2.

Environmental Setting and Contaminants at the Site. The environmental setting at the Depot is described in Section 2.0. An ecological assessment checklist was completed as described in the *Process Document* (EPA, 1997d) and is provided in Appendix S. Site characteristics most relevant to the ERA are discussed here.

Most of the land cover within FU4 consists of open storage areas lined with gravel or asphalt; railroad tracks; and administrative, maintenance, and general purpose warehouse buildings. The western half of this FU was used primarily for open storage of steel, PVC pipe, miscellaneous nonhazardous materials, petroleum products, equipment, transformers, and drums that stored flammables. Four large warehouses also are located in the western half of this FU and were used to store flammables and hazardous materials such as reactives, oxidizers, corrosives, pesticides, and others.

The FU overall is relatively flat with large expanses of gravel, pavement, routinely mowed grass areas, and a few warehouses and buildings. The entire area is interspersed with railroad tracks that were used to transport stored materials. A perimeter fence is located along the northern, western, and eastern sides, beyond which are dense residential areas. Along the southern side of FU4 are the industrialized areas of FUs3, 5, and 6. Typically, dry stormwater swales and ditches occur throughout the area and stormwater is discharged primarily through Outfall 005 along the western perimeter.

Potentially occurring terrestrial wildlife may include urban-adapted birds such as sparrows, rock doves, grackles, and mockingbirds, and small mammals such as mice, rats, and shrews. The stormwater ditches and swales do not provide suitable habitat for aquatic plant or animal species. Overall, there is no suitable ecological habitat within or near this FU.

The media sampled at FU4 to which ecological receptors could be exposed included surface soil, surface water, and sediment, and these are therefore evaluated in this ERA. A list of media COPCs at FU4 is provided in Section 22.1.1.

Contaminant Fate and Transport. An overview of contaminant fate and transport of chemicals detected at FU4 is provided in Section 21.0 and is not repeated here.

Complete Exposure Pathways. For a pathway to be complete, a contaminant must travel from the source medium or media to an ecological receptor and be taken up by the receptor via one or more exposure routes. Although ecological habitats are minimal at FU4, a conservative assumption was made that a potentially complete exposure pathway may exist for direct contact of terrestrial plants and invertebrates with contaminants detected in surface soil, and direct contact of surface water and sediment to aquatic species

Assessment and Measurement Endpoints. Assessment endpoints are expressions of the environmental value(s) to be protected. The assessment endpoint for FU4 is to sustain soil, surface water, and sediment quality and to achieve COPC concentrations that are below adverse effect thresholds for terrestrial plants and soil invertebrates, and aquatic fish and invertebrates. Measurement endpoints are measurable ecological characteristics of the assessment endpoint. In this screening level evaluation, the measurement endpoint is the ratio of maximum media concentrations to conservative screening level benchmarks for these media. An exceedance of COPC concentrations compared to the benchmarks would be a "measure" of a potential effect. If an exceedance occurs, it can be inferred that a possible adverse effect may occur to exposed ecological receptors.

Screening Level Ecological Effects Evaluation. Conservative thresholds for adverse ecological effects, or screening ecotoxicity values, were used for contaminants detected in surface soil, surface water, and sediment. These values were determined as follows:

- **Surface Soil:** The soil ecological screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from a variety of sources, including the USFWS, the ORNL, the Canadian Council of Ministers of the Environment, the Netherlands Ministry of Housing, and the RIVM;
- **Surface Water.** The surface water ecotoxicity screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from *EPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Freshwater Surface Water Screening Values for Hazardous Waste Sites* (EPA, 1995b); and

- **Sediment.** The sediment ecotoxicity screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from *EPA Region 4 Supplemental Guidance to RAGS: Region 4 Bulletins, Sediment Screening Values for Hazardous Waste Sites* (EPA, 1995c).

The screening ecotoxicity values are shown in Table 7-14.

Uncertainty Assessment. Uncertainty is inherent in each step of the ERA. The following text presents major factors contributing to uncertainty in this assessment.

EPCs were assumed to be maximum media concentrations. This is a highly conservative assumption that may overestimate risk. Under this assumption, the receptor spends 100 percent of its life cycle at the highest concentration area; although this can be true for plants, most terrestrial wildlife and aquatic receptors are mobile and can be exposed to the complete range of soil concentrations.

The ecological screening values used were obtained from various sources in the literature and may not be representative of actual site conditions. Exposure pathways to terrestrial plants and animals were assumed to be potentially complete, even though the maintained grass- and gravel-covered areas provide low-quality habitat in this generally disturbed and industrial setting.

22.2.1.2 Step 2: Screening Level Exposure Estimate and Risk Calculation

This step includes estimating exposure levels and screening for ecological risks as the last two phases of the screening level ERA. At the end of Step 2, an SMDP will be made to evaluate whether ecological risks are negligible or whether further evaluation is warranted.

Screening Level Exposure Estimate. The maximum concentration of all chemicals detected in surface soil, surface water, and sediment at FU4 was used as the EPC for estimating risk to directly exposed organisms.

Screening Level Risk Characterization. The quantitative screening level risk estimate was conducted using the HQ approach. This approach divides the EPCs (maximum detected media value) by the EPA screening ecotoxicity values.

Tables 22-13, 22-14, and 22-15 summarize the results of the surface soil, surface water, and sediment screening level risk calculations. These tables provide information about the FOD, range of detection, selected ecotoxicity values, and HQs based on comparison of the maximum concentration to the criteria. An HQ less than 1.0 indicates that the contaminant is unlikely to cause adverse effects, and it was therefore not considered further in the ERA. Contaminants with HQs greater than or equal to 1.0, or contaminants for which criteria were not available, were identified as COPCs and were carried forward to Step 3.

Surface Soil Screening Results–A total of 17 inorganic and 41 organic compounds were identified as COPCs in surface soil. No screening criteria were available for 10 of the compounds.

Surface Water Screening Results–A total of 11 inorganic and 10 organic compounds were identified as COPCs in surface soil. No screening criteria were available for 9 of the compounds.

Sediment Screening Results–A total of 16 inorganic and 47 organic compounds were identified as COPCs in surface soil. No screening criteria were available for 35 of the compounds.

Scientific Management Decision Point. The information indicates a potential for adverse ecological effects in all media, and a more thorough assessment is warranted. The identified COPCs are to be carried forward to Step 3.

22.2.1.3 Step 3: Baseline Risk Assessment Problem Formulation

Step 3 refines the problem formulation developed in the screening level assessment. In this step, the results of the screening level assessment and additional site-specific information are used to evaluate the scope and goals of the baseline ERA.

Refinement of COPCs. In Steps 1 and 2, conservative assumptions were used. As a result, some of the COPCs were retained for Step 3, although they may pose only negligible risk Therefore, in the first phase of Step 3, the assumptions used were further evaluated and other site-specific information was considered to refine the list of COPCs. In this refinement phase, the revised assumptions and site-specific considerations used were as follows:

- Arithmetic mean contaminant concentrations were considered, along with maximum concentrations when a comparison to the benchmarks was conducted;
- Arithmetic mean and maximum values were compared to background concentrations,
- Contaminant concentrations were compared to background values;
- The FOD was considered; and
- Less conservative screening ecotoxicity values were considered in addition to the more conservative ecotoxicity screening values used in Step 2.

For soil, less conservative screening ecotoxicity values are termed "secondary benchmarks" in this report. The secondary benchmark selection process for soil focused on identifying the next highest benchmark value among the soil literature references used by EPA Region IV (1998). This was a stepwise process in which the first set of toxicological benchmarks considered was from two ORNL studies (Efroymson et al., 1997). These studies established separate screening benchmarks for soil microorganisms, earthworms, and plants. A secondary screening value was chosen from these three data sets that was the next highest value above the primary EPA Region IV screening value. If no values were available, the selection process proceeded to the Netherlands values (MHSPE, 1994). In addition, if the selected value from ORNL was found to be greater than the highest Netherlands value, then the ORNL value was rejected and the process moved forward to the Netherlands values as a conservative measure.

The Netherlands values included optimum values and action values. When this set of data was considered, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark. If a value was not available, the process proceeded to a final set of data as compiled by the USFWS (Beyer, 1990). The values in this data set represent Dutch background, moderate contamination, and cleanup values. As stated above, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark.

For surface water COPC refinement, acute screening values, as identified by EPA Region IV (1998), were used as the less conservative screening criteria for Step 3.

For sediment, EPA Region IV (1998) had used conservative TELs or ERL values for the initial screening; therefore, the values chosen for this Step 3 refinement were the less conservative PELs and ERM. The lowest of these two literature values was used in Step 3.

In Step 3, the conservative ecological exposure pathways used in Step 2 also were reevaluated based on actual site conditions. All of this information provides a WoE to evaluate which, if any, contaminants should be recommended for further evaluation in a baseline ERA.

The results of the Step 3 refinement of the COPC lists are summarized in Tables 2-10, 2-11, and 2-12. These tables present the maximum and average EPCs, background concentrations, conservative/primary and less conservative/secondary screening criteria, range of HQs, background comparisons, and FOD.

Surface Soil COPC Refinement Results–On the basis of the weight of evidence presented in Table 22-16, a few of the inorganic and many organic COPCs indicated a potential for adverse effects. These included chromium, selenium, zinc, dieldrin, and Aroclor-1260. These are contaminants for which all HQs were at or above 1.0 and also were above background in all comparisons. Many of the contaminants could be removed from further consideration as a result of some HQs being near or less than 1.0, being less than background, or having an FOD at 5 percent or below. Surface soil criteria for a total of seven contaminants were not available for comparison, so HQs could not be determined; however, three of these contaminants were compared to available background concentrations.

The key consideration in this refinement step is the lack of ecological exposure pathways at FU4. As previously discussed, the screening process in Steps 1 and 2 was conducted as a conservative measure, given that EPA guidance recommends minimal or no risk management considerations in a screening level ERA. FU4 is entirely an industrial area, and this land use is expected to continue into the future. The on-site habitat is limited to a few large mowed grassy areas adjacent to gravel lots and roadways. There are no on-site or near-site natural habitats that could support significant populations of terrestrial wildlife. Given the industrial nature of FU4, and the lack of suitable on-site habitats, ecological effects are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

Surface Water COPC Refinement Results–On the basis of the WoE presented in Table 22-17, none of the inorganic or organic COPCs indicated a significant potential for adverse effects on aquatic organisms. This conclusion was based on an evaluation of the range of HQs, comparison to background, and FOD.

The stormwater swales and ditches sampled within FU4 do not provide suitable habitat for aquatic species. The sampled areas are typically dry throughout the year and only contain substantial water during rain events. Therefore, aquatic ecological effects are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

Sediment COPC Refinement Results–On the basis of on the WoE presented in Table 22-18, several of the organic COPCs indicated a potential for adverse effects to aquatic benthic organisms. These included alpha-chlordane, DDD, DDT, dieldrin, and several PAHs. These are contaminants for which all HQs were at or above 1.0 and also were above background in all comparisons. Many of the contaminants could be removed from further consideration as a result of some HQs being near or less than 1.0, being less than background, or having an FOD at 5 percent or below. Sediment criteria for a total of 36 contaminants were not available for comparison, so HQs could not be determined.

As described in the surface water results section, stormwater swales and ditches sampled within FU4 do not provide suitable habitat for aquatic species; therefore, benthic organisms are not likely to be exposed to sediment contaminants. Therefore, ecological effects on benthic organisms are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

Scientific Management Decision Point. Although a few COPCs were identified in surface soil and sediment in the Step 3 refinement phase, the lack of complete ecological exposure pathways at FU4 indicates that current and future ecological effects are negligible. Therefore, no further assessment of ecological risk associated with contaminants at FU4 is warranted.

22.3 Human Health Evaluation for Screening Site 36

Screening Site 36 was selected as the surrogate site for FU4 because it resulted in one of the highest human health risk ratios during the PRE (see Appendix E). This site was selected based on PRE ratio estimates that result in risk, and HI ratios. The risks identified were primarily due to PAHs in surface soils at this site. Screening Site 36 is a past storage area consisting of the eastern half of the concrete pad. The storage pad is part of the DRMO Hazardous Waste Storage Area, measuring 300 ft by 60 ft, and the pad is located in the northern portion of FU4. Hazardous wastes were stored in this area until shipment to a licensed hazardous waste disposal facility (CH2M HILL, 1998a). There are no materials currently stored in this area; therefore, the current investigation focus is to evaluate possible past spills and the potential effects on the environmental media.

22.3.1 Selection of COPCs for Screening Site 36

Twenty-three surface soil samples (zero- to 1-ft deep) were included for analysis of SVOCs, and 24 samples were analyzed for inorganic chemicals. A total of 42 subsurface soil samples were analyzed for organic and inorganic chemical groups at Screening Site 36. The maximum detected chemical concentration within this data group was compared against background concentrations and the RBCs for direct exposure, as well as groundwater protection concentrations (SSLs). The subsurface soil (greater than 1 to 10 ft) maximum detected concentrations were compared with the background concentrations and SSL criteria for COPC selection.

The COPC selection indicated that surface soils at the site had antimony, arsenic, selenium, dieldrin, PCP, and 1,1,2,2-Tetrachloroethane exceeding the background levels and comparison criteria (see Table 22-19). The PRE indicates PAHs, pesticides, and metals as the primary risk drivers (Appendix E) in surface soil. In the deep soil samples group for utility worker exposure evaluations, soils from zero to 10 ft are included. The subsurface soils (greater than 1 ft to water) (see Table 22-20) had antimony, arsenic, chromium (total), copper, selenium, dieldrin, PCP, 1,2-DCE (total), TCE, and 1,1,2,2-Tetrachloroethane that were selected as COPCs. However, the chemicals selected as COPCs for subsurface soil include the same compounds that were selected for surface soil.

22.3.2 Exposure Assessment for Screening Site 36

Figure 22-1 depicts the site and its relative location within FU4. Screening Site 36 is located in Parcel 15, in the northeastern part of FU4, along B Street. Screening Site 36 is an old storage pad for hazardous waste drum storage and consists of a concrete pad. It also is located adjacent to a major railroad confluence area in the center of the Main Installation. Figure 22-5 presents the exposure CSM for Screening Site 36.

22.3.3 Potentially Exposed Human Population and Identification of Potentially Complete Exposure Pathways

Site 36 has been inactive since the closure of the Depot. There are no potentially exposed populations under the current conditions specific to this site. Maintenance workers performing periodic weed control and other maintenance-related activities could be present for limited periods of time. Maintenance worker exposure at Site 36 was not quantitatively evaluated because of the small area of the site. A maintenance worker exposure scenario was quantified for FU4, including Site 36 data. Other potential receptors evaluated qualitatively for surface soil exposure at this site were landscapers.

Potentially exposed populations under future land use are unknown at this time. On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), it is likely that the area around Site 36 will be used in the future for light industrial or commercial operations, and Site 36 may become part of the future planned parking area. Under such a scenario, direct exposure to the site soils will be eliminated because of the presence of impervious asphalt. However, a future direct exposure to the site media is assumed to future industrial workers. Future residential use of this site is highly unlikely, because of its location within a highly industrial area, and future redevelopment plans include conversion of the site into commercial use facility. However, hypothetical future residential exposures were evaluated for comparison purposes as a worst-case scenario for FU4. A detailed list of exposure factors and the rationale for their selection are included in tables in Appendix G.

Subsurface soils were evaluated for direct exposure of a future utility worker and an industrial worker. These scenarios are based on the assumption that, in the future, if the contaminated subsurface soil (zero to 10 ft bgs) is disturbed (for installation or maintenance of underground utilities), exposure to contaminated subsurface soil for utility workers or future industrial workers in the area could become a complete pathway. A summary of exposure pathways for Screening Site 36 is included in Table 22-21.

A UCL 95% concentration was estimated for EPC for surface soil (zero to 1 ft) and subsurface (zero to 10 ft) data for the COPCs identified. The EPCs for surface and subsurface soil data sets were selected from the lognormal distributions. These values are listed in Tables 22-22 and 22-23, and the estimation methodology is described in Appendix H. The dose (intake) was estimated for each of the complete exposure pathways. The dose estimates are included in Appendix I.

22.3.3.1 Toxicity Assessment for Screening Site 36

The COPCs for Screening Site 36 are a subset of those previously listed in the FU4 RA section (Section 22.1.1). Table 22-10 includes the toxicity factors for the COPCs identified at Screening Site 36.

22.3.3.2 Risk Characterization for Screening Site 36

The carcinogenic risks and noncarcinogenic HIs are summarized in Table 22-24. A set of histograms is included on Figures 22-6 and 22-7. The ELCRs and HIs were estimated for a future industrial worker and utility worker.

The carcinogenic risks for industrial worker exposures to Site 36 surface soil resulted in estimated risks of 8 x 10^{-6} and a noncarcinogenic HI of 0.06. The carcinogenic risks are from arsenic and dieldrin. The carcinogenic risks for exposures to Site 36 subsurface soil resulted in estimated risks of 6 x 10^{-6} and a noncarcinogenic HI of 0.05. The carcinogenic risks are primarily from arsenic. Because deep soils include surface and subsurface soils, the risks are not additive. Thus, total risks are the higher of the two sets of risks estimated for the industrial worker. This worker scenario conservatively assumes a full workday exposure, 250 days per year, for an exposure period of 25 years. The resulting risks are within the acceptable range for cancer risks of 1 to 100 in one million and below the target HI of 1.0. Thus, the overall Screening Site 36 soils do not pose a health threat to future industrial workers.

Exposures of a utility worker assume exposure to the soil column that includes surface and subsurface soil mixed during excavation. Exposure to the utility worker resulted in an ELCR of 7 x 10^{-7} and noncarcinogenic HI of 0.006. Both carcinogenic and noncarcinogenic health risks are below the acceptable limits of 10^{-6} to 10^{-4} and 1.0, respectively. Thus, excavation-types of activities do not pose health threats to these site workers.

Uncertainties associated with this RA are similar to those listed in the FU4 RA section (Section 22.1.4). RGOs were not calculated for the industrial worker at Screening Site 36 because the risks were not excessive.

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TABLE 22-1

Constituents of Potential Concern in FU4 - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
4	SS	MG/KG	1,1,2,2-TETRACHLOROETHANE	105	3	0.01	0.025	0.004	0.007	0.0053		3.2	0.003	Yes	A
4	SS	MG/KG	ALPHA-CHLORDANE	108	22	0.0018	0.78	0.00075	3.4	0.18	0.029	1.8		Yes	A
4	SS	MG/KG	ALUMINUM	43	43	0.85	28	674	27600	8896	23810	7800		Yes	A
4	SS	MG/KG	ANTIMONY	147	46	0.18	10	0.37	27.5	4	7	3.1	5	Yes	A
4	SS	MG/KG	ARSENIC	150	147	0.14	3.3	1.1	66.3	13	20	0.43	29	Yes	A
4	SS	MG/KG	BENZO(a)ANTHRACENE	129	47	0.057	6.2	0.037	6.6	0.64	0.71	0.87	2	Yes	A
4	SS	MG/KG	BENZO(a)PYRENE	129	49	0.057	6.2	0.04	6.3	0.60	0.96	0.087	8	Yes	A
4	SS	MG/KG	BENZO(b)FLUORANTHENE	129	50	0.057	6.2	0.048	6.4	0.59	0.9	0.87	5	Yes	A
4	SS	MG/KG	CARBAZOLE	99	12	0.34	2.2	0.035	1.8	0.44	0.067	32	0.6	Yes	A
4	SS	MG/KG	CHROMIUM, TOTAL	150	150	0.036	3.3	5	4385	93	24.8	10800	38	Yes	A
4	SS	MG/KG	CHRYSENE	129	50	0.057	6.2	0.045	7.1	0.69	0.94	87	160	Yes	G
4	SS	MG/KG	COPPER	150	150	0.1	3.3	1.4	1400	35	33.5	310		Yes	A
4	SS	MG/KG	DDE	108	34	0.0034	1.5	0.0013	3	0.23	0.16	1.9	54	Yes	A
4	SS	MG/KG	DDT	108	48	0.0034	1.5	0.0024	13	0.48	0.074	1.9	11	Yes	A
4	SS	MG/KG	DIBENZ(a,h)ANTHRACENE	129	7	0.057	6.2	0.046	0.87	0.241	0.26	0.087	2	Yes	A
4	SS	MG/KG	DIELDRIN	108	44	0.0034	1.5	0.0012	5.6	0.57	0.086	0.04	0.004	Yes	A
4	SS	MG/KG	GAMMA-CHLORDANE	108	22	0.0018	0.78	0.00097	3.3	0.18	0.026	1.8		Yes	A
4	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	129	37	0.057	6.2	0.042	4.1	0.53	0.7	0.87	14	Yes	A
4	SS	MG/KG	LEAD	150	150	0.11	6.5	5	2800	153	30	400		Yes	A
4	SS	MG/KG	MANGANESE	43	43	0.011	2.8	34.3	2260	391	1304	1100		Yes	A
4	SS	MG/KG	PCB-1260 (AROCLOR 1260)	54	5	0.034	15	0.28	18	8.424	0.11	0.32	17	Yes	A
4	SS	MG/KG	PENTACHLOROPHENOL	99	8	0.17	1.2	0.048	0.3	0.1125		5.3	0.03	Yes	A
4	SS	MG/KG	PETROLEUM HYDROCARBONS	3	2	1.7	111	1300	1570	1435		34	340	Yes	A
4	SS	MG/KG	SELENIUM	150	36	0.15	1.8	0.28	14.5	3	0.8	39	5	Yes	A
4	SS	MG/KG	TCDD Equivalent	27	27	0.001	0.001	0.0000010	0.00047	0	0.00001	0.0000043	0.005	Yes	A
4	SS	MG/KG	THALLIUM	150	2	0.14	3.3	2.8	6.5	4.65		0.55	0.7	Yes	A
4	SS	MG/KG	ZINC	150	149	0.076	7	9.5	9915	238	126	2300	12000	Yes	A

Note Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgement was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 22-2

Constituents of Potential Concern in FU4 - Subsurface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
4	SB	MG/KG	1,1,2,2-TETRACHLOROETHANE	157	5	0.01	0.024	0.005	0.02	0.0124		0.003	Yes	A
4	SB	MG/KG	ALPHA-CHLORDANE	144	1	0.0018	0.0083	0.022	0.022	0.022	0.0026		Yes	D
4	SB	MG/KG	ALUMINUM	57	57	0.8	25	1800	26800	11481	21829		Yes	D
4	SB	MG/KG	ANTIMONY	154	9	0.22	10	0.51	8.7	2.5		5	Yes	A
4	SB	MG/KG	ARSENIC	157	157	0.15	3.3	1.3	34	13	17	29	Yes	A
4	SB	MG/KG	CHROMIUM, TOTAL	157	157	0.058	3.3	1.8	140	22	26	38	Yes	A
4	SB	MG/KG	COBALT	57	57	0.032	2.5	1.1	28	8.6	20		Yes	D
4	SB	MG/KG	COPPER	157	157	0.1	3.3	3	57	24	33		Yes	D
4	SB	MG/KG	GAMMA-CHLORDANE	144	1	0.0018	0.0083	0.024	0.024	0.024	0.0022		Yes	D
4	SB	MG/KG	LEAD	157	156	0.076	1	1.8	38	17	24		Yes	D
4	SB	MG/KG	MANGANESE	57	57	0.013	2.5	39	2960	661	1540		Yes	D
4	SB	MG/KG	PENTACHLOROPHENOL	154	1	0.12	50	470	470	470		0.03	Yes	A
4	SB	MG/KG	TCDD Equivalent	35	32	0.001	0.001	0.000000045	0.013	0.00042	0.000006	0.005	Yes	A
4	SB	MG/KG	THALLIUM	157	2	0.15	3.29999995	3.5	4.7	4.1		0.7	Yes	A
4	SB	MG/KG	TOTAL 1,2-DICHLOROETHENE	157	4	0.01	0.025	0.006	0.11	0.06325			Yes	D
4	SB	MG/KG	TRICHLOROETHYLENE (TCE)	157	10	0.01	0.025	0.001	0.32	0.0556		0.06	Yes	A
4	SB	MG/KG	BENZO(a)ANTHRACENE	157	3	0.055	2	0.042	0.18	0.099		2	Yes	H
4	SB	MG/KG	BENZO(a)PYRENE	157	3	0.055	2	0.049	0.16	0.093		8	Yes	H
4	SB	MG/KG	BENZO(b)FLUORANTHENE	157	3	0.055	2	0.057	0.21	0.12		5	Yes	H
4	SB	MG/KG	CARBAZOLE	151	1	0.35	2	0.07	0.07	0.07		0.6	Yes	H
4	SB	MG/KG	CHRYSENE	157	3	0.055	2	0.066	0.27	0.14		160	Yes	H
4	SB	MG/KG	DDE	144	5	0.0034	0.016	0.002	0.024	0.00894	0.0015	54	Yes	H
4	SB	MG/KG	DDT	144	8	0.0034	0.016	0.0033	0.019	0.0089	0.0072	11	Yes	H
4	SB	MG/KG	DIELDRIN	144	7	0.0034	0.016	0.0014	0.039	0.011	0.37	0.004	Yes	H
4	SB	MG/KG	INDENO(1,2,3-c,d)PYRENE	157	1	0.055	2	0.14	0.14	0.14		14	Yes	H
4	SB	MG/KG	PETROLEUM HYDROCARBONS	5	2	1.7	2	19	20	19		340	Yes	H
4	SB	MG/KG	SELENIUM	157	8	0.13	1.70000005	0.57	2	1.5	0.6	5	Yes	H
4	SB	MG/KG	ZINC	157	156	0.076	6.7	9.9	223	83	114	12000	Yes	H

Note Data evaluated include field duplicates and normal samples (2 feet and below)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

TABLE 22-3

Constituents of Potential Concern in FU4 - Sediment

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Sediments	Regulatory Criteria for Leachability	COPC/BASIS	
4	SE	MG/KG	2-METHYLNAPHTHALENE	11	3	0 36	9 5	0 026	10	5 7		160	6 1	Yes	A
4	SE	MG/KG	4-METHYLPHENOL (p-CRESOL)	11	1	0 36	13	0 17	0 17	0 17		39	0 02	Yes	A
4	SE	MG/KG	BENZO(a)ANTHRACENE	11	10	0 36	9 5	0 06	20	3 6	2 9	0 87	2	Yes	A
4	SE	MG/KG	BENZO(a)PYRENE	11	10	0 36	9 5	0 085	19	3 4	2 5	0 087	8	Yes	A
4	SE	MG/KG	BENZO(b)FLUORANTHENE	11	10	0 36	13	0 18	26	4 7	2 2	0 87	5	Yes	A
4	SE	MG/KG	BENZO(k)FLUORANTHENE	11	10	0 36	9 5	0 12	25	4 1	2 3	8 7	49	Yes	A
4	SE	MG/KG	CARBAZOLE	11	5	0 36	13	0 1	2 4	1	1 1	32	0 6	Yes	A
4	SE	MG/KG	CARBON TETRACHLORIDE	11	1	0 011	0 014	0 078	0 078	0 078		4 9	0 07	Yes	A
4	SE	MG/KG	CHROMIUM, TOTAL	11	11	0 23	0 32	3 7	68 5	23	20		38	Yes	A
4	SE	MG/KG	DIELDRIN	11	8	0 0039	0 36	0 038	0 31	0 15	0 011	0 04	0 004	Yes	A
4	SE	MG/KG	INDENO(1 2,3-c,d)PYRENE	11	8	0 36	13	0 1	9 1	1 3	1 7	0 87	14	Yes	A
4	SE	MG/KG	LEAD	11	11	0 21	2 4	1 8	484	92	35 2	400		Yes	A
4	SE	MG/KG	METHYLENE CHLORIDE	11	2	0 011	0 014	0 032	0 045	0 0385		85	0 02	Yes	A
4	SE	MG/KG	PENTACHLOROPHENOL	11	2	0 18	31	0 08	0 26	0 17		5 3	0 03	Yes	A
4	SE	MG/KG	TCDD Equivalent	11	11	0	0 001	0 0000003	0 000	0 000095	0 000009	0 0000043	0 005	Yes	A
4	SE	MG/KG	CHRYSENE	11	10	0 36	9 5	0 16	30	4 929	3 2	87	160	Yes	G

Note

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgement was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

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TABLE 22-4

Constituents of Potential Concern in Residential Point Estimate at Station SS14A - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
4	SS	MG/KG	BENZO(a)ANTHRACENE	6	0.71	0.87	2	Yes	A
4	SS	MG/KG	BENZO(a)PYRENE	6.1	0.96	0.087	8	Yes	A
4	SS	MG/KG	CARBAZOLE	1.4	0.067	32	0.6	Yes	A
4	SS	MG/KG	PENTACHLOROPHENOL	0.11		5.3	0.03	Yes	A
4	SS	MG/KG	CHRYSENE	0.11	0.94	87	160	Yes	G

Note Data evaluated include field duplicates and normal samples (0-2 feet).

A Exceeds Criteria

B Does not exceed Criteria

C Does not exceed Background

D No Criteria available & exceeds Background, or no Criteria or Background available

E Chemical is an essential nutrient and professional judgement was used in eliminating it as a COPC

F Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC

G Chemical is a member of a chemical class that contains other COPCs

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TABLE 22-5
Summary of Exposure Pathways to be Quantified at FU4
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils, and ingestion and dermal contact with sediments from drainage systems	Yes	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil, and cleaning drainage ways
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils, and ingestion and dermal contact with sediments from drainage systems	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0 to 10 feet below ground surface)	No	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil. This is evaluated as part of the surrogate site exposure unit
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be short exposure duration (less than one year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Evaluated for comparison purposes only

TABLE 22-6

Exposure Point Concentrations for FU4 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ALUMINUM	38	38	8970	27600	10611	12727	12727
MG/KG	ANTIMONY	126	41	3	28	3.5	4.3	4.3
MG/KG	ARSENIC	129	126	13	66	14	17	17
MG/KG	CHROMIUM, TOTAL	129	129	103	4385	167	67	67
MG/KG	COPPER	129	129	37	1400	55	34	34
MG/KG	LEAD	129	129	165	2800	227	162	162
MG/KG	MANGANESE	38	38	402	2260	531	718	718
MG/KG	SELENIUM	129	32	0.98	13	1.2	1.1	1.1
MG/KG	THALLIUM	129	2	0.66	6.5	0.77	0.98	0.98
MG/KG	ZINC	129	128	260	9915	397	222	222
MG/KG	ALPHA-CHLORDANE	92	22	0.07	3.4	0.13	0.074	0.074
MG/KG	DDE	92	30	0.11	3	0.18	0.15	0.15
MG/KG	DDT	92	44	0.27	13	0.51	0.31	0.31
MG/KG	DIELDRIN	92	39	0.23	5.6	0.36	0.39	0.39
MG/KG	GAMMA-CHLORDANE	92	22	0.072	3.3	0.13	0.087	0.087
MG/KG	PCB-1260 (AROCLOR 1260)	47	5	1.9	18	2.9	6.6	6.6
MG/KG	BENZO(a)ANTHRACENE	107	40	0.5	6.6	0.65	0.54	0.54
MG/KG	BENZO(a)PYRENE	107	43	0.49	6.3	0.64	0.54	0.54
MG/KG	BENZO(b)FLUORANTHENE	107	44	0.49	6.4	0.63	0.54	0.54
MG/KG	CARBAZOLE	83	12	0.24	1.8	0.29	0.26	0.26
MG/KG	CHRYSENE	107	43	0.53	7.1	0.7	0.58	0.58
MG/KG	DIBENZ(a,h)ANTHRACENE	107	6	0.33	0.87	0.42	0.37	0.37
MG/KG	INDENO(1,2,3-c,d)PYRENE	107	31	0.44	4.1	0.56	0.49	0.49
MG/KG	PENTACHLOROPHENOL	83	7	0.12	0.30	0.13	0.12	0.12
MG/KG	PETROLEUM HYDROCARBONS	2	1	650	1300	4752	1 E+160	1300
MG/KG	1,1,2,2-TETRACHLOROETHANE	88	2	0.0058	0.007	0.0059	0.0059	0.0059
MG/KG	TCDD Equivalent	23	23	0.00011	0.00047	0.00015	0.00058	0.00047

Note Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation

TABLE 22-7

Exposure Point Concentrations for FU4 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ALUMINUM	91	91	10410	27600	11303	12390	12390
MG/KG	ANTIMONY	245	49	2.6	28	2.9	3.5	3.5
MG/KG	ARSENIC	250	247	13	66	14	16	16
MG/KG	CHROMIUM, TOTAL	250	250	62	4385	95	38	38
MG/KG	COBALT	91	91	7.5	28	8	10	10
MG/KG	COPPER	250	250	31	1400	40	29	29
MG/KG	LEAD	250	250	93	2800	126	65	65
MG/KG	MANGANESE	91	91	558	2960	635	787	787
MG/KG	SELENIUM	250	40	0.82	13	1	0.8	0.8
MG/KG	THALLIUM	250	4	0.68	6.5	0.75	0.93	0.93
MG/KG	ZINC	250	249	175	9915	247	141	141
MG/KG	DDE	205	33	0.052	3	0.081	0.021	0.021
MG/KG	DDT	205	49	0.12	13	0.23	0.035	0.035
MG/KG	ALPHA-CHLORDANE	205	23	0.032	3.4	0.06	0.011	0.011
MG/KG	DIELDRIN	205	45	0.1	5.6	0.17	0.034	0.034
MG/KG	GAMMA-CHLORDANE	205	23	0.033	3.3	0.06	0.012	0.012
MG/KG	PCB-1260 (AROCLOR 1260)	98	5	0.92	18	1.40	0.87	0.87
MG/KG	BENZO(a)ANTHRACENE	227	43	0.33	6.6	0.41	0.32	0.32
MG/KG	BENZO(a)PYRENE	227	46	0.33	6.3	0.4	0.32	0.32
MG/KG	BENZO(b)FLUORANTHENE	227	47	0.33	6.4	0.4	0.32	0.32
MG/KG	CARBAZOLE	199	13	0.22	1.8	0.24	0.23	0.23
MG/KG	CHRYSENE	227	46	0.35	7.1	0.43	0.33	0.33
MG/KG	DIBENZ(a,h)ANTHRACENE	227	6	0.26	0.87	0.3	0.27	0.27
MG/KG	INDENO(1,2,3-c,d)PYRENE	227	32	0.31	4.1	0.37	0.31	0.31
MG/KG	PENTACHLOROPHENOL	202	8	2.4	470	6.3	0.14	0.14
MG/KG	PETROLEUM HYDROCARBONS	7	3	192	1300	551	7192816	1300
MG/KG	TOTAL 1,2-DICHLOROETHENE	204	2	0.0067	0.11	0.0076	0.0066	0.0066
MG/KG	1,1,2,2-	204	6	0.0062	0.02	0.0064	0.0063	0.0063
MG/KG	TRICHLOROETHYLENE (TCE)	204	8	0.0063	0.057	0.0067	0.0064	0.0064
MG/KG	TCDD Equivalent	35	35	0.00043	0.013	0.001	0.00096	0.00096

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

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TABLE 22-8
Exposure Point Concentrations for FU4 - Sediment
Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	CHROMIUM, TOTAL	9	9	22	69	35	59	69
MG/KG	DIELDRIN	9	6	0.1	0.31	0.17	4	0.31
MG/KG	BENZO(a)ANTHRACENE	9	8	2.5	20	6.6	34	20
MG/KG	BENZO(a)PYRENE	9	8	2.4	19	6.2	19	19
MG/KG	BENZO(b)FLUORANTHENE	9	8	3.3	26	8.6	25	26
MG/KG	BENZO(k)FLUORANTHENE	9	8	3.1	25	8.2	26	25
MG/KG	CARBAZOLE	9	4	0.53	2.4	1	1.6	2.4
MG/KG	CHRYSENE	9	8	3.9	30	10	42	30
MG/KG	INDENO(1,2,3-c,d)PYRENE	9	7	0.91	0.39	2.2	3.7	0.39
MG/KG	2-METHYLNAPHTHALENE	9	2	1.46	10	3.5	27	10
MG/KG	4-METHYLPHENOL (p-CRESOL)	9	1	0.6	0.17	1	2	0.17
MG/KG	PENTACHLOROPHENOL	9	2	0.8	0.26	1.8	4.8	0.26
MG/KG	TCDD Equivalent	9	9	0.0001	0.00049	0.0002	0.041	0.00049
MG/KG	CARBON TETRACHLORIDE	9	1	0.014	0.078	0.029	0.029	0.078
MG/KG	METHYLENE CHLORIDE	9	1	0.01	0.045	0.018	0.018	0.045

Note. Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

TABLE 22-9

Exposure Point Concentrations for FU4, Station SS14A - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Parameter	EPC (mg/kg)
BENZO(a)ANTHRACENE	2 9
BENZO(a)PYRENE	2 5
CARBAZOLE	1
CHRYSENE	3 1
PENTACHLOROPHENOL	0 11

Notes

Data evaluated include normal samples only

Field duplicates have been dropped from risk evaluation

EPC values represent the maximum PRE sample within Functional Unit 4 at location SS14A

TABLE 22-10

Toxicity Factors for FU4

Memphis Depot Main Installation RI

Name	Weight-of-Evidence Class	ABSGI	Oral SF kg-day/mg	Dermal SF kg-day/mg	Inhal SF kg-day/mg	C Oral RfD mg/kg-day	Dermal RfD mg/kg-day	C Inhal RfD mg/kg-day
1,1,2,2-Tetrachloroethane	C	7.00E-01	2.00E-01	2.86E-01	2.03E-01			
1,2-DCE (total)		1.00E+00				9.00E-03	9.00E-03	
2-Methylnaphthalene	D	8.00E-01				2.00E-02	1.60E-02	9.00E-04
4-Methylphenol (p-cresol)	C	6.50E-01				5.00E-03	3.25E-03	
alpha-Chlordane	B2	5.00E-01	3.50E-01	7.00E-01	3.50E-01	5.00E-04	2.50E-04	2.00E-04
Aluminum		1.00E-01				1.00E+00	1.00E-01	1.00E+00
Antimony	D	2.00E-02				4.00E-04	8.00E-06	
Arsenic	A	4.10E-01	1.50E+00	3.66E+00	1.51E+01	3.00E-04	1.23E-04	
Barium	D	7.00E-02				7.00E-02	4.90E-03	1.43E-04
Benzo(a)anthracene	B2	3.10E-01	7.30E-01	2.35E+00	3.10E-01			
Benzo(a)pyrene	B2	3.10E-01	7.30E+00	2.35E+01	3.10E+00			
Benzo(b)fluoranthene	B2	3.10E-01	7.30E-01	2.35E+00	3.10E-01			
Carbazole	B2	7.00E-01	2.00E-02	2.86E-02				
Carbon tetrachloride	B2	6.50E-01	1.30E-01	2.00E-01	5.25E-02	7.00E-04	4.55E-04	5.71E-04
Chromium (total)	A	2.00E-02			4.20E+01	3.00E-03	6.00E-05	2.86E-05
Chrysene	B2	3.10E-01	7.30E-03	2.35E-02	3.10E-03			
Cobalt		8.00E-01				6.00E-02	4.80E-02	
Copper	D	3.00E-01				3.70E-02	1.11E-02	
DDE	B2	7.00E-01	3.40E-01	4.86E-01				
DDT	B2	7.00E-01	3.40E-01	4.86E-01	3.40E-01	5.00E-04	3.50E-04	
Dibenz(a,h)anthracene	B2	3.10E-01	7.30E+00	2.35E+01	3.10E+00			
Dieldrin	B2	5.00E-01	1.60E+01	3.20E+01	1.60E+01	5.00E-05	2.50E-05	
gamma-Chlordane	B2	5.00E-01	3.50E-01	7.00E-01	3.50E-01	5.00E-04	2.50E-04	2.00E-04
Indeno(1,2,3-c,d)pyrene	B2	3.10E-01	7.30E-01	2.35E+00	3.10E-01			
Manganese	D	4.00E-02				1.40E-01	5.60E-03	1.43E-05
Methylene chloride	B2	9.50E-01	7.50E-03	7.89E-03	1.65E-03	6.00E-02	5.70E-02	8.57E-01
PCB-1260 (Aroclor 1260)	B2	9.00E-01	2.00E+00	2.22E+00	2.00E+00			
Pentachlorophenol	B2	1.00E+00	1.20E-01	1.20E-01		3.00E-02	3.00E-02	
Petroleum Hydrocarbons		5.00E-01				4.00E-02	2.00E-02	6.00E-02
Selenium	D	4.40E-01				5.00E-03	2.20E-03	
TCDD Equivalent	B2	5.00E-01	1.50E+05	3.00E+05	1.50E+05			
Thallium	D	1.50E-01				7.00E-05	1.05E-05	
Trichloroethylene (TCE)	B2	1.50E-01	1.10E-02	7.33E-02	6.00E-03	6.00E-03	9.00E-04	
Zinc	D	2.00E-01				3.00E-01	6.00E-02	

Note: Master list of toxicity factors, with sources and basis is provided in Section 7

TABLE 22-11
Carcinogenic Risks and Noncarcinogenic Hazards of FU4
Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	*Chemicals of Concern*
Industrial Worker					
	Surface Soil (0-2ft)		2E-05	0 1	*Arsenic, Dieldrin, PCB-1260, TCDD*
	Soil Column (0-10ft)[1]		3E-05	0 08	*Arsenic, TCDD*
	Sediment		1E-05	0.003	*TCDD, Benzo(a)pyrene*
		Total[2]	***4E-05***	***0.1***	***TCDD, Dieldrin, Benzo(a)pyrene, Arsenic, PCB-1260***
Maintenance Worker					
	Surface Soil (0-2ft)		3E-06	0 01	*TCDD*
	Sediment		4E-06	0 001	*Benzo(a)pyrene*
		Total	***7E-06***	***0.01***	***TCDD, Benzo(a)pyrene***
Residential Adult (age-adjusted)					
	Soil point exposure at SS14A		3E-05	0 000005	*Benzo(a)anthracene, Benzo(a)pyrene*
		Total	***3E-05***	***0 000005***	***Benzo(a)anthracene, Benzo(a)pyrene***
Residential Child[3]					
	Soil point exposure at SS14A		3E-05	0 00005	*Benzo(a)anthracene, Benzo(a)pyrene*
		Total	***3E-05***	***0.00005***	***Benzo(a)anthracene, Benzo(a)pyrene***

Notes

Residential receptors have been included for comparison purposes only

[1] *Soil Column includes surface and subsurface soil, therefore cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media*

TCDD = 2,3,7,8 TCDD equivalent

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TABLE 22-12

Carcinogenic Risks and Noncarcinogenic Hazards for All Media of FU4

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways	Total ELCR	Total HI	Chemicals of Concern
Industrial Worker				
	Groundwater - Site-wide Inorganics	1E-05	0.5	*Arsenic*
	Groundwater - Plume C Organics (Averages)	5E-06	0.02	*1,1,2,2-Tetrachloroethane, PCE*
	Groundwater Total	***2E-05***	***0.5***	
	Surface Soil (0-2ft)	2E-05	0.1	*Arsenic, Dieldrin, PCB-1260, TCDD*
	Soil Column (0-10ft)[1]	3E-05	0.08	*Arsenic, TCDD*
	Sediment	1E-05	0.003	*TCDD, Benzo(a)pyrene*
	Other Media Total[2]	***4E-05***	***0.1***	
	Totals for All Media (including Groundwater)	***5E-05***	***0.6***	***TCDD, Dieldrin, PCE, 1,1,2,2-Tetrachloroethane, Arsenic, BaP, PCB-1260***
Maintenance Worker				
	Surface Soil (0-2ft)	3E-06	0.01	*TCDD*
	Sediment	4E-06	0.001	*Benzo(a)pyrene*
	Total	***7E-06***	***0.01***	***TCDD, Benzo(a)pyrene, Pentachlorophenol***
Residential Adult (age-adjusted)				
	Groundwater - Site-wide Inorganics	5E-05	1	*Arsenic*
	Groundwater - Plume C Organics (Averages)	2E-05	0.05	*1,1,2,2-Tetrachloroethane, PCE, TCE, DBCM*
	Groundwater Total	***7E-05***	***1***	
	Soil point exposure at SS14A	3E-05	0.000005	*Benzo(a)anthracene, Benzo(a)pyrene*
	Other Media Total	***3E-05***	***0.000005***	
	Totals for All Media (including Groundwater)	***1E-04***	***1***	***Benzo(a)anthracene, Benzo(a)pyrene, Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane, DBCM***
Residential Child[3]				
	Groundwater - Site-wide Inorganics	2E-05	3	*Arsenic*
	Groundwater - Plume C Organics (Averages)	8E-06	0.1	*1,1,2,2-Tetrachloroethane, PCE*
	Groundwater Total	***3E-05***	***3***	
	Soil point exposure at SS14A	3E-05	0.00005	*Benzo(a)anthracene, Benzo(a)pyrene*
	Other Media Total	3E-05	*0.00005*	
	Totals for All Media (including Groundwater)	***5E-05***	***3***	***Benzo(a)anthracene, Benzo(a)pyrene, Arsenic, PCE, 1,1,2,2-Tetrachloroethane***

Notes

Residential receptors have been included for comparison purposes only

[1] *Soil Column includes surface and subsurface soil, therefore cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media*

BaP = Benzo(a)pyrene

DBCM = Dibromochloromethane

PCE = Tetrachloroethane

TCDD = 2,3,7,8 TCDD equivalent

TCE = Trichloroethene

TABLE 22-13
Step 2 Surface Soil Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value[1] (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	43	43	674	=	27600	=	50	**552**	Y
ANTIMONY	147	46	0 37	J	27 5	J	3 5	**7.9**	Y
ARSENIC	150	147	1 1	J	66 3	=	10	**6 6**	Y
BARIUM	43	43	6 7	J	366	=	165	**2.2**	Y
BERYLLIUM	150	80	0 02	J	1 6	=	1 1	**1.5**	Y
CADMIUM	150	66	0 12	J	4 8	=	1 6	**3.0**	Y
CHROMIUM, TOTAL	150	150	5	J	4385	=	0 4	**10963**	Y
COBALT	43	43	0 25	J	18 9	=	20	0 9	N
COPPER	150	150	1 4	J	1400	=	40	**35**	Y
IRON	43	43	1360	=	66100	=	200	**331**	Y
LEAD	150	150	5	J	2800	=	50	**56**	Y
MANGANESE	43	43	34 3	J	2260	=	100	**23**	Y
MERCURY	150	44	0 01	J	0 11	=	0 1	**1.1**	Y
NICKEL	150	150	2 3	J	43 8	=	30	**1.5**	Y
SELENIUM	150	36	0 28	J	14 5	=	0 81	**18**	Y
SILVER	150	18	0 045	J	0 63	J	2	0 3	N
THALLIUM	150	2	2 8	=	6 5	J	1	**6.5**	Y
VANADIUM	43	43	3 4	J	50 9	=	2	**25**	Y
ZINC	150	149	9 5	J	9915	J	50	**198**	Y
Organics									
1,1,2,2-TETRACHLOROETHANE	105	3	0 004	J	0 007	J	0 1	0 1	N
1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	27	25	0 000003	J	0 012004	=	0 1	0 1	N
1,2,3,4,6,7,8-HEPTACHLORODIBENZO-p-DIOXIN	26	23	0 000018	J	0 023402	=	0 1	0 2	N
1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	27	8	0 000009	J	0 00018	J	0 1	0 0	N
1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	27	11	0 000009	J	0 000401	J	0 1	0 0	N
1,2,3,4,7,8-HEXACHLORODIBENZO-p-DIOXIN	27	6	0 000006	J	0 000131	J	0 1	0 0	N
1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	27	9	0 000005	J	0 000135	J	0.1	0.0	N
1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	27	17	0 000012	J	0 001318	J	0 1	0 0	N
1,2,3,7,8,9-HEXACHLORODIBENZOFURAN	27	1	0 000012	J	0 000012	J	0 1	0 0	N
1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	27	9	0 000006	J	0 000292	J	0 1	0.0	N
1,2,3,7,8-PENTACHLORODIBENZOFURAN	27	1	0 000012	J	0 000012	J	0 1	0 0	N
1,2,3,7,8-PENTACHLORODIBENZO-p-DIOXIN	27	2	0 000012	J	0 000055	J	0 1	0 0	N
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	27	8	0 000008	J	0 000414	J	0 1	0 0	N
2,3,4,7,8-PENTACHLORODIBENZOFURAN	27	1	0 000014	J	0 000014	J	0 1	0 0	N

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TABLE 22-13
Step 2 Surface Soil Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection		Range of Detected Values						
	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
2-HEXANONE	105	2	0.001	J	0.001	J		NA	Y
2-METHYLNAPHTHALENE	129	4	0.051	J	0.13	J	0.1	1.3	Y
ACENAPHTHENE	129	7	0.041	J	1.2	J	20	0.1	N
ACENAPHTHYLENE	129	2	0.074	J	0.2	J	0.1	2.0	Y
ACETONE	105	33	0.002	J	0.31	=		NA	Y
ALKALINITY, TOTAL (AS CaCO3)	3	3	805	=	465000	=		NA	Y
ALPHA-CHLORDANE	108	22	0.00075	J	3.4	=	0.1	34	Y
ANTHRACENE	129	15	0.048	J	1.9	=	0.1	19	Y
BENZENE	105	1	0.002	J	0.002	J	0.05	0.0	N
BENZO(a)ANTHRACENE	129	47	0.037	J	6.6	=	0.1	66	Y
BENZO(a)PYRENE	129	49	0.04	J	6.3	=	0.1	63	Y
BENZO(b)FLUORANTHENE	129	50	0.048	J	6.4	=	0.1	64	Y
BENZO(g,h,i)PERYLENE	129	41	0.041	J	4.2	=	0.1	42	Y
BENZO(k)FLUORANTHENE	129	48	0.04	J	5.7	=	0.1	57	Y
BENZYL BUTYL PHTHALATE	99	3	0.11	J	0.7	=	0.1	7.0	Y
bis(2-ETHYLHEXYL) PHTHALATE	99	43	0.038	J	3	=	0.1	30	Y
BROMOMETHANE	105	2	0.001	J	0.003	J		NA	Y
CARBAZOLE	99	12	0.035	J	1.8	=		NA	Y
CARBON DISULFIDE	105	2	0.001	J	0.001	J		NA	Y
CHLOROMETHANE	105	1	0.001	J	0.001	J	0.1	0.0	N
CHRYSENE	129	50	0.045	J	7.1	=	0.1	71	Y
DDD	108	1	0.033	J	0.033	J	0.0025	13	Y
DDE	108	34	0.0013	J	3	=	0.0025	1200	Y
DDT	108	48	0.0024	J	13	=	0.0025	5200	Y
DIBENZ(a,h)ANTHRACENE	129	7	0.046	J	0.87	J	0.1	8.7	Y
DIBENZOFURAN	99	4	0.05	J	0.44	=	0.1	4.4	Y
DIELDRIN	108	44	0.0012	J	5.6	J	0.0005	11200	Y
DIETHYL PHTHALATE	99	1	0.18	J	0.18	J	0.1	1.8	Y
DI-n-BUTYL PHTHALATE	99	12	0.041	J	0.15	J	0.1	1.5	Y
DI-n-OCTYLPHTHALATE	99	1	0.12	J	0.12	J	0.1	1.2	Y
ETHYLBENZENE	105	1	0.008	J	0.008	J	0.05	0.2	N
FLUORANTHENE	129	51	0.049	J	14	=	0.1	140	Y
FLUORENE	129	8	0.04	J	0.77	J	0.1	7.7	Y
GAMMA-CHLORDANE	108	22	0.00097	J	3.3	=	0.1	33	Y
INDENO(1,2,3-c,d)PYRENE	129	37	0.042	J	4.1	=	0.1	41	Y

TABLE 22-13

Step 2 Surface Soil Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
METHYL ETHYL KETONE (2-BUTANONE)	105	8	0.006	J	0.044	=		**NA**	Y
METHYLENE CHLORIDE	105	21	0.001	J	0.01	J	0.1	0.1	N
NAPHTHALENE	129	4	0.045	J	0.38	J	0.1	**3.8**	Y
OCTACHLORODIBENZOFURAN	27	25	0.000003	J	0.039746	=	0.1	0.4	N
OCTACHLORODIBENZO-p-DIOXIN	24	24	0.000239	J	0.072102	=	0.1	0.7	N
PCB-1260 (AROCHLOR 1260)	54	5	0.28	J	18	J	0.02	**900**	Y
PENTACHLOROPHENOL	99	8	0.048	J	0.3	=	0.002	**150**	Y
PETROLEUM HYDROCARBONS	3	2	1300	=	1570	=		**NA**	Y
PHENANTHRENE	129	47	0.038	J	9.7	=	0.1	**97**	Y
PYRENE	129	53	0.0500000	J	12	=	0.1	**120**	Y
TCDD Equivalent	27	27	0.00000024	=	0.000083	=		**NA**	Y
TETRACHLOROETHYLENE(PCE)	105	1	0.008	J	0.008	J	0.01	0.8	N
TOLUENE	105	4	0.002	J	0.017	=	0.05	0.3	N
Total Xylenes	105	4	0.001	J	0.002	J		**NA**	Y
TRICHLOROETHYLENE (TCE)	105	1	0.005	J	0.005	J	0.001	**5**	Y

Note Ca, Mg, K, Na were detected, however these parameters were not evaluated since they are commonly occurring elements

1 = Memorandum, Ecological Risk Assessment at Military Bases Process Consideration, Timing, of Activities, and Inclusion of Stakeholders EPA Region 4, December 22, 1998

TABLE 22-14
Step 2 Surface Water Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection: Number Analyzed	Frequency of Detection: Number Detected	Range of Detected Values: Minimum (mg/l)	Qual.	Range of Detected Values: Maximum (mg/l)	Qual.	Surface Water Screening Value[1] (mg/l)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	5	5	0.228	=	1.7	=	0.087	**19.5**	Y
Aluminum, Dissolved	5	1	0.32	=	0.32	=	0.087	**3.7**	Y
ARSENIC	8	5	0.0046	J	0.0125	=	0.19	0.1	N
Arsenic, Dissolved	8	5	0.0042	J	0.0892	=	0.19	0.5	N
BARIUM	5	5	0.0203	J	0.0339	J		**NA**	Y
Barium, Dissolved	5	5	0.0189	J	0.0288	J		**NA**	Y
Chromium, Dissolved	8	2	0.0022	J	0.004	J	0.011	0.4	N
CHROMIUM, TOTAL	8	4	0.0029	J	0.0082	J	0.011	0.7	N
COPPER	8	1	0.0593	=	0.0593	=	0.00654	**9.1**	Y
Copper, Dissolved	8	1	0.0297	=	0.0297	=	0.00654	**4.5**	Y
IRON	5	5	0.312	=	2.52	=	1	**2.5**	Y
Iron, Dissolved	5	5	0.0719	J	0.445	J	1	0.4	N
LEAD	8	7	0.0026	J	0.0387	=	0.00132	**29.3**	Y
Lead, Dissolved	8	2	0.0028	J	0.0071	=	0.00132	**5.4**	Y
MANGANESE	5	5	0.0108	J	0.0492	=		**NA**	Y
Manganese, Dissolved	5	5	0.0031	J	0.0102	J		**NA**	Y
NICKEL	8	6	0.006	J	0.0121	J	0.08771	0.1	N
Selenium, Dissolved	8	1	0.0101	=	0.0101	=	0.005	**2.0**	Y
Silver, Dissolved	8	1	0.0023	J	0.0023	J	0.000012	**191.7**	Y
VANADIUM	5	2	0.0032	J	0.004	J		**NA**	Y
Vanadium, Dissolved	5	2	0.0018	J	0.0093	J		**NA**	Y
ZINC	8	8	0.0251	J	0.0702	J	0.05891	**1.2**	Y
Zinc, Dissolved	8	3	0.0188	J	0.064	=	0.05891	**1.1**	Y
Organics									
1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	8	4	0.0000001	J	0.0000007	J		**NA**	Y
1,2,3,7,8,9-HEXACHLORODIBENZOFURAN	8	4	0.0000001	J	0.0000003	J		**NA**	Y
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	8	5	0.0000015	J	0.0000051	J		**NA**	Y

TABLE 22-14

Step 2 Surface Water Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	**Number Analyzed**	**Number Detected**	**Minimum (mg/l)**	**Qual.**	**Maximum (mg/l)**	**Qual.**	**Surface Water Screening Value[1] (mg/l)**	**Hazard Quotient (based on Max. detect)**	**Retained as a COPC?**
bis(2-ETHYLHEXYL) PHTHALATE	8	1	0.019	=	0.019	=	0.0003	**63.3**	**Y**
DDT	8	4	0.000066	J	0.00022	=	0.000001	**220.0**	**Y**
DIELDRIN	8	5	0.000034	J	0.00024	=	0.0000019	**126.3**	**Y**
OCTACHLORODIBENZOFURAN	8	6	8.10E-08	J	1.30E-06	J		**NA**	**Y**
OCTACHLORODIBENZO-p-DIOXIN	8	8	1.63E-07	J	2.71E-05	J		**NA**	**Y**
PENTACHLOROPHENOL	8	3	0.006	=	0.013	=	0.013	**1.0**	**Y**
TCDD Equivalent	8	8	1.63E-10	=	2.84E-08	=		**NA**	**Y**

Note: Ca, Mg, K, Na were detected, however these parameters were not evaluated since they are commonly occurring elements

1 = Memorandum, Ecological Risk Assessment at Military Bases: Process Consideration, Timing, of Activities, and Inclusion of Stakeholders EPA Region 4, December 22, 1998.

TABLE 22-15

Step 2 Sediment Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Sediment Screening Value[1] (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	8	8	203	=	3450	=		NA	Y
ANTIMONY	11	2	1.3	J	1.4	J	12	0.1	N
ARSENIC	11	10	0.26	J	10.1	=	7.24	1.4	Y
BARIUM	8	8	5.8	J	78.6	=		NA	Y
BERYLLIUM	11	7	0.04	J	0.35	J		NA	Y
CADMIUM	11	4	1.3	=	3	=	1	3.0	Y
CHROMIUM, TOTAL	11	11	3.7	=	68.5	J	52.3	1.3	Y
COBALT	8	8	1.5	J	10.8	J		NA	Y
COPPER	11	11	2.9	J	56.5	=	18.7	3.0	Y
CYANIDE	3	2	0.6	J	0.7	=		NA	Y
IRON	8	8	2960	=	12200	=		NA	Y
LEAD	11	11	1.8	=	484	=	30.2	16.0	Y
MANGANESE	8	8	37.3	J	341	J		NA	Y
MERCURY	11	2	0.1	=	0.12	=	0.13	0.9	N
NICKEL	11	10	3	J	19.1	=	15.9	1.2	Y
SELENIUM	11	2	0.87	J	1.1	J		NA	Y
VANADIUM	8	8	2.1	J	17.5	=		NA	Y
ZINC	11	11	16.2	J	288	=	124	2.3	Y
Organics									
1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	11	10	0.0000069	J	0.006989	=		NA	Y
1,2,3,4,6,7,8-HEPTACHLORODIBENZO-p-DIOXIN	11	8	0.00018	J	0.0238	=		NA	Y
1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	11	3	0.000021	J	0.00011	J		NA	Y
1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	11	4	0.00001	J	0.000074	J		NA	Y
1,2,3,4,7,8-HEXACHLORODIBENZO-p-DIOXIN	11	3	0.000008	J	0.000014	J		NA	Y
1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	11	5	0.000004	J	0.000079	J		NA	Y
1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	11	5	0.000007	J	0.00026	J		NA	Y
1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	11	4	0.000015	J	0.00015	J		NA	Y
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	11	1	0.000022	J	0.000022	J		NA	Y

TABLE 22-15
Step 2 Sediment Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection		Range of Detected Values				Sediment Screening Value[1] (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.			
2-METHYLNAPHTHALENE	11	3	0.026	J	10	J	0.33	**30.3**	Y
4-METHYLPHENOL (p-CRESOL)	11	1	0.17	J	0.17	J		**NA**	Y
ACENAPHTHENE	11	1	0.061	J	0.061	J	0.33	0.2	N
ACENAPHTHYLENE	11	1	0.038	J	0.038	J	0.33	0.1	N
ACETONE	11	1	0.025	J	0.025	J		**NA**	Y
ALPHA ENDOSULFAN	11	1	0.032	J	0.032	J		**NA**	Y
ALPHA-CHLORDANE	11	5	0.0032	J	0.53	J	0.0017	**311.8**	Y
ANTHRACENE	11	5	0.094	J	6.9	J	0.33	**20.9**	Y
BENZO(a)ANTHRACENE	11	10	0.06	J	20	J	0.33	**60.6**	Y
BENZO(a)PYRENE	11	10	0.085	J	19	J	0.33	**57.6**	Y
BENZO(b)FLUORANTHENE	11	10	0.18	J	26	J	0.33	**78.8**	Y
BENZO(g,h,i)PERYLENE	11	8	0.095	J	9.5	J	0.33	**28.8**	Y
BENZO(k)FLUORANTHENE	11	10	0.12	J	25	J	0.33	**75.8**	Y
bis(2-ETHYLHEXYL) PHTHALATE	11	2	0.074	J	1.5	=	0.182	**8.2**	Y
CARBAZOLE	11	5	0.1	J	2.4	J		**NA**	Y
CARBON TETRACHLORIDE	11	1	0.078	=	0.078	=		**NA**	Y
CHRYSENE	11	10	0.16	J	30	J	0.33	**90.9**	Y
DDD	11	7	0.03	=	0.99	J	0.0033	**300.0**	Y
DDE	11	7	0.015	J	0.25	J	0.0033	**75.8**	Y
DDT	11	10	0.022	=	0.27	J	0.0033	**81.8**	Y
DIBENZ(a,h)ANTHRACENE	11	1	0.09	J	0.09	J	0.33	0.3	N
DIELDRIN	11	8	0.038	J	0.31	J	0.0033	**93.9**	Y
DIETHYL PHTHALATE	11	1	7.7	J	7.7	J		**NA**	Y
DI-n-BUTYL PHTHALATE	11	1	0.034	J	0.034	J		**NA**	Y
ENDRIN	11	2	0.045	J	0.048	J	0.0033	**14.5**	Y
ENDRIN ALDEHYDE	11	2	0.029	J	0.043	J		**NA**	Y
FLUORANTHENE	11	10	0.16	J	32	J	0.33	**97.0**	Y
FLUORENE	11	3	0.066	J	7.2	J	0.33	**21.8**	Y
GAMMA-CHLORDANE	11	5	0.0038	J	0.65	J	0.0017	**382.4**	Y

TABLE 22-15
Step 2 Sediment Screening Level Risk Calculations for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection		Range of Detected Values				Sediment Screening Value[1] (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.			
HEPTACHLORINATED DIBENZOFURANS, (TOTAL)	3	3	0 0000069	=	0.0043	J		NA	Y
HEPTACHLORINATED DIBENZO-p-DIOXINS, (TOTAL)	3	2	0 0084	J	0.0093	J		NA	Y
INDENO(1,2,3-c,d)PYRENE	11	8	0 1	J	9 1	J	0 33	27.6	Y
METHYL ETHYL KETONE (2-BUTANONE)	11	1	0 014	J	0 014	J		NA	Y
METHYLENE CHLORIDE	11	2	0.032	=	0.045	=		NA	Y
OCTACHLORODIBENZOFURAN	11	10	0.0000243	J	0.014863	J		NA	Y
OCTACHLORODIBENZO-p-DIOXIN	11	11	0.000207	J	0 114256	J		NA	Y
PENTACHLOROPHENOL	11	2	0 08	J	0 26	=		NA	Y
PHENANTHRENE	11	10	0 02	J	33	J	0 33	100.0	Y
PYRENE	11	10	0 13	J	55	J	0 33	166.7	Y
TCDD Equivalent	11	11	0.00000023	=	0 0001291	=		NA	Y
Total Xylenes	11	2	0.018	J	0 036	J		NA	Y

Note: Ca, Mg, K, Na were detected, however these parameters were not evaluated since they are commonly occurring elements

1 = Memorandum, Ecological Risk Assessment at Military Bases Process Consideration, Timing, of Activities, and Inclusion of Stakeholders EPA Region 4, December 22, 1998

TABLE 22-16
Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max. Compared to Primary	Avg. Compared to Primary	Max. Compared to Secondary	Avg. Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics														
ALUMINUM	27600	8896	23810	50	2	600	3	552	178	46	15	Y	N	100
ANTIMONY	27 5	4 4	7	3 5	9	5	2	8	1 2	6	0 9	Y	N	31
ARSENIC	66 3	13	20	10	2	29	4	7	1 3	2	0 5	Y	N	98
BARIUM	366	81	234	165	6	500	2	2	0 5	0 7	0 2	Y	N	100
BERYLLIUM	1 6	0 38	1 1	1 1	6			1 5	0 3			Y	N	53
CADMIUM	4 8	0 92	1 4	1 6	9	4	2	3	0 6	1 2	0 2	Y	N	44
CHROMIUM, TOTAL	4385	93	24 8	0 4	1	1	2	10963	232	4385	93	Y	Y	100
COPPER	1400	35	33 5	40	9	50	2,6	35	0 9	28	0 7	Y	Y	100
IRON	66100	15737	37040	200	3			331	79			Y	N	100
LEAD	2800	153	30	50	2 5	500	1	56	3	6	0 3	Y	Y	100
MERCURY	0 11	0 04	0 4	0 1	1	0 3	2,4	1 1	0 4	0 4	0 1	N	N	29
MANGANESE	2260	391	1304	100	3	500	2	23	4	5	0 8	Y	N	100
NICKEL	43 8	19	30	30	2	90	3	1 5	0 6	0 5	0 2	Y	N	100
SELENIUM	14 5	3 1	0 8	0 81	6	1	2	18	4	15	3	Y	Y	24
THALLIUM	6 5	4 7		1	2			7	5			NA	NA	1
VANADIUM	50 9	21 0	48 4	2	2	20	3	25	10	3	1 0	Y	N	100
ZINC	9915	238	126	50	2	100	3	198	5	99	2	Y	Y	99
Organics														
2-HEXANONE	0 001	0 001										NA	NA	2
2-METHYLNAPHTHALENE	0 13	0 089		0 1	6	5	7	1 3	0 9	0 0	0 0	NA	NA	3
ACENAPHTHYLENE	0 2	0 14	0 19	0 1	6	1	7	2	1 4	0 2	0 1	Y	N	2
ACETONE	0 31	0 035										NA	NA	31
ALPHA-CHLORDANE	3 4	0 18	0 029	0 1	5	0 5	7	34	2	7	0 4	Y	Y	20
ANTHRACENE	1 9	0 49	0 096	0 1	5	10	7	19	5	0 2	0 0	Y	Y	12
BENZO(a)ANTHRACENE	6 6	0 64	0 71	0 1	5	1	7	66	6	7	0 6	Y	N	36
BENZO(a)PYRENE	6 3	0 60	0 96	0 1	5	1	7	63	6	6	0 6	Y	N	38
BENZO(b)FLUORANTHENE	6 4	0 59	0 9	0 1	5	1	7	64	6	6	0 6	Y	N	39
BENZO(g,h,i)PERYLENE	4 2	0 45	0 82	0 1	5	1	7	42	5	4	0 5	Y	N	32
BENZO(k)FLUORANTHENE	5 7	0 63	0 78	0 1	5	1	7	57	6	6	0 6	Y	N	37
PHTHALATE	0 7	0 34	0 645	0 1	4	100	4	7	3	0 0	0 0	Y	N	3
PHTHALATE	3	0 35		0 1	4	100	4	30	3	0 0	0 0	NA	NA	43
BROMOMETHANE	0 003	0 002										NA	NA	2
CARBAZOLE	1 8	0 435	0 067									Y	Y	12

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TABLE 22-16
Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

COPCs	COPC Detected Concentrations (mg/kg) Maximum	Average	Background	Comparison Criteria (mg/kg) Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Hazard Quotients Max. Compared to Primary	Avg. Compared to Primary	Max. Compared to Secondary	Avg. Compared to Secondary	Background Comparisons Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
CARBON DISULFIDE	0 001	0 001	0 002									N	N	2
CHRYSENE	7 1	0 69	0 94	0 1	5	1	7	71	7	7	0 7	Y	N	39
DDD	0 033	0 033	0 0067	0 0025	4	4	5	13	13	0 0	0 0	Y	Y	1
DDE	3	0 23	0 16	0 0025	4	4	5	1200	91	0 8	0 1	Y	Y	31
DDT	13	0 48	0 074	0 0025	4	4	5	5200	191	3	0 1	Y	Y	44
DIBENZ(a,h)ANTHRACENE	0 87	0 24	0 26	0 1	6	1	7	9	2	0 9	0 2	Y	N	5
DIBENZOFURAN	0 44	0 27	0 647	0 1	6	1	7	4	3	0 4	0 3	N	N	4
DIELDRIN	5 6	0 57	0 086	0 0005	4			11200	1139			Y	Y	41
DIETHYL PHTHALATE	0 18	0 18		0 1	4	100	2	2	2	0 0	0 0	NA	NA	1
DI-n-BUTYL PHTHALATE	0 15	0 09		0 1	4	200	2	2	0 9	0 0	0 0	NA	NA	12
DI-n-OCTYLPHTHALATE	0 12	0 12		0 1	4	200	2	1 2	1 2	0 0	0 0	NA	NA	1
FLUORANTHENE	14	1 4	1 6	0 1	5	10	7	140	14	1 4	0 1	Y	N	40
FLUORENE	0 77	0 36		0 1	5	1	7	8	4	0 8	0 4	NA	NA	6
GAMMA-CHLORDANE	3 3	0 18	0 026	0 1	5	0 5	7	33	2	7	0 4	Y	Y	20
INDENO(1,2,3-c,d)PYRENE	4 1	0 53	0 7	0 1	5	1	7	41	5	4	0 5	Y	N	29
BUTANONE)	0 044	0 022	0 002									Y	Y	8
NAPHTHALENE	0 38	0 19		0 1	6	5	7	4	2	0 1	0 0	NA	NA	3
1260)	18	8 4	0 11	0 02	4	1	5	900	421	18	8	Y	Y	9
PENTACHLOROPHENOL	0 3	0 11		0 002	4	3	2	150	56	0 1	0 0	NA	NA	8
HYDROCARBONS	1570	1435										NA	NA	67
PHENANTHRENE	9 7	0 95	0 61	0 1	5	5	7	97	9	2	0 2	Y	Y	36
PYRENE	12	1 1	1 5	0 1	5	10	7	120	11	1 2	0 1	Y	N	41
TCDD Equivalent	0 00046646	0 000096	0 00001	0 1	6	1	7	0 0	0 0	0 0	0 0	Y	Y	100
Total Xylenes	0 002	0 002	0 009	0 05	4,5	25	5	0 0	0 0	0 0	0 0	N	N	4
(TCE)	0 005	0 005		0 001	4	0 1	5	5	5	0 1	0 1	NA	NA	1

Notes
1 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for earthworms
2 Efroymson, R A et al 1997b Oak Ridge National Laboratory, toxicological banchmarks for plants
3 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for microorganisms
4 Ministry of Housing, Spatial Planning and Environment, 1994 optimum soil quality standards
5 Beyer, W N 1990 US Fish and Wildlife Service Dutch background
6 Crommenttuijn, T et al , 1997 RIVM Report No 601501002

TABLE 22-17
Step 3 Refinement of Surfacewater Preliminary Contaminants of Concern for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/L)			Comparison Criteria[1] (mg/L)		Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Chronic Screening Value	Acute Screening Value	Max Compared to Chronic	Avg. Compared to Chronic	Max. Compared to Acute	Avg. Compared to Acute	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics												
ALUMINUM	1 7	0 63	5 08	0 087	0 75	20	7	2	0 8	N	N	100
Aluminum, Dissolved	0 32	0 32	0 47	0 087	0 75	4	4	0 4	0 4	N	N	20
BARIUM	0 034	0 027	0 125							N	N	100
Barium, Dissolved	0 029	0 024	0 876							N	N	100
COPPER	0 0593	0 0593	0 0746	0 00654	0 00922	9	9	6	6	N	N	13
Copper, Dissolved	0 0297	0 0297		0 00654	0 00922	5	5	3	3	NA	NA	13
IRON	2 52	0 83	6 10	1 0		3	0 8			N	N	100
LEAD	0 039	0 010	0 019	0 00132	0 03378	29	8	1 1	0 3	Y	N	88
LEAD, Dissolved	0 007	0 005	0 023	0 00132	0 03378	5	4	0 2	0 1	N	N	25
MANGANESE	0 049	0 021	0 656							N	N	100
Manganese, Dissolved	0 010	0 007	0 352							N	N	100
Selenium, Dissolved	0 010	0 010	0 003	0 005	0 02	2	2	0 5	0 5	Y	Y	13
Silver, Dissolved	0 0023	0 0023		0 000012	0 00123	192	192	2	2	NA	NA	13
VANADIUM	0 004	0 0036	0 039							N	N	40
Vanadium, Dissolved	0 0093	0 0056								NA	NA	40
ZINC	0 070	0 044	0 287	0 05891	0 06504	1 2	0 8	1 1	0 7	N	N	100
Zinc, Dissolved	0 064	0 047	0 410	0 05891	0 06504	1 1	0 8	1 0	0 7	N	N	38
Organics												
1,2,3,4 6 7,8 HEPTACHLORODIBENZOFURAN	0 00000071	0 00000025								NA	NA	50
1,2,3,7,8,9-HEXACHLORODIBENZOFURAN	0 00000026	0 00000016								NA	NA	50
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	0 0000051	0 0000031								NA	NA	63
bis(2-ETHYLHEXYL) PHTHALATE	0 019	0 019		0 0003	1 11	63	63	0 0	0 0	NA	NA	13
DDT	0 00022	0 00011		0 000001	0 0011	220	110	0 2	0 1	NA	NA	50
DIELDRIN	0 00024	0 00014		0 0000019	0 0025	126	76	0 1	0 1	NA	NA	63
OCTACHLORODIBENZOFURAN	0 0000013	0 0000004								NA	NA	75
OCTACHLORODIBENZO-p-DIOXIN	0 000027	0 000006	0 000001							Y	Y	100
PENTACHLOROPHENOL	0 0130	0 0087		0 013	0 02	1 0	0 7	0 7	0 4	NA	NA	38
TCDD Equivalent	0 00000054	0 00000021	0 00000002							Y	Y	100

Note

[1] EPA Region IV Supplemental Guidance to RAGS, Freshwater Surfacewater Screening Values for Hazardous Waste Sites

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TABLE 22-18
Step 3 Refinement of Sediment Preliminary Contaminants of Concern for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

COPCs	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)			Hazard Quotients				Background Comparisons		
	Maximum	Average	Background	Chronic Screening Value ^{1}	Acute Screening Value	Basis	Max Compared to Chronic	Avg Compared to Chronic	Max. Compared to Acute	Avg. Compared to Acute	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics													
ALUMINUM	3450	2063	10085								N	N	100
ARSENIC	10.1	5.2	12	7.24	41.6	3	1.4	0.7	0.2	0.1	N	N	91
BARIUM	78.6	41.4	118								N	N	100
BERYLLIUM	0.35	0.14	1.3								N	N	64
CADMIUM	3	2.4	28.9	1	4.21	3	3	2	0.7	0.6	N	N	36
CHROMIUM, TOTAL	68.5	23.3	20	52	160	3	1.3	0.4	0.4	0.1	Y	Y	100
COBALT	10.8	4.2	13.6								N	N	100
COPPER	56.5	22.2	58	18.7	108	3	3	1.2	0.5	0.2	N	N	100
CYANIDE	0.7	0.65									NA	NA	67
IRON	12200	7386	23080								N	N	100
LEAD	484	92.4	35.2	30.2	112	3	16	3	4	0.8	Y	Y	100
MANGANESE	341	152	871								N	N	100
NICKEL	19.1	8.4	30.5	15.9	42.8	3	1.2	0.5	0.4	0.2	N	N	91
SELENIUM	1.1	1.0	1.7								N	N	18
VANADIUM	17.5	9.9	30								N	N	100
ZINC	288	96.1	797	124	271	3	2	0.8	1.1	0.4	N	N	100
Organics													
1,2,3,4,6,7,8-HEPTACHLORODIBENZOFURAN	0.00699	0.00139									N	N	91
1,2,3,4,6,7,8-HEPTACHLORODIBENZO-p-DIOXIN	0.0238	0.005800	0.000583								Y	Y	73
1,2,3,4,7,8,9-HEPTACHLORODIBENZOFURAN	0.000110	0.000063									NA	NA	27
1,2,3,4,7,8-HEXACHLORODIBENZOFURAN	0.000074	0.000036									NA	NA	36
1,2,3,4,7,8-HEXACHLORODIBENZO-p-DIOXIN	0.0000140	0.0000117									NA	NA	27
1,2,3,6,7,8-HEXACHLORODIBENZOFURAN	0.000079	0.000023									NA	NA	45
1,2,3,6,7,8-HEXACHLORODIBENZO-P-DIOXIN	0.000260	0.000071									NA	NA	45
1,2,3,7,8,9-HEXACHLORODIBENZO-P-DIOXIN	0.000150	0.000052									NA	NA	36
2,3,4,6,7,8-HEXACHLORODIBENZOFURAN	0.000022	0.000022									NA	NA	9
2-METHYLNAPHTHALENE	10	5.7									NA	NA	27
4-METHYLPHENOL (p-CRESOL)	0.17	0.17									NA	NA	9
ACETONE	0.025	0.025									NA	NA	9
ALPHA ENDOSULFAN	0.032	0.032									NA	NA	9
ALPHA-CHLORDANE	0.53	0.127	0.0052	0.0017	0.00479	3	312	75	111	26	Y	Y	45
ANTHRACENE	6.9	2.3	1.6	0.33	1.1	2	21	7	6	2	Y	Y	45
BENZO(a)ANTHRACENE	20	3.6	2.9	0.33	0.693	3	61	11	29	5	Y	Y	91
BENZO(a)PYRENE	19	3.4	2.5	0.33	0.763	3	58	10	25	4	Y	Y	91
BENZO(b)FLUORANTHENE	26	4.72	2.22	0.33	0.763	5	79	14	34	6	Y	Y	91
BENZO(g,h,i)PERYLENE	9.5	1.4	1.8	0.33	0.763	5	29	4	12	2	Y	N	73
BENZO(k)FLUORANTHENE	25	4.1	2.3	0.33	0.763	5	76	12	33	5	Y	Y	91
bis(2-ETHYLHEXYL) PHTHALATE	1.5	0.8	0.48	0.182	2.647	3	8	4	0.6	0.3	Y	Y	18
CARBAZOLE	2.4	1.0	1.1								Y	N	45

TABLE 22-18
Step 3 Refinement of Sediment Preliminary Contaminants of Concern for FU4
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)			Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Chronic Screening Value [1]	Acute Screening Value	Basis	Max Compared to Chronic	Avg. Compared to Chronic	Max. Compared to Acute	Avg Compared to Acute	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
CARBON TETRACHLORIDE	0.078	0.078									NA	NA	9
CHRYSENE	30	4.9	3.2	0.33	0.846	3	91	15	35	6	Y	Y	91
DDD	0.99	0.1973	0.0061	0.0033	0.00781	3	300	60	127	25	Y	Y	64
DDE	0.25	0.0869	0.0072	0.0033	0.374	3	76	26	0.7	0.2	Y	Y	64
DDT	0.27	0.1325		0.0033	0.00477	3	82	40	57	28	NA	NA	91
DIELDRIN	0.31	0.154	0.011	0.0033	0.0043	3	94	47	72	36	Y	Y	73
DIETHYL PHTHALATE	7.7	7.7									NA	NA	9
DI-n-BUTYL PHTHALATE	0.034	0.034									NA	NA	9
ENDRIN	0.048	0.047		0.0033	0.045	2	15	14	1.1	1.0	NA	NA	18
ENDRIN ALDEHYDE	0.043	0.036									NA	NA	18
FLUORANTHENE	32	7.0	7.1	0.33	1.494	3	97	21	21	5	Y	N	91
FLUORENE	7.2	4.16	0.87	0.33	0.54	2	22	13	13	8	Y	Y	27
GAMMA-CHLORDANE	0.65	0.16	2	0.0017	0.00479	3	382	92	136	33	N	N	45
HEPTACHLORINATED DIBENZOFURANS, (TOTAL	0.0043	0.0020									NA	NA	100
HEPTACHLORINATED DIBENZO-p-DIOXINS, (TOT	0.0093	0.0089									NA	NA	67
INDENO(1,2,3-c,d)PYRENE	9.1	1.3	1.7	0.33	0.763	5	28	4	12	2	Y	N	73
METHYL ETHYL KETONE (2-BUTANONE)	0.014	0.014	0.01								Y	Y	9
METHYLENE CHLORIDE	0.045	0.0385									NA	NA	18
OCTACHLORODIBENZOFURAN	0.0149	0.0030									NA	NA	91
OCTACHLORODIBENZO-p-DIOXIN	0.1143	0.0289	0.0086								Y	Y	100
PENTACHLOROPHENOL	0.26	0.17									NA	NA	18
PHENANTHRENE	33	6.82	6.9	0.33	0.544	3	100	21	61	13	Y	N	91
PYRENE	55	8.98	2.882	0.33	1.398	3	167	27	39	6	Y	Y	91
TCDD Equivalent	0.000494	0.000095	0.000009								Y	Y	100
Total Xylenes	0.036	0.027									NA	NA	18

Notes
[1] EPA Region IV Supplemental Guidance to RAGS, Sediment Screening Values for Hazardous Waste Sites
[2] Long et al 1995
[3] MacDonald 1994
[4] Long and Morgan 1991
[5] benzo(a)pyrene surrogate

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TABLE 22-19
Constituents of Potential Concern In Screening Site 36 - Surface Soil
Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
4	36	SS	MG/KG	1,1,2,2-TETRACHLOROETHANE	23	3	0 011	0 013	0 004	0 007	0 0053		3 2	0 003	Yes	A
4	36	SS	MG/KG	ANTIMONY	24	3	0 19	7 6	2	18	9 4	7	3 1	5	Yes	A
4	36	SS	MG/KG	ARSENIC	24	24	0 16	2 5	11	28	20	20	0 43	29	Yes	A
4	36	SS	MG/KG	DIELDRIN	23	6	0 0037	0 8	0 0012	2 6	0 45	0 086	0 04	0 004	Yes	A
4	36	SS	MG/KG	PENTACHLOROPHENOL	23	1	0 19	0 79	0 11	0 11	0 11		5 3	0 03	Yes	A
4	36	SS	MG/KG	SELENIUM	24	8	0 17	1 3	0 79	14 5	4 1	0 8	39	5	Yes	A

Note Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgement was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 22-20

Constituents of Potential Concern in Screening Site 36 - Subsurface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
4	36	SB	MG/KG	1,1,2,2-TETRACHLOROETHANE	42	5	0.01	0.024	0.005	0.02	0.012		0.003	Yes	A
4	36	SB	MG/KG	ANTIMONY	42	1	1.8	9.4	8.7	8.7	8.7		5	Yes	A
4	36	SB	MG/KG	ARSENIC	42	42	0.2	3.1	3.2	29.9	16	17	29	Yes	A
4	36	SB	MG/KG	CHROMIUM, TOTAL	42	42	0.26	3.1	10.3	45.3	28	26	38	Yes	A
4	36	SB	MG/KG	COPPER	42	42	0.14	3.1	15.6	44.4	29	33		Yes	D
4	36	SB	MG/KG	LEAD	42	42	0.23	0.94	7.6	31.6	19	24		Yes	D
4	36	SB	MG/KG	SELENIUM	42	3	0.17	1.6	1.3	1.7	1.6	0.6	5	Yes	H
4	36	SB	MG/KG	TOTAL 1,2-DICHLOROETHENE	42	3	0.01	0.025	0.042	0.11	0.082			Yes	D
4	36	SB	MG/KG	TRICHLOROETHYLENE (TCE)	42	8	0.01	0.025	0.001	0.32	0.069		0.06	Yes	A

Note Data evaluated include field duplicates and normal samples (2 feet and below)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

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TABLE 22-21
Summary of Exposure Pathways to be Quantified at Screening Site 36
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil.
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers.
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0-10' bgs)	Yes	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil.
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Landscaper exposure to surface soil would be shorter exposure duration (less than 1 year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper.
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Evaluated for comparison purposes only

TABLE 22-22

Exposure Point Concentrations for Screening Site 36 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	17	2	3.6	18	5.3	10	10
MG/KG	ARSENIC	17	17	20	28	22	22	22
MG/KG	SELENIUM	17	6	0.81	2	1	1	1
MG/KG	DIELDRIN	16	6	0.17	3	0.46	0.36	0.36
MG/KG	PENTACHLOROPHENOL	16	1	0.1	0.1	0.1	0.1	0.1
MG/KG	1,1,2,2-TETRACHLOROETHANE	16	2	0.0059	0.007	0.0062	0.0062	0.0062

Note. Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation.

TABLE 22-23

Exposure Point Concentrations for Screening Site 36 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	45	3	4	18	4	5	5
MG/KG	ARSENIC	45	45	20	30	21	21	21
MG/KG	CHROMIUM, TOTAL	45	45	25	33	26	27	27
MG/KG	COPPER	45	45	33	86	36	37	37
MG/KG	LEAD	45	45	28	142	34	31	31
MG/KG	SELENIUM	45	9	0.71	2	0.82	1	1
MG/KG	DIELDRIN	44	6	0.063	2.6	0.16	0.01	0.01
MG/KG	PENTACHLOROPHENOL	44	1	0.1	0.11	0.1	0.1	0.1
MG/KG	TOTAL 1,2-DICHLOROETHENE	44	2	0.0092	0.11	0.013	0.009	0.009
MG/KG	1,1,2,2-TETRACHLOROETHANE	44	6	0.0068	0.02	0.0075	0.0072	0.0072
MG/KG	TRICHLOROETHYLENE (TCE)	44	6	0.0073	0.057	0.0093	0.0081	0.0081

Note Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation.

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

TABLE 22-24

Carcinogenic Risks and Noncarcinogenic Hazards of Screening Site 36

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Surface Soil (0-2ft)		8E-06	0.06	*Arsenic, Dieldrin*
	Soil Column (0-10ft)[1]		6E-06	0.05	*Arsenic*
		Total[2]	***8E-06***	***0.06***	***Arsenic, Dieldrin***
Utility Worker					
	Soil Column (0-10ft)		7E-07	0.006	
		Total	***7E-07***	***0.006***	

Notes

[1] *Soil Column includes surface and subsurface soil, therefore, it cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

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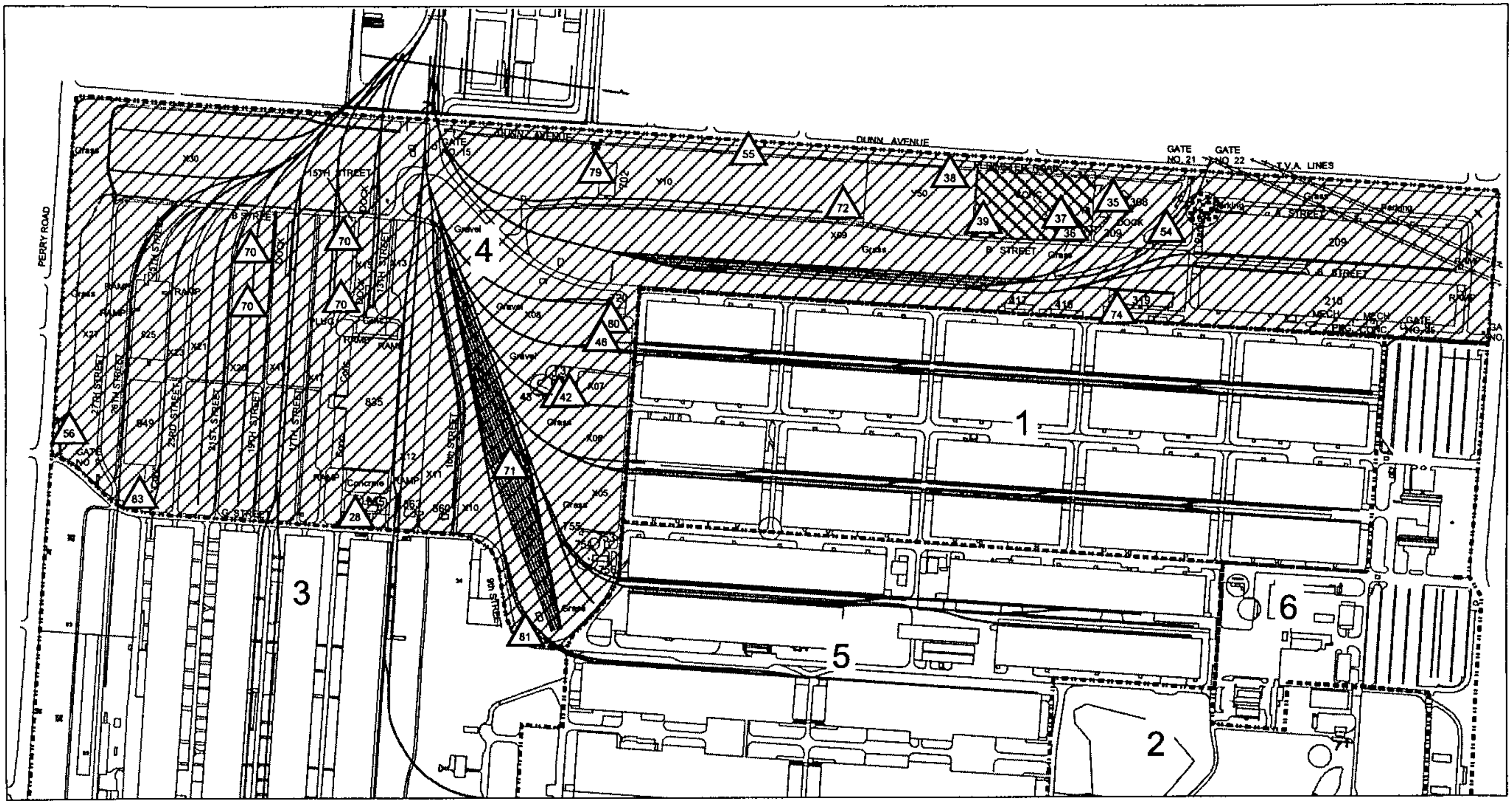

△56 Screening Site

▩ 1\2 acre circle around the highest PRE sample (SS14A) as a hypothetical residential exposure unit

▧ Surrogate site, Site 36, exposure unit for a future a industrial and a utility worker

▨ FU-wide - Exposure Units for current and a future maintenance and industrial workers, recreational receptors, and hypothetical residents

Functional Unit Boundary
Base Features
Buildings

N

0 400 800 Feet
SCALE IS APPROXIMATE

FIGURE 22-1
DIFFERENT EXPOSURE UNITS FOR BASELINE RISK ASSESSMENT WITHIN FUNCTIONAL UNIT 4
MEMPHIS DEPOT MAIN INSTALLATION RI

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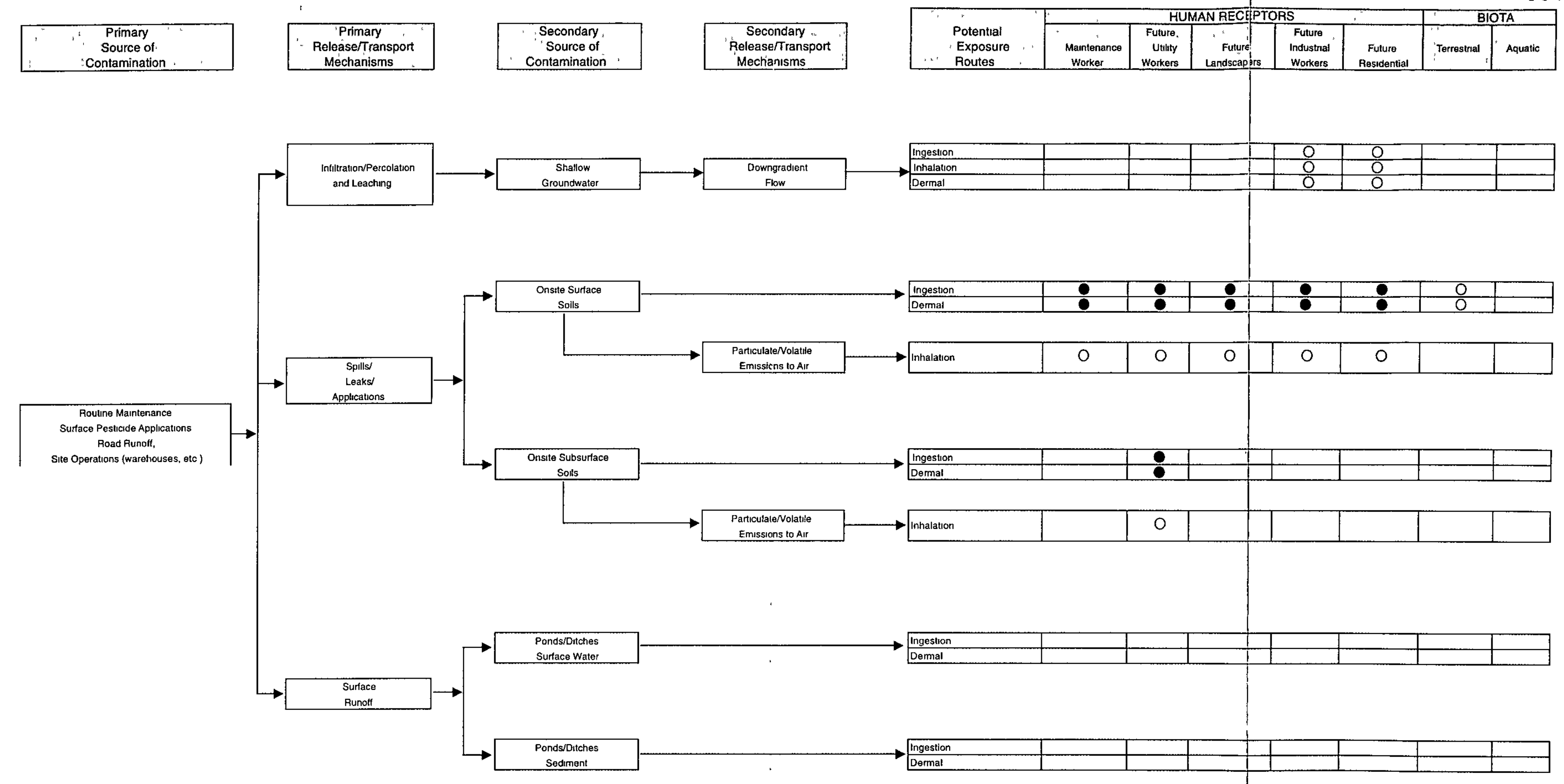

Potential Exposure Routes	HUMAN RECEPTORS					BIOTA	
	Maintenance Worker	Future, Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Ingestion				○	○		
Inhalation				○	○		
Dermal				○	○		
Ingestion	●	●	●	●	●	○	
Dermal	●	●	●	●	●	○	
Inhalation	○	○	○	○	○		
Ingestion		●					
Dermal		●					
Inhalation		○					
Ingestion							
Dermal							
Ingestion							
Dermal							

○ = minor exposure route

= primary exposure route

FIGURE 22-2
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: FUNCTIONAL UNIT 4
MEMPHIS DEPOT MAIN INSTALLATION RI

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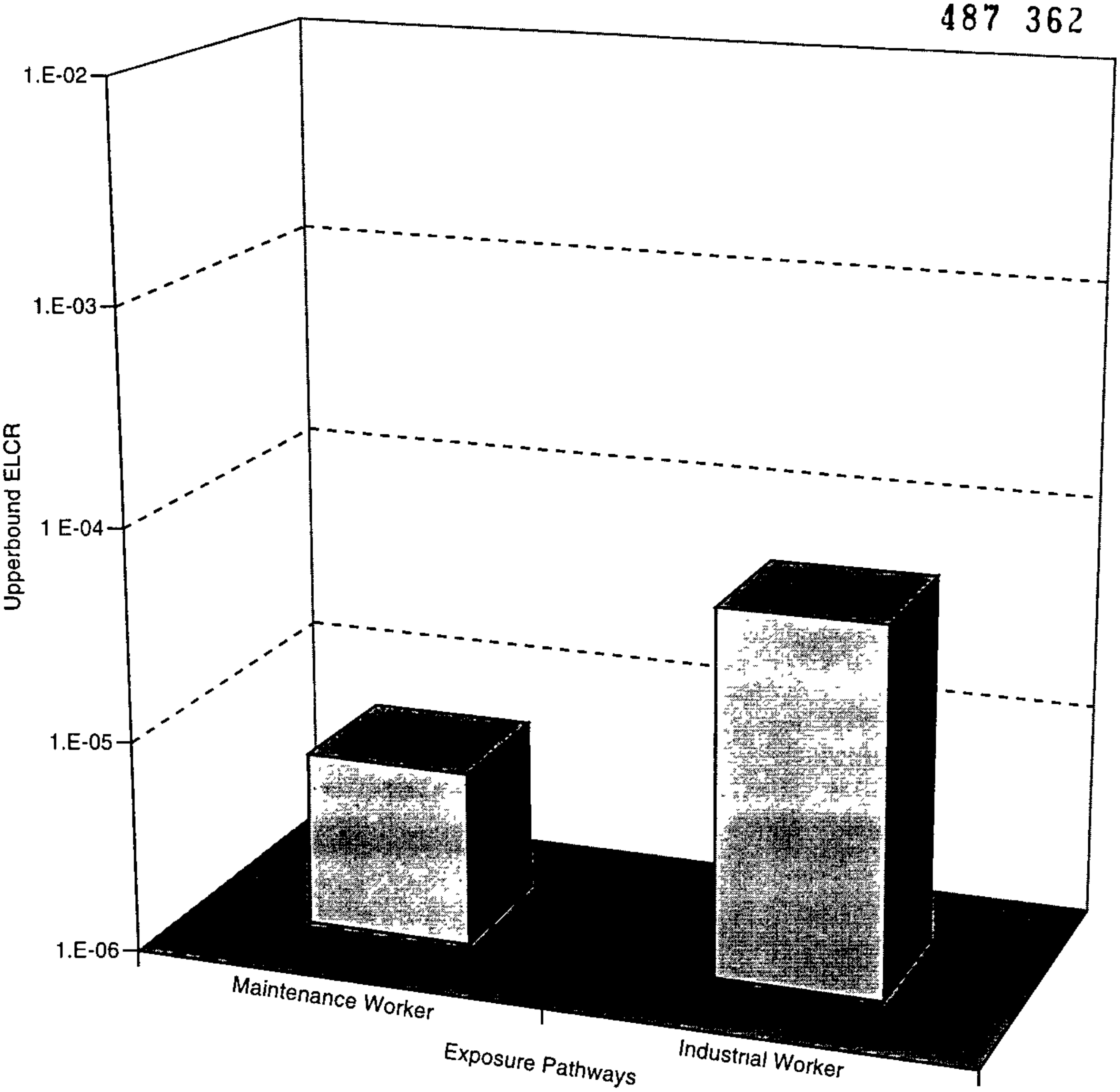

☐ Total ELCR (accepted range of 1E-4 to 1E-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 22-3
TOTAL EXCESS LIFETIME CANCER RISKS FOR TOTAL SOIL AND GROUNDWATER EXPOSURE AT FUNCTIONAL UNIT 4
MEMPHIS DEPOT MAIN INSTALLATION RI

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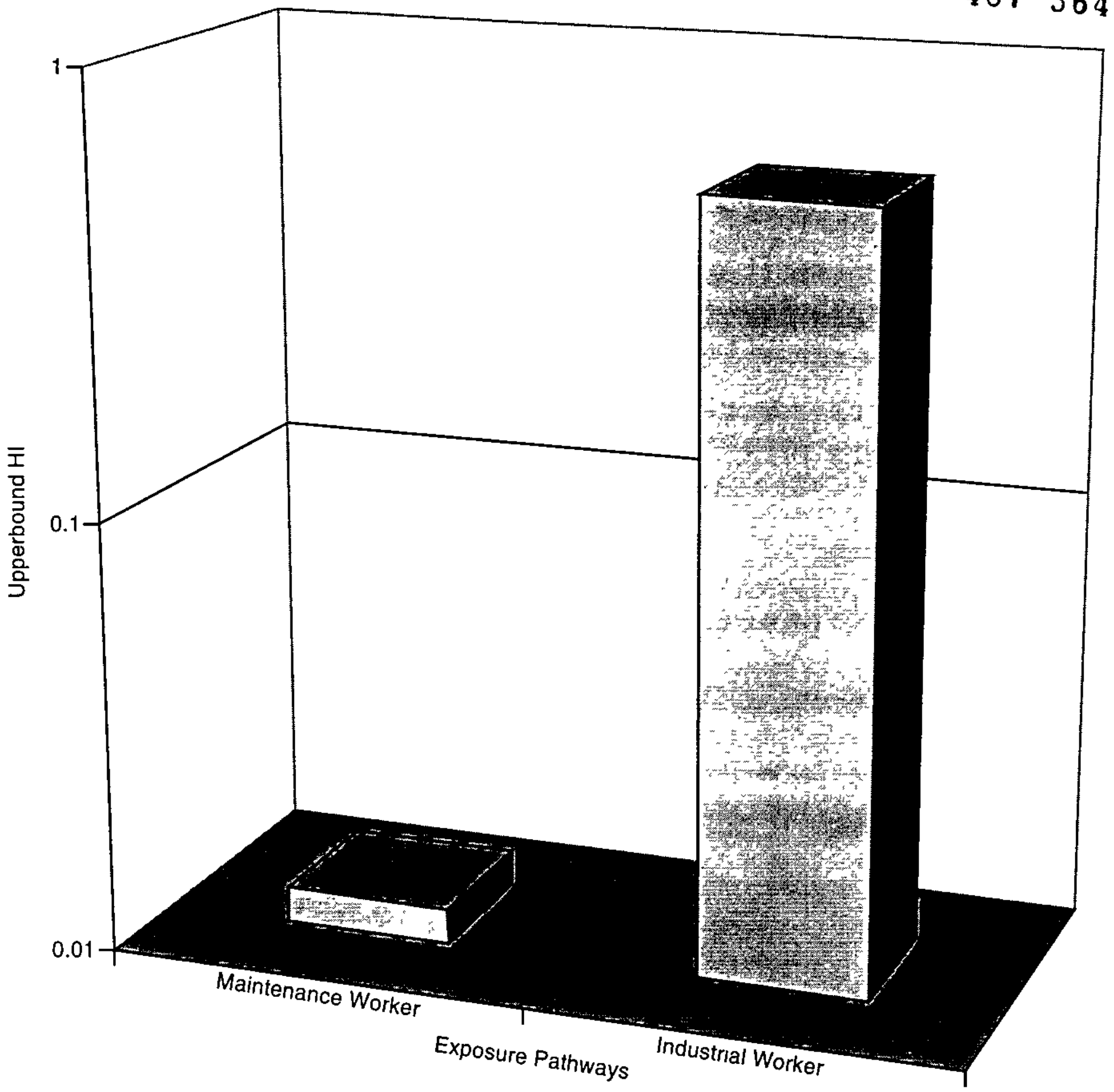

□ Total HI (threshold of 1.0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 22-4
TOTAL HAZARD INDICES FOR TOTAL SOIL AND GROUNDWATER EXPOSURE AT FUNCTIONAL UNIT 4
MEMPHIS DEPOT MAIN INSTALLATION RI

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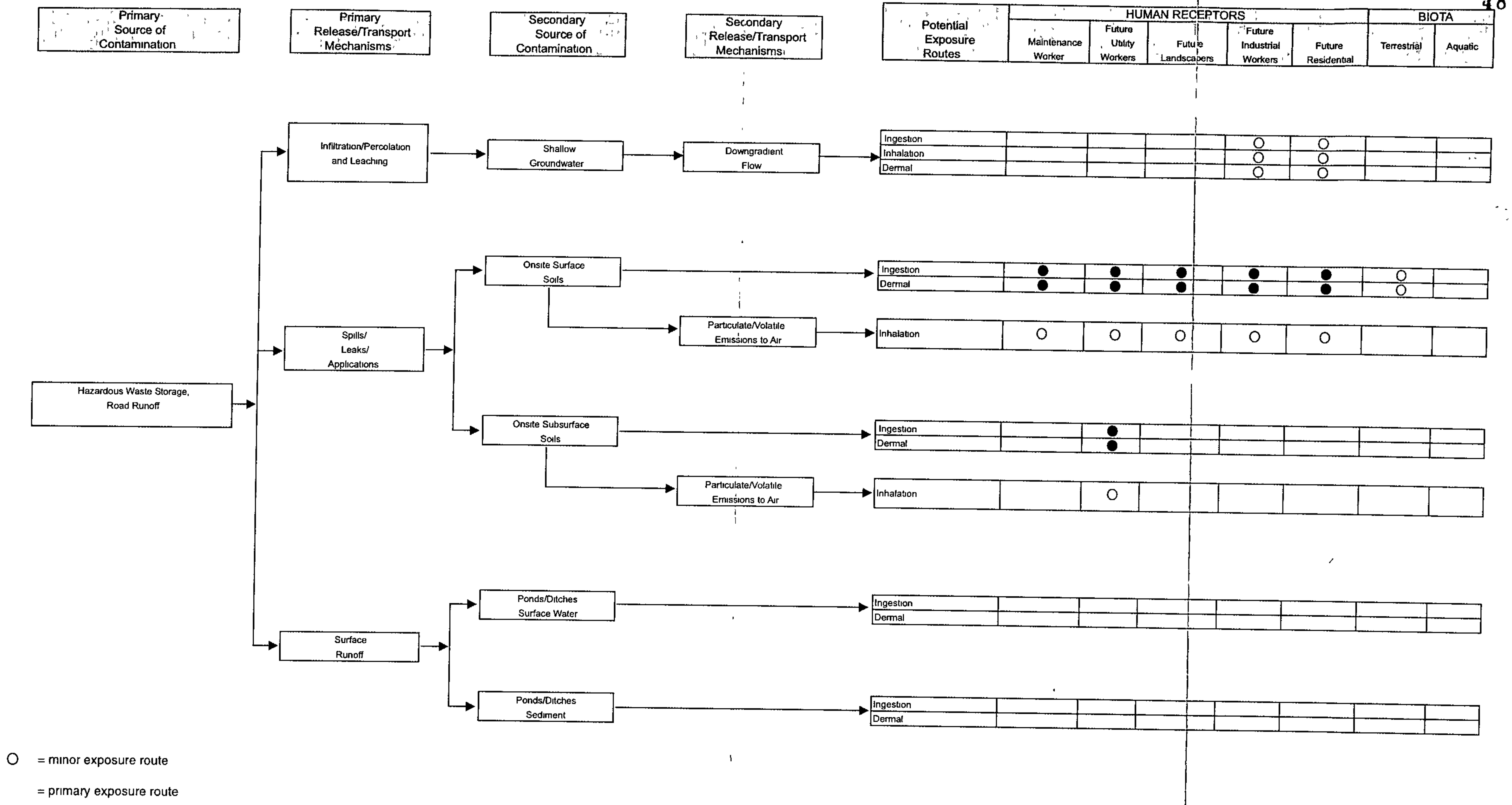

Secondary Source of Contamination	Potential Exposure Routes	Maintenance Worker	Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Shallow Groundwater	Ingestion				○	○		
	Inhalation				○	○		
	Dermal				○	○		
Onsite Surface Soils	Ingestion	●	●	●	●	●	○	
	Dermal	●	●	●	●	●	○	
	Inhalation	○	○	○	○	○		
Onsite Subsurface Soils	Ingestion		●					
	Dermal		●					
	Inhalation		○					
Ponds/Ditches Surface Water	Ingestion							
	Dermal							
Ponds/Ditches Sediment	Ingestion							
	Dermal							

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FIGURE 22-5
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: SITE 36

MEMPHIS DEPOT MAIN INSTALLATION RI

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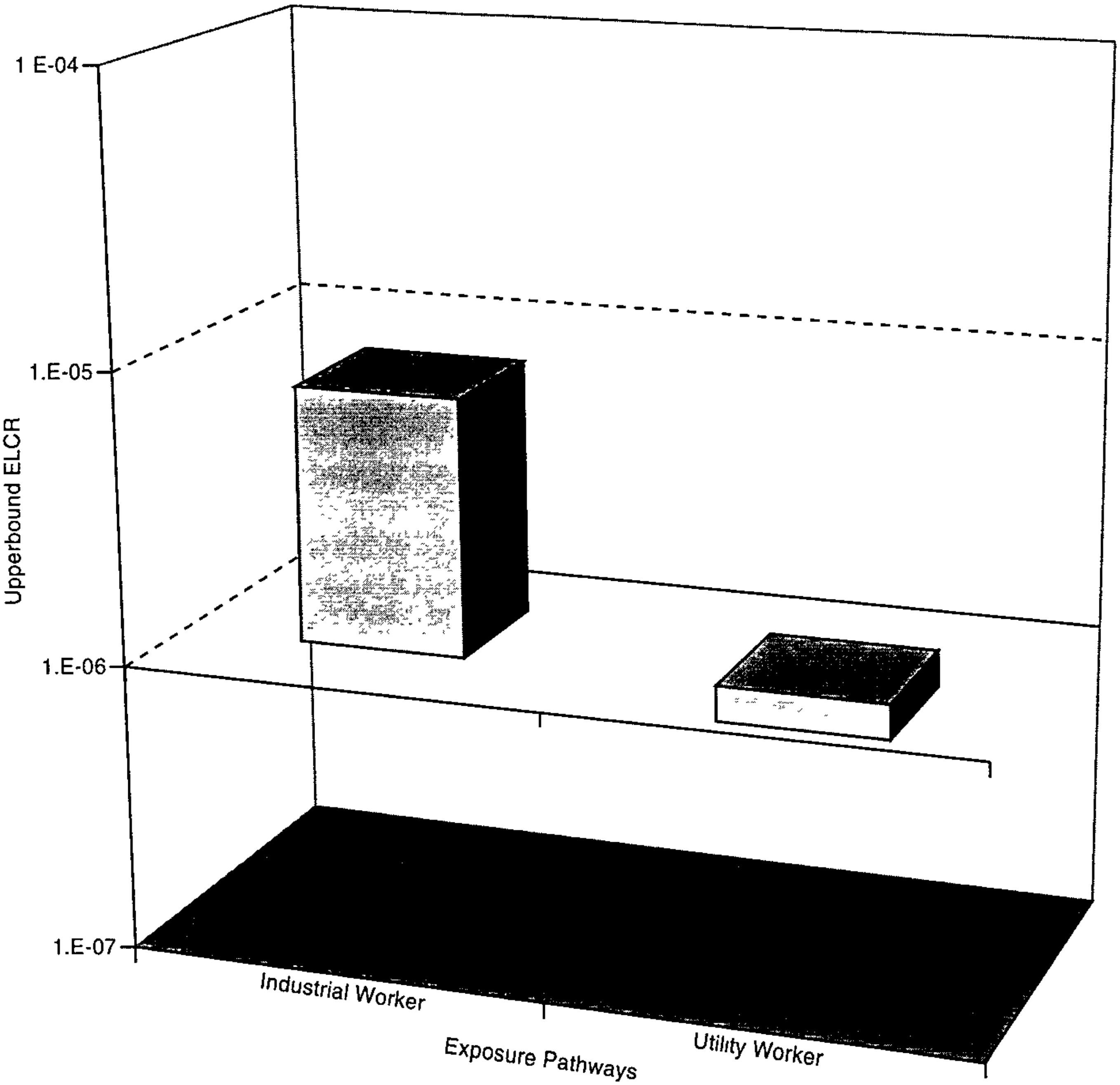

☐ Total ELCR (accepted range of 1E-4 to 1E-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 22-6
TOTAL EXCESS LIFETIME CANCER RISKS FOR SOIL EXPOSURE AT SCREENING SITE 36
MEMPHIS DEPOT MAIN INSTALLATION RI

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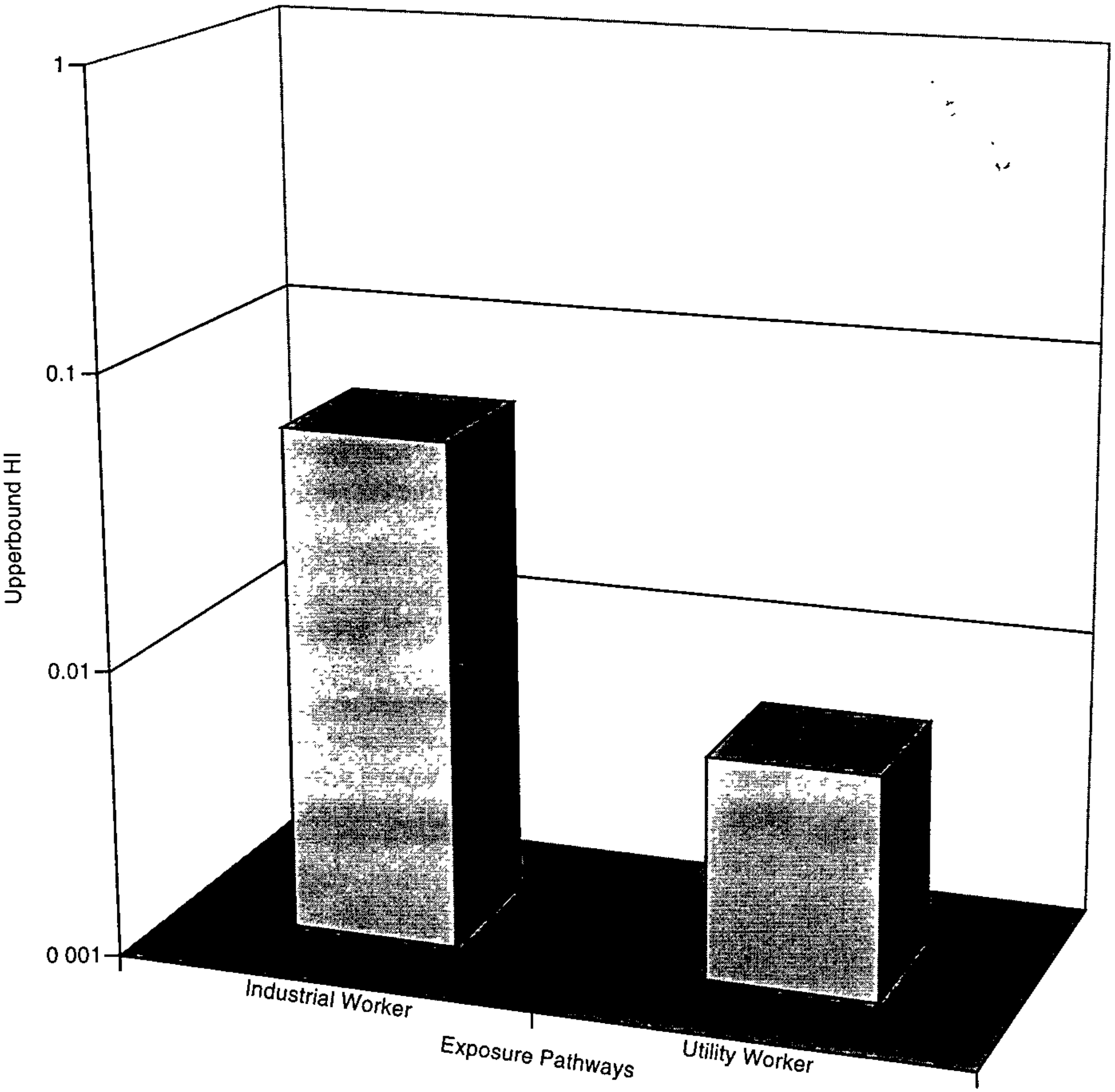

☐ Total HI (threshold of 1.0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 22-7
TOTAL HAZARD INDICES FOR SOIL EXPOSURE AT SCREENING SITE 36
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 23

TAB

23. Summary and Conclusions for FV4

23.0 Summary and Conclusions for FU4

23.1 Summary

23.1.1 Nature and Extent of Contamination

RI data were collected for surface and subsurface soil, sediment, and surface water to assess the nature and extent of contamination at FU4.

23.1.1.1 Soil

Metals, PAHs, pesticides, VOCs, and dioxins were detected in the soils across FU4. Some of these contaminants were detected at elevated concentrations (concentrations above background values) in areas that may have contributed to contamination based on past operations. The data interpretation associates the detected contamination with the following historical site operations:

- The southwestern section of FU4 for metals (lead and chromium)–at the dried paint area (near Building 949);
- The central section of FU4 for dioxins, pesticides, and PAHs–at the former PCP dip vat area, the former underground PCP storage tank area, and the pallet drying area. The PCP operations area was remediated in 1986. The detected contaminant concentrations were similar to those detected across the Main Installation; and
- The northeastern section of FU4 for metals, SVOCs, pesticides, and dioxins–at the DRMO drum storage area, grassy areas around Buildings 209 and 210, and the east stormwater drainage canal.

In addition, the elevated concentrations typically were detected in the surface soils. Contaminants detected in the subsurface soil were generally below (or near) background values.

Metals. Arsenic, total chromium, copper, lead, nickel, selenium, and zinc are the commonly detected metals of concern throughout FU4. These constituents exceeded background values in surface soil in a few specific areas within FU4:

- The surface soil at the dried paint area south of Building 949;
- The surface soil at the waste loading and unloading area adjacent to Building 702;
- The surface soil at the DRMO Drum Storage Area near Building 309; and
- The surface soil at the recoupment area at Building 865.

Arsenic was detected in the surface soil at concentrations just above background levels throughout the Depot. The observed arsenic may be associated with site-wide pesticide application activities. Total chromium, lead, and zinc were detected in surface soil at concentrations significantly above background values near Building 949 at the dried paint disposal area.

None of the metals of concern in surface soil appear to have infiltrated to the subsurface soil with the exception of total chromium in one location (discussed in the following paragraph). Metals detected in the subsurface soil such as arsenic and lead appear to be attributable to natural soil formations rather than to surface infiltration. Concentrations of these contaminants were at or just above background levels in the subsurface soil.

Total chromium was detected in the 1996 boring SB79C located at the former waste loading and unloading area adjacent to Building 702 at a concentration greatly above background. In 1998, boring SB79D was drilled relative to boring SB79C to confirm this elevated chromium concentration. Chromium concentrations detected in boring SB79D were much lower than those detected in boring SB79C. The elevated 1996 chromium concentration could not be confirmed, but the lateral extent of contamination appears to be bound. The observed chromium could be naturally occurring due to the geology, because these concentrations are similar to chromium occurrences elsewhere across the Main Installation at these depths.

Pesticides. Most of the samples analyzed for pesticides within FU4 indicate no detections or detections below background concentrations. DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin were the only pesticides detected above background levels in surface soil at FU4. The pesticides were detected in two areas of FU4:

- West-central portion of FU4–in the surface soil just north of Building 737 in the open gravel area; and
- The far eastern portion of FU4–in the surface soil near Building 209 and Building 210 in the grassy areas and the grassy areas surrounding these buildings.

The pesticide concentrations detected probably are attributable to site-wide application rather than to site-specific releases. DDT was the most common pesticide detected in the subsurface soil above background. The pesticide concentrations detected in subsurface soil were located infrequently throughout FU4, normally at the 8- to 10-ft depth, and possibly associated with sampling artifacts.

SVOCs. The primary SVOCs of concern in the surface soil at FU4 were PAH compounds. PAHs were detected throughout the Main Installation, with the highest concentrations in proximity to railroad tracks. PAH compounds can originate from the seepage of creosote from railroad ties, from historical railcar leaks, or from PCP and used-oil mixtures historically applied for weed control along the tracks. At Parcels 30 and 33 (western portion of FU4), where the highest levels of PAH compounds were detected, the elevated concentrations probably resulted from railroad ties.

SVOCs, including PAHs, generally were not detected in the subsurface soils.

VOCs and Other Organics. The majority of the surface and subsurface soil sampling results for VOCs within FU4 indicate no detections. MEK was one of the most common VOCs detected, with the exception of laboratory contaminants. MEK was detected in the following locations:

- Northwestern corner outside of Building 209–in the surface soil;
- Northwestern corner outside of Building 210–in the surface soil; and
- South of the concrete pad located west of Building 309 (former DRMO drum storage area)–in the surface soil.

The VOCs in the subsurface soil also were detected south of the concrete pad in the former DRMO drum storage area. Two chlorinated VOCs–1,1,2,2-Tetrachloroethane and TCE–were the only VOCs detected at concentrations that exceeded the GWP values. These VOC concentrations above the GWP values were detected at the lowest sample depth of 18 to 20 ft. TCE was detected in the groundwater just north of this site in MW53.

Other Organics. Concentrations of petroleum hydrocarbons were detected in the surface and subsurface soil at depths of zero to 10 ft in one sample location, A(24.2), and in its duplicate located near Building 770, at the FU4 and FU3 boundary. The surface soil sample concentrations exceeded the Region III RBC direct exposure value of 34 mg/kg and the GWP value of 340 mg/kg. The subsurface soil sample concentrations did not exceed the GWP value of 340 mg/kg.

Fewer than 50 surface and subsurface soil samples were analyzed for dioxins and furans. All of the analyzed samples had detectable levels of dioxins and furans, mostly the hepta- and octa- isomers. Concentrations of dioxins and furans were detected in the surface soil in the PCP dip vat area and along the east stormwater drainage canal. The soil around the former PCP dip vat area and storage tank area previously was contaminated with dioxins and furans, based on past practices. The area was remediated in 1986 for possible PCP and dioxin contamination in the surface soil. The highest dioxin concentrations are now detected at the east stormwater drainage canal; the source of these contaminants in this location is not known. However, background samples indicated dioxins and furans at similar concentrations.

23.1.1.2 Surface Water

Metals, pesticides, and dioxins were detected in the water collected during rain events from the drainage ditches and drainage areas within FU4. The specific constituents with concentrations that exceeded background values in the drainage ditches are dissolved arsenic, dissolved iron, dissolved selenium, and octachlorodibenzo-p-dioxin. Background values were not established or available for some constituents, but some of these constituents had detectable concentrations above the ecological criterion value. These include DDT, dieldrin, octachlorodibenzofuran, and dissolved silver. The detected constituents could be associated with suspended particulates in the rainwater.

Metals. Dissolved arsenic, dissolved iron, dissolved selenium, and lead were the only metals detected above background values. The elevated concentrations of dissolved arsenic were detected at the east stormwater drainage canal and the west stormwater drainage canal. The elevated concentrations of lead and dissolved selenium were only detected in the west stormwater drainage canal. The elevated lead detection could be a result of surface runoff from the dried paint disposal area. Dissolved iron was detected at elevated concentrations at the north stormwater drainage area and the west stormwater drainage canal.

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Pesticides. The pesticides detected in the surface water runoff at FU4 are DDT and dieldrin. Both pesticides were detected in the east stormwater drainage canal. The west stormwater drainage ditch only had detections of dieldrin, and the north stormwater drainage area only had a detection of DDT. Pesticide detections in the drainage ditches are probably an indication of surface water runoff from the grassy areas within FU4. Background values were not established for pesticides in surface water.

Dioxins. Octachlorodibenzo-p-dioxin was detected at concentrations above background in the north and east stormwater drainage areas. The source of these contaminants in the drainage areas is not known. The detections are not a result of surface water runoff from the PCP dip vat area, because surface water runoff from this site discharges through the west stormwater drainage canal (Site 56). The estimated TCDD equivalents are a result of the detected octa-isomer. The octa-isomers are the most persistent and could be from atmospheric deposition and not related to the Depot's activities.

23.1.1.3 Sediment

Metals, pesticides, SVOCs (including PAHs), VOCs, and dioxins were detected in the sediment samples collected from the drainage ditches and drainage areas within FU4. Background values were not established or available for some constituents, but some of these constituents had detectable concentrations above the EPA Region III RBC exposure and GWP values. These include a number of hepta-, hexa-, and octa- dioxin isomers, carbon tetrachloride, DDT, endrin, and PCP.

Metals. Total chromium, calcium, lead, and magnesium were the only metals detected above background values. The elevated concentrations of lead and total chromium were detected in the same sample locations at the east and west stormwater drainage canals at sediment samples SD14, SE56A, SE56B, and SB56C. Calcium and magnesium are naturally occurring metals.

Pesticides. The pesticides detected in the sediment at FU4 at concentrations above background are alpha-chlordane, DDD, DDE, and dieldrin. The pesticides were detected in the east and west stormwater drainage canals and in the north stormwater drainage area. Pesticide detections in the drainage ditch sediment are probably an indication of site-wide pesticide application within the Main Installation.

Dioxins. A number of dioxins were detected in the sediment at FU4. The ones detected at concentrations above background include 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin, octachlorodibenzo-p-dioxin, and TCDD equivalent. The dioxins were detected at concentrations above background in the sediment at the north, west, and east stormwater drainage areas. The source of these contaminants in the east and north drainage areas is not known. Stormwater runoff from the PCP dip vat area discharges through the west stormwater drainage canal. TCDD equivalent was detected above background in the north stormwater drainage canal, as well.

23.1.2 Fate and Transport

23.1.2.1 Migration Pathways

FU4 is mostly an open storage area with a number of loading docks and general purpose warehouse buildings, covered mostly with coarse gravel, some grass, railroad tracks, and paved roads (see Figure 2-16). Potential pathways for migration at FU4 are surface runoff, leaching, volatilization, and dust emission.

Surface runoff will migrate from concrete-, asphalt-, and gravel-covered areas around the warehouse buildings, the gravel-covered open storage areas, and the grassy areas located near the FU boundaries. Leaching could occur and dust emissions could be generated from the grass- and gravel-covered areas within FU4. However, dust emissions will be reduced dramatically, based on the types of ground cover within FU4.

FU4 consists of three drainage basins that normally route stormwater runoff to three different drainage areas: the east stormwater runoff canal (Screening Site 54), the west gate stormwater drainage canal (Screening Site 56), and the north stormwater drainage area (Screening Site 55). All stormwater drainages discharge into the city collection system The area most affected by contaminants at FU4 is Screening Site 83. Stormwater runoff from this area flows in a westerly direction into storm drains, which connect to a drain pipe that discharges into the west gate stormwater canal.

The western and northern boundaries of FU4 are also the Main Installation-site boundaries, which are fenced and covered with grass. The area outside of the northern boundary is Dunn Avenue and the area outside of the western boundary is Perry Road. The areas outside of the fenced area on the western and northern boundaries are not accessible to direct releases from site operations at the Main Installation because runoff from the Main Installation discharges into the concrete berms downhill from Perry Road and Dunn Avenue. However, some stormwater runoff in the northern boundary of FU4 discharges directly to the City of Memphis.

23.1.2.2 Contaminant Persistence and Migration

Metals, dioxins, and PAHs were the most frequently detected contaminants at FU4. Metals are persistent in the environment; however, they are likely to remain bound to soil/sediments. Emissions of metals to the ambient air would be in the form of particulate emissions. PAHs and dioxins are not very volatile and are expected to remain bound to the soil; thus, they are likely to be released through dust.

The surface soils at the site operations areas involving past wood treatment and pallet drying areas have been remediated. Surface runoff to drainage ditches on the northern and eastern sides is not possible. The storm drain from the Sites 42 and 43 runs to the Site 56 drainage system. The surface runoff migration of dioxins is not likely for any of the sites within FU4. The detected hexa- and octa- isomers probably are from atmospheric deposition and may not be related to the site's past operations. Although the dioxin and furan compounds are persistent in the environment, off-site runoff from the site is not a concern because of the lack of a site-specific source, the lack of a significant flow to the off-site areas, and the relatively low levels detected in the off-site drainage ditch sediments.

The soils immediately above shallow groundwater at a depth of 18 to 20 ft had detected concentrations of TCE, with a maximum concentration of 0.32 mg/kg. At this maximum concentration, TCE exceeded the groundwater transfer (GWP/SSL) criteria. Thus, soils within FU4 at Screening Sites 36 through 39 may be a continuing source of groundwater contamination. Most of the other detected concentrations of TCE also were from samples collected at Screening Sites 36 through 39. Additionally, 1,2-DCE (total) was detected in the subsurface soil at a maximum concentration of 0.11 mg/kg. This detected maximum is below the GWP values of 0.4 to 0.7 mg/kg (*cis-DCE and trans-DCE* isomers). Thus, this compound may no longer be at high enough concentrations to be a continuing source for groundwater contamination. Also, it could be the result of the degradation of the TCE, which is the parent compound.

Fluvial aquifer groundwater beneath the Depot in general has been affected by VOCs, primarily TCE and PCE. Groundwater at FU4 flows to the west and southwest onto the Depot, so contaminated groundwater is likely to flow onto the site. The potential effects on the groundwater also are addressed as part of FU7 in Sections 32.0 through 35.0.

23.1.3 Risk Assessment

23.1.3.1 Summary and Conclusions of Risk Assessment for FU4

The human health risk RA for FU4 included all of the data collected within this physical unit. The primary conclusions of this RA are as follows:

- The RA included data for the surface and subsurface soils, which included more than 300 samples in total. The COPCs selected for the soils are inorganic chemicals, SVOCs (including PAHs), chlorinated pesticides, and dioxins, reported as TCDD equivalents Sediments and rainwater collected from the drainage ditches at Sites 54, 55, and 56 also had similar constituents as COPCs. Metals, chromium, and lead from the past paint stripping waste disposal area near Building 949 were elevated. The subsurface soil also had chlorinated solvents, TCE, and 1,2-DCE as COPCs because of the potential for leaching to groundwater;

- There are three drainage ditch systems, identified as Screening Sites 54, 55, and 56, leading to different areas. These ditches were sampled for dry sediments and surface water during a rain event. Only sediments were included for the RA, and COPCs identified in the sediments were similar to those found in surface soil elsewhere within the Depot. TCDD equivalents reported in the sediments primarily were from hexa- and octa-isomers of the dioxin and furans. The concentrations appear to be similar to background and are likely to be from atmospheric depositions common in urban areas;

- Overall human health risks and noncarcinogenic hazards to current and future maintenance workers in FU4 are within acceptable risk limits. Risks and HIs to a future industrial worker are within the acceptable limits (in the range of 10^{-6} to 10^{-5}) from surface and subsurface soils; and

- Potential risks from direct exposure to the surrogate site (Site 36) are negligible. The COPCs identified are a subset of those found in FU4. Overall risks to a utility worker and industrial worker were within acceptable levels.

23.1.3.2 Summary and Conclusions of Ecological Risk Assessment for FU4

A screening-level ERA was conducted for the entire FU4 to evaluate whether constituent concentrations potentially could adversely affect ecological receptors. Although ecological habitat at FU4 is limited, the ERA was conducted in accordance with EPA guidance, which recommends little or no risk management input in the screening assessment. The screening assessment (Steps 1 and 2) identified a number of COPCs for consideration in Step 3. The refinement process in Step 3 indicated that there were no COPCs in the rainwater at FU4, based on WoE. Although some COPCs remained for surface soil and sediment, ecological exposure pathways are incomplete at this site because of the lack of suitable terrestrial or aquatic habitat. Therefore, there is adequate information to conclude that the ecological risk at FU4 is negligible, and remediation based on ecological risk is not warranted.

23.1.3.3 Summary and Conclusions for RI Site 36

Conclusions specific to the surrogate site RA performed at Site 36 are presented below:

- Site 36 is selected as the surrogate site to represent the worst-case potential risk areas within FU4, based on the results of the evaluation presented in Section 7.0;
- A human health RA also was conducted for this site because it represents one of the worst-case exposures to human receptors. An ERA was not conducted at this site because it is an industrial site and not a suitable habitat for terrestrial receptors. Also, the ecological risks overall from FU4 were evaluated as part of the FU4-wide RA section;
- Surface soil samples indicated the presence of several inorganic chemicals, SVOCs (including PAHs), organo-chlorine pesticides, and dioxins above screening criteria and/or background values; these were selected as COPCs. The subsurface soils had two CVOCs;
- Deep soil risk evaluations included the soil column from the surface to a 10-ft depth. Nine surface soil (zero to 1 ft) and six deeper samples (greater than 1 to 10 ft) were included in this data set;
- Risks and noncarcinogenic hazards estimated for workers under various exposure scenarios represent risks within the 1 to 100 in a million range (10^{-6} to 10^{-4}) and HIs below a target value of 1.0. The total risks are represented by the higher of the surface and deeper soil risk estimates; and
- Site 36 does not pose a significant human health concern for future industrial land use at FU4, even under high-end exposure assumptions.

23.2 Conclusions

23.2.1 Data Limitations and Recommendations for Future Work

The nature and extent of the chemical constituents in surface and subsurface soil have been defined both vertically and horizontally in FU4. In general, surface soil samples with concentrations attributable to source areas within FU4 were delineated until the least-contaminated area concentrations were similar to those in the background. Similarly, subsurface soil samples with elevated concentrations generally were located in borings that contained deeper samples with concentrations below the background values. As a result, no data limitations exist with respect to the surface or subsurface soil samples collected in FU4. Therefore, no additional future work is recommended for FU4.

The combined risks from groundwater, and soil are above acceptable limits, primarily from groundwater contamination. Potential continuing sources for groundwater contamination at Site 36 may need further evaluation.

23.2.2 Recommended Remedial Action Objectives

As shown in the RA detailed in Section 22.0, overall human health risks and noncarcinogenic hazards associated with exposure to soil and sediment are within acceptable risk limits. Groundwater risks are further discussed in Section 34.0. Some of the PCP operations-related areas previously were remediated. Elevated metals around Building 949 are within acceptable exposure levels for lead and chromium. Elevated concentrations of metals, primarily lead, exceeding the target concentration value of 1,530 mg/kg require the removal of soils to reduce potential hot spots, although overall EPCs are within the target levels. The combined risks from groundwater and soil are above acceptable limits, primarily from groundwater contamination. Potential continuing sources at Site 36 may require further actions.

TAB

Section 24

TAB

24. Nature and Extent of Contamination
at FUS

24.0 Nature and Extent of Contamination at FU5

This section addresses the nature and extent of contamination within FU5, the Newer Warehouses. The subsections below provide a description of how FU5 was defined, discuss the probable sources of contamination that exist within FU5, and identify the nature and extent of contamination at FU5 by identifying the distribution and location of widespread contaminants in the surface and subsurface soil of FU5. Groundwater contamination beneath FU5 is addressed in Section 32.0.

As described in the following subsections, FU5 contains CERCLA sites identified in the original RI activities prior to 1990, as well as screening sites and TEC sites identified by CH2M HILL. These sites were investigated as possible sources of contaminant releases to the environment. Areas not associated with a specific site were sampled as part of the BRAC characterization program. This section discusses the nature and extent of contamination within the entire FU area by evaluating the combined CERCLA and BRAC data.

24.1 Functional Unit Background

24.1.1 FU5 Description

FU5 is described as the Newer Warehouses, consisting of Screening Sites 70/71, 73, 75, 76, 77, and 78; BRAC Parcel Areas 16, 17, 18, 19, to, 21, 22, and 34; and proposed NFA sites (see Figure 1-1). As discussed in Section 1.1, FU5 was established based on similar operational activities in the south-central portion of the Main Installation, including general purpose warehouse buildings. Most of the buildings within FU5 were constructed after the 1980s.

24.1.2 FU5 History

FU5 consists of 13 buildings surrounded by asphalt, grass, and/or gravel. Six of these buildings were constructed after the 1980s. Most of the buildings in FU5 were described as general purpose warehouses. The warehouses were used to store materials such as clothes, miscellaneous equipment, medical supplies, hazardous materials, waste petroleum product drums, waste oil, and material handling equipment. Figure 24-1 shows the locations of buildings within FU5. Railroads used for the transport of warehoused materials also are adjacent to some of the buildings.

24.2 Summary of Remedial Investigations at FU5

24.2.1 Historical Remedial Investigations

No previous media sampling has occurred at FU5. However, Building 490 and Building 469 are the location of proposed NFA Sites 40 and 41. Although no analytical data are available for the NFA sites, the sites were evaluated during the 1990 RFA (Law, 1990), with the results indicating that the potential for release from all pathways was low. There was no history or evidence of uncontrolled leaks or spills, the units appeared to be in good condition, and the sites were designated for no further action. Additionally, the FFA designates these sites as NFA sites (CH2M HILL, September 1998c).

24.2.2 Summary of Key Findings from Past Remedial Investigations

There have been no previous RIs conducted at FU5. However, the surface soils surrounding buildings at FU5 may contain pesticides as a result of routine pesticide application at the facility. In addition, the FU contains railroad tracks that historically were sprayed with pesticides, herbicides, and waste oil containing PCP. A biased sampling approach was conducted to evaluate whether contaminants exist within the FU. A number of BRAC surface soil samples were collected to provide information regarding the presence of pesticides and PCBs in surface soil.

24.2.3 Current Remedial Investigations

The screening sites within this FU initially were investigated by CH2M HILL from December 1996 through January 1997. At this time, the surface soil was sampled to assess the nature and horizontal extent of contamination at these sites, and the subsurface soil was sampled at most of these sites to assess the vertical extent of contamination. No surface water bodies exist at FU5, so no surface water data were collected.

Additional investigations of the screening sites and initial investigations of areas of potential concern identified in aerial photographs taken by the TEC were conducted from September 1998 through October 1998. Additional surface and subsurface soil sample data were collected to accomplish the following:

- Further characterize the nature and extent of contamination;
- Collect a sufficient number of data points to perform an RA;
- Confirm the absence of contamination at some screening sites based on initial (1996-1997) screening results;
- Assess the groundwater contamination; and
- Collect FS samples where remedial activities are likely.

The sites investigated within FU5 and the sampling rationale for each are described in Table 24-1. Figure 24-1 shows the location of these sites. The basis for the 1996 sampling rationale was the same for each site identified at the time:

1) To collect soil samples that are representative of site conditions;
2) To compare the detected concentrations to background and screening levels; and
3) To develop appropriate recommendations.

The 1998 sampling rationale was developed so that the recommendations made from the 1996-1997 sampling event could be accomplished. Information about specific activities that occurred at the FU5 sites of concern is presented in Section 24.3.

24.3 Potential Sources of Contamination

Because hazardous materials were handled and stored at some buildings within FU5, there was the potential for spills of hazardous materials to soil surrounding the buildings. Furthermore, soil may have been contaminated with pesticides as a result of routine pesticide application at the facility. In addition, the FU contains railroad tracks that historically were sprayed with pesticides, herbicides, and waste oil containing PCP.

24.3.1 Building 359

Building 359, a general purpose warehouse, has 240,000 square ft of space and was used to store medical supplies, caustic soda, historical USTs, and sodium chloride. Built in 1942, Building 359 formerly housed a boiler; an out-of-service incinerator also is located in this building.

On August 27, 1993, a sulfuric acid spill was reported in Section 2 of Building 359. The quantity of material spilled is unknown.

The expired medical supplies storage area, located near the center of Building 359 and consisting of a concrete-floored storage bay approximately 50 ft by 30 ft, is a proposed NFA site under the FFA. The storage area is used to store expired-shelf-life medical supplies in their original containers, on pallets or shelves throughout the unit, until these supplies are transported or disposed. The site was evaluated during the RFA in 1990, and it was concluded that no remedial actions are necessary for the protection of human health or the environment (CH2M HILL, September 1994).

No "red bag" medical waste has been stored in this building. Some "red bag" wastes were generated by the Health Clinic, which was located on the western end of the building. These wastes would have consisted mainly of tongue depressors and possibly syringes (for allergy or insulin shots), and were disposed of at a local landfill (personal communication, Denise Cooper/Memphis Depot, April 1998).

24.3.2 Building 469

Building 469, a battery shop, was built in 1960 and includes 9,600 square ft of space used to store sulfuric acid, batteries, lead, and spray paint. In the past, this building has housed an electrical shop and acid recycling facility. In December 1993, about 6 ounces of transformer oil were spilled in Building 469. The Depot Spill Team contained the spill and removed the affected materials. Depot, EPA, and TDEC staff conducted a site inspection and concurred that the remedial action had been complete and no further investigation was necessary.

Building 469 is also the location of proposed NFA Sites 40 (Safety Kleen units) and 41 (satellite drums). Site 40 consists of nine locations throughout the installation where the self-contained Safety-Kleen solvent parts cleaning stations are located. The 20-to 40-gallon steel holding tanks, supported by steel legs, have been used in various locations since 1985. The parts cleaning solvent is recirculated in the tanks and periodically replaced by Safety-Kleen (CH2M HILL, September 1998c).

The Safety-Kleen units are used for carburetor and cold parts cleaning. New cleaning material contains 11.9 percent cresylic acids, 31.7 percent methylene chloride, and

81.3 percent ortho-di-chlorobenzene. Used material generally is contaminated with various oils and greases from the parts themselves. Safety-Kleen handles the manifesting, transporting, and recycling of the used material.

Building 469 is one of the five locations of proposed NFA Site 41 (satellite drum accumulation areas). Site 41 consists of five satellite drum storage locations throughout the installation that have been used since 1985 to store drums of waste materials. The units vary in the number and size of drums that they contain, but all units are located on concrete floors within buildings. Building S469 has one unit, and the stored wastes include sulfuric acid. The drums and areas are maintained in good condition and are regulated All wastes collected in these areas are transported to the DRMO before off-site disposal (CH2M HILL, September 1998c).

24.3.3 Unknown Wastes Near Building 690 (Screening Site 76)

Building 690, a general purpose warehouse, was built in 1953 and includes 218,000 square ft of space used to store material-handling equipment and materials awaiting shipment. At times in the past, unknown wastes and vehicle maintenance supplies have been stored here.

24.3.4 Unknown Wastes Near Buildings 689 and 690; and Alcohol, Acetone, Toluene, and Hydrofluoric Acid Area, Building 689 (Screening Sites 75, 77, and 78; NFA Site 40)

Building 689, another general purpose warehouse built in 1954 and measuring 228,000 square ft, was used to store material-handling equipment and materials awaiting shipment. Only the western end of Building 689 was used for temporary staging before shipment. In the past, this facility has been used to store Safety-Kleen parts cleaning units and unknown waste.

Building 689 is associated with the following activities: 11 spills documented from May 8, 1990, through November 16, 1995, inside and outside of Building 689; Screening Site 78 (alcohol, acetone, toluene, and hydrofluoric acid area, Building 689); Screening Site 75 (unknown wastes near Building 689); and proposed NFA Site 40 (Safety-Kleen units).

The materials spilled at Building 689 include nitric acid, corrosion-removing compound, hydraulic fluid, oil, and sulfuric acid. Absorbent was applied to clean up the spills (Memphis Depot, November 1997).

Screening Site 78 is located in the northern section of Building 689. This section of the building historically staged hazardous substances prior to shipment (Memphis Depot, November 1997).

Screening Site 75 is located between Buildings 689 and 670, on the eastern side. The area is not bermed and is adjacent to a storm sewer inlet (Memphis Depot, November 1997).

The proposed NFA Site 40 consists of nine locations throughout the installation where the self-contained Safety-Kleen solvent parts cleaning stations are located. The 20- to 40-gallon steel holding tanks, supported by steel legs, have been used in various locations since 1985. The parts cleaning solvent is recirculated in the tanks. The parts cleaning solvent periodically is replaced by Safety-Kleen Corporation (CH2M HILL, September 1998c).

The Safety-Kleen units are used for carburetor and cold parts cleaning. New cleaning material contains 11.9 percent cresylic acids, 31.7 percent methylene chloride, and 81.3 percent ortho-di-chlorobenzene. Used material generally contains various oils and greases from the parts themselves. Safety-Kleen handles the manifesting, transporting, and recycling of the used material.

24.3.5 Former Container Storage Strip

A rectangular area oriented east-west in the 1945-1946 aerial photos is shown between what is now Buildings 670 and 560. The containers do not appear to be drums, because they are rectangular and probably 10 ft wide by less than 20 ft long. Their contents and purpose are not known. It is also not known if they were placed in a trench, or on the ground surface.

24.3.6 Railroad Tracks (Screening Site 70/71)

Railroad operations were the main means of transporting materials to the warehouses for storage. Throughout the Main Installation, railroad tracks historically were sprayed with pesticides, herbicides, and waste oil containing PCP.

24.3.7 All Grassed Areas (Screening Site 73)

Grassed areas throughout the Main Installation were treated as one screening site during the investigation. The historical application of pesticides such as dieldrin on grassy areas was cause to consider areas as a potential source of contamination.

24.3.8 BRAC Parcels

Environmental sampling was performed at BRAC property parcels to assess whether the property was suitable for transfer or lease. Sampling was conducted to assess whether chemicals existed in the surface and subsurface soils in concentrations that might present a concern for industrial, and in some portions of the Main Installation, residential uses.

24.4 Nature and Extent of Soil and Subsurface Soil Contamination

To characterize the nature and extent of contamination within FU5, surface and subsurface soil samples were collected and analyzed for VOCs, SVOCs, metals, and the TCL/TAL parameters (organochlorine pesticides, herbicides, PCBs, and hexavalent chromium). Figure 24-2 shows the sample locations for FU5, and Table 24-2 lists the parameters analyzed for at each site. Appendix P provides a list of all parameters detected in the surface and subsurface soil samples collected at FU5 and compares them to screening and background values. The nature and extent of the contaminants detected above background values at the FU are discussed below.

24.4.1 Nature and Extent of Metal Contamination

Several metals were detected throughout FU5 at concentrations above background values. The results of the analyses are presented in Table 24-3. The metals that exceeded background values were divided into three categories based on the number of concentrations that exceeded background values and the relative importance of the metal as potential contaminants. Each metal that exceeded an background value was classified as a "primary metal of concern," a "distributed metal," or a "naturally occurring metal." Primary metals of concern were those detected above background values in a significant number of samples and may indicate a release from source areas in FU5. Distributed metals were those detected above background values in a relatively small and insignificant number of samples. Naturally occurring metals are metals associated with the natural soil conditions that were detected above background levels.

24.4.1.1 Primary Metals of Concern

On the basis of the results of the surface and subsurface soil sampling, arsenic, total chromium, copper, lead, nickel, and zinc were designated as the primary metals of concern throughout FU5. The soil samples that exceeded the background values for these constituents are shown on Figures 24-3 through 24-16. These constituents were designated as primary metals of concern primarily because, with the exception of arsenic, they exceeded background levels in a number of concentrated discrete areas throughout FU5.

Arsenic. Two of the 21 surface soil samples analyzed for arsenic contained an arsenic concentration that exceeded the background value of 20 mg/kg. SS75D contained a concentration of 29.0 mg/kg. SB77B contained a concentration of 22.9 mg/kg; however, the duplicate sample taken at this location contained a concentration (18.7 mg/kg) below the background value. Arsenic was detected below background levels in each of the remaining samples, with concentrations ranging from 5.05 mg/kg to 18.7 mg/kg. No significant cluster of elevated arsenic concentrations that might indicate a release from a specific source could be delineated, so no figure was generated. The highest arsenic concentration was 29 mg/kg, relatively close to the background value of 20 mg/kg.

Arsenic was detected in each of the 27 subsurface soil samples analyzed. Seven of these samples contained concentrations that exceeded the background value of 17 mg/kg. The concentrations did not greatly exceed the background value; in fact, the highest arsenic concentration was only 22.6 mg/kg (1- to 3-ft interval of SB78D). Screening Site 78 was the location of six of the seven elevated concentrations, as shown on Figures 24-3 and 24-4. The upper portions of the sample locations (1 ft to 7 ft) contained the majority of the elevated concentrations. The only elevated arsenic concentration deeper than 7 ft occurred in the 18- to 21-ft interval of SB78D (17.8 mg/kg). These factors indicate that the upper subsurface arsenic concentrations may occur as a result of surface infiltration.

As described above, the arsenic samples that exceeded the background values in both the surface and subsurface were located primarily at Screening Site 78. In most cases, the concentrations of arsenic did not significantly exceed the background value. The highest surface or subsurface concentration of arsenic was only 29.0 mg/kg, and only four surface or subsurface samples contained arsenic concentrations that exceeded 20 mg/kg. Arsenic is present in low concentrations throughout the Depot, probably because of site-wide pesticide management activities and naturally elevated background levels in soil that may be misinterpreted as specific source areas in FU5.

Chromium. Six total chromium concentrations, including 1 duplicate, exceeded the background value of 24.8 mg/kg in the 21 surface soil samples. As shown on Figure 24-5, chromium concentrations that exceeded the background value primarily were located in Screening Site 76 (unknown waste storage). This site is located in a grassy area outside of the southwestern corner of Building S690. Total chromium was detected in the remaining 15 surface soil samples at concentrations ranging from 6.15 mg/kg to 24.6 mg/kg.

Chromium concentrations in 17 of the 27 subsurface soil samples exceeded the background value of 26.4 mg/kg. The concentrations detected over background occurred at all sample intervals, with the majority (11 of 17) being found in the 4- to 6-ft and 18- to 21-ft intervals, as shown on Figures 24-6 and 24-7, respectively. Screening Sites 76, 77, and 78 contained at least three concentrations each in the 4- to 7-ft interval. Screening Sites 76 and 78 contained three concentrations each in the 18-to 21-ft interval. Overall, chromium was detected in all 27 subsurface soil samples, with concentrations ranging from 9.6 mg/kg to 48.3J mg/kg.

Elevated chromium concentrations in the surface and subsurface soil in FU5 were located primarily in Screening Site 76. Half of the elevated surface concentrations and nearly one third of the elevated subsurface concentrations were observed in this site.

Copper. Copper concentrations in 3 of the 21 surface soil samples, including 1 duplicate, exceeded the background value of 33.5 mg/kg. However, the copper concentrations remained relatively low. The three elevated concentrations were observed in two surface soil sample locations. SB77B contained a copper concentration of 43.3 mg/kg (the duplicate concentration was 36.3 mg/kg) and SS77C contained a copper concentration of 51.6 mg/kg. Copper was detected in the remaining 18 samples at concentrations ranging from 9.55J mg/kg to 29.0 mg/kg.

Of the 27 subsurface soil samples analyzed for copper, 5 samples contained concentrations that exceeded the background value of 32.7 mg/kg. The elevated copper concentrations were found primarily in the upper portion of each sample location. Figure 24-8 shows the concentrations detected from 1 ft to 4 ft and Figure 24-9 shows the concentrations from 4 ft to 7 ft. The copper concentrations were not significantly higher than the background value of 32.7 mg/kg. Only three concentrations exceeded 35 mg/kg. The highest detected copper concentration in the subsurface (38.3 mg/kg) was observed in the 1- to 3-ft interval of SB78C. Copper was detected in the remaining 22 subsurface soil samples, with concentrations ranging from 3.3J mg/kg to 32.4 mg/kg. The concentrations were detected throughout FU5, primarily in the 4- to 6-ft and the 18- to 21-ft sample intervals.

Screening Sites 77 and 78 were the only areas where elevated concentrations of copper were observed. Detected concentrations below background values were dispersed throughout the FU.

Lead. Of the 21 surface soil samples analyzed for lead, 6 samples contained lead concentrations that exceeded the background value of 30 mg/kg. As shown on Figure 24-10, three elevated lead values (38.1 mg/kg, 32.8 mg/kg, and 71.3 mg/kg) and four concentrations below the background value were observed in Screening Site 77. The other elevated concentrations were dispersed throughout FU5, ranging from 37.3 mg/kg to 109J mg/kg. Lead was detected in the remaining 15 surface soil samples throughout FU5 at concentrations ranging from 8.7 mg/kg to 26.9 mg/kg.

Lead concentrations in 6 of the 27 subsurface soil samples exceeded the background value of 23 9 mg/kg. Three of the elevated concentrations occurred in the 1- to 3-ft interval (shown on Figure 24-11) at Screening Site 78. The other three elevated concentrations occurred in the 4- to 6-ft sample interval (shown on Figure 24-12). Only one of the subsurface soil samples contained a lead concentration that exceeded 30 mg/kg. The sample collected from the 4- to 6-ft interval of SB76B contained a lead concentration of 53.8 mg/kg. Lead was detected at concentrations below background value in the remaining 21 samples dispersed throughout FU5. The concentrations ranged from 4.8 mg/kg to 21.4 mg/kg and were located primarily in the 4- to 6-ft and the 18- to 21-ft sample intervals.

Lead concentrations were frequently detected throughout the surface and subsurface soil in FU5. Elevated concentrations were located primarily in the surface soils of Screening Site 77 and the subsurface soils of Screening Site 78. Concentrations detected in the surface soils were notably higher than those detected in the subsurface soils.

Nickel. Nickel concentrations were detected in all 21 surface soil samples analyzed, though only two of the sample locations contained concentrations that exceeded the background value of 30 mg/kg. SB76A contained a concentration of 33.7 mg/kg. A concentration of 51.1 mg/kg was observed in SB77B (39.3 mg/kg was the concentration detected in the duplicate sample).

Eight of 27 subsurface soil samples contained nickel concentrations that exceeded the background value of 36.6 mg/kg. These elevated concentrations were detected primarily in the 1- to 3-ft and 4- to 6-ft intervals. Screening Site 78 contained two of these concentrations in the 1- to 3-ft sample interval (Figures 24-13). Screening Sites 77 and 78 each contained two elevated concentrations in the 4- to 6-ft interval (Figure 24-14). Concentrations below background were detected in the remaining 19 samples, ranging from 1.7J mg/kg to 34.4 mg/kg. These concentrations were found primarily in the 4- to 6-ft and the 18- to 21-ft sample intervals.

Nickel concentrations were frequently detected throughout FU5 in both the surface and subsurface soils; however, the elevated concentrations did not significantly exceed the background values.

Zinc. One of the 21 surface soil samples analyzed for zinc contained a concentration that exceeded the background value of 126 mg/kg. SB77B had a concentration of 136 mg/kg. The duplicate sample taken at this location contained a concentration of 108 mg/kg. Concentrations in the remaining 19 samples ranged from 28.8J mg/kg to 91.9J mg/kg.

Zinc concentrations in 6 of the 27 subsurface soil samples exceeded the background value of 114 mg/kg. Screening Site 78 contained five of the six elevated concentrations, with three concentrations occurring in the 1- to 3-ft interval (Figure 24-15) and the other two occurring in the 4- to 6-ft interval (Figure 24-16). SB77A contained the remaining elevated concentration (121 mg/kg) in the 4- to 5-ft sample. The zinc concentrations in the subsurface did not significantly exceed the background limit. In fact, the zinc concentrations that exceeded the background limit of 114 mg/kg ranged from 120 mg/kg to 132 mg/kg. The elevated zinc concentrations were dispersed through the upper portion of the borings. No concentrations above the background limit were detected at intervals deeper than 9 ft.

Elevated zinc concentrations in the surface and subsurface soils were observed in Screening Sites 77 and 78. The concentrations did not greatly exceed background values, ranging from 114 mg/kg to 136 mg/kg.

Distributed Metals. Antimony, beryllium, cadmium, manganese, and selenium were detected at concentrations that exceeded background values. However, the elevated concentrations for these constituents occurred infrequently (see Table 24-3) and were widely dispersed. As a result, the elevated concentrations of these constituents were not considered indicative of a release from a source area in FU5, and these constituents were classified as distributed metals.

Antimony. Antimony was detected in three of the 17 surface soil samples. The concentrations ranged from 0.87J mg/kg to 7.4 mg/kg. Only one concentration (SS77B) exceeded the background value of 7.0 mg/kg. One antimony concentration was detected out of the 27 subsurface soil samples. A concentration of 0.89J mg/kg was detected in the 3- to 5-ft interval of TEC91A. No background value was established for the subsurface antimony concentrations.

Beryllium. The background value of 1.1 mg/kg for beryllium was not exceeded by any of the 21 surface soil samples. Beryllium was detected at a lower concentration in 13 of the 21 samples. The detected concentrations ranged from 0.18J mg/kg to 0.56J mg/kg.

Beryllium concentrations in one subsurface soil sample exceeded the background value of 1.2 mg/kg. A concentration of 1.4 mg/kg was detected in the 18- to 21-ft interval of SB78D Concentrations ranged from 0.33J mg/kg to 1.2 mg/kg in the 8 samples detected below the background value.

Cadmium. The background value of 1.4 mg/kg was exceeded by 2 of the 21 surface soil samples. Concentrations ranged from 0.02J mg/kg to 1.17 mg/kg in the 9 samples detected below the background value.

One subsurface soil sample out of 27 exceeded the background value of 1.4 mg/kg. A cadmium concentration of 77.4 mg/kg was detected in SB78C Cadmium also was detected at a concentration of 0.11J mg/kg in TEC91A.

Selenium. The background value of 0.8 mg/kg was exceeded in 2 of the 21 surface soil samples. Concentrations of 1.4 mg/kg and 1.3 mg/kg were observed in SS77F and TEC91A, respectively. SS75D contained selenium at a concentration of 0.76 mg/kg.

The background value of 0.8 mg/kg was exceeded in three of the 27 subsurface soil samples. Concentrations of 1.9 mg/kg, 1.5 mg/kg, and 1.3 mg/kg were observed in TEC91A, SB78C, and SB78B, respectively.

Naturally Occurring Metals. Various samples collected throughout FU5 contained concentrations of calcium and potassium that exceeded background values. However, these metals frequently occur in the natural clay soils beneath the site. Most soil samples analyzed for these constituents at FU5 contained a detected concentration. In addition, these metals do not pose significant health risks and generally are not indicative of a release from source areas in FU5. Therefore, calcium and potassium were classified as naturally occurring metals.

Calcium. Calcium was detected in all nine surface soil samples and all seven subsurface soil samples. Concentrations in two surface soil samples exceeded the background value of 5,840 mg/kg. TEC91A and A(20.6) had concentrations of 12,1000 mg/kg and 39,800 mg/kg, respectively. Calcium concentrations in one subsurface soil sample exceeded the background value of 2,432 mg/kg. The concentration was located in the 3- to 5-ft interval of TEC91A.

Potassium. Potassium concentrations in five surface soil samples exceeded the background value of 1,820 mg/kg. These elevated potassium concentrations were detected throughout FU5. Potassium concentrations in the subsurface soil samples did not exceed the background value of 1,800 mg/kg. Four out of the seven subsurface samples did contain potassium concentrations ranging from 523 mg/kg to 1,580 mg/kg.

24.4.1.2 Metals below Background Values

Aluminum, barium, cobalt, iron, magnesium, and vanadium were detected in each of the 9 surface and 7 subsurface soil samples analyzed for these constituents. However, no concentrations of these constituents exceeded the background values of 23,800 mg/kg, 234 mg/kg, 18.3 mg/kg, 37,000 mg/kg, 1,300 mg/kg, and 48.4 mg/kg, respectively, in the surface and 21,800 mg/kg, 20.4 mg/kg, and 1,540 mg/kg, respectively, in the subsurface.

Mercury and silver both were detected below background values of 0.4 mg/kg and 2 0 mg/kg, respectively, in the surface soil of FU5. Mercury concentrations ranging from 0.01J mg/kg to 0.14 mg/kg were observed in seven of 21 samples. One silver concentration of 0.6J mg/kg was observed out of 21 samples. Neither metal was detected in the subsurface soil samples from FU5.

24.4.2 Nature and Extent of SVOC Contamination

24.4.2.1 Surface Soil

On the basis of soil sample results for FU5, the primary SVOCs of concern in the surface soil were determined to be PAHs. As shown on Figure 24-17 and Table 24-4, 22 of 31 surface samples, including 1 duplicate, contained detectable concentrations of total PAHs. No background for total PAHs was established for the surface soil in FU5. The detected concentrations were located primarily in Screening Sites 75 (grassy area located outside the northwestern corner of Building 689) and 77 (gravelly area located between Buildings 689 and 690). Screening Site 75 had seven concentrations ranging from 0.105J mg/kg in SS75B to 23.83 kg/mg in SS75F. Screening Site 77 had five concentrations ranging from 1.259J mg/kg in SS77B to 335.4 mg/kg in SS77C. Other detected concentrations of PAHs in the surface soil were dispersed throughout FU5, ranging from 0.087J mg/kg to 85.5 mg/kg.

PAHs are observed throughout the Main Installation, generally from surface soil samples in proximity to railroad tracks and those not adjacent to railroad tracks. PAH compounds can generate from creosote seepage that comes from railroad track cross ties, from historical railcar leaks to the surface, or from application of a PCP/used-oil mixture that historically was applied for weed control along the tracks. PAH compounds also can be generated as a result of engine exhaust from trucks, automobiles, and trains. To further assess the presence of PAH compounds in surface soil from railroad track cross ties and asphalt, two samples (RR57A and RR65A) were collected from the cross ties and two samples were collected from asphalt (RD57A and RD65A) and analyzed for PAHs (see Figure 8-2).

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As shown in Table 8-5, high concentrations of the following PAHs were detected in the railroad cross tie samples, indicating potential source contamination from railroad tracks. acenaphthene, benzo(a)anthracene, chrysene, fluoranthene, naphthalene, phenanthrene, and pyrene.

Section 8.4.2.1 discusses the correlation between the presence of railroad tracks and asphalt to the presence of PAHs. The conclusion is that although a correlation exists, it is not the sole factor responsible for the presence of PAHs.

24.4.2.2 Subsurface Soil

As shown in Table 24-4, PAHs were not detected frequently in subsurface soil samples. Total PAH concentrations were detected in 6 of 32 subsurface soil sample samples throughout FU5. Background values were not established for the subsurface soil in FU5. SB78A contained concentrations of 1.564J mg/kg and 4.55 mg/kg in the 1- to 3-ft and the 4- to 6-ft intervals, respectively. SB78D contained a concentration of 2.013J mg/kg in the 1- to 3-ft interval. A concentration of 2.508 mg/kg was detected in the 3- to 5-ft interval of TEC91A. SB75A, and A(20.6) contained concentrations of 0.688J mg/kg (4- to 6-ft interval) and 0.29J mg/kg (1- to 4-ft interval). No concentrations were detected below 6 ft in any of the 32 samples taken.

24.4.3 Nature and Extent of Pesticide Contamination

A total of six pesticides were detected in 24 surface soil samples at FU5: alpha-chlordane, DDT, DDE, DDD, dieldrin, and gamma-chlordane. Table 24-5 lists these pesticides, the number of times they were analyzed, and the minimum and maximum concentrations detected.

There are three general areas in which elevated concentrations of pesticides were detected within FU5:

- Screening Site 75–Unknown Wastes Near Building 689;
- Screening Site 76–Unknown Wastes Near Building 690; and
- Screening Site 77–Unknown Wastes Near Building 689 and Building 690.

DDT was detected in 15 of 24 surface soil samples, with 5 concentrations exceeding the background value of 0.074 mg/kg (as shown on Figure 24-18). Screening Site 77 appears to be the primary area of detected concentrations, with elevated concentrations in SB77A, SS77A, and BRAC sample A(22.1). The 10 samples with concentrations below background values ranged from 0.0022J mg/kg to 0.071 mg/kg.

Dieldrin was detected throughout the Main Installation and is not associated with known sources of contamination at FU5. It was sprayed routinely on grassy areas and around warehouses. Within FU5, dieldrin exceeded its background concentration (0.086 mg/kg) in 5 samples, ranging from 0.26 mg/kg to 1.1J mg/kg, taken from both grass and gravel surfaces. Concentrations ranged from 0.0041 mg/kg to 0.083 mg/kg in 10 other samples. Figure 24-19 shows the location of the dieldrin concentrations.

Alpha-chlordane was observed in 6 out of 24 samples, with 2 concentrations exceeding background. A(34.2) and SS34A, both BRAC samples, had concentrations of 0 14J mg/kg and 0.033 mg/kg, respectively.

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24.4.3.1 Pesticides in Subsurface Soil

DDE, DDT, and dieldrin were each detected in 1 out of 13 subsurface soil samples. The pesticides were observed in the 3- to 5-ft interval of TEC91A, located by the railroad tracks outside of the northwestern corner of Building 670. The concentration of DDE (0.002J mg/kg) barely exceeded the background level of 0.0015 mg/kg. Background values were not exceeded by the DDT and dieldrin concentrations. The remaining subsurface samples showed no detected concentrations of pesticide concentrations.

24.4.4 Nature and Extent of Dioxin and Furan Contamination

Dibenzofuran was detected in 3 of the 21 surface soil samples in FU5, as shown in Table 24-6. The background value of 0.647 mg/kg was exceeded in one sample. BRAC sample A(20.6) had a concentration of 1.2J mg/kg. Concentrations of 0.11J mg/kg and 0.31J mg/kg were observed in SS75A and TEC91A, respectively. No concentrations of dibenzofuran were observed in the subsurface soils.

24.4.5 Nature and Extent of VOC Contamination in Surface and Subsurface Soil

24.4.5.1 VOCs in Surface Soil

A total of 10 VOCs were detected in the 21 surface soil samples analyzed for VOCs throughout FU5. The compounds are 2-Hexanone, acetone, benzene, bromomethane, carbon disulfide, ethyl benzene, MEK, methylene chloride, toluene, and total xylenes. Table 24-7 presents a list of these compounds, the number of times they were detected, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected.

The majority of the surface soil sample results for VOCs within FU5 indicate no detected concentrations or detected concentrations below background. However, there are three VOCs with concentrations detected above the background value within FU5:

- MEK was detected five times, all above the background value of 0.002 mg/kg. The sample locations are dispersed throughout FU5, with concentrations ranging from 0.016 mg/kg to 0.076 mg/kg, as shown on Figure 24-20;
- Toluene was detected in TEC91A and A(20.6) at concentrations of 0.007J mg/kg and 0.001J mg/kg, respectively. The background value for toluene is 0.002 mg/kg; and
- Carbon disulfide was detected in A(20.6) at a concentration of 0.037 mg/kg, exceeding the background value of 0.002 mg/kg.

24.4.5.2 VOCs in Subsurface Soil

Thirty-two subsurface soil samples were analyzed for VOCs. The compounds detected were acetone, chlorobenzene, MEK, methylene chloride, PCE, total 1,2-DCE, and TCE (see Table 24-7). Background values for these detected VOC constituents have not been established in the subsurface soil.

Probably because of volatilization at the surface, detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations, as noted below:

- 2-Hexanone, benzene, bromomethane, carbon disulfide, ethyl benzene, toluene, and total xylenes were not detected in any subsurface soil sample from FU5. Each of these compounds was detected in at least one surface soil sample;
- Chlorobenzene, PCE, total 1,2-DCE, and TCE were detected in the subsurface soil at FU5, but were not present in the surface soil; and
- Methylene chloride was observed in the 18- to 20-ft interval of SB76A and the 4- to 6-ft interval of SB76B at concentrations of 0.001J mg/kg and 0.002J mg/kg, respectively. Methylene chloride was not detected in any surface soil sample from Screening Site 76.

The GWP values for the VOCs detected in the subsurface soil are 16 mg/kg (acetone), 1.0 mg/kg (chlorobenzene), 17 mg/kg (MEK), 0.02 mg/kg (methylene chloride), 0.06 mg/kg (PCE), and 0.06 mg/kg (TCE). A GWP value is not available for total 1,2-DCE. TCE was the only VOC detected in the subsurface soil at concentrations that exceeded its GWP value. Elevated TCE concentrations were detected in boring SB78B at 11 mg/kg (18 to 20 ft), 0.4 mg/kg (1 to 3 ft), and 0.085 mg/kg (4 to 6 ft). The boring was drilled in the subsurface soil a few ft west of the 10th loading dock from the south of Building 689. TCE concentrations were not detected in any other borings at FU5. It appears that the subsurface soil in this area may be a potential continuing source of contamination to groundwater, because detected TCE concentrations exceeded the GWP values at the lowest sample depth of 18 to 20 ft and the vertical extent of contamination has not been bounded.

24.5 Nature and Extent of Surface Water Contamination

The majority of stormwater collected in FU5 is transported via the underground pipe system to the concrete-lined ditch that runs parallel to N Street south of Lake Danielson (Black & Veatch, 1999). This ditch discharges (Outfall 4) to an unnamed tributary south of N Street that eventually discharges to Nonconnah Creek. A small portion of stormwater from the western end of FU5 flows via the underground pipe system and is discharged to Tarrant Branch at Gate 9 (Outfall 5).

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TABLE 24-1
Sampling Rationale at FU5
Memphis Depot Main Installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media
Screening Site 70/71 All Railroad Tracks	Evaluate whether releases have occurred to surface soils and subsurface soils	Further delineate PAH contamination in surface soils based on previous sampling.	5 Surface Soil 3 Subsurface Soil
Screening Site 73 All Grassed Areas	Evaluate whether releases have occurred to surface soil from past pesticide use.	No additional environmental sampling was necessary	4 Surface Soil 9 Subsurface Soil
Screening Site 75 Unknown Wastes near Building 689	Evaluate whether releases have occurred to surface soils and subsurface soils.	Delineate lateral extent of PAH contamination in surface soil	8 Surface Soil 6 Subsurface Soil
Screening Site 76 Unknown Wastes near Building 690	Evaluate whether releases have occurred to surface soils and subsurface soils	No additional environmental sampling was necessary.	3 Surface Soil 6 Subsurface Soil
Screening Site 77 Unknown Wastes near Buildings 689 and 690	Evaluate whether releases have occurred to surface soils and subsurface soils	Evaluate risk of PAHs in surface soil	9 Surface Soil 4 Subsurface Soil
Screening Site 78 Alcohol, Acetone, Toluene, and Hydrofluoric Acid Area, Building 689	Evaluate whether releases have occurred to surface soils and subsurface soils	No additional environmental sampling was necessary	12 Subsurface Soil
TEC 91 Container Storage Strip	Site not identified at this time	Evaluate whether releases have occurred to surface soils and subsurface soils as a result of the unknown contents in the storage containers	1 Surface Soil 1 Subsurface Soil
BRAC–Parcels 16, 17, 18, 19 20, 21, 22, and 34	Assess the environmental condition of soil in Parcels 16, 17, 18, 19, 20, 21, 22, and 34	Assess the presence of contaminants (other than pesticides and PCBs) to further characterize the soils in these parcels.	16 Surface Soil 3 Subsurface Soil

Notes
BRAC–Baseline Realignment and Closure site
PAH–Polynuclear aromatic hydrocarbon
TEC–Topographic Engineering Center, site identified on TEC aerial photographs
Surface Soil–Surface Soil Sample
Subsurface Soil–Subsurface Soil Sample
SE–Sediment Sample
SW–Surface Water Sample
* Groundwater samples were collected throughout the Main Installation and are identified under FU7, which is discussed in Section 32 0

487 397

487 398

TABLE 24-2
Analytes Investigated for FU5
Memphis Depot Main Installation RI

Functional Unit	Site	Matrix[1]	Event	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	Pesticides	Pesticides, TCLP	Pesticides/PCB	Pesticides/PCBs	PAHs	Pet_ Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
5	75	SB	SS							X				X				X		X
5	75	SS	MAINRIFS							X	X				X			X		X
5	75	SS	SS							X				X				X		X
5	76	SB	SS							X				X				X		X
5	76	SS	SS							X				X				X		X
5	77	SB	SS		X					X				X				X		X
5	77	SS	MAINRIFS		X	X			X	X					X				X	
5	77	SS	SS		X					X				X				X		X
5	78	SB	SS		X					X				X				X		X
5	91	SB	MAINRIFS							X	X							X		X
5	91	SS	MAINRIFS							X	X							X		X
5	BRAC	SB	BRAC							X								X		X
5	BRAC	SS	BRAC							X				X				X		X
5	BRAC	SS	MAINRIFS		X	X				X	X				X			X	X	X
5	NA	SB	DO4			X														

Notes

[1]Matrix	SB-subsurface soil, SS-surface soil
[2]GW	Groundwater sampled in March 1996, March 1997, September 1997, June 1998, and October 1998
[3]MAINRIFS	Additional samples for RI, BRAC, and Screening Sites (and initial investigations for TEC sites) collected in September and October 1998
[4]RI	RI Sites sampled in December 1996 and January 1997
[5]SS	Screening Sites sampled in December 1996 and January 1997
BRAC	Base Realignment and Closure

TABLE 24-3

Frequency of Metals Detection in Surface and Subsurface Soil at FU5

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALUMINUM	9	9	1 95E+03	J	1 22E+04	=	2 38E+04	0
SS	ANTIMONY	17	3	8 70E-01	J	7 40E+00	=	7 00E+00	1
SS	ARSENIC	21	21	5 05E+00	=	2 90E+01	=	2 00E+01	2
SS	BARIUM	9	9	2 20E+01	J	1 22E+02	=	2 34E+02	0
SS	BERYLLIUM	21	13	1 80E-01	J	5 60E-01	J	1 10E+00	0
SS	CADMIUM	21	11	2 00E-02	J	6 00E+00	=	1 40E+00	2
SS	CALCIUM	9	9	1 58E+03	=	3 98E+04	=	5 84E+03	2
SS	CHROMIUM, TOTAL	21	21	6 15E+00	=	3 70E+01	=	2 48E+01	6
SS	COBALT	9	9	3 30E+00	J	1 24E+01	=	1 83E+01	0
SS	COPPER	21	21	9 55E+00	J	5 16E+01	=	3 35E+01	3
SS	IRON	9	9	6 43E+03	J	1 98E+04	=	3 70E+04	0
SS	LEAD	21	21	8 70E+00	=	1 09E+02	J	3 00E+01	6
SS	MAGNESIUM	9	9	1 16E+03	=	2 39E+03	=	4 60E+03	0
SS	MANGANESE	9	9	4 37E+01	J	7 13E+02	=	1 30E+03	0
SS	MERCURY	21	7	1 00E-02	J	1 40E-01	=	4 00E-01	0
SS	Mercury, TCLP	1	1	1 50E-04	J	1 50E-04	J		
SS	NICKEL	21	21	4 10E+00	J	5 11E+01	=	3 00E+01	3
SS	POTASSIUM	9	8	7 43E+02	=	2 50E+03	=	1 82E+03	5
SS	SELENIUM	21	3	7 60E-01	=	1 40E+00	=	8 00E-01	2
SS	SILVER	21	1	6 00E-01	J	6 00E-01	J	2 00E+00	0
SS	SODIUM	9	2	1 33E+02	J	1 92E+02	J		
SS	VANADIUM	9	9	7 20E+00	J	2 81E+01	J	4 84E+01	0
SS	ZINC	21	21	2 88E+01	J	1 36E+02	=	1 26E+02	1
SS	Zinc, TCLP	1	1	2 16E-01	=	2 16E-01	=		
Subsurface Soil									
SB	ALUMINUM	7	7	4 84E+03	=	1 17E+04	=	2 18E+04	0
SB	ANTIMONY	27	1	8 90E-01	J	8 90E-01	J		
SB	ARSENIC	27	27	2 80E+00	=	2 26E+01	=	1 70E+01	7
SB	BARIUM	7	7	8 50E+00	J	8 75E+01	J	3 00E+02	0
SB	BERYLLIUM	27	9	3 30E-01	J	1 40E+00	=	1 20E+00	1
SB	CADMIUM	27	2	1 10E-01	J	7 74E+01	=	1 40E+00	1
SB	CALCIUM	7	7	5 20E+02	J	5 15E+03	=	2 43E+03	1
SB	CHROMIUM, TOTAL	27	27	9 60E+00	=	4 83E+01	J	2 64E+01	17
SB	COBALT	7	7	1 10E+00	J	1 70E+01	J	2 04E+01	0
SB	COPPER	27	27	3 30E+00	J	3 83E+01	=	3 27E+01	5
SB	IRON	7	7	1 16E+04	J	2 48E+04	J	3 85E+04	0
SB	LEAD	27	27	4 80E+00	=	5 38E+01	=	2 39E+01	6
SB	MAGNESIUM	7	7	2 79E+02	J	2 51E+03	=	4 90E+03	0
SB	MANGANESE	7	7	1 73E+01	=	2 26E+03	J	1 54E+03	1
SB	NICKEL	27	27	1 70E+00	J	4 63E+01	=	3 66E+01	8
SB	POTASSIUM	7	4	5 23E+02	J	1 58E+03	=	1 80E+03	0
SB	SELENIUM	27	3	1 30E+00	=	1 90E+00	=	6 00E-01	3
SB	SODIUM	7	1	1 57E+02	J	1 57E+02	J		
SB	THALLIUM	27	1	2 30E-01	J	2 30E-01	J		
SB	VANADIUM	7	7	2 36E+01	=	3 74E+01	J	5 13E+01	0
SB	ZINC	27	27	4 50E+00	J	1 32E+02	=	1 14E+02	6

Note

All units are mg/kg

TABLE 24-4
Frequency of SVOCs Detection in Surface and Subsurface Soil at FU5
Memphis Depot Main Installation RI

Matrix	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil										
SS	PAH	2-METHYLNAPHTHALENE	31	1	1 20E-01	J	1 20E-01	J		
SS	PAH	ACENAPHTHENE	31	7	8 60E-02	J	4 10E+00	J		
SS	PAH	ANTHRACENE	31	8	1 40E-01	J	6 70E+00	J	9 60E-02	8
SS	PAH	BENZO(a)ANTHRACENE	31	17	7 00E-02	J	2 60E+01	=	7 10E-01	10
SS	PAH	BENZO(a)PYRENE	31	16	6 40E-02	J	2 60E+01	=	9 60E-01	9
SS	PAH	BENZO(b)FLUORANTHENE	31	16	8 00E-02	J	2 60E+01	=	9 00E-01	9
SS	PAH	BENZO(g h,i)PERYLENE	31	14	6 20E-02	J	1 80E+01	=	8 20E-01	8
SS	PAH	BENZO(k)FLUORANTHENE	31	16	7 70E-02	J	2 00E+01	=	7 80E-01	9
SS	PAH	CARBAZOLE	21	6	1 20E-01	J	4 00E+00	J	6 70E-02	6
SS	PAH	CHRYSENE	31	17	8 10E-02	J	3 00E+01	=	9 40E-01	10
SS	PAH	DIBENZ(a,h)ANTHRACENE	31	2	1 10E+00	J	4 00E+00	J	2 60E-01	2
SS	PAH	FLUORANTHENE	31	21	4 70E-02	J	6 70E+01	=	1 60E+00	11
SS	PAH	FLUORENE	31	7	6 10E-02	J	2 60E+00	J		
SS	PAH	INDENO(1,2,3-c,d)PYRENE	31	14	5 90E-02	J	1 70E+01	=	7 00E-01	8
SS	PAH	NAPHTHALENE	31	2	1 90E-01	J	1 40E+00	J		
SS	PAH	PHENANTHRENE	31	19	5 50E-02	J	3 60E+01	=	6 10E-01	13
SS	PAH	PYRENE	31	22	4 00E-02	J	5 60E+01	=	1 50E+00	11
SS	PAH	Total Polynuclear Aromatic Hydrocarbons	31	22	8 70E-02	J	3 35E+02	=		
SS	SVOC	4-METHYLPHENOL (p-CRESOL)	21	1	5 60E-02	J	5 60E-02	J		
SS	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	21	4	1 00E-01	J	2 50E+02	=		
SS	SVOC	PENTACHLOROPHENOL	21	2	4 00E-02	J	3 20E-01	=		
Subsurface Soil										
SB	PAH	CARBAZOLE	32	1	4 80E-02	J	4 80E-02	J		
SB	PAH	CHRYSENE	32	6	4 00E-02	J	6 70E-01	=		
SB	PAH	FLUORANTHENE	32	6	1 00E-01	J	8 50E-01	=	4 50E-02	6
SB	PAH	INDENO(1,2,3-c,d)PYRENE	32	4	8 20E-02	J	2 40E-01	J		
SB	PAH	PHENANTHRENE	32	6	6 90E-02	J	3 70E-01	J		
SB	PAH	PYRENE	32	6	8 10E-02	J	7 40E-01	=	4 20E-02	6
SB	PAH	Total Polynuclear Aromatic Hydrocarbons	32	6	2 90E-01	J	4 55E+00	=		
SB	SVOC	BENZYL BUTYL PHTHALATE	32	1	7 70E-02	J	7 70E-02	J		
SB	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	32	6	4 60E-02	J	8 20E-02	J		
SB	SVOC	DI-n-BUTYL PHTHALATE	32	9	7 00E-02	J	2 10E-01	J		

Note
All units are mg/kg

TABLE 24-5
Frequency of Pesticides Detection in Surface and Subsurface Soil at FU5
Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALPHA-CHLORDANE	24	6	6 80E-04	J	1 40E-01	J	2 90E-02	2
SS	DDD	24	2	1 30E-02	J	2 20E-02	J	6 70E-03	2
SS	DDE	24	14	3 80E-03	J	7 70E-02	=	1 60E-01	0
SS	DDT	24	15	2 20E-03	J	2 60E-01	=	7 40E-02	5
SS	DIELDRIN	24	15	4 10E-03	=	1 10E+00	J	8 60E-02	5
SS	GAMMA-CHLORDANE	24	6	6 90E-04	J	1 50E-01	J	2 60E-02	3
Subsurface Soil									
SB	DDE	13	1	2 00E-03	J	2 00E-03	J	1 50E-03	1
SB	DDT	13	1	4 60E-03	=	4 60E-03	=	7 20E-03	0
SB	DIELDRIN	13	1	5 70E-03	=	5 70E-03	=	3 70E-01	0

Note
All units are mg/kg

TABLE 24-6
Frequency of Dioxins Detection in Surface Soil at FU5
Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	DIBENZOFURAN	21	3	1 10E-01	J	1 20E+00	J	6 47E-01	1

Note
All units are mg/kg

TABLE 24-7
Frequency of VOCs Detection in Surface and Subsurface Soil at FU5
Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	2-HEXANONE	21	3	2 00E-03	J	3 00E-03	J		
SS	ACETONE	21	4	4 00E-03	J	5 00E-03	J		
SS	BENZENE	21	1	2 00E-03	J	2 00E-03	J		
SS	BROMOMETHANE	21	1	2 00E-03	J	2 00E-03	J		
SS	CARBON DISULFIDE	21	1	3 70E-02	=	3 70E-02	=	2 00E-03	1
SS	ETHYLBENZENE	21	1	2 00E-03	J	2 00E-03	J		
SS	METHYL ETHYL KETONE (2-BUTANONE)	21	5	1 60E-02	=	7 60E-02	=	2 00E-03	5
SS	METHYLENE CHLORIDE	21	5	2 00E-03	J	6 00E-03	J		
SS	TOLUENE	21	2	1 00E-03	J	7 00E-03	J	2 00E-03	1
SS	Total Xylenes	21	1	9 00E-03	J	9 00E-03	J	9 00E-03	0
Subsurface Soil									
SB	ACETONE	32	16	4 00E-03	J	7 90E-02	=		
SB	CHLOROBENZENE	32	1	2 00E-03	J	2 00E-03	J		
SB	METHYL ETHYL KETONE (2-BUTANONE)	32	3	2 00E-03	J	1 00E-02	J		
SB	METHYLENE CHLORIDE	32	7	1 00E-03	J	4 00E-03	J		
SB	TETRACHLOROETHYLENE(PCE)	32	3	1 00E-03	J	3 00E-03	J		
SB	TOTAL 1,2-DICHLOROETHENE	32	1	2 00E-03	J	2 00E-03	J		
SB	TRICHLOROETHYLENE (TCE)	32	3	8 50E-02	=	1 10E+01	=		

Note
All units are mg/kg

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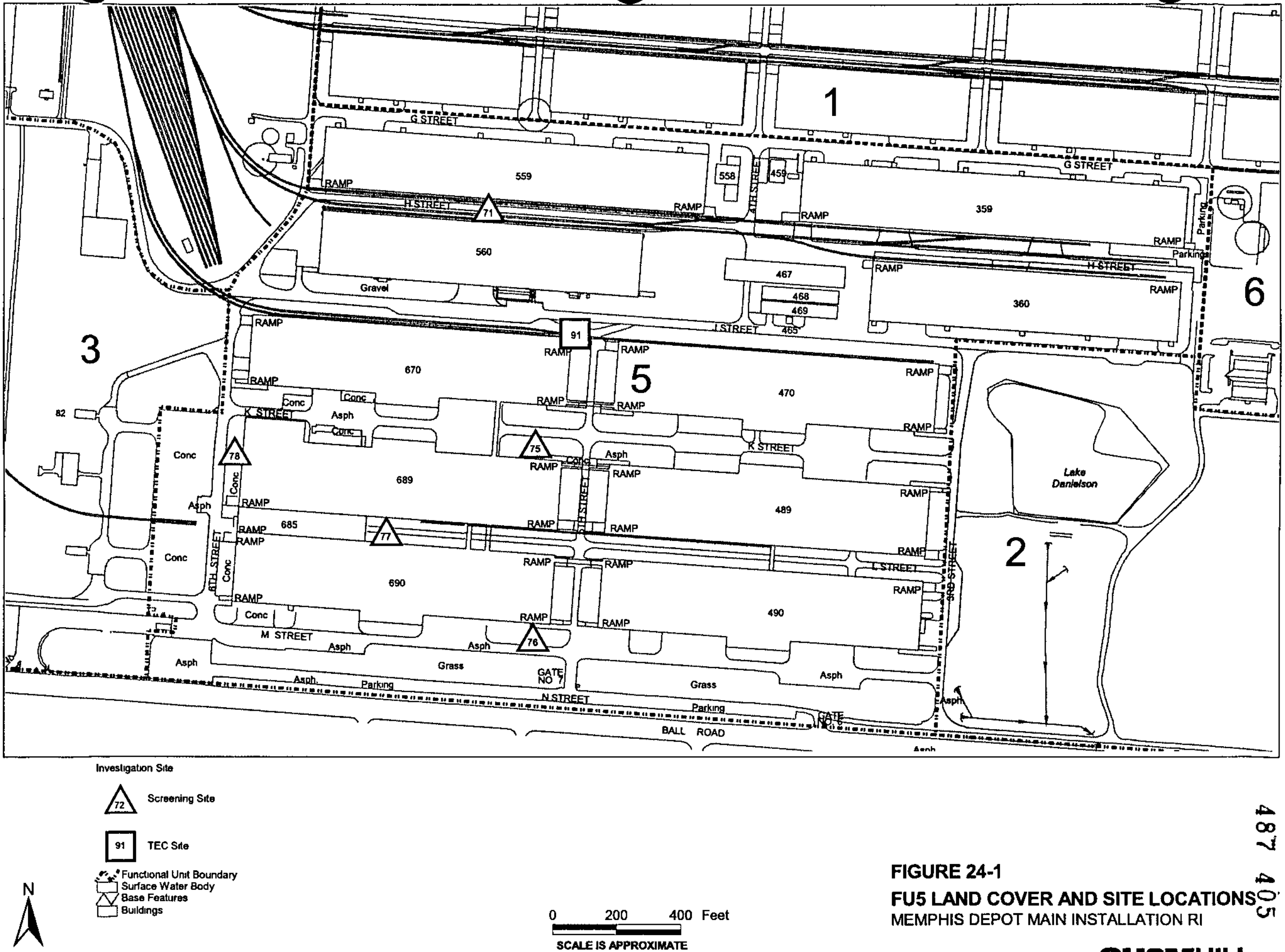

FIGURE 24-1
FU5 LAND COVER AND SITE LOCATIONS
MEMPHIS DEPOT MAIN INSTALLATION RI

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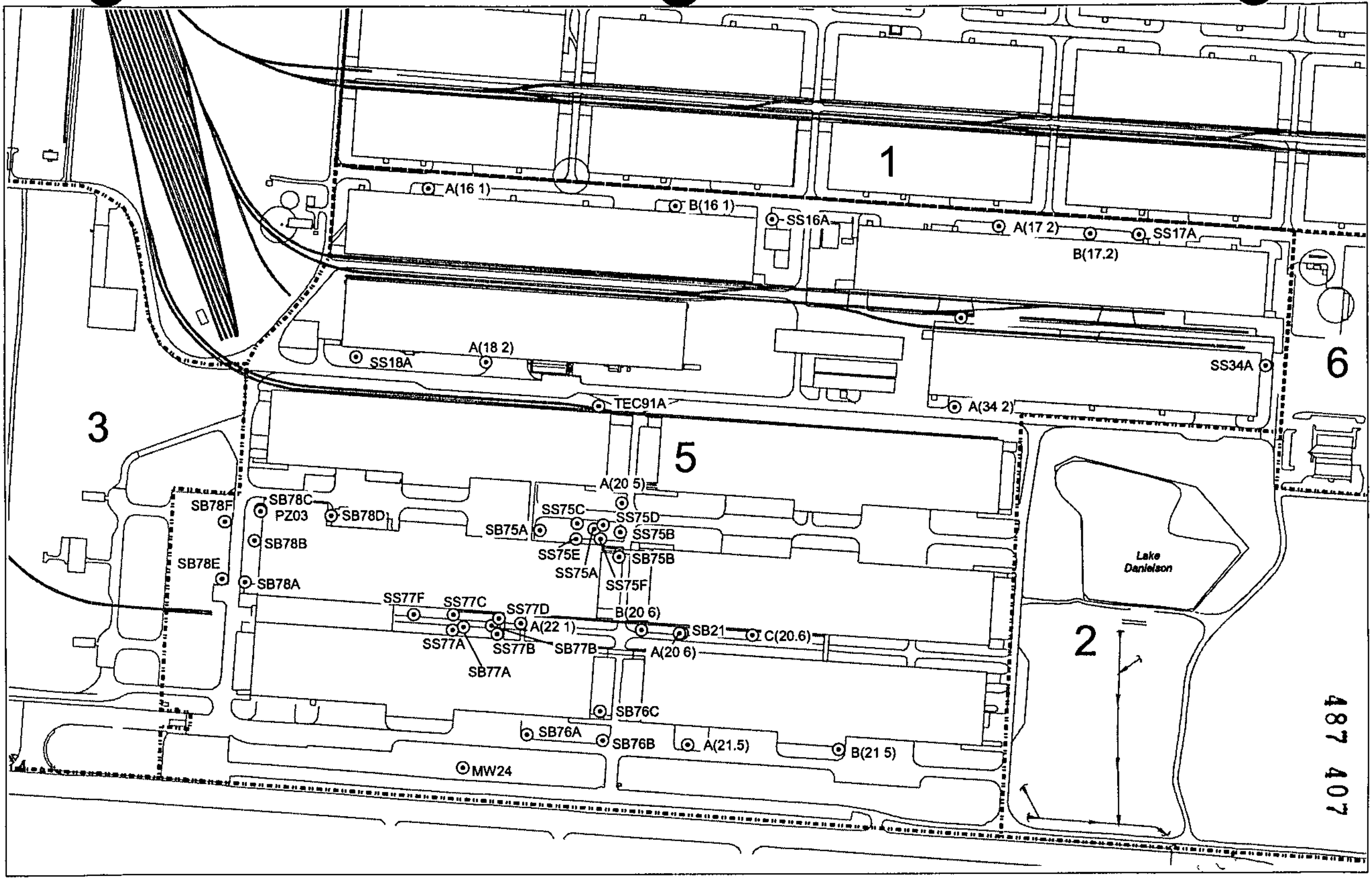

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FIGURE 24-2
SAMPLE LOCATIONS IN FU5
MEMPHIS DEPOT MAIN INSTALLATION RI

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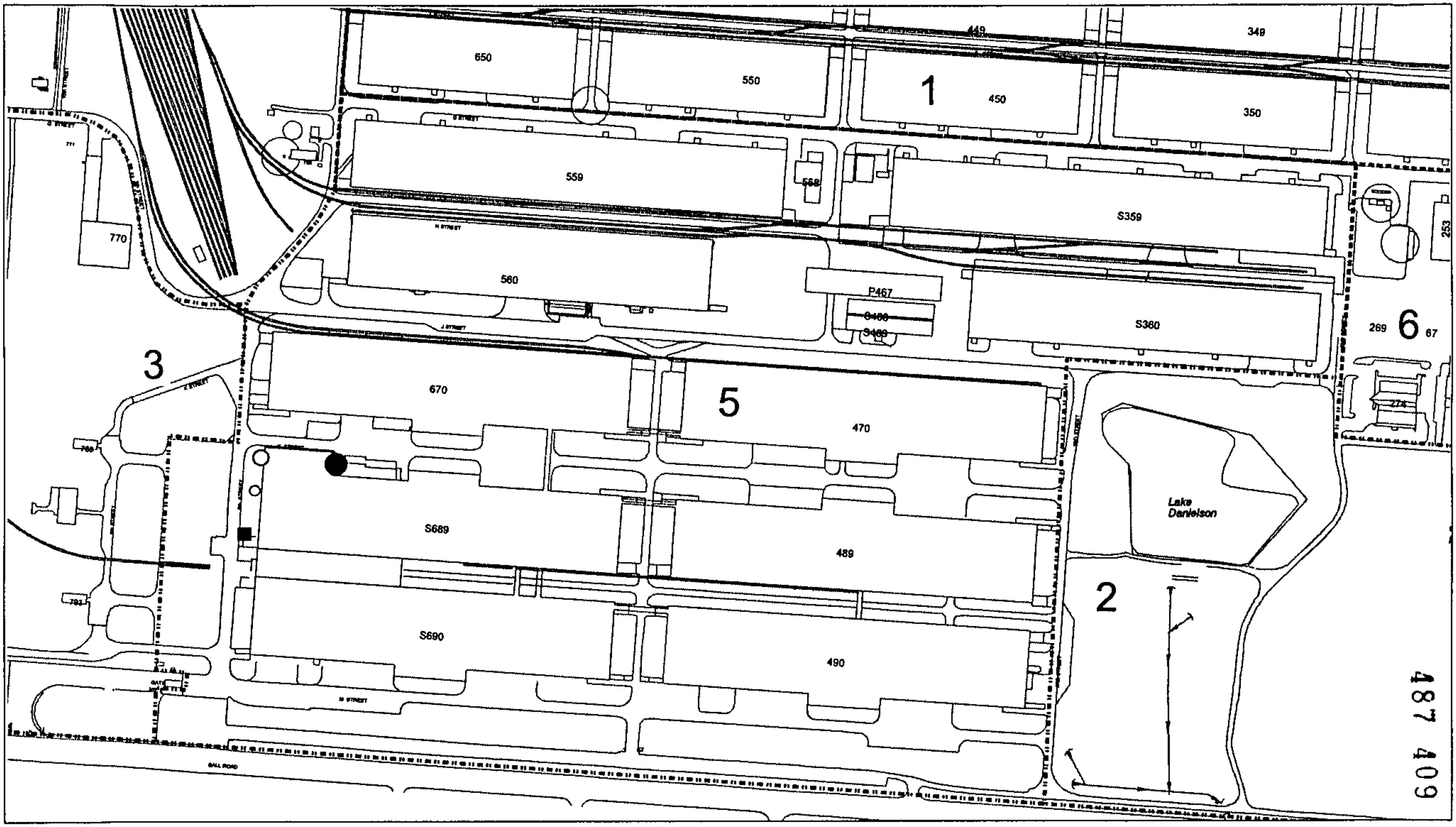

Arsenic Concentrations in Depths 1 - 3 Feet
- ○ 20 4 MG\KG
- ○ 22 2 MG\KG
- ● 22 6 MG\KG

- ■ Concentrations Detected\Below Background (<17 0 MG\KG)
- Functional Unit Boundary
- Surface Water Bodies
- Text Building Numbers and Road Names
- Base Features
- Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

FIGURE 24-3

ARSENIC CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 1-3 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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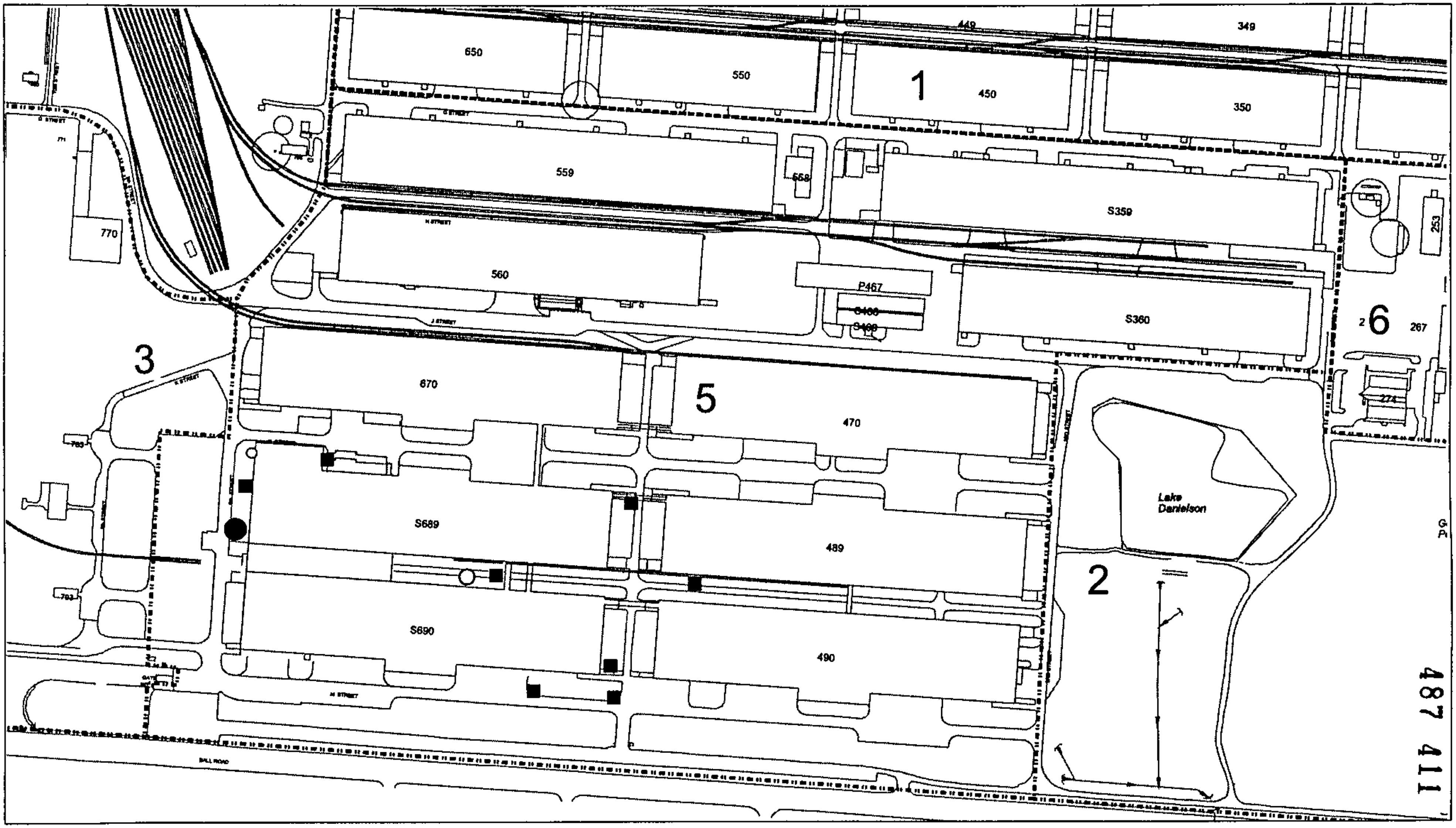

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Arsenic Concentrations in Depths 4 - 7 Feet
○ 17 2 MG\KG
◯ 17 9 MG\KG
18 2 MG\KG

■ Concentrations Detected\Below Background (<17 0 MG\KG)
Functional Unit Boundary
Surface Water Bodies
Text Building Numbers and Road Names
Base Features
Buildings

N

0 200 400 Feet
SCALE IS APPROXIMATE

FIGURE 24-4

ARSENIC CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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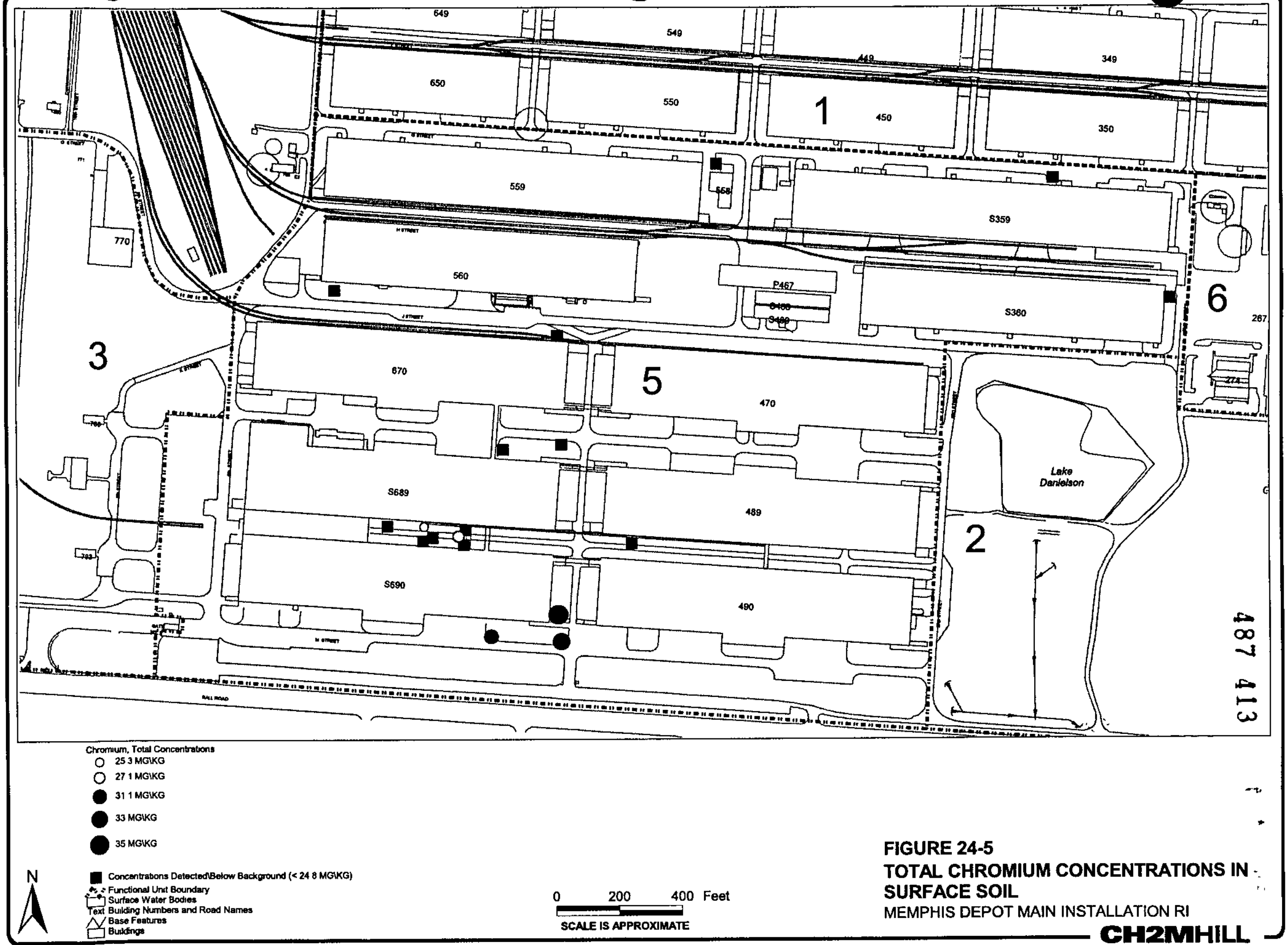

FIGURE 24-5

TOTAL CHROMIUM CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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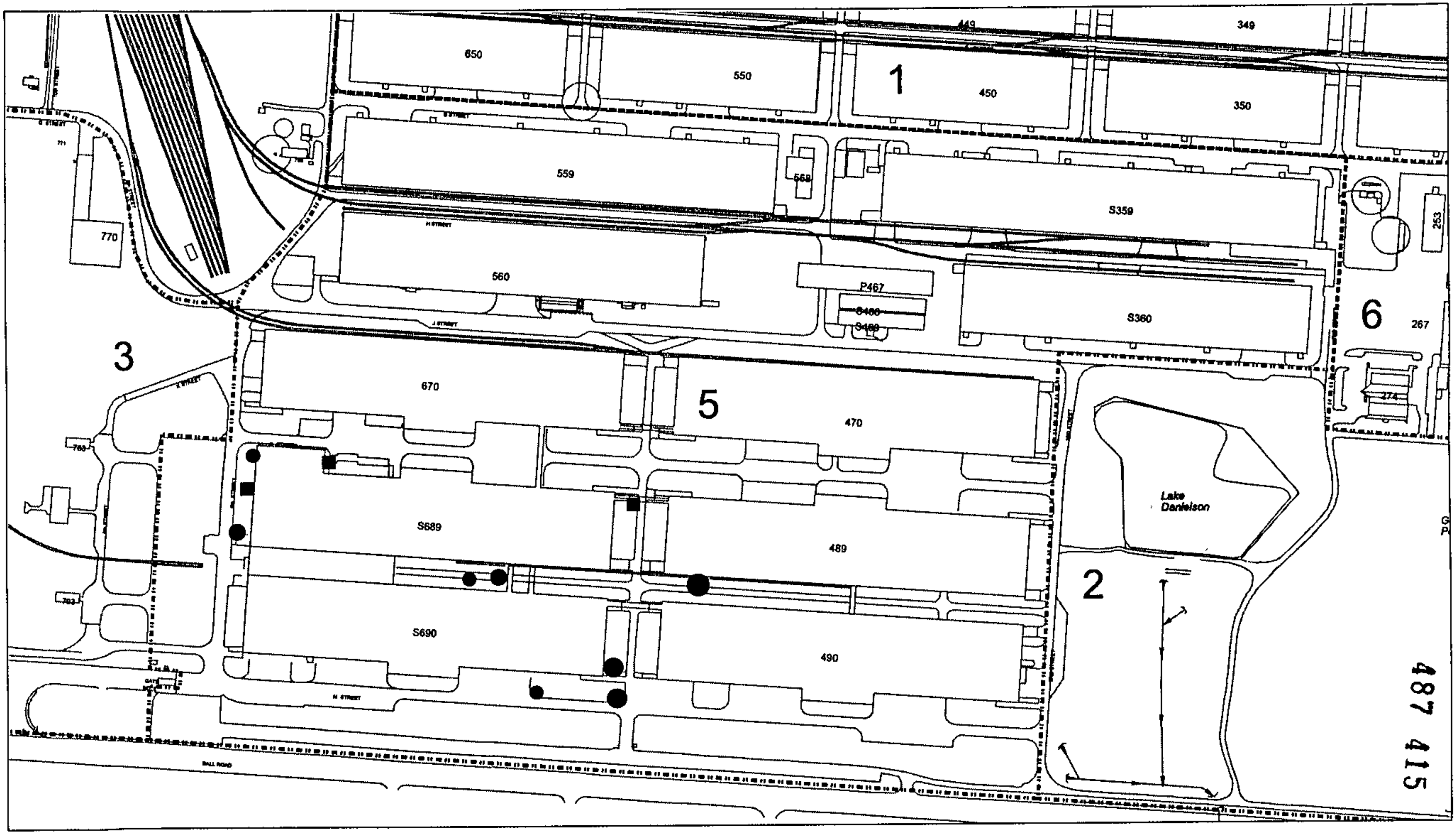

Chromium Concentrations in Depths 4 - 7 Feet

27 7 - 29 1 MG\KG

● 29 1 - 29 8 MG\KG

● 29 8 - 39 7 MG\KG

39 7 - 48 3 MG\KG

■ Concentrations Detected\Below Background (<26 4 MG\KG)

Functional Unit Boundary

Surface Water Bodies

Text Building Numbers and Road Names

Base Features

Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

FIGURE 24-6

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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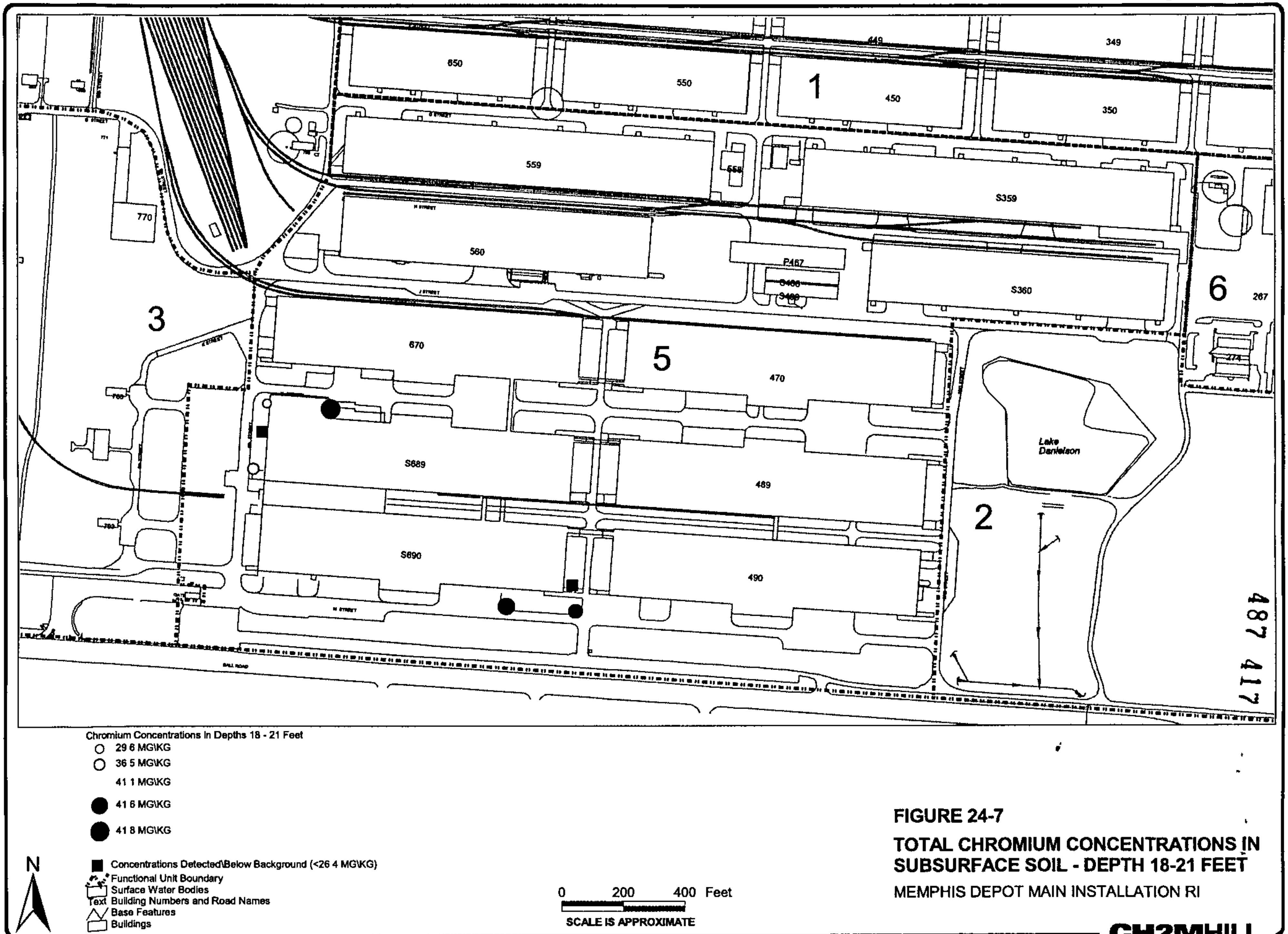

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FIGURE 24-7

TOTAL CHROMIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 18-21 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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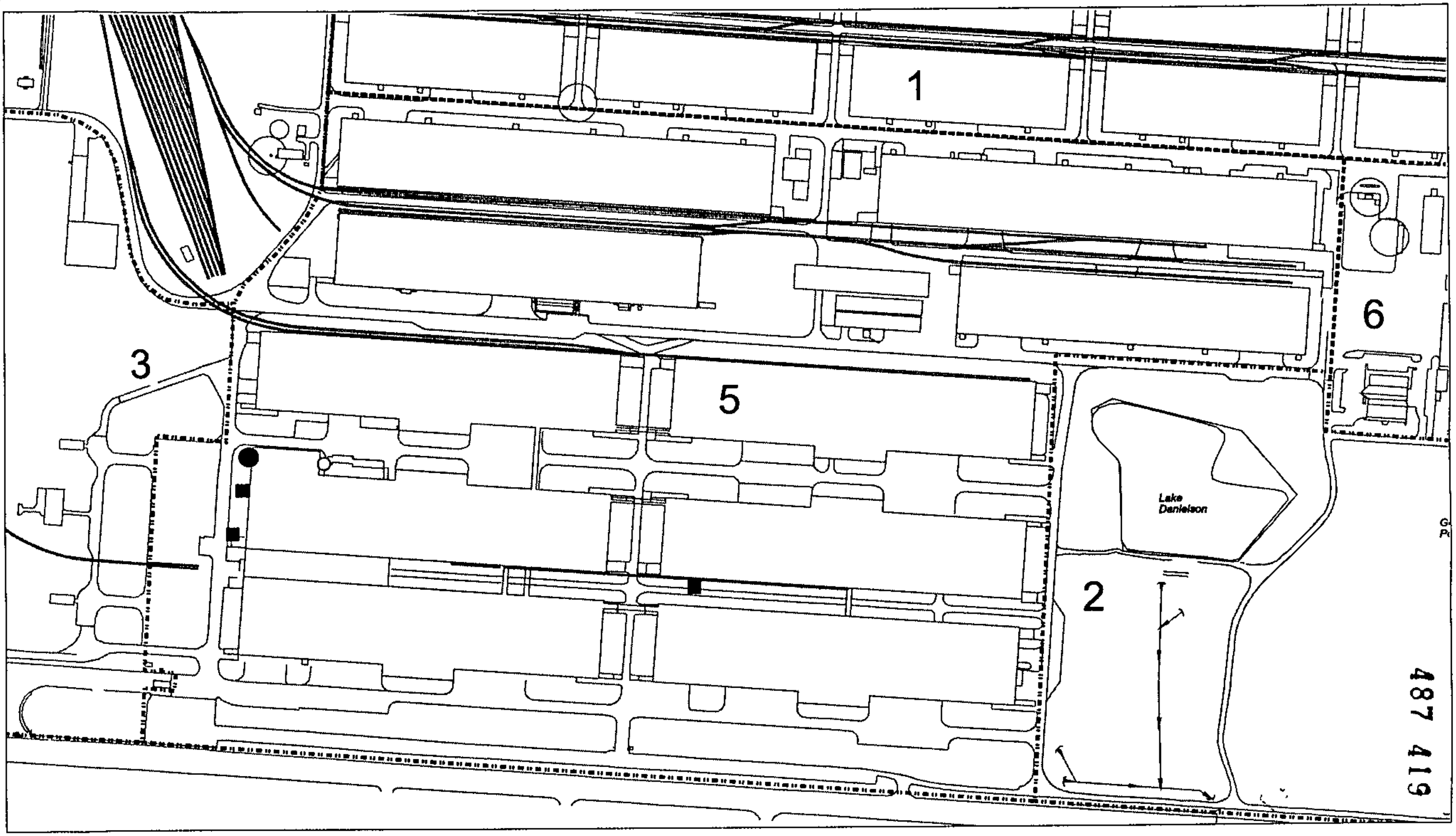

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FIGURE 24-8
COPPER CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 1-4 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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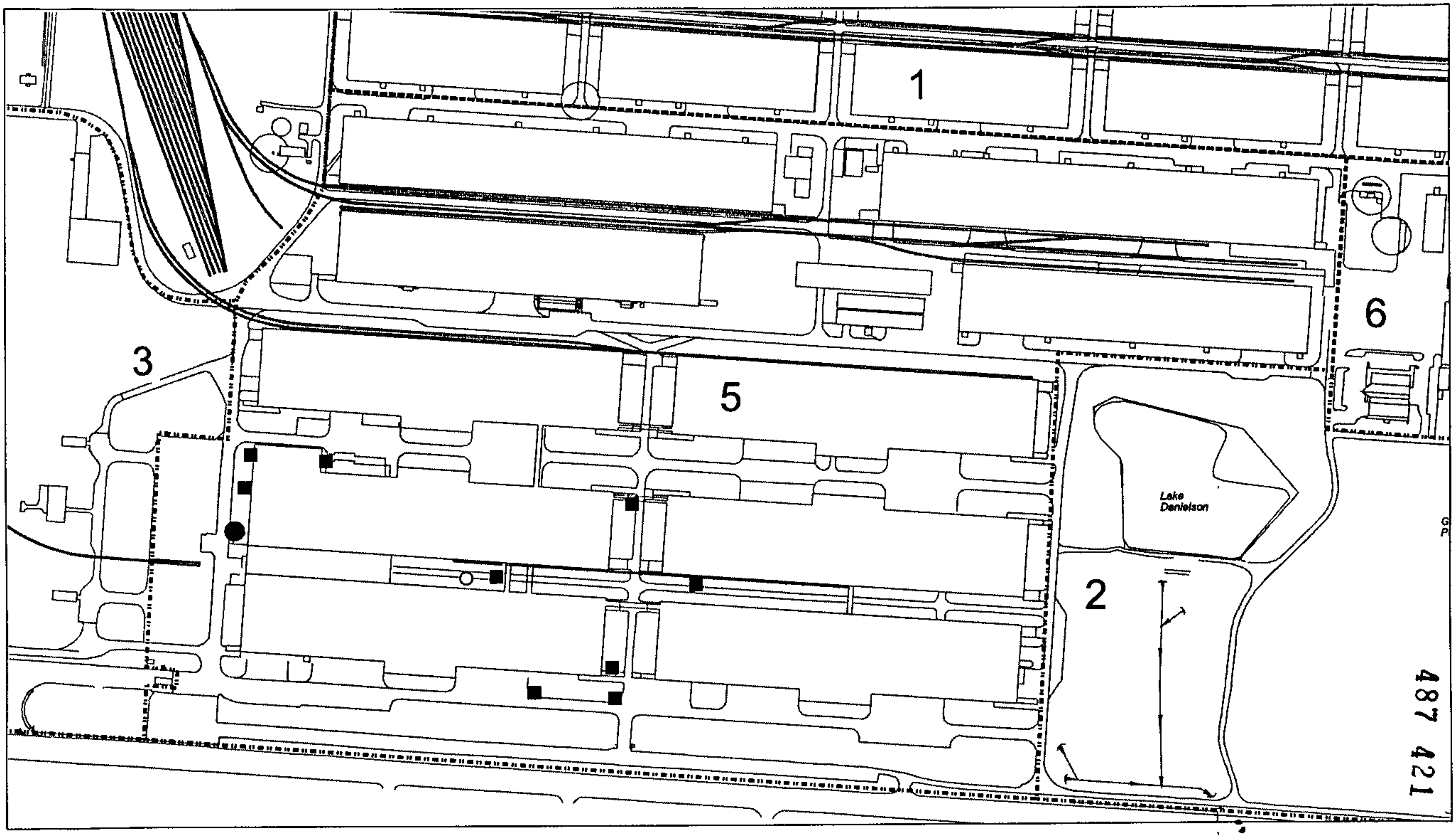

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FIGURE 24-9

COPPER CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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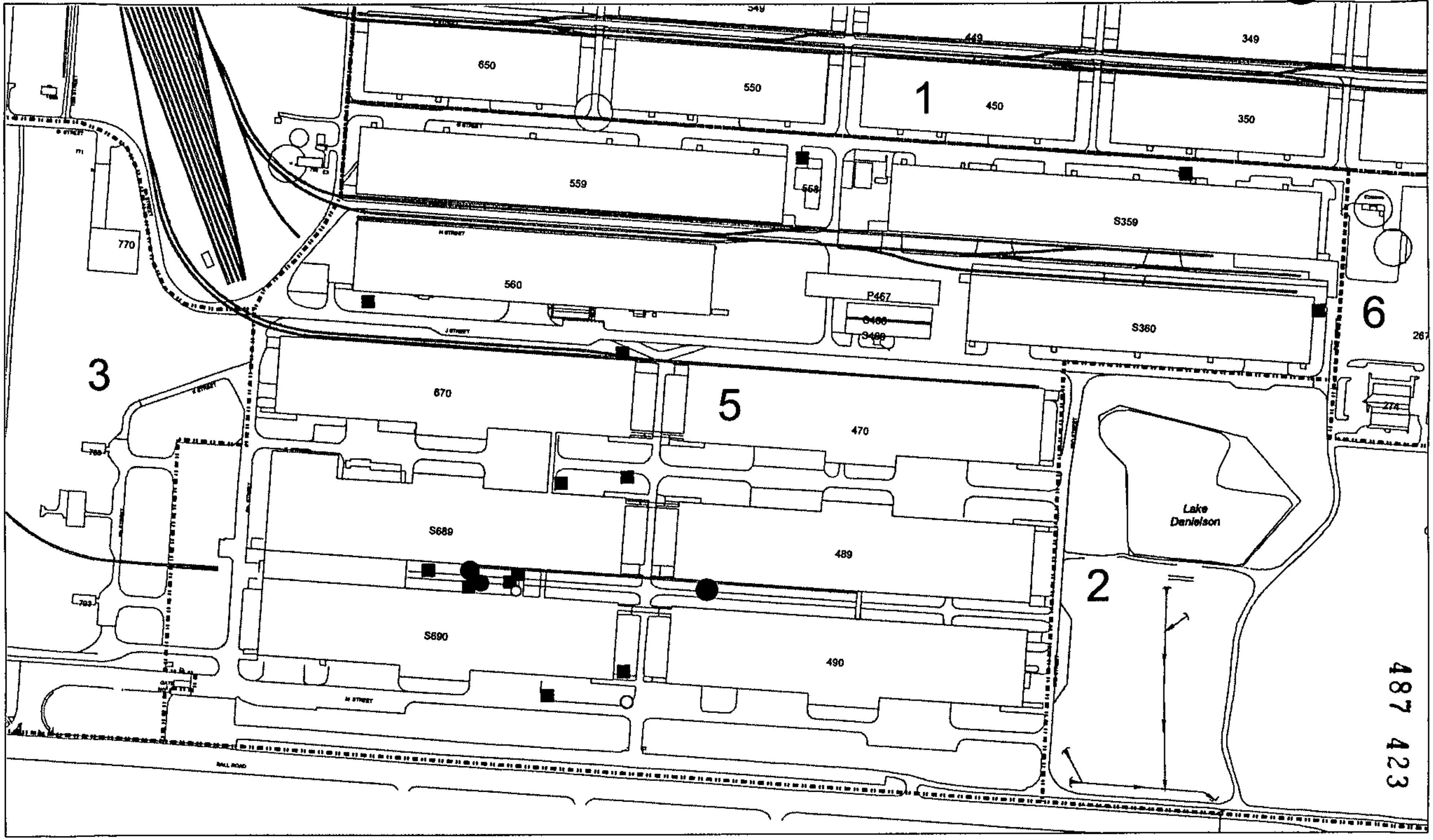

487 423

FIGURE 24-10
LEAD CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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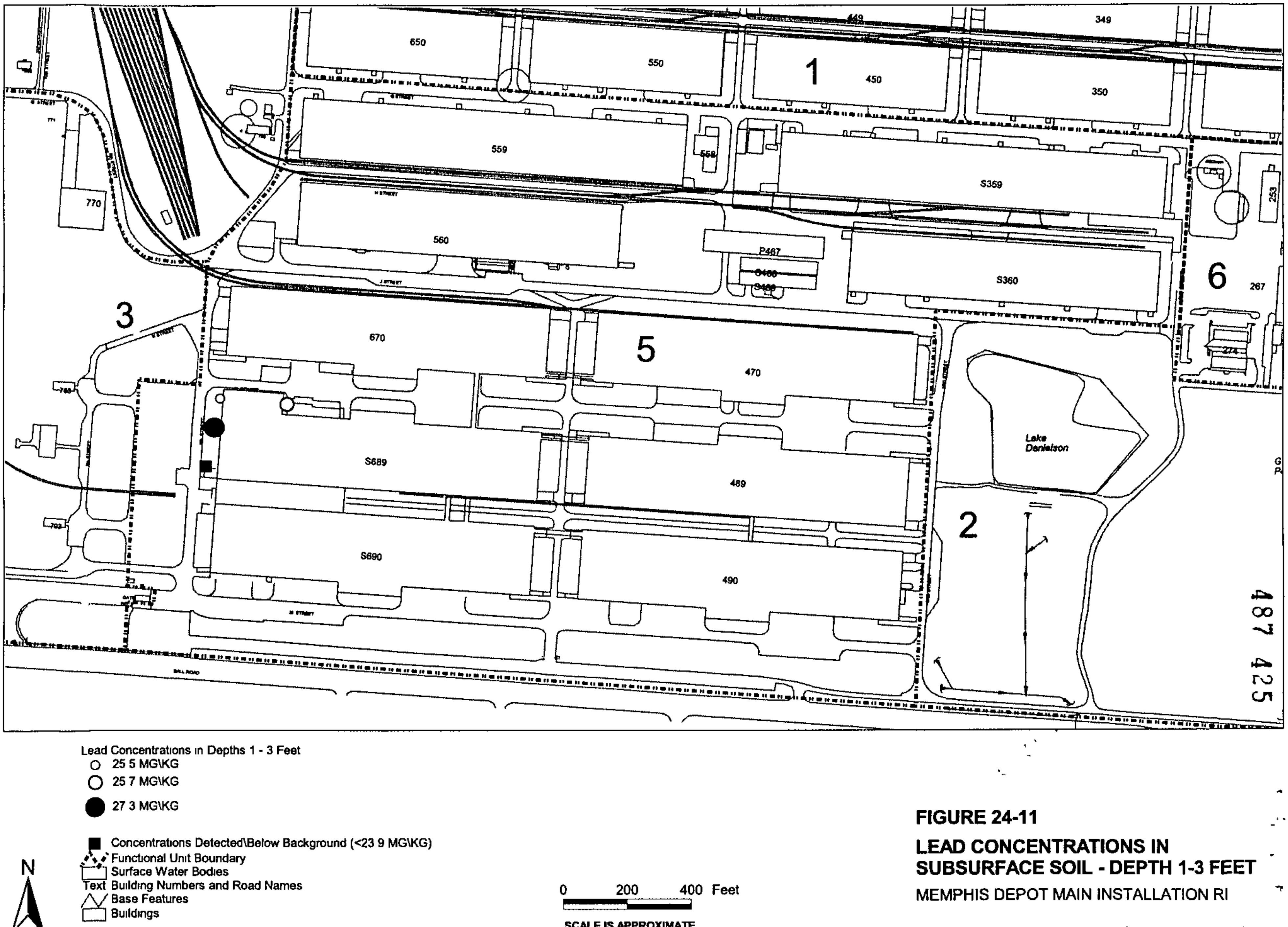

FIGURE 24-11

LEAD CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 1-3 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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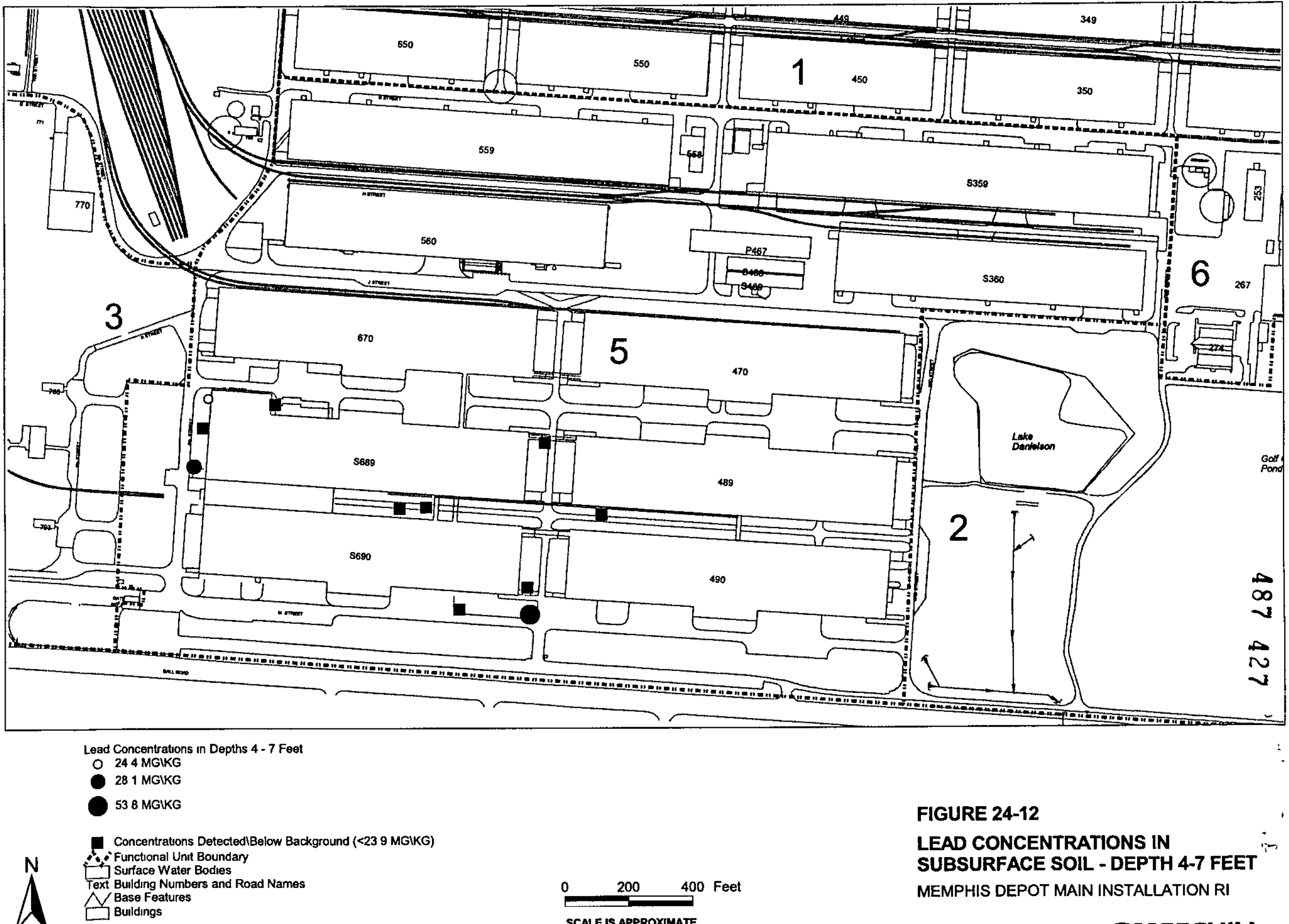

487 427

FIGURE 24-12

LEAD CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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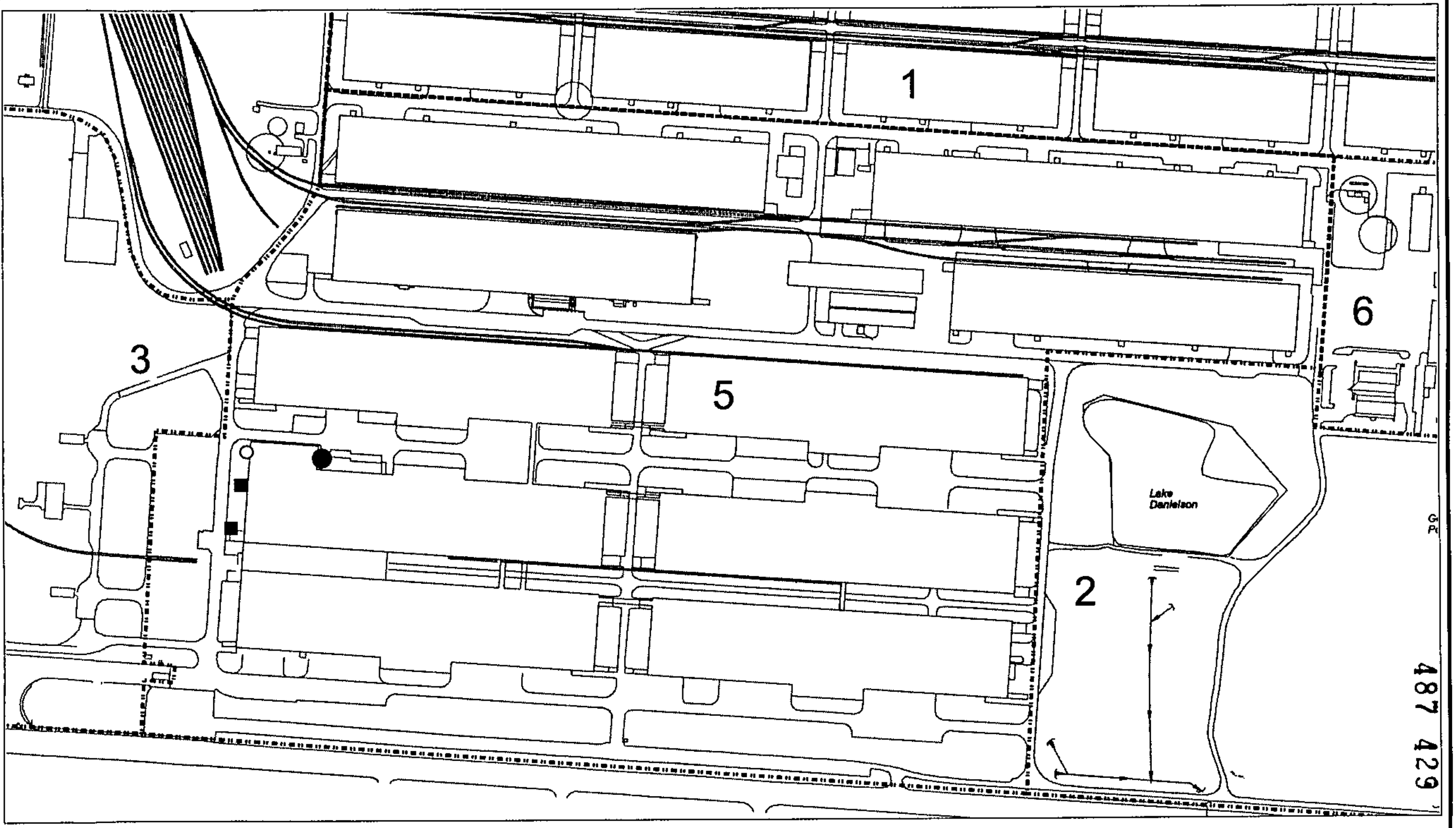

FIGURE 24-13

NICKEL CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 1-3 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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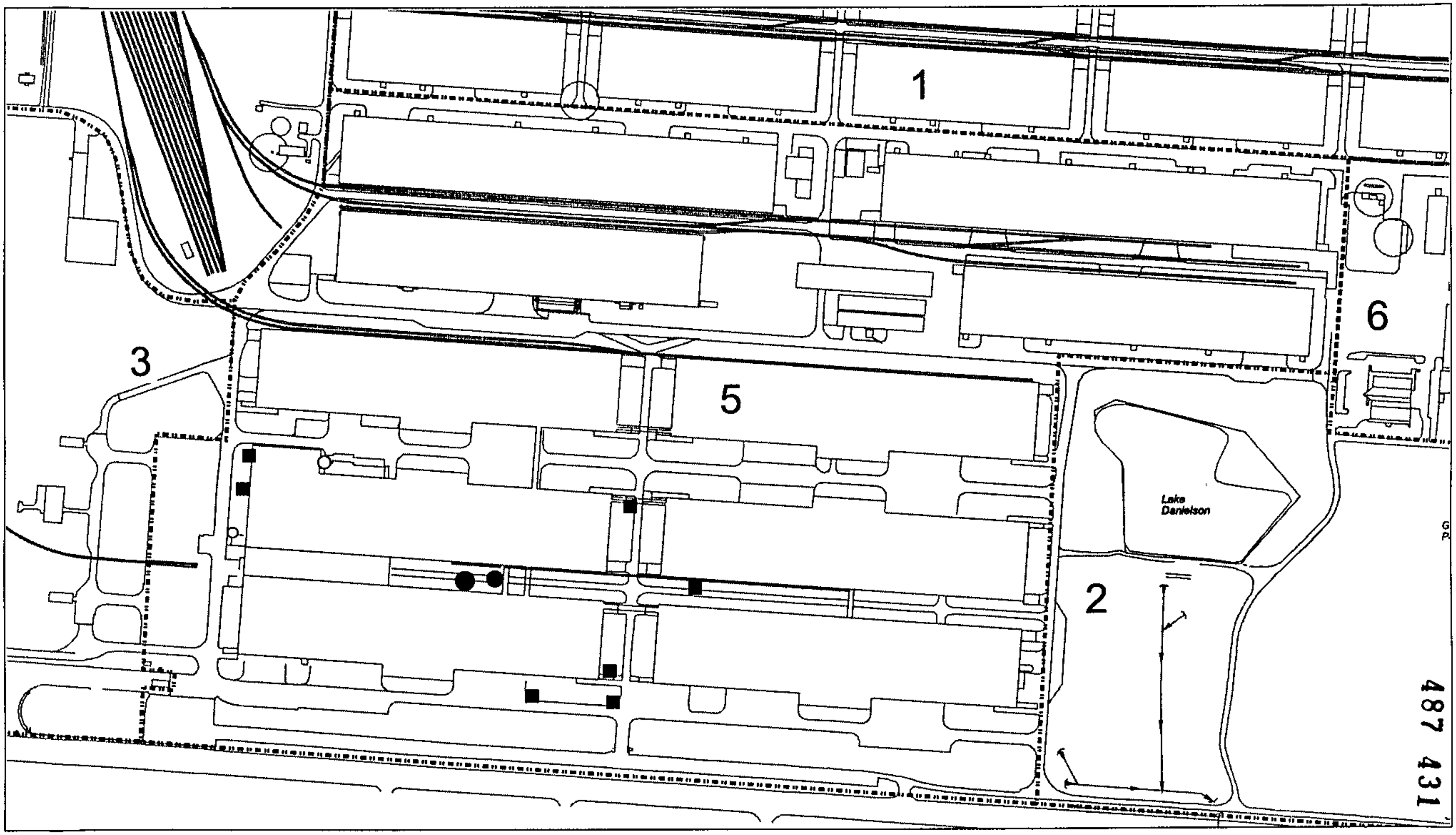

487 431

FIGURE 24-14

NICKEL CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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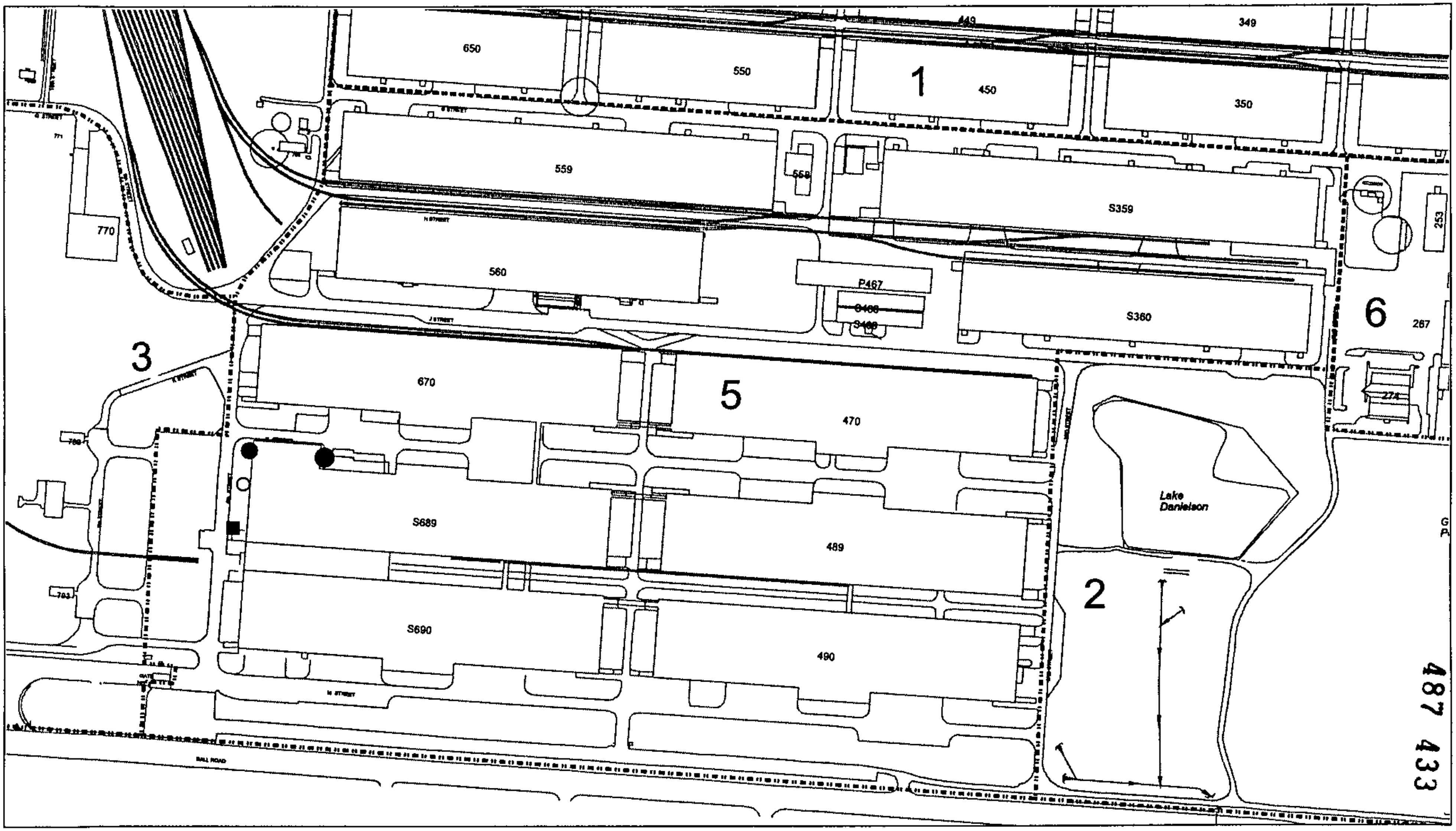

Zinc Concentrations in Depths 1 - 3 Feet

○ 120 MG\KG

130 MG\KG

132 MG\KG

■ Concentrations Detected\Below Background (<114 0 MG\KG)

Functional Unit Boundary

Surface Water Bodies

Text Building Numbers and Road Names

Base Features

Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

FIGURE 24-15

ZINC CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 1-3 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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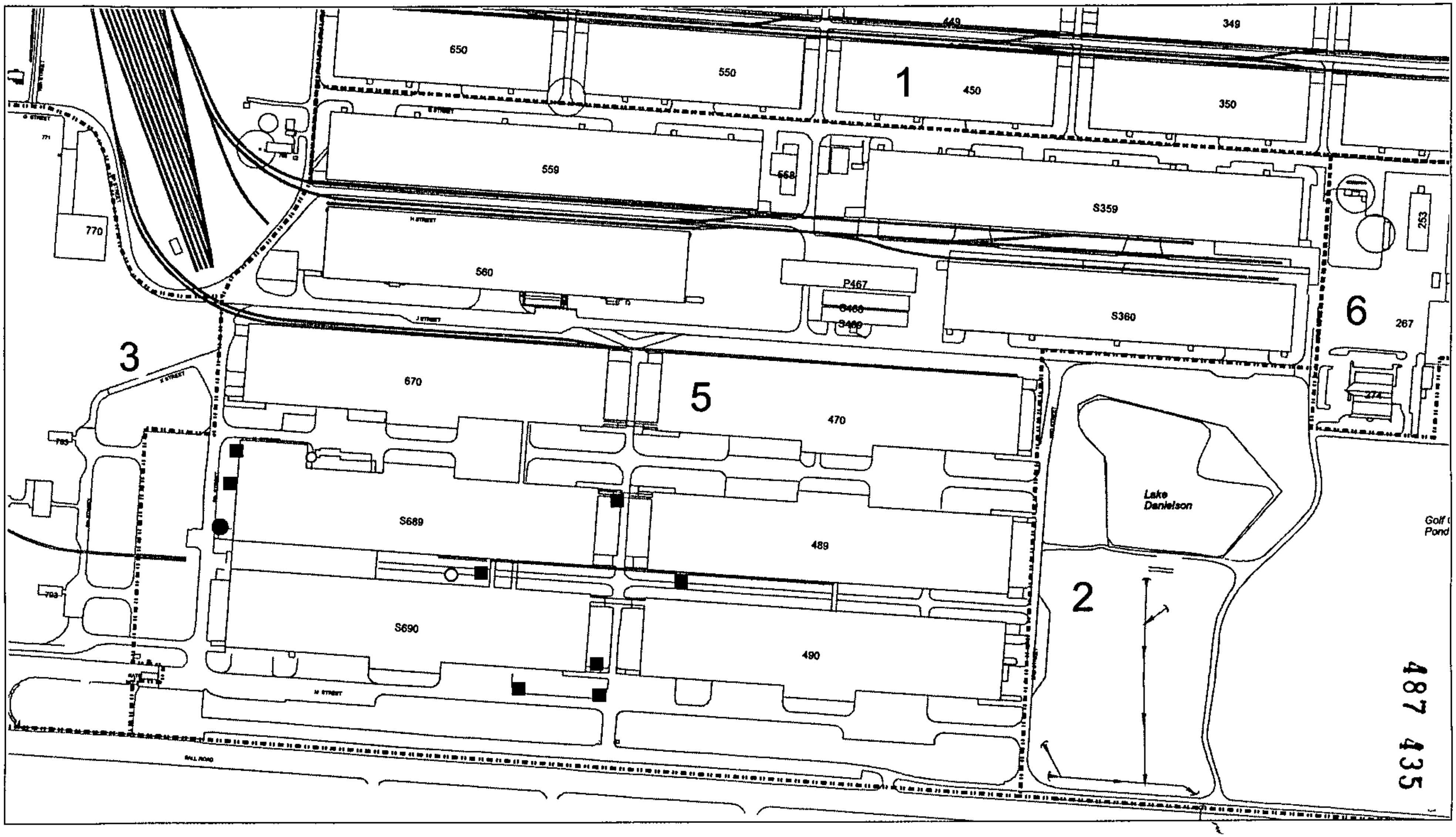

487 435

FIGURE 24-16

ZINC CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 4-7 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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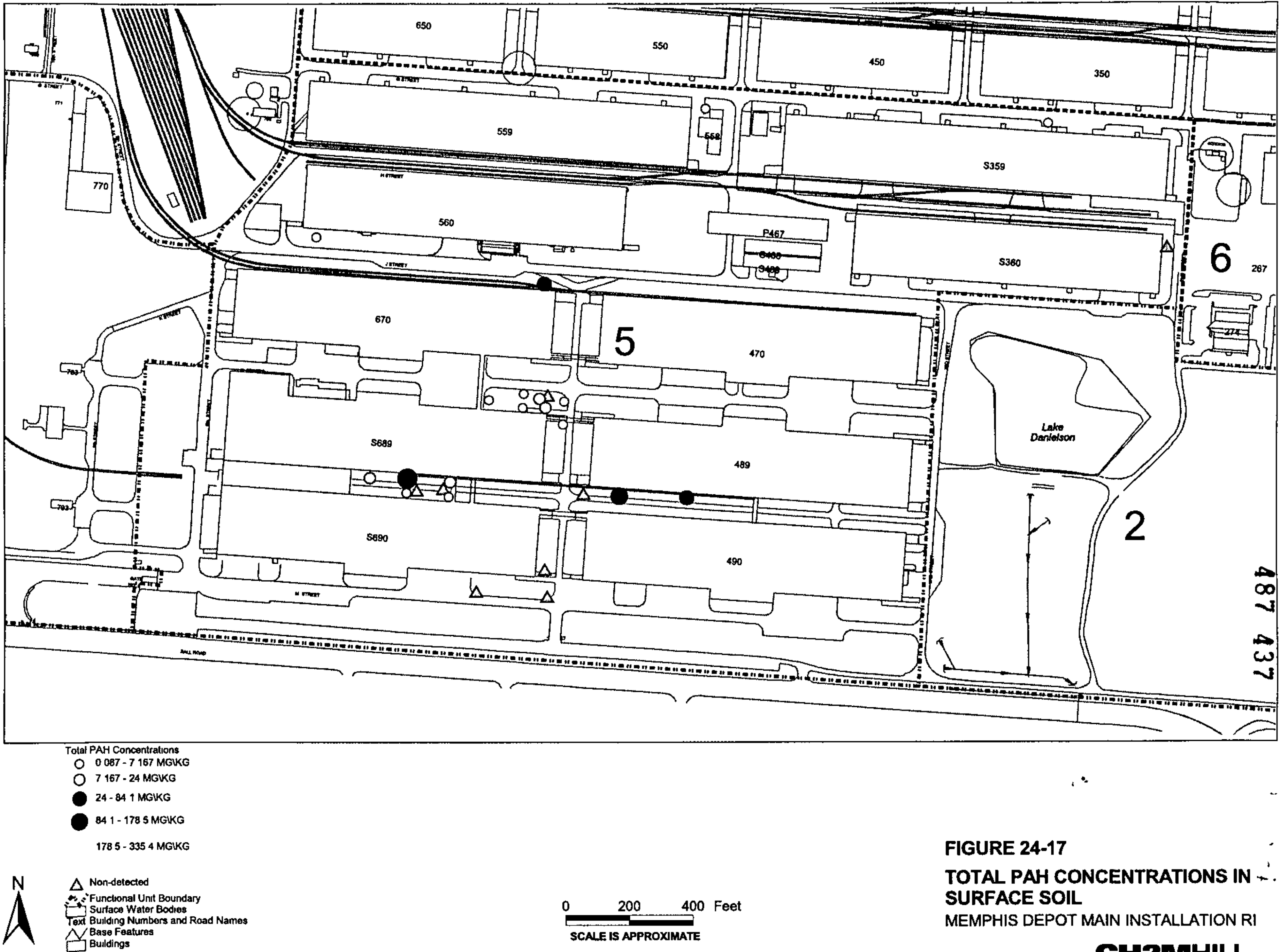

FIGURE 24-17

TOTAL PAH CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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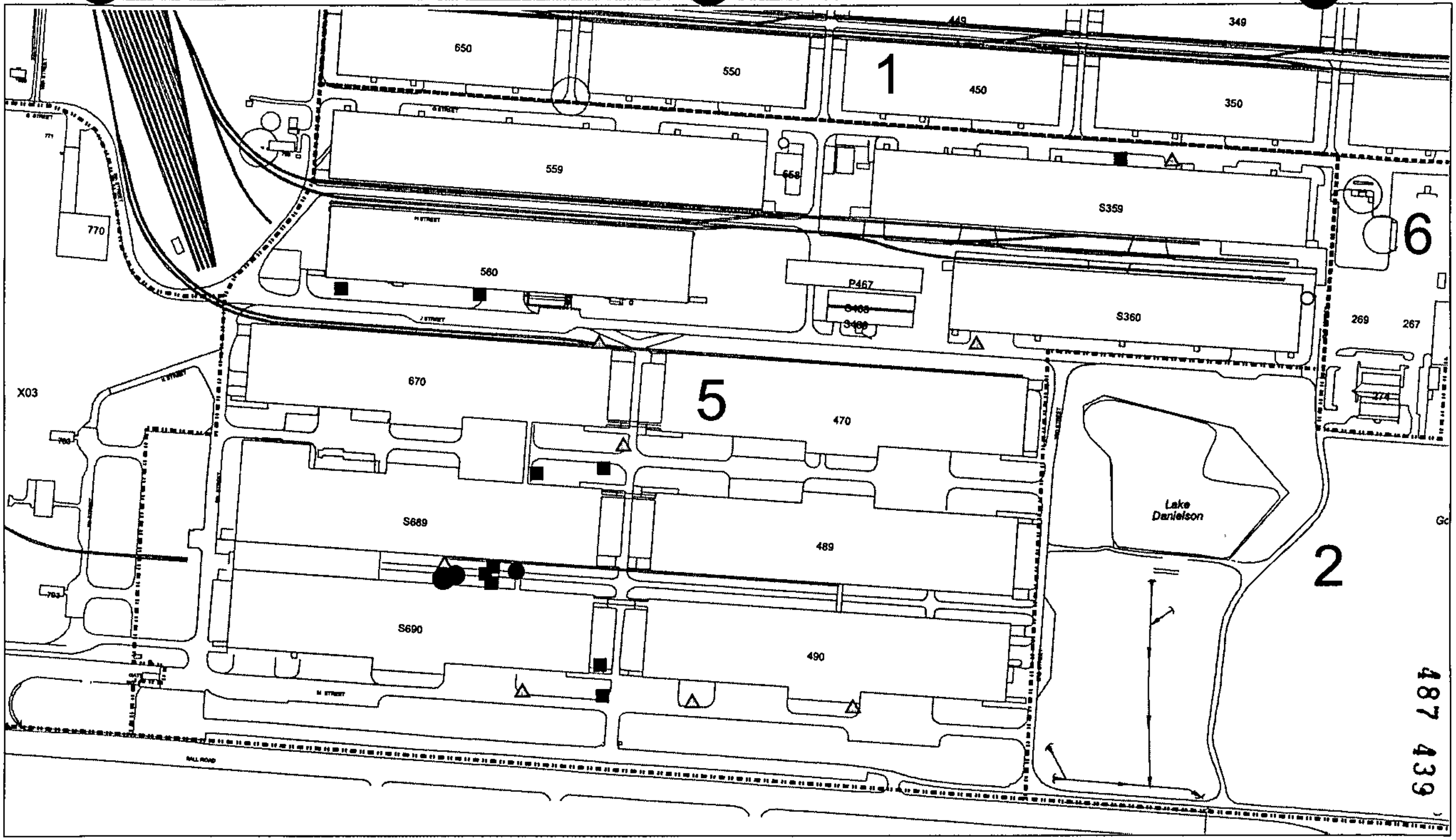

FIGURE 24-18

DDT CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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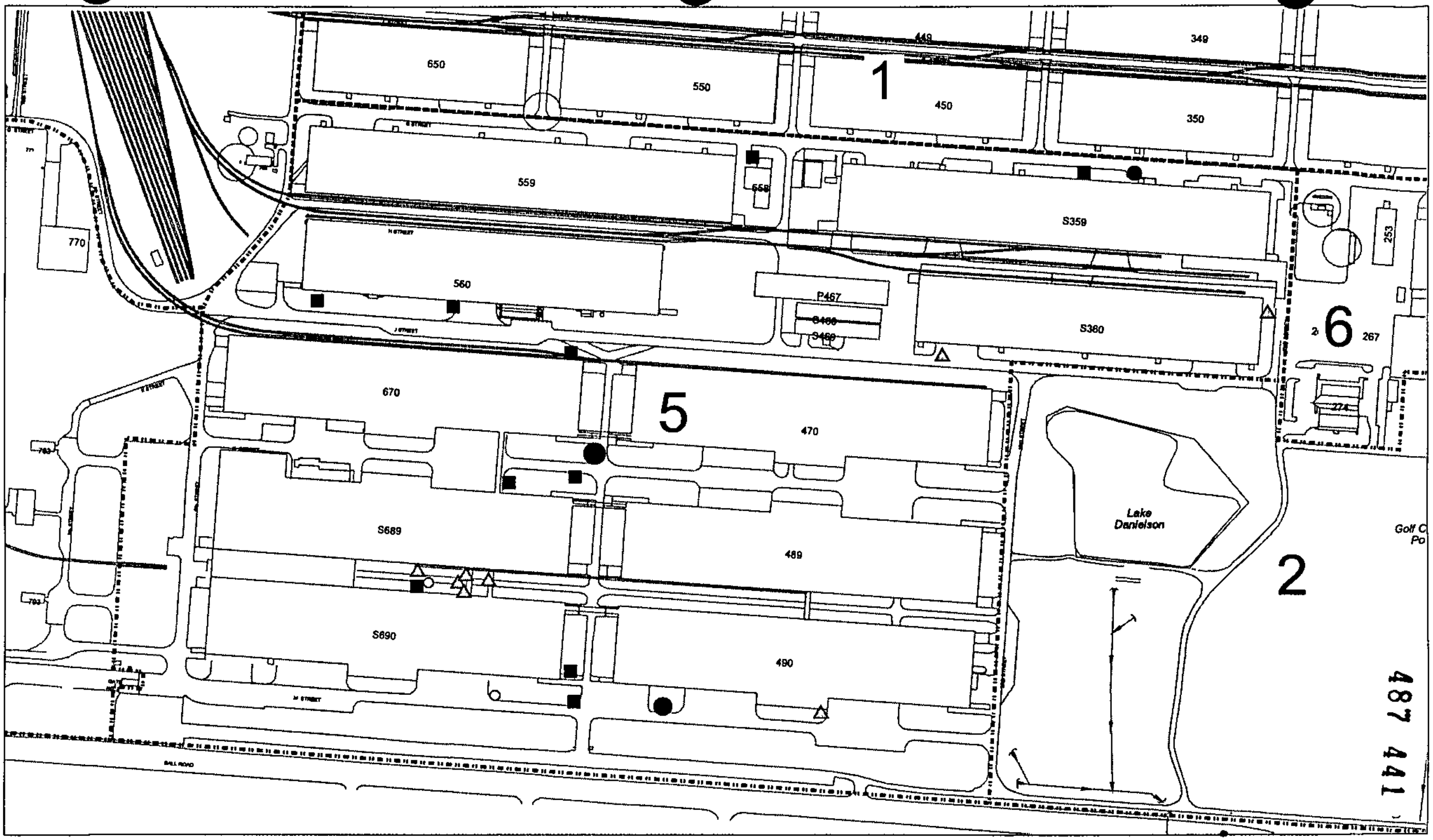

DIELDRIN Concentrations

○ 0 26 - 0 3 MG\KG

● 0 3 - 0 35 MG\KG

● 0 35 - 0 9 MG\KG

● 0 9 - 1 1 MG\KG

■ Concentrations Detected\Below Background (<0 086 MG\KG)

△ Non-detected

Functional Unit Boundary

Surface Water Bodies

Text Building Numbers and Road Names

Base Features

Buildings

N

0 200 400 Feet

SCALE IS APPROXIMATE

FIGURE 24-19
DIELDRIN CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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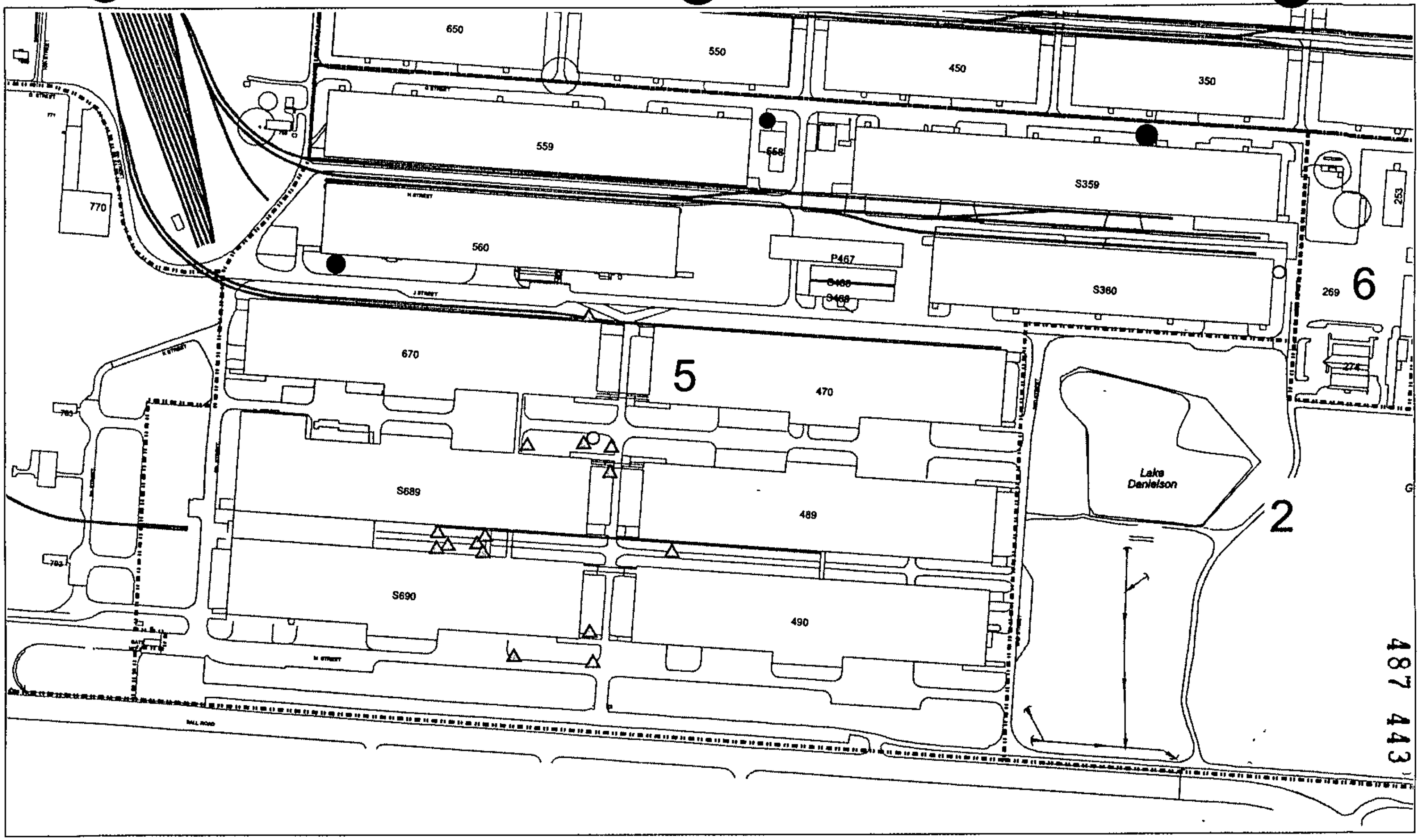

Methyl Ethyl Ketone Concentrations
○ 0 016 - 0 02 MG\KG
0 02 - 0 035 MG\KG
● 0 035 - 0 05 MG\KG
0 05 - 0 076 MG\KG

N

△ Non-detected
Functional Unit Boundary
Surface Water Bodies
Text Building Numbers and Road Names
Base Features
Buildings

0 200 400 Feet
SCALE IS APPROXIMATE

FIGURE 24-20

METHYL ETHYL KETONE CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

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TAB

Section 25

TAB

25. Fate and Transport for FUS

25.0 Fate and Transport for FU5

The overall fate and transport discussion was included in Section 6.0. This section covers information specific to FU5 and Site 77. The CSM for FU5 is presented on Figure 26-2.

25.1 Fate and Transport for FU5

A summary of site conditions influencing the fate and transport of site contamination is presented in this discussion. Figures 2-16 and 24-1 show the land cover types within FU5.

Source Area Characterization: FU5 is an entirely industrialized area covered mostly with paved roads and railroad tracks, large warehouses (closed), and some grassy and small gravel areas. The warehouses are large (218,000 ft^2 or larger) and were built during the 1940s and 1950s mostly for the storage of clothing and other materials, as well as for various types of equipment. Specific uses included storage of medical supplies, historical USTs, and hazardous wastes (Building 359); microfiche development and dipping of machine parts for preservation (Building 490); and storage of Safety-Kleen parts cleaning units and unknown wastes (Building 689). A Safety Kleen machine was located and used in Building 689, which also staged hazardous materials prior to shipment. Some office spaces were developed in the 1980s in Building 685. Most of the surface area around the buildings is covered with concrete or asphalt pavement, interspersed with grass or gravel in areas surrounding the buildings. Most of the area (more than 70 percent) is covered with asphalt or concrete.

The majority of stormwater collected in FU5 is transported via the underground pipe system to the concrete-lined ditch that runs parallel to N Street south of Lake Danielson (Black & Veatch, 1999). This ditch discharges (Outfall 4) to an unnamed tributary south of N Street that eventually discharges to Nonconnah Creek. A small portion of stormwater from the western end of FU5 flows via the underground pipe system and is discharged to Tarrant Branch at Gate 9 (Outfall 5).

Table 6-4 presents the comparison of site soil constituents, their comparison criteria, and the number of concentrations above the criteria. In the nature and extent of contamination investigation, two inorganic chemicals (arsenic and antimony) were detected slightly above background levels at the maximum detected concentrations in surface soil (see Table 26-1). Surface soil also had PAHs in 50 percent of the samples analyzed, mostly along the railroad tracks. Antimony was detected in 3 of the 7 samples analyzed for this metal, and the highest detected concentration was 7.4 mg/kg, compared to a background concentration of 7 mg/kg. The highest detected concentration of arsenic was 29 mg/kg compared to a background value of 20 mg/kg. Table 26-1 lists the COPCs for the FU5 surface soils. Thus, he inorganic chemicals at this FU could be within the naturally occurring levels. Several of the samples had residual dieldrin, which was detected across the Main Installation and is thought to be from historical applications. Subsurface soils had low levels of metals, PAHs, dieldrin, and VOCs in a few locations. The PAHs and dieldrin were detected at lower concentrations and lower frequencies than in the surface soil.

CVOCs detected in the groundwater under Main Installation also were detected in soil boring samples at Site 78, located west of Building 689. A detailed presentation of the results of the Site 78 investigation is included in the Screening Sites Letter Reports (CH2M HILL, 1998). The samples were collected from underneath concrete adjacent to 6th Street. Sample SB78B had TCE at different depths ranging between 0.085 and 11 mg/kg. These CVOCs can be a potential source of groundwater contamination in the area.

Potential Contaminant Migration, Persistence, and Exposure Points: The potential transport and migration pathways at FU5 are considered to be surface runoff, percolation/ leaching to groundwater, and dust emission/volatilization. These pathways are likely to occur mostly in the areas without an impervious cover, which are limited to the strips of grass-covered areas around the warehouse buildings. The relevance of each of these migration pathways for FU5 is discussed in further detail below.

Surface Runoff Pathway: As described above, much of the site is covered by buildings, asphalt, and concrete-covered roads. There is no distinct slope or gradient at the site, all of the open areas are grass-covered, and the stormwater is collected into the stormwater drainage system. For these reasons, surface soil erosion-related runoff from the grassy areas to off-site is not likely. Stormwater from the site is expected to percolate through grassy areas, and from paved areas is collected through a stormwater drainage system that eventually flows to an open drainage ditch in a location south of the Depot. Thus, surface runoff to adjacent FUs or release to surface water features such as the off-site ditch is not a pathway of concern for FU5. Historical investigations sampled the open drainage ditches and found no site-related contamination and no contamination, except for low-level chlorinated pesticides at concentrations lower than those found in surface soils across the Depot (CH2M HILL, 1996). The storm drains from the southern part of the Depot eventually drain to the Nonconnah Creek in the downgradient location (see Figure 2-15).

Air/Dust Emission Pathway: The surface soil COPCs such as PAHs and dieldrin have low volatility and thus are not readily airborne. However, these could become airborne whenever activities resulting in dust generation occur in the open areas. The only likely airborne pathway for the site COPCs is through dust, although to a limited extent. Potential dust emissions were included in the risk estimations using EPA-recommended dust emission assumptions (PEF = 1.3×10^9 m^3/kg).

The subsurface soils at FU5 had a trace level of 1,2-DCE (0.002 mg/kg) in 1 of the 31 samples analyzed for this compound. TCE was detected in 3 of the 31 samples analyzed, with a maximum concentration of 11 mg/kg at a depth of 16 to 30 ft at Site 78. The potential for volatilization of TCE from such depths within small areas with low concentrations is considered negligible. Thus, the airborne volatile emission pathway is considered unimportant at FU5.

Migration to Groundwater Pathway: Leaching to groundwater is not an issue for any of the surface soil COPCs in FU5, based on their physico-chemical properties, their absence in the subsurface soil, and regional groundwater. Also, a large part of the surface area is occupied by paved surfaces, including roadways, which minimizes the potential for leaching. Considering the time that has elapsed since the releases may have taken place, migration would have occurred by now. Also, these COPCs tend to sorb to soil and have a low migration potential (see Table 6-2).

Subsurface soils at Site 78 had CVOCs. The three detected concentrations (ranging from 0.085 to 11 mg/kg) exceeded the groundwater transfer (GWP/SSL) criteria, indicating that soils in FU5 may be a continuing source of groundwater contamination. The subsurface soil near Site 78 had TCE at 11 mg/kg (Sample SB78B). Additional samples collected from the northern end of the concrete pad contained TCE compounds throughout the soil column, although at lower concentrations. Thus, pavement may limit the percolation-related leaching; however, slow leaching from gravitational pull could be occurring.

Groundwater: The groundwater underneath FU5 had detectable levels of chlorinated VOC contamination. Fluvial aquifer groundwater beneath the Depot in general has been affected by VOCs, primarily PCE and TCE (see Figures 32-2 and 32-3). The groundwater contamination and the potential source areas for the groundwater contamination were addressed as part of FU7.

Groundwater from FU5 flows to the center of the Main Installation to a central trough, so migration beyond the property boundary from FU5 is not a potential pathway. Also, regional groundwater use patterns are established, with the City of Memphis supplying the potable water for the area residents and the Depot. As a result, future potential exposures may not be a concern for FU5.

25.2 Fate and Transport for Screening Site 77

The following is a brief summary of the site features that could influence the fate and transport of the contaminants in the site media. Site 77 is located in Parcel 22, between Buildings 689 and 690, is situated at the end of 1st Street, and is about 2/3 of an acre. Part of Site 77 formerly was used as a battery recoupment area. On the basis of this historical use, constituents most likely to be present at this site are metals, and lead in particular. However, a TCL/TAL analysis was performed on the surface and subsurface soil samples collected from this site (CH2M HILL, 1998). Figure 24-2 shows the surface and subsurface soil sampling locations.

The surface soil COPCs included low levels of arsenic, antimony, PAHs, PCP, and dieldrin. The detected arsenic, at a maximum concentration of 22.9 mg/kg compared to a background value of 20 mg/kg, does not indicate a site-specific exceedance. Also, antimony was detected at a maximum concentration of 7.4 mg/kg compared to a background level of 7 mg/kg. Lead was not a COPC at the site. Thus, there are no inorganic chemicals of importance for the site.

The subsurface soil included arsenic at a maximum concentration of 17.9 mg/kg compared to a background value of 17 mg/kg. Copper was detected at a maximum concentration of 33.4 mg/kg compared to a background value of 28.7 mg/kg. No organic chemicals were detected in the subsurface soil. Thus, site soils have inorganic chemicals at levels similar to naturally occurring levels and the subsurface soils are free of contamination. The detected organic chemicals are similar to those detected across the site (e.g., PAHs, PCP, and dieldrin). Therefore, there is no site-specific source of contamination at Site 77.

The CSM for Site 77 is identical to the one for FU5, and is presented on Figure 26-5. As indicated in the CSM, the primary release mechanisms typically include historical spills and storage. No such spills or leaks are apparent at Site 77, because of the lack of contamination specific to the battery recoupment activities. The PAHs and PCP detected in site surface soils could be associated with the railroad tracks and the dieldrin is thought to be from routine spraying to protect stored materials in the warehouses. Secondary sources of contamination are the site soils that have PAHs and pesticides.

Contaminants could be transported through surface runoff, suspension of entrained dust particles, volatilization into ambient air, and infiltration and leaching from soil to shallow groundwater. Potential off-site migration pathways include surface runoff and dust emissions.

Surface Runoff Pathway: There are no significant drainage features for Screening Site 77. The site is located between two large buildings that are connected. The only potential for surface water flow from the site is via percolation or draining to the stormwater drainage system (see Figures 2-1 and 2-16). Although COPCs such as PAHs bound to soil particles have been detected in site soils, off-site migration is not likely. The Depot stormwater from FU5 is released to the open ditch located in the south of the Depot.

Dust/Air Pathway: Because of the presence of the gravel cover on the surface area at Site 77, dust generation is not an important emission pathway for COPCs. Potential dust generation was included in the risk calculations under conservative dust emission assumptions (EPA's PEF of 1.32×10^9 m^3/kg).

Groundwater Migration Pathway: Potential migration to the subsurface soil is not indicated at this site because of the absence of surface soil constituents in the deeper soil column. The detected COPCs are relatively insoluble (see Table 6-2), and therefore, are not mobile. Leaching to groundwater is not considered a significant migration pathway for this site because COPCs were not detected in subsurface soil or groundwater. All other migration pathways are negligible at this site, based on the media monitoring information.

TAB

Section 26

TAB

26. Baseline Risk Assessment for FUS

26.0 Baseline Risk Assessment for FU5

26.1 Human Health Evaluation for FU5

This section presents the baseline RA for FU5. Because FU5 comprises numerous parcels and sites, a conservative, surrogate approach was implemented to assess potential human health risks. Exposure units were developed to assess risks across FU5 in lieu of an individual RA at each of the identified parcels and sites. Three exposure units were developed for this RA. First, a maintenance worker is assumed to work across the entire Screening Site 77. Site 77 is an appropriate surrogate site for FU5 because Site 77 has the highest concentrations among all the sites in FU5. Finally, a residential receptor is assumed to be exposed to a 0.5-acre lot represented by the highest PRE data point within FU5. Figure 26-1 presents the different hypothetical exposure units within FU5. The exposure unit approach was presented in Section 7.0. The PRE results used as the basis for the surrogate site and the highest PRE data-point selection are presented in Appendix E.

FU5 is a physically contiguous unit that includes large warehouses within Parcels 16-22 and 34. It includes six screening sites–Sites 70/71, 73, 75, 76, 77, and 78. All railroad tracks across the base are grouped under Screening Site 70, part of which is also included in FU5. FU5 consists of highly industrialized areas with 10 large warehouses, all of which are in good working condition. To make the site more accessible for future light industrial and commercial uses, the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997) proposes to remove two of the large warehouses (Buildings 359 and 559). These areas will be converted into parking areas and access roads to the remaining warehouses.

The RA was conducted using data collected as part of the BRAC sampling program (from BRAC Parcels 16-22 and 34), and Screening Sites 73, 75, 76, 77, and 78. There are no RI sites located within this FU. Data were collected from biased locations within known historical site activity areas to evaluate maximum possible contamination levels within a site and parcel. Once a sample was identified as having contamination, the extent of the contamination was further defined around that sample in the next phase of sampling. In general, several surface and subsurface soil samples were collected within each site to evaluate the nature and extent of chemical distributions. A summary of the number of samples collected and the frequency of detection for the detected chemicals are included in Tables 26-1 and 26-12.

Screening Site 77 is the surrogate site for FU5. Site 77 was chosen as the surrogate site for FU5 because it had the highest human health risk ratio during the PRE (see Section 7.1 [Table 7-1] and Appendix E). As presented on Figure 26-1, the surrogate site, Site 77, was evaluated as an exposure unit for a future industrial worker and a utility worker exposure in the RA. RGOs were calculated for COPCs, when risks for an industrial worker were above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4} within the FU5 and/or Site 77 risk estimates. In an attempt to limit the number of quantified exposure scenarios, relative exposure levels were compared (Appendix F), and the most conservative representative exposure scenario for an industrial setting was used in the risk estimations

487 454

for FU5. Also, for the FU5 evaluations, all samples across the FU were used for risk estimations. The highest risk area was identified by the PRE evaluations (Appendix E), and the future residential scenario was evaluated for the highest risk sampling point from the results of the PRE estimations (i.e., SS77C) to calculate the potential exposure at a future residential lot (assumed to be a 0.5-acre lot).

26.1.1 Selection of COPCs for FU5

As previously stated, data collected from parcels and screening sites were used for this RA at FU5. The primary media of interest for FU5 are soil (surface and subsurface) and groundwater. The groundwater underneath the Main Installation was addressed as part of FU7 (Sections 32.0 through 35.0). The groundwater RA is included in Section 34.0, which identifies various contamination areas within the groundwater. The southern end of Plume C, which is a coalesced region of Plumes A and B (see Figure 32-2), is located under FU5. However, wells with higher levels of contamination are under FU4. Therefore, the cumulative risks from exposures to groundwater from the center of the plume were added to the surface media risk estimates for FU4. The COPC selection was based on results from soil samples collected from the gravel or grass strips along the railroad tracks and from the grass adjacent to paved roadway areas around the warehouses within FU5. There is no sediment or surface water within FU5.

The soil samples were analyzed for TCL/TAL compounds in most, but not all, of the samples. As a result, the number of samples analyzed for various chemical groups differed for soils. The total number of samples included in this FU-wide RA ranged from 16 to 30 for surface soil samples and from 14 to 51 for subsurface soil samples. As described further below, surface soil results were combined with subsurface soil data to select subsurface COPCs. These data were used to select COPCs to evaluate the industrial worker exposure under current and future land use scenarios.

A description of the COPC selection methodology was provided in Section 7.0. Chemicals detected above background values and the RBCs were selected as COPCs for surface and subsurface soil. A list of COPCs was selected for FU5 by comparing the detected chemical maximum concentration with background and health-based criteria (RBC), as presented in Tables 26-1 through 26-3. A list of the human health screening criteria by medium and the results of the COPC selection screening are provided in Appendix D.

The COPCs were selected separately for the FU-wide RA, Site 77 (surrogate site), and the single sample point used for the residential RA. COPCs for FU5 surface soil are antimony, arsenic, PAHs, dieldrin, carbazole, PCP, and 4-Methylphenol. COPCs for FU5 subsurface soil are antimony, arsenic, cadmium, chromium, copper, manganese, PAHs, dieldrin, carbazole, PCP, 4-Methylphenol, 1,2-DCE (total), and TCE. However, for a conservative assessment of risks during excavation type exposures, all the surface soil COPCs also were included for subsurface soil to account for exposure to the excavated soils from zero- to 10-ft depths by commercial or industrial workers. This scenario represents a conservative risk analysis for future commercial or industrial worker exposures.

Four PAH constituents from data point SS77C were evaluated as COPCs for residential exposure-related risk estimations.

26.1.2 Exposure Assessment for FU5

The regional land use within a 3-mile radius of the Depot is presented on Figure 2-15. The exposure units identified within FU5 are presented on Figure 26-1. Historically, operations in FU5 included general purpose warehouses for the storage of clothes, miscellaneous equipment, medical and general supplies, caustic soda, sodium chloride, petroleum product drums, and batteries. The storage activities at the warehouses were discontinued between 1990 and 1996. Currently, only Buildings 685, 689, and 690 are used (for McAuley's Potpourri) in FU5. The future proposed use plan includes future light industrial storage/distribution types of use for the selected remaining warehouses. Future redevelopment may include demolition of two of the larger warehouses, removal of railroad tracks throughout FU5, and new landscaping along the roadways and new parking areas (The Pathfinders et al., 1997). The environmental samples collected from the media within this FU were analyzed for a variety of constituents (e.g., TCL/TAL). The following text presents a CSM for FU5, as well as potentially exposed human receptors within the FU5 under current and future land use scenarios.

26.1.2.1 Conceptual Site Model and Fate and Transport Overview

Figure 26-2 presents the exposure CSM for FU5. Each of the components of a CSM are discussed below, including the primary and secondary sources of contamination, primary and secondary release pathways, mechanisms, potential receptors, and routes of exposure.

The primary sources of COPCs in the soil at FU5 are suspected to be historical site operations involving the storage of various industrial materials and chemicals and maintenance applications of pesticides and herbicides. As noted in the fate and transport discussion in Section 6.0, primary release mechanisms include historical spills and leaks from the storage of chemicals and the surface application of pesticides, herbicides, and waste oil. Some of the chemicals detected in the environmental media could be the result of past railroad operations.

Soils could become secondary sources of contamination. Over time, surface soils could leach more mobile constituents to subsurface soil and eventually to shallow groundwater, if the conditions are favorable. "Favorable conditions" can be described as the presence of shallow groundwater under soils that are very porous, high precipitation conditions, and the presence of very mobile chemicals. These conditions do not exist at the Main Installation. The depth to groundwater averages more than 85 ft bgs, with the maximum depth of 132 ft bgs in the northwestern portion (MW-38) and a minimum depth of more than 55 ft bgs; surficial soils are clayey and relatively impervious; and there are no highly mobile organic COPCs. A large part of the FU5 surface area is covered with warehouses, roadways, and concrete pads, thus reducing surface infiltration of water and the potential for leaching to groundwater. However, subsurface soil at SB78B (15- to 20-ft depth) has a TCE concentration of 11 mg/kg, whereas adjacent sample SB78C had PCE at 0.003 mg/kg (see Figure 32-9). In a sample to the south (SB78A), neither TCE nor any other CVOCs were detected. Therefore, the soils at Site 78 could potentially be a continuing contributor of contamination to groundwater.

Additional, generic potential migration pathways for contaminants include suspension of entrained dust particles and chemical volatilization into ambient air. On the basis of the characteristics of the COPCs identified at FU5, volatilization is not an important migration pathway. No significant concentrations of volatile constituents were identified in the surface and shallower subsurface soils within FU5. Volatile emissions from shallow groundwater to ambient air within FU5 are expected to be negligible because of the approximately 50-ft depth to groundwater, the clayey nature of the overlying soils, and the presence of low levels of groundwater contamination within FU5. Most of the COPCs identified for soils are naturally occurring inorganic chemicals and semivolatile constituents. Migration of these chemicals could occur via surface runoff and/or dust-borne emissions.

There are no surface water bodies or drainage ditches within FU5. Surface water runoff within FU5 flows in a generally north to south pattern based on surface topography. The runoff is routed through a stormwater drainage system that discharges into a concrete-lined drainage ditch at the northeastern corner of the intersection of 3rd Street and N Street. This ditch ultimately discharges to Nonconnah Creek south of the Depot and south of N Street. Because of the paved areas across FU5 and limited open areas, runoff is likely to be limited. Drainage ditches at Sites 51 and 52 and the confluence with the open ditch previously were sampled to estimate the potential for runoff and were found to have low levels of inorganic chemicals and organo-chlorine pesticides such as DDE and DDT. However, these low levels may have been from direct applications to these areas in the past, and the runoff pathway is not significant from FU5. The releases to Lake Danielson, which had similar constituents, also were studied as part of this investigation.

Dust emission from the soil areas covered with grass and gravel had been included as potentially complete exposure pathways. Potential releases from surface soil were included for risk estimations as a complete pathway.

Potential exposure points on-site include areas where human activities and/or ecological receptor occurrences are likely and could result in physical contact with one or more contaminated media. Most of the FU is inactive, with human activity limited to the surrounding outdoor areas and McAuley's Potpourri. Thus, human activity in this area currently is limited to maintenance work in the vicinity of the warehouse buildings. In the future, when the warehouse buildings are leased for light industrial storage and distribution centers, industrial workers are assumed to be present at FU5. The potential for direct human exposure depends on the presence of exposed contaminated soil and the types of activities within the contaminated areas. Direct human exposure is limited by pavement, gravel, and grass cover (see Figure 2-16). A large portion of the surface area within FU5 is covered with grass, gravel, concrete, or asphalt pavement, thus limiting the exposure to soils during maintenance activities. However, for the purposes of this risk evaluation, exposures were assumed to be unlimited, so dust intakes were included for quantitation. Future exposures were evaluated assuming unrestricted land use. Exposures under a future land use are therefore assumed to be maintenance -related work and industrial and residential activities for the entire FU. Exposure units within FU5 are presented on Figure 26-1. Soil sample SS77C was collected from a location next to Site 77 along the railroad tracks. The railroad tracks and associated gravel and surface soils are proposed to be removed before re-use of the facility. Thus, this area and the contamination conditions will be altered before use in the future. As a result, this evaluation is a worst-case scenario for future residents. The utility worker can work anywhere in the FU and therefore can be exposed to the larger exposure unit. However, Site 77 was used as a surrogate, potential RME site to evaluate both the industrial and utility workers' exposures. Also, the

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future subsurface exposures are assumed to have the same COPCs as surface soil. These theoretical assumptions were included to evaluate the site under conservative exposure assumptions.

On the basis of the good functional condition of the warehouse buildings in the area and planned re-use activities described in the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), the site is likely to remain industrial. The future land use plans indicate a need to demolish some of the older buildings to provide for adequate parking space for future industrial use. Potential exposure routes for the maintenance worker include incidental ingestion and dermal contact with surface soil and inhalation of particulate emissions via dust from surface soil. Surface runoff is not a concern for FU5, because of the lack of surface runoff. Given the presence of pavement, concrete, gravel, and grassy land cover over FU5, dust generation is anticipated to be limited.

26.1.2.2 Potentially Exposed Population and Identification of Complete Exposure Pathways

Currently, most warehouses in FU5 are not in use, with the exception of Buildings 685, 689, and 690. A potentially exposed population under current conditions could be maintenance workers occasionally cutting grass between the warehouses. Based on the overgrowth of the grass and weeds observed in some of the areas, the site may not be under a regular maintenance program. However, if the site is to be re-used, routine maintenance is likely to occur.

Under foreseeable future conditions, potential receptors could include maintenance workers, similar to those identified under current land use. The site is not likely to be used for residential land use because of its physical attributes and historical use; also, site conditions indicate that some of the warehouses and the surrounding Depot property could be used for light industrial purposes that would provide economic benefits to the surrounding community. Therefore, current and future potentially exposed populations are likely to be industrial workers.

For conservative risk estimation purposes, future workers are assumed to contact soils around the warehouses routinely on a daily basis, during their entire ED (25 years).

A general description of activities to be performed by a maintenance worker within the Depot was provided in Section 7.0. On the basis of occupational duties, it is assumed that a maintenance worker spends half-a-day (4 hours) of an 8-hour workday, once per week (excluding vacation), 50 days per year for 25 years, cutting grass or weeds in the grass-covered areas around the warehouses. These are conservative assumptions considering the small size of the grass- and gravel-covered surface area available for exposure within FU5. Exposure of these workers is assumed to occur via incidental ingestion of soil (50 mg/day). The skin surface area accessible for dermal exposure is assumed to include face (1/2 of head area), hands, and forearms. About 4 hours of the 8-hour maintenance workday is assumed to be spent in contaminated parts of the grass- and gravel-covered areas of the FU, so half of the total incidentally ingested soil is assumed to come from the contaminated soil. Thus, the FI or ET term of the dose estimates is 0.5. The adherence factors used are estimated as documented in Appendix G. Most of the other exposure factors used are default assumptions from the *Exposure Factors Handbook* (EPA, 1997b). Site-specific factors used for

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EF and ED, as discussed above (e.g., ½ workday), are based on best professional judgment. Exposure factors and the rationale for their selection are included in tables in Appendix G.

As noted previously, future base redevelopment is expected to focus on light industrial and redistribution center types of warehouse uses, so site activities are expected to remain industrial. Therefore, future potentially exposed populations are expected to be the same as the current human receptors for the site. Additional landscaping may increase the area that requires landscape maintenance work. However, in the interest of conservatism in risk estimations, it was assumed that the site would be converted to an alternate industrial facility that requires workers to spend more time on the site, with a higher frequency of visits to the contaminated soil areas. The railroad tracks and surrounding materials are proposed to be removed as part of the redevelopment plan for FU5, thus eliminating some of the highest PAH contamination areas identified within FU5 (near Site 77). This represents the RME scenario for industrial land use. Routes of exposure are identical to those for a maintenance worker, which include incidental ingestion, dermal contact, and inhalation of dust from surface soils. Future industrial worker exposures were assumed to occur from the surface soil and from subsurface soil in the event that the Depot undergoes construction or excavation and subsurface soils become surface soils. Thus, a future industrial worker's long-term exposure to subsurface soil was evaluated. Exposure factors used were the default values for industrial workers from the *Exposure Factors Handbook* (EPA, 1997b) and other published sources, as referenced in Appendix G. Under these assumptions, this hypothetical receptor category would represent the maximum or most conservative degree of exposure that would be associated with this site.

Selected areas of the Depot and areas within FU5 will be landscaped for aesthetic purposes. Such land use alterations could expose landscaping workers to surface soil (zero to 2 ft bgs) via direct contact and inhalation of particulate emissions during future redevelopment activities. This potential future receptor would be expected to have a short ED (1 year or less). Because this scenario results in relatively lower exposure levels compared to those of a maintenance worker, this scenario was not included for quantitation (see Appendix F for relative exposure comparisons).

On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), future residential use of FU5 is highly unlikely. A hypothetical future residential receptor was evaluated in this RA for comparison purposes only. There are no residents within the Main Installation under current land use conditions. The southeastern portion of FU6 includes residential housing from the period when the Depot was in operation. However, this housing is not currently used. In the future, these residential units may be used by the City for alternatives such as shelters. Currently, the nearest residential areas in the vicinity of FU5 are to the south across Ball Road. The only potentially complete exposure pathway for off-site residents is the inhalation of particulate emissions (dust) from surface soil. Because the routine activities involving dust generation are limited and on-site dust is likely to attenuate with travel distance, off-site exposures through dust inhalation are lower than those of an assumed on-site resident. Thus, the inhalation pathway for a hypothetical future on-site resident is compared with potential off-site dust exposures in the risk characterization subsection below..

The area east of FU5 is occupied by a golf course (Parcel 3), which will remain a golf course and could be opened for public use. FU5 is separated from off-site areas by a barbed-wire fence and the road. Thus, casual trespassing onto the site is not a possible scenario.

Table 26-4 summarizes potential current and future exposure pathways for FU5 and identifies the pathways that were evaluated quantitatively in this RA. As discussed above, the receptors selected represent the higher exposures of all of the potentially exposed receptors in the area under current and future land use conditions. Thus, the selected receptors were conservatively protective of the all other relatively lower exposure populations. Appendix F compares each potential receptor to the selected representative exposure scenarios to ensure that selected exposure scenarios are protective against all potential current and future exposures. Under these assumed conditions for exposure under current and future land use, the receptor groups that were considered in deriving estimates of exposures and health risks for FU5 were as follows:

- Current on-site maintenance worker;
- Hypothetical future on-site commercial or industrial worker; and
- Hypothetical future on-site resident–adult and child (for comparison purposes only)

The EPCs were the estimated UCL 95% concentrations for surface and subsurface soils. EPCs for a maintenance worker and a future industrial worker are either the UCL 95% estimates or maximum detected concentrations for the COPCs detected in the surface soil. Some COPCs defaulted to the maximum detected concentrations even when sample size was above 10 (n=,>10) because of data distributions that do not fit normal or lognormal distribution curves, or where variance in the lognormal distribution was so great that the calculated UCL 95% exceeded the maximum detected value. Thus, most of the concentrations are conservative estimates of the potential EPCs. The EPCs for subsurface soil for the UCL 95% were estimated by combining samples collected from zero- to 10-ft depths (assuming future soil conditions if surface and subsurface soils are mixed during construction and excavation activities). A description of the UCL 95% calculation is provided in Appendix H.

The EPCs for the future residential scenario are the maximum PRE sampling location concentrations for all chemicals detected in that particular sample (e.g., SS77C). The estimated EPCs are listed in Tables 26-5 through 26-7. The dose (intake) was estimated for each of the complete exposure pathways (see Appendix I).

26.1.3 Toxicity Assessment for FU5

Table 26-8 presents the toxicity factors for COPCs and the WoE classifications for each. Detailed information regarding the basis for toxicity classification and the uncertainty associated with the listed toxicity factors based on the EPA toxicity database are listed in the master toxicity tables in Section 7.0, Tables 7-7 and 7-8.

Oral CSFs are available for dieldrin, individual PAHs, PCP, TCE, methylene chloride, and arsenic. An inhalation CSF is available for the same constituents, with the exception of carbazole and PCP, and the addition of cadmium and chromium. The individual CSFs for the PAHs were derived using the TEF compared to the BaP CSF. TEF values are provided in Table 7-9.

Oral RfD values are available for antimony, arsenic, cadmium, chromium, copper, manganese, dieldrin, 4-Methylphenol, PCP, methylene chloride, and TCE. Inhalation RfD values are available for chromium, manganese, mercury, and methylene chloride. Oral toxicity factors were adjusted by the gastrointestinal ABS_{GI} factors for comparisons with dermal intake estimates. These values are provided in Table 7-10. EPA *RAGS* guidance recommends a discussion of chemicals without toxicity factors. All of the COPCs identified had toxicity criteria.

26.1.4 Risk Characterization for FU5

The methodology used for the risk and HI calculations is described in Section 7.0, and risk and HI calculations are included in Appendix I. The carcinogenic risks and noncarcinogenic HI results from Appendix I are summarized in Table 26-9. A set of histograms of the risks and HIs is presented on Figures 26-3 and 26-4. FU5 was evaluated as one exposure unit. Workers and residents were assumed to have uniform exposures, and the EPCs were assumed to be present over the entire surface area of the FU. These are conservative assumptions, because most soil is covered by gravel, pavement, or warehouse buildings (see Figures 2-16 and 24-1), thus restricting direct contact with soil.

The ELCR from surface soil to a maintenance worker from FU5 is estimated at 4 x 10^{-6}, because of BaP. The carcinogenic risks are within the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}). The noncarcinogenic HI for the maintenance worker is estimated at 0.006, below the target value of 1.0. Both carcinogenic and noncarcinogenic risk estimates are within the acceptable limits. Thus, maintenance worker exposure to the site soils is not a health concern, given that the risks and HIs are within acceptable limits.

The estimated ELCR to an industrial worker from surface soil is 3 x 10^{-5}, and subsurface soil mixed with surface soil presents an ELCR of 1 x 10^{-5}, both of which are within the acceptable risk limit range of 10^{-6} to 10^{-4}. Cancer risks were due to arsenic, dieldrin, and PAHs (especially BaP) for both surface and subsurface soil estimates. The noncarcinogenic hazards from surface soil and from the soil column (surface and subsurface together) are 0.05 and 0.07, respectively, both of which are below 1.0. Thus, the FU5 soils do not pose a health threat to future industrial workers, despite the conservative exposure assumptions used.

The single point (SS77C) specific risk estimate for the residential receptor resulted in an ELCR of 4 x 10^{-4}. Cancer risks were above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4} because of arsenic and PAHs. Noncarcinogenic hazards were below the standard of 1.0 for both adult and child receptors (0.07 and 0.7, respectively). This worst-case scenario is included as a hypothetical conservative evaluation scenario, although the site is unlikely to be used for residential purposes. The dust inhalation pathway for an on-site hypothetical resident resulted in a risk estimate of 2.3 x 10^{-9} (see Appendix I, Table I16-4b), which is below 1 in a million. When extrapolating this value to an off-site resident who is likely to receive average concentrations of the attenuated dust, the risks are likely to be much lower. Thus, there are no health concerns for off-site residents from exposures to on-site contamination at FU5.

There are no present groundwater exposures for these receptors. None are likely in the foreseeable future because of the established water use patterns and the fact that users are provided with water from a public water supply system. The groundwater underneath FU5 has low levels of chlorinated solvents (PCE and TCE) resulting from plumes originating in the southeastern and southwestern portions of FU5. The centers of these three organic contamination plumes are not under FU5. Plume descriptions and migration potentials are described in Section 32.0 and 33.0, respectively. A risk evaluation for the groundwater contamination under FU5 is presented in Section 34.0.

The site-specific risk evaluations under current land use conditions do not present excess risks. Future potential use of FU5 for industrial purposes also does not pose a human health risk concern. A future residential scenario indicated unacceptable risks because of the presence of PAHs (Table 26-9). The risks are mainly from PAHs in the sample collected from the railroad track area. These PAHs are likely to be eliminated as part of the future redevelopment.

Because the industrial worker scenarios evaluated did not exceed the acceptable risk and HI criteria, RGOs were not developed for FU5.

26.1.4.1 Uncertainty Analysis

Section 7.0 and Table 7-11 introduce the general concepts and sources of uncertainty in RA at a given site. The following are some of the major points pertaining to FU5.

Constituents of Potential Concern. Data were collected from 1996 to 1998. Many of the COPCs, such as PAHs and metals, also were detected in background soils. Several of the PAHs were detected at higher concentrations along the railroad tracks and adjacent warehouses within FU5. Site operations at several of the sites did not involve PAHs as potential source constituents. Pesticides and the PCB Aroclor-1260 were not used in the storage-related operations, but were applied during routine maintenance of the storage facilities. Likewise, site-wide data statistical evaluations indicated that the contaminants were similarly distributed in the background samples. Some of the inorganic COPCs were selected based on their exceedances of the GWP criteria. These chemicals are not a direct exposure concern. However, their inclusion contributes to the conservatism of the risk estimation.

A certain level of uncertainty is expected in the sampling design across the FU, because biased sampling was performed in the areas with suspected site-related activities. Selected sampling locations are conservatively biased. Because parcels were divided based on historical nonhazardous waste-related use, only few samples were collected. However, contaminated areas were further investigated to evaluate the nature and extent of the contamination, thus reducing the uncertainty.

Subsurface soil organic COPCs are the same as surface soil COPCs, although most of the organic chemicals within FU5 were not detected in soils below a depth of 1 ft. In this RA, surface soils were defined as those from zero to 2 ft, whereas deeper soil was evaluated from zero to 10 ft. EPA Region IV typically defines a surface soil as being in the zero- to 1-ft range. The original work plan proposed using samples within a zero- to 2-ft interval as surface soil. However, most of the surface soil samples were collected at intervals ranging from zero to 0.5 ft or zero to 1 ft. Thus, there is little uncertainty associated with the surface soil sampling. Appendix P provides the data with the sample depths.

Exposure Assessment. There are no human receptors in FU5 under current conditions, except occasional maintenance workers cutting back overgrowth. Most of the area within

FU5 is paved or grass-covered. Some of the samples collected were from paved areas, which were assumed to be readily available for exposure. This site is highly unlikely to be used for residential purposes without significant structural changes to the existing warehouse buildings. The railroad tracks from around the warehouses are likely to be removed. Future land use considerations for the Depot include various small industrial uses; thus, land use is likely to remain industrial/commercial. Under future land use, also, indoor warehouse workers are rarely in contact with the grass strips around the warehouses. Much of the direct exposure is limited because of the presence of paved roads and walkways around the buildings. Utility and future industrial worker exposure to subsurface soil that could become surface soil through excavation activities is a conservative risk estimation scenario.

Most of the quantitative exposure values such as EF and ED are assumed values, and the true likely exposure of a receptor is not known. Most of the uncertainty within RAs is attributable to this exposure quantitation step.

Also, because of the presence of chlorinated solvents, exposure to groundwater under FU4 could occur if this aquifer were tapped for industrial or potable use. The City of Memphis requires permits to install wells in any aquifer, and the shallow aquifer probably will not be permitted for use, so such future use is unlikely.

Toxicity Assessment. The toxicity criteria used are those recommended by EPA through the toxicity databases; therefore, the uncertainty associated with this section is predetermined by the methods used and the studies selected by EPA in calculating these toxicity factors. EPA has classified the cancer potential of the carcinogenic chemicals into groups from A through E, where chemicals with direct evidence of human cancers are included in Group A, and those with no evidence are included in E. EPA has proposed changing this classification system.

The quantitative UFs associated with reference doses are included in the master toxicity factors tables (Tables 7-7 and 7-8). Some of the primary sources of uncertainty are listed here. Most of the toxicity factors are based on studies from animals extrapolated to humans using arbitrary assumptions (e.g. UF, or MF), which introduces a major uncertainty. In extrapolating from carcinogenic dose to estimate slope factor, no threshold for toxicity is assumed. Some of the metal toxicity factors are based on evidence of toxicity from occupational exposures (e.g., chromium) involving a high level of exposures to fumes and airborne particles. These data may have limited applicability in cases of much lower environmental exposures.

Significant uncertainty also is expected from using the PAH slope factors, which used experimental animal data for the carcinogenicity assessments. Other human carcinogenicity evidence is from exposures to occupational exposures. However, the presence of PAHs in the environmental media, being exposed to sunlight and other environmental weathering processes, could alter the bioavailability and the toxicity of these compounds.

Risk Characterization. As noted previously, the risks and hazards estimated in this assessment are conservative. Several scenarios were evaluated to simulate possible alternative future land uses for FU5. The fact that samples were collected from biased locations within suspected past activity and spill areas near warehouses adds to the conservatism of the estimates. Thus, the areas represented by each sample in the combined assessment at the FU5 level represent the areas of highest contamination within the site and FU.

Surrogate site and the worst-case sample-based exposure unit selection, EPC calculations, and risk evaluations to a hypothetical future resident and future industrial and utility workers are highly uncertain, and assumptions are conservative based on the sampling results, which indicated that contamination is not widespread in areas where the maximum concentrations were detected.

26.1.4.2 Remedial Goal Options

No quantitative RGOs were calculated for any of the surface media for industrial exposure at the site.

Exposure of a worker under current land use conditions did not result in excessive risks associated with the soils and other surface media. The estimations of industrial worker exposure also were within the acceptable risk limits. However, there were some risks at the acceptable boundaries for residential exposure, primarily from four of the PAH constituents. There are no human health protection-based ARARs for soils. Thus, no quantitative RGOs were included for FU5 because of the lack of unacceptable risks and HIs. The groundwater in the area is addressed as part of the groundwater FU (Section 34.0). The subsurface soil at one location within Site 78 indicates the presence of CVOCs at concentrations that could leach to groundwater. The site groundwater currently is not used within the Depot. Shallow groundwater does not qualify for potable use. The low-level chlorinated solvent plume under FU5 in the shallow aquifer and the potential source areas for the groundwater contamination in subsurface soil (see Figure 33-1b) are addressed as part of FU7 (see Sections 32.0 and 35.0).

26.2 Environmental Evaluation for FU5

26.2.1 Introduction

An ERA was conducted at FU5, the Newer Warehouses area in the south-central portion of the Main Installation, to evaluate whether contaminants detected in surface soil potentially pose adverse ecological effects to terrestrial receptors. FU5 is an entirely industrialized area containing a few mowed grass strips adjacent to the warehouses that provide little, if any, ecological habitat for plants or animals. This FU also is expected to remain an industrial area in the future. EPA ERA guidance (EPA, 1997d) recommends a screening level ERA for risk management decisions. Although mowed grass strips along the existing warehouses in FU5 do not provide a significant habitat, a screening level ERA was initiated to aid in risk management decisions.

This ERA was conducted in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (Process Document)*(EPA, 1997d). Steps 1, 2, and 3 of the EPA ERA model were completed, as summarized in Section 7.8.

26.2.2 Step 1: Screening Level Problem Formulation and Effects Evaluation

This is the initial step in the ERA and includes all of the elements of a problem formulation and ecological effects analysis, but on a screening level. The results of this step support the exposure estimates and risk calculation in Step 2.

26.2.2.1 Environmental Setting and Contaminants at the Site

The environmental setting at the Depot is described in Section 2.0. An ecological assessment checklist was completed as described in the *Process Document* (EPA, 1997d) and is provided in Appendix S. Site characteristics most relevant to the ERA are discussed here.

FU5 is an entirely industrial area located in the south-central portion of the Main Installation, and consists of about 10 large warehouses with interspersed roadways and railroad tracks. The limited groundcover consists predominantly of paved roadways and strips of infrequently mowed grass along the warehouses. The industrial land use of this FU is expected to remain unchanged into the foreseeable future.

Potential ecological habitat is limited to narrow maintained grassed areas along the edges of warehouses and roadways. There are a few small landscape trees or shrubs in the grassed areas, and there are no on-site aquatic habitats (e.g., ponds or ditches). Potentially occurring plants are limited to a low diversity of landscape grass and other weed species. Potentially occurring wildlife may include tolerant birds such as sparrows, rock doves, grackles, and mockingbirds, and small mammals such as mice, rats, and shrews. There are no wetlands, and no state or federally listed or proposed endangered or threatened species are known to inhabit the area of the site (TDEC, 1996; USFWS, 1996; and Appendix T). Overall, the limited ecological habitat is highly disturbed and of poor quality.

Land use in the immediate vicinity of the site consists of industrial areas associated with the Main Installation. A residential community is located to the south, beyond the fenced property boundary (Figure 2-15). Stormwater flow is directed primarily into a system of stormwater ditches that ultimately discharge at Outfall 4 and into Nonconnah Creek

Surface soil was the only medium sampled at FU5 to which terrestrial ecological receptors could be exposed and is, therefore, the only medium evaluated in this ERA. A list of surface soil COPCs at this FU is provided in Section 26.1.1.

26.2.2.2 Contaminant Fate and Transport

An overview of contaminant fate and transport of chemicals detected at FU5 is provided in Section 25.0 and is not repeated here.

26.2.2.3 Complete Exposure Pathways

For a pathway to be complete, a contaminant must travel from the source medium or media to an ecological receptor and be taken up by the receptor via one or more exposure routes. Although ecological habitats are minimal to non-existent at FU5, a conservative assumption was made that a potentially complete exposure pathway may exist for direct contact of terrestrial plants and invertebrates with contaminants detected in surface soil. There are no other potentially complete exposure pathways at this site.

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26.2.2.4 Assessment and Measurement Endpoints

Assessment endpoints are expressions of the environmental value(s) to be protected. The assessment endpoint for FU5 is to sustain soil quality and to achieve COPC concentrations that are below adverse effect thresholds for plants and soil invertebrates. Measurement endpoints are measurable ecological characteristics of the assessment endpoint. In this screening level evaluation, the measurement endpoint is the ratio of surface soil maximum concentrations to conservative screening level soil benchmarks. An exceedance of soil COPC concentrations compared to the benchmarks would be a "measure" of a potential effect. If an exceedance occurs, it can be inferred that a possible adverse effect may occur to exposed ecological receptors.

26.2.2.5 Screening Level Ecological Effects Evaluation

Conservative thresholds for adverse ecological effects, or screening ecotoxicity values, were used for contaminants detected in surface soil. These values were determined as follows:

- **Surface Soil:** the soil ecological screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from a variety of sources, including the USFWS, the ORNL, the Canadian Council of Ministers of the Environment, the Netherlands Ministry of Housing, and the RIVM.

The screening soil ecotoxicity values are provided in Table 7-14.

26.2.2.6 Uncertainty Assessment

Uncertainty is inherent in each step of the ERA. The following text presents major factors contributing to uncertainty in this assessment.

EPCs were assumed to be maximum soil concentrations. This is a highly conservative assumption that may overestimate risk. Under this assumption, the receptor spends 100 percent of its life cycle at the highest concentration area; although this can be true for plants, most terrestrial wildlife receptors are mobile and can be exposed to the complete range of soil concentrations.

The soil criteria used were obtained from various sources in the literature and may not be representative of actual site conditions. Exposure pathways to terrestrial plants and animals were assumed to be potentially complete, even though the maintained grass habitats do not provide suitable habitat in this industrial setting.

26.2.3 Step 2: Screening Level Exposure Estimate and Risk Calculation

This step includes estimating exposure levels and screening for ecological risks as the last two phases of the screening level ERA. At the end of Step 2, an SMDP will be made to evaluate whether ecological risks are negligible or whether further evaluation is warranted.

26.2.3.1 Screening Level Exposure Estimate

The maximum concentration of all chemicals detected in surface soil at FU5 was used as the EPC for estimating risk to directly exposed terrestrial organisms.

26.2.3.2 Screening Level Risk Characterization

The quantitative screening level risk estimate was conducted using the HQ approach. This approach divides the EPCs (maximum detected soil value) by the soil screening ecotoxicity values.

Table 26-10 summarizes the results of the surface soil screening level risk calculations. This table provides information regarding the FOD, range of detection, selected soil criteria, and HQs based on a comparison of the maximum concentration to the criteria. An HQ less than 1.0 indicates that the contaminant is unlikely to cause adverse effects and is therefore not considered further in the ERA. Contaminants with HQs greater than or equal to 1.0, or contaminants for which criteria were not available, were identified as COPCs and were carried forward to Step 3.

A total of 14 inorganic and 32 organic compounds were identified as COPCs in surface soil No screening criteria were available for 7 of the organic compounds.

26.2.3.3 Scientific Management Decision Point

The Step 2 screening information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted. The identified COPCs are to be carried forward to Step 3.

26.2.4 Step 3: Baseline Risk Assessment Problem Formulation

Step 3 refines the problem formulation developed in the screening level assessment. In this step, the results of the screening level assessment and additional site-specific information are used to assess the scope and goals of the baseline ERA.

26.2.4.1 Refinement of COPCs

In Steps 1 and 2, conservative assumptions were used. As a result, some of the COPCs were retained for Step 3, although they may pose only negligible risk. Therefore, in this first phase of Step 3, the assumptions used were further evaluated and other site-specific information was considered to refine the list of COPCs. In this refinement phase, the revised assumptions and site-specific considerations used were as follows:

- Arithmetic average contaminant concentrations were considered, along with maximum concentrations when a comparison to the benchmarks was conducted;
- Arithmetic average and maximum values were compared to background concentrations;
- Contaminant concentrations were compared to background values;
- The FOD was considered; and
- Less conservative (secondary) soil screening values were considered in addition to the more conservative (primary) screening values used in Step 2.

The secondary benchmarks described above were identified to provide a less conservative benchmark for comparison with site contaminant exposure concentrations. The secondary benchmark selection process focused on identifying the next highest benchmark value among the soil literature references used by EPA Region IV. This was a stepwise process in which the first set of toxicological benchmarks considered was from two ORNL studies (Efroymson et al., 1997). These studies established separate screening benchmarks for soil microorganisms, earthworms, and plants. A secondary screening value was chosen from these three data sets that was the next highest value above the primary EPA Region IV screening value. If no values were available, the selection process proceeded to the Netherlands values (MHSPE, 1994). In addition, if the selected value from ORNL was found to be greater than the highest Netherlands value, then the ORNL value was rejected and the process moved forward to the Netherlands values as a conservative measure.

The Netherlands values included optimum values and action values. When this set of data was considered, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark. If a value was not available, the process proceeded to a final set of data as compiled by the USFWS (Beyer, 1990). The values in this data set represent Dutch background, moderate contamination, and cleanup values. As stated above, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark.

In addition, the conservative ecological exposure pathways used in Step 2 were reevaluated based on actual site conditions. All this information provides WoE to evaluate which, if any, contaminants should be recommended for further evaluation in a baseline ERA.

The results of the Step 2 refinement of the COPCs list are summarized in Table 26-11. This table presents the maximum and average EPCs, background concentrations, primary and secondary surface soil screening criteria, range of HQs and background comparisons, and FOD.

The WoE is presented in Table 26-11 for one inorganic and many organic COPCs. These included selenium, dieldrin, and several PAHs. These are contaminants for which all HQs were at or above 1.0and that also were above background in all comparisons. Many of the contaminants could be removed from further consideration as a result of some HQs being near or less than 1.0, being less than background, or having an FOD at 5 percent or below. Surface soil criteria for a total of 6 contaminants were not available for comparison, so HQs could not be determined; however, 3 of these contaminants were compared to available background concentrations.

The key consideration in this refinement step is the lack of ecological exposure pathways at FU5. As previously discussed, the screening process in Steps 1 and 2 was conducted as a conservative measure, given that EPA guidance recommends minimal or no risk management considerations in a screening level ERA. FU5 is entirely an industrial area, and this land use is expected to continue into the future. The on-site habitat is limited to small, mowed grassy strips adjacent to warehouses and roadways. There are no on-site or near-site natural habitats that could support significant populations of terrestrial wildlife. The effects are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

26.2.4.2 Scientific Management Decision Point

Although several COPCs were identified in the refinement phase of Step 3 as potentially causing adverse ecological effects, the lack of complete ecological exposure pathways at

FU5 indicates that current and future ecological impacts are negligible. Therefore, no further assessment of ecological risk to contaminants at FU5 is warranted.

26.3 Human Health Evaluation for Screening Site 77

Screening Site 77 was selected as the surrogate site for FU5 because it resulted in the highest human health risk ratio during the PRE (Appendix E). This site had the highest calculated PRE risk and HI ratios, primarily because of the presence of PAHs in surface soils at this site.

Site 77, located in Parcel 22, is situated at the end of the L Street and is about 2/3 of an acre. Part of Site 77 was formerly used as a battery recharge area. Residues from overfilled batteries were historically washed out the adjacent door to the ground behind Building 685. On the basis of this historical use, the most likely constituents expected to be present at this site are metals, lead in particular. However, a TCL/TAL analysis was performed on the surface and subsurface soil samples collected from this site (CH2M HILL, 1998c).

26.3.1.1 Selection of COPCs for Screening Site 77

Nine surface soil (zero to 1 ft deep) samples were included for the analysis of metals and SVOCs, and six samples were analyzed for pesticides and VOCs at Site 77. The maximum detected chemical concentration within this data group was compared against background concentrations and the RBCs for direct exposure, as well as against the GWP concentrations (SSLs). There were a total of 13 samples of subsurface soil (greater than 1 to 10 ft) included for the RA.

The COPC selection indicated that surface soils at the site had antimony, arsenic, copper, dieldrin, PCP, and PAHs that exceeded the background levels and comparison criteria (Table 26-12). The PRE indicated PAHs as the primary risk drivers in surface soil (Appendix E). In the deep soil samples group for utility worker exposure evaluations, soils from zero to 10 ft are included. The subsurface soils (greater than 1 ft to water) (Table 26-13) had arsenic and copper that were selected as COPCs. However, the chemicals selected as COPCs for subsurface soil include all compounds that were selected as COPCs for surface soil. This approach ensures conservatism in the risk estimations for the site.

26.3.1.2 Exposure Assessment for Screening Site 77

Figure 24-1 depicts the site and its relative location within FU5. Site 77 is located between warehouse Buildings 689 and 690, at the end of L Street. The site was used as the recharge area for the used batteries. The site is located at an open gravel covered area on northern and southern sides of the street between the buildings, and is about 2/3 of an acre. A railroad track runs along the northern edge of the site along the southern edge of warehouse Building 689. Future redevelopment actions may remove these railroad tracks and maintain the warehouses as storage and distribution centers. Figure 26-5 presents the exposure CSM for Site 77.

26.3.1.3 Potentially Exposed Human Population and Identification of Potentially Complete Exposure Pathways

The Depot (including the Site 77 area) has been inactive since its closure. There are no potentially exposed populations under current conditions specific to this site, except for McAuley's Potpourri in Buildings 685, 689, and 690. Maintenance workers for the Depot involved in weed control in the gravel area and other maintenance-related activities could be present for limited periods of time. Maintenance worker exposure at Site 77 was not quantitatively evaluated because of the small area of the site. A maintenance worker exposure scenario was quantified for FU5, including Site 77 data. Other potential receptors evaluated qualitatively for surface soil exposure at this site were landscapers.

Potentially exposed populations under future land use are unknown at this time. On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), it is likely that Site 77 will be used in the future for light industrial or commercial operations. Under such a scenario, likely future receptors are also site workers. Future residential use of this site is highly unlikely, because of the site's central location within an industrial facility. Hypothetical future residential exposures were evaluated for the worst-case scenario for FU5; a separate evaluation for Site 77, therefore, was not required. Also, the highest detected concentration point selected for the residential scenario evaluation is located within Site 77. A detailed list of exposure factors and the rationale for their selection are included in tables in Appendix G.

Subsurface soils were evaluated for direct exposure of a future utility worker and an industrial worker. These scenarios were based on the assumption that, in the future, if the contaminated subsurface soil (zero to 10 ft bgs) is disturbed (e.g., for installation or maintenance of underground utilities), exposure could become a complete pathway Exposures were assumed to occur to a utility worker, and an industrial worker through incidental ingestion, inhalation, and dermal contact. A summary of exposure pathways for Site 77 is included in Table 26-14.

A UCL 95% concentration was estimated for the EPC for surface soil (zero to 1 ft) and subsurface (zero to 10 ft) data for the COPCs identified. The EPC defaulted to the maximum detected concentrations for both the organic and inorganic COPCs in surface and subsurface soils, possibly because of the high level of the maximum detected concentration and the relatively small sample size. These values are listed in Tables 26-15 and 26-16, and the estimation methodology is described in Appendix H. The dose (intake) was estimated for each of the complete exposure pathways. The dose estimates are included in Appendix I.

Toxicity Assessment for Screening Site 77. The COPCs for Site 77 are a subset of those previously listed in the FU5 RA section (Section 26.1.1). Table 26-8 includes the carcinogenic and noncarcinogenic toxicity factors, and the WoE classification for the carcinogens for the COPCs identified at Site 77.

Risk Characterization for Screening Site 77. The carcinogenic risks and noncarcinogenic HIs are summarized in Table 26-17. A set of histograms of risks and HIs for the industrial land use is included on Figures 26-6 and 26-7. The ELCRs and HIs were estimated for a future industrial worker and utility worker. The carcinogenic risks for industrial worker exposures to the Site 77 surface soil resulted in estimated risks of 7 x 10^{-5} and a noncarcinogenic HI of 0.05. The majority of the carcinogenic risks are from arsenic and PAHs. Deeper soil risks and hazards are identical to or less than those for surface soil, because these include surface soils and represent carcinogenic COPCs in shallow soils. Risk drivers also were identical. Because deep soils include surface and subsurface soils, the risks are not additive. Thus, total risks are the higher of the two sets of risks estimated for the industrial worker. This worker scenario conservatively assumes a full workday exposure, 250 days per year, for an exposure period of 25 years. The resulting risks are at the upper limit for cancer risks of 1 to 100 in one million and below the accepted HI of 1.0. Thus, the overall Site 77 soils do not pose a health threat to future industrial workers.

Exposures of a utility worker assume that surface and subsurface soil are mixed during excavation. Exposure to the utility worker resulted in an ELCR of 1×10^{-5} and a noncarcinogenic HI of 0.005, because of BaP. Both carcinogenic and noncarcinogenic health risks are within the acceptable limits of 10^{-6} to 10^{-4} and 1.0, respectively. Thus, excavation-types of activities do not pose a health threat to these site workers.

Uncertainties associated with this RA are similar to those listed in the FU5 RA section (Section 26.1.4). RGOs were not calculated for the industrial worker at Site 77 because risks were not exceeded above the acceptable limits for the carcinogens or noncarcinogens.

TABLE 26-1

Constituents of Potential Concern in FU5 - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
5	SS	MG/KG	4-METHYLPHENOL (p-CRESOL)	21	1	0 37	38	0 056	0 056	0 056		39	0 02	Yes	A
5	SS	MG/KG	ANTIMONY	17	3	0 19	7 3	0 87	7 4	3 2	7	3 1	5	Yes	A
5	SS	MG/KG	ARSENIC	21	21	0 16	2 6	5 05	29	13	20	0 43	29	Yes	A
5	SS	MG/KG	BENZO(a)ANTHRACENE	31	17	0 11	38	0 07	26	3 9	0 71	0 87	2	Yes	A
5	SS	MG/KG	BENZO(a)PYRENE	31	16	0 11	38	0 064	26	4 0	0 96	0 087	8	Yes	A
5	SS	MG/KG	BENZO(b)FLUORANTHENE	31	16	0 11	38	0 08	26	4 0	0 9	0 87	5	Yes	A
5	SS	MG/KG	BENZO(k)FLUORANTHENE	31	16	0 11	38	0 077	20	3 6	0 78	8 7	49	Yes	A
5	SS	MG/KG	CARBAZOLE	21	6	0 37	38	0 12	4	1 6	0 067	32	0 6	Yes	A
5	SS	MG/KG	CHRYSENE	31	17	0 11	38	0 081	30	4 4	0 94	87	160	Yes	G
5	SS	MG/KG	DIBENZ(a,h)ANTHRACENE	31	2	0 11	38	1 1	4	2 6	0 26	0 087	2	Yes	A
5	SS	MG/KG	DIELDRIN	24	15	0 0037	1 9	0 0041	1 1	0 21	0 086	0 04	0 004	Yes	A
5	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	31	14	0 11	38	0 059	17	3 2	0 7	0 87	14	Yes	A
5	SS	MG/KG	PENTACHLOROPHENOL	21	2	0 19	19	0 04	0 32	0 18		5 3	0 03	Yes	A

Note Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgement was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgement was used in eliminating it as a COPC
G	Chemical is a member of a chemical class which contains other COPCs

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TABLE 26-2

Constituents of Potential Concern in FU5 - Subsurface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
5	SB	MG/KG	CADMIUM	27	2	0 011	1 3	0 11	77	39	1 4	8	Yes	A
5	SB	MG/KG	CHROMIUM, TOTAL	27	27	0 13	2 6	9 6	48	28	26	38	Yes	A
5	SB	MG/KG	COPPER	27	27	0 13	2 6	3 3	38	22	33		Yes	D
5	SB	MG/KG	LEAD	27	27	0 16	0 77	4 8	54	17	24		Yes	D
5	SB	MG/KG	MANGANESE	7	7	0 013	0 066	17	2260	545	1540		Yes	D
5	SB	MG/KG	TOTAL 1,2-DICHLOROETHENE	32	1	0 011	0 81	0 002	0 002	0 002			Yes	D
5	SB	MG/KG	TRICHLOROETHYLENE (TCE)	32	3	0 011	0 81	0 085	11	3 8		0 06	Yes	A
5	SB	MG/KG	ANTIMONY	27	1	0 21	7 7	0 89	0 89	0 89		5	Yes	H
5	SB	MG/KG	ARSENIC	27	27	0 18	2 6	2 8	23	12	17	29	Yes	H
5	SB	MG/KG	BENZO(a)ANTHRACENE	32	5	0 37	0 43	0 054	0 43	0 18		2	Yes	H
5	SB	MG/KG	BENZO(a)PYRENE	32	5	0 37	0 43	0 057	0 31	0 15		8	Yes	H
5	SB	MG/KG	BENZO(b)FLUORANTHENE	32	5	0 37	0 43	0 05	0 41	0 18		5	Yes	H
5	SB	MG/KG	BENZO(k)FLUORANTHENE	32	5	0 37	0 43	0 047	0 38	0 17		49	Yes	H
5	SB	MG/KG	CARBAZOLE	32	1	0 37	0 43	0 048	0 048	0 048		0 6	Yes	H
5	SB	MG/KG	CHRYSENE	32	6	0 37	0 43	0 04	0 67	0 23		160	Yes	H
5	SB	MG/KG	DIELDRIN	13	1	0 0037	0 0043	0 0057	0 0057	0 0057	0 37	0 004	Yes	H
5	SB	MG/KG	INDENO(1,2,3-c,d)PYRENE	32	4	0 37	0 43	0 082	0 24	0 14		14	Yes	H

Note Data evaluated include field duplicates and normal samples (2 feet and below)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgement was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

TABLE 26-3

Constituents of Potential Concern in Residential Point Estimate at Station SS77C - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Analytical Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
5	SS	MG/KG	BENZO(a)ANTHRACENE	6 0	0 71	0 87	2	Yes	A
5	SS	MG/KG	BENZO(a)PYRENE	6 1	0 96	0 087	8	Yes	A
5	SS	MG/KG	BENZO(b)FLUORANTHENE	6 1	0 9	0 87	5	Yes	A
5	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	4 6	0 7	0 87	14	Yes	A

Note: Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC.
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC.
G	Chemical is a member of a chemical class that contains other COPCs

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TABLE 26-4

Summary of Exposure Pathways to be Quantified at FU5

Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil.
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0 to 10 feet below ground surface)	No	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil This is evaluated as part of the surrogate site exposure unit
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be short exposure duration (less than one year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Evaluated for comparison purposes only.

TABLE 26-5

Exposure Point Concentrations for FU5 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	16	3	2.2	7.4	3.1	6.3	6.3
MG/KG	ARSENIC	20	20	12	29	14	15	15
MG/KG	DIELDRIN	23	15	0.27	1.1	0.48	1.9	1.1
MG/KG	BENZO(a)ANTHRACENE	30	17	3	26	4.9	9	9
MG/KG	BENZO(a)PYRENE	30	16	2.9	26	4.8	8.4	8.4
MG/KG	BENZO(b)FLUORANTHENE	30	16	2.9	26	4.8	8.1	8.1
MG/KG	BENZO(k)FLUORANTHENE	30	16	2.7	20	4.4	7.8	7.8
MG/KG	CARBAZOLE	20	6	0.71	4	1.2	1.1	1.1
MG/KG	CHRYSENE	30	17	3.3	30	5.4	10	10
MG/KG	DIBENZ(a,h)ANTHRACENE	30	2	0.88	4	1.4	1.3	1.3
MG/KG	INDENO(1,2,3-c,d)PYRENE	30	14	2.4	17	3.8	6.5	6.5
MG/KG	4-METHYLPHENOL (p-CRESOL)	20	1	0.77	0.056	1.4	1.1	0.056
MG/KG	PENTACHLOROPHENOL	20	2	0.4	0.32	0.74	0.59	0.32

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

TABLE 26-6

Exposure Point Concentrations for FU5 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	36	4	2.6	7.4	3	4.3	4.3
MG/KG	ARSENIC	40	40	13	29	14	15	14
MG/KG	CADMIUM	40	13	2.5	77	5.8	2.6	2.6
MG/KG	CHROMIUM, TOTAL	40	40	22	48	25	26	25
MG/KG	COPPER	40	40	23	52	25	26	26
MG/KG	MANGANESE	14	14	546	2260	799	1147	1147
MG/KG	DIELDRIN	32	16	0.19	1.1	0.35	1.1	1.1
MG/KG	BENZO(a)ANTHRACENE	51	22	1.8	26	3	2.1	2.1
MG/KG	BENZO(a)PYRENE	51	21	1.8	26	2.9	2	2
MG/KG	BENZO(b)FLUORANTHENE	51	21	1.8	26	2.9	2	2
MG/KG	BENZO(k)FLUORANTHENE	51	21	1.7	20	2.7	1.9	1.9
MG/KG	CARBAZOLE	41	7	0.45	4	0.68	0.46	0.46
MG/KG	CHRYSENE	51	23	2	30	3	2	2
MG/KG	DIBENZ(a,h)ANTHRACENE	51	2	0.6	4	0.90	0.61	0.61
MG/KG	INDENO(1,2,3-c,d)PYRENE	51	18	1.5	17	2.4	1.6	1.6
MG/KG	4-METHYLPHENOL (p-CRESOL)	41	1	0.48	0.056	0.8	0.44	0.056
MG/KG	PENTACHLOROPHENOL	41	2	0.25	0.32	0.41	0.23	0.23
MG/KG	TOTAL 1,2-DICHLOROETHENE	41	1	0.006	0.002	0.0064	0.0064	0.002
MG/KG	TRICHLOROETHYLENE (TCE)	41	2	0.017	0.4	0.034	0.012	0.012

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

TABLE 26-7

Exposure Point Concentrations for FU5, Station SS77C - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Parameter	EPC (mg/kg)
BENZO(a)ANTHRACENE	26
BENZO(a)PYRENE	26
BENZO(b)FLUORANTHENE	26
INDENO(1,2,3-c,d)PYRENE	17

Notes

Data evaluated include normal samples only

Field duplicates have been dropped from risk evaluation

EPC values represent the maximum PRE sample within Functional Unit 5 at location SS77C

TABLE 26-8
Toxicity Factors for FU5
Memphis Depot Main Installation RI

Name	Weight-of-Evidence Class	ABS_{GI}	Oral SF kg-day/mg	Dermal SF kg day/mg	Inhal SF kg-day/mg	C Oral RfD mg/kg-day	Dermal RfD mg/kg-day	C Inhal RfD mg/kg-day
Antimony	D	2%				4.00E-04	8.00E-06	
Arsenic	A	41%	1.50E+00	3.66E+00	1.51E+01	3.00E-04	1.23E-04	
Benzo(a)anthracene	B2	31%	7.30E-01	2.35E+00	3.10E-01			
Benzo(a)pyrene	B2	31%	7.30E+00	2.35E+01	3.10E+00			
Benzo(b)fluoranthene	B2	31%	7.30E-01	2.35E+00	3.10E-01			
Benzo(k)fluoranthene	B2	31%	7.30E-02	2.35E-01	3.10E-02			
Cadmium	B1	1%			6.30E+00	1.00E-03	1.00E-05	
Carbazole	B2	70%	2.00E-02	2.86E-02				
Chromium (total)	A	2%			4.20E+01	3.00E-03	6.00E-05	2.86E-05
Chrysene	B2	31%	7.30E-03	2.35E-02	3.10E-03			
Copper	D	30%				3.70E-02	1.11E-02	
Dibenz(a,h)anthracene	B2	31%	7.30E+00	2.35E+01	3.10E+00			
Dieldrin	B2	50%	1.60E+01	3.20E+01	1.60E+01	5.00E-05	2.50E-05	
Indeno(1,2,3-c,d)pyrene	B2	31%	7.30E-01	2.35E+00	3.10E-01			
Manganese	D	4%				1.40E-01	5.60E-03	1.43E-05
4-Methylphenol (p-cresol)	C	65%				5.00E-03	3.25E-03	
Pentachlorophenol	B2	100%	1.20E-01	1.20E-01		3.00E-02	3.00E-02	
1,2-Dichloroethene (total)		100%						
Trichloroethylene (TCE)	B2	15%	1.10E-02	7.33E-02	6.00E-03	6.00E-03	9.00E-04	

Note Master list of toxicity factors, with sources and basis is provided in Section 7

TABLE 26-9
Carcinogenic Risks and Noncarcinogenic Hazards of FU5
Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	*Chemicals of Concern*
Industrial Worker					
	Surface Soil (0-2ft)		3E-05	0.05	*Arsenic, Dieldrin, PAHs*
	Soil Column (0-10ft)[1]		1E-05	0.07	*Arsenic, Dieldrin, BaP*
		Total[2]	***3E-05***	***0.05***	***Arsenic, Dieldrin, PAHs***
Maintenance Worker					
	Surface Soil (0-2ft)[3]		4E-06	0.006	*Benzo(a)pyrene*
		Total	***4E-06***	***0.006***	***Benzo(a)pyrene***
Residential Adult (age-adjusted)					
	Soil point exposure at SS77C		4E-04	N/A	*PAHs*
		Total	***4E-04***	***N/A***	***PAHs***
Residential Child[3]					
	Soil point exposure at SS77C		3E-04	N/A	*PAHs*
		Total	***3E-04***	***N/A***	***PAHs***

Notes

Residential receptors have been included for comparison purposes only

[1] *Soil Column includes surface and subsurface soil, therefore cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media.*

N/A = no toxicity factors available for these COPCs

BaP = Benzo(a)pyrene

PAHs = Polynuclear aromatic hydrocarbons

TABLE 26-10

Step 2 Surface Soil Screening Level Risk Calculations for FU5

Ecological Risk Assessment

Memphis Depot Main Installation RI

Parameter	Frequency of Detection: Number Analyzed	Frequency of Detection: Number Detected	Range of Detected Values: Minimum (mg/kg)	Qual.	Range of Detected Values: Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	9	9	1950	J	12200	=	50	**244**	Y
ANTIMONY	17	3	0.87	J	7.4	=	3.5	**2.1**	Y
ARSENIC	21	21	5.05	=	29	=	10	**2.9**	Y
BARIUM	9	9	22	J	122	=	165	0.7	N
BERYLLIUM	21	13	0.18	J	0.56	J	1.1	0.5	N
CADMIUM	21	11	0.02	J	6	=	1.6	**3.8**	Y
CHROMIUM, TOTAL	21	21	6.15	=	37	=	0.4	**93**	Y
COBALT	9	9	3.3	J	12.4	=	20	0.6	N
COPPER	21	21	9.55	J	51.6	=	40	**1.3**	Y
IRON	9	9	6430	J	19800	=	200	**99**	Y
LEAD	21	21	8.7	=	109	J	50	**2.2**	Y
MANGANESE	9	9	43.7	J	713	=	100	**7.1**	Y
MERCURY	21	7	0.01	J	0.14	=	0.1	**1.4**	Y
ZINC	21	21	4.1	J	51.1	=	30	**1.7**	Y
SELENIUM	21	3	0.760	=	1.40	=	0.81	**1.7**	Y
SILVER	21	1	0.6	J	0.6	J	2	0.3	N
VANADIUM	9	9	7.2	J	28.1	=	2	**14**	Y
ZINC	21	21	28.8	J	136	=	50	**2.7**	Y
Organics									
2-HEXANONE	21	3	0.002	J	0.003	J		**NA**	Y
2-METHYLNAPHTHALENE	31	1	0.12	J	0.12	J	0.1	**1.2**	Y
4-METHYLPHENOL (p-CRESOL)	21	1	0.056	J	0.056	J	0.05	**1.1**	Y
ACENAPHTHENE	31	7	0.086	J	4.1	J	20	0.2	N
ACETONE	21	4	0.004	J	0.005	J		**NA**	Y
ALPHA-CHLORDANE	24	6	0.00068	J	0.14	J	0.1	**1.4**	Y
ANTHRACENE	31	8	0.14	J	7	J	0.1	**67**	Y
BENZENE	21	1	0.002	J	0.002	J	0.05	0.0	N
BENZO(a)ANTHRACENE	31	17	0.07	J	26	=	0.1	**260**	Y
BENZO(a)PYRENE	31	16	0.064	J	26	=	0.1	**260**	Y
BENZO(b)FLUORANTHENE	31	16	0.08	J	26	=	0.1	**260**	Y
BENZO(g,h,i)PERYLENE	31	14	0.062	J	18	=	0.1	**180**	Y
BENZO(k)FLUORANTHENE	31	16	0.077	J	20	=	0.1	**200**	Y
bis(2-ETHYLHEXYL) PHTHALATE	21	4	0.1	J	250	=	0.1	**2500**	Y
BROMOMETHANE	21	1	0.002	J	0.002	J		**NA**	Y

TABLE 26-10

Step 2 Surface Soil Screening Level Risk Calculations for FU5

Ecological Risk Assessment

Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
CARBAZOLE	21	6	0 12	J	4	J		NA	Y
CARBON DISULFIDE	21	1	0 037	=	0 037	=		NA	Y
CHRYSENE	31	17	0 081	J	30	=	0 1	300	Y
DDD	24	2	0 013	J	0 022	J	0 0025	8.8	Y
DDE	24	14	0 0038	J	0 077	=	0 0025	31	Y
DDT	24	15	0 0022	J	0 26	=	0 0025	104	Y
DIBENZ(a,h)ANTHRACENE	31	2	1 1	J	4	J	0 1	40	Y
DIBENZOFURAN	21	3	0 11	J	1 2	J	0 1	12	Y
DIELDRIN	24	15	0 0041	=	1 1	=	0 0005	2200	Y
ETHYLBENZENE	21	1	0 002	J	0 002	J	0 05	0 0	N
FLUORANTHENE	31	21	0 047	J	67	=	0 1	670	Y
FLUORENE	31	7	0 061	J	2 6	J	0 1	26	Y
GAMMA-CHLORDANE	24	6	0 00069	J	0 15	J	0 1	1.5	Y
INDENO(1,2,3-c,d)PYRENE	31	14	0 059	J	17	=	0 1	170	Y
METHYL ETHYL KETONE (2-BUTANONE)	21	5	0 016	=	0 076	=		NA	Y
METHYLENE CHLORIDE	21	5	0 002	J	0 006	J	0 1	0 1	N
NAPHTHALENE	31	2	0 19	J	1 4	J	0 1	14	Y
PENTACHLOROPHENOL	21	2	0 040	J	0 32	=	0 002	160	Y
PHENANTHRENE	31	19	0 055	J	36	=	0 1	360	Y
PYRENE	31	22	0 040	J	56	=	0 1	560	Y
TOLUENE	21	2	0 001	J	0 007	J	0 05	0 1	N
Total Xylenes	21	1	0 009	J	0 009	J		NA	Y

Note Ca, Mg, K, Na were detected, however these parameters were not evaluated since they are commonly occurring elements

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TABLE 26-11
Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU5
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max Compared to Primary	Avg Compared to Primary	Max. Compared to Secondary	Avg. Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics														
ALUMINUM	12200	8908	23810	50	2	600	3	244	178	20	15	N	N	100
ANTIMONY	7.4	3.2	7	3.5	6	5	2	2	0.9	1.5	0.6	Y	N	18
ARSENIC	29	12.7	20	10	2	29	4	3	1.3	1.0	0.4	Y	N	100
CADMIUM	6	1.1	1.4	1.6	6	4	2	4	0.7	2	0.3	Y	N	52
CHROMIUM, TOTAL	37	18.4	24.8	0.4	1	1	2	93	46	37	18	Y	N	100
COPPER	51.6	22.4	33.5	40	9	50	2,6	1.3	0.6	1.0	0.4	Y	N	100
IRON	19800	15526	37040	200	3			99	78			N	N	100
LEAD	109	28	30	50	2.5	500	1	2	0.6	0.2	0.1	Y	N	100
MANGANESE	713	489	1304	100	3	500	2	7	5	1.4	1.0	N	N	100
MERCURY	0.14	0.07	0.4	0.1	1	0.3	2,4	1.4	0.7	0.5	0.2	N	N	33
NICKEL	51.1	19.6	30	30	2	90	3	2	0.7	0.6	0.2	Y	N	100
SELENIUM	1.4	1.2	0.8	0.81	6	1	2	2	1.4	1.4	1.2	Y	Y	14
VANADIUM	28.1	21.5	48.4	2	2	20	3	14	11	1.4	1.1	N	N	100
ZINC	136	69	126	50	2	100	3	3	1.4	1.4	0.7	Y	N	100
Organics														
2-HEXANONE	0.0030	0.0027										NA	NA	14
2-METHYLNAPHTHALENE	0.12	0.12		0.1	5	5	7	1.2	1.2	0.0	0.0	NA	NA	3
4-METHYLPHENOL (p-CRESOL)	0.056	0.056		0.05	4	40	5	1.1	1.1	0.0	0.0	NA	NA	5
ACETONE	0.005	0.004										NA	NA	19
ALPHA-CHLORDANE	0.14	0.034	0.029	0.1	5	0.5	7	1.4	0.3	0.3	0.1	Y	Y	25
ANTHRACENE	6.7	1.859	0.096	0.1	5	10	7	67	19	0.7	0.2	Y	Y	26
BENZO(a)ANTHRACENE	26	3.86	0.71	0.1	5	1	7	260	39	26	4	Y	Y	55
BENZO(a)PYRENE	26	3.96	0.96	0.1	5	1	7	260	40	26	4	Y	Y	52
BENZO(b)FLUORANTHENE	26	4.0	0.9	0.1	5	1	7	260	40	26	4	Y	Y	52
BENZO(g,h,i)PERYLENE	18	3.16	0.82	0.1	5	1	7	180	32	18	3	Y	Y	45
BENZO(k)FLUORANTHENE	20	3.61	0.78	0.1	5	1	7	200	36	20	4	Y	Y	52
bis(2-ETHYLHEXYL) PHTHALATE	250	63		0.1	4	100	4	2500	626	3	0.6	NA	NA	19
BROMOMETHANE	0.002	0.002										NA	NA	5
CARBAZOLE	4	1.6	0.067									Y	Y	29
CARBON DISULFIDE	0.037	0.037	0.002									Y	Y	5
CHRYSENE	30	4.4	0.94	0.1	5	1	7	300	44	30	4	Y	Y	55
DDD	0.022	0.0175	0.0067	0.0025	4	4	5	9	7	0.0	0.0	Y	Y	8
DDE	0.077	0.031	0.16	0.0025	4	4	5	31	13	0.0	0.0	N	N	58
DDT	0.26	0.073	0.074	0.0025	4	4	5	104	29	0.1	0.0	Y	N	63
DIBENZ(a,h)ANTHRACENE	4	2.6	0.26	0.1	5	1	7	40	26	4	3	Y	Y	6
DIBENZOFURAN	1.2	0.54	0.647	0.1	5	1	7	12	5	1.2	0.5	Y	N	14

TABLE 26-11
Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU5
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max. Compared to Primary	Avg. Compared to Primary	Max. Compared to Secondary	Avg. Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
DIELDRIN	1 1	0 21	0 086	0 0005	4			2200	427			Y	Y	63
FLUORANTHENE	67	7 9	1 6	0 1	5	10	7	670	79	7	0 8	Y	Y	68
FLUORENE	2 6	0 9		0 1	5	1	7	26	9	3	0 9	NA	NA	23
GAMMA-CHLORDANE	0 15	0 04	0 026	0 1	5	0 5	7	2	0 4	0 3	0 1	Y	Y	25
INDENO(1,2,3-c,d)PYRENE	17	3 2	0 7	0 1	5	1	7	170	32	17	3	Y	Y	45
METHYL ETHYL KETONE (2-BUTANONE)	0 076	0 036	0 002									Y	Y	24
NAPHTHALENE	1 4	0 80		0 1	5	5	7	14	8	0 3	0 2	NA	NA	6
PENTACHLOROPHENOL	0 32	0 18		0 002	4	3	2	160	90	0 1	0 1	NA	NA	10
PHENANTHRENE	36	5 04	0 61	0 1	5	5	7	360	50	7	1 0	Y	Y	61
PYRENE	56	6 2	1 5	0 1	5	10	7	560	62	6	0 6	Y	Y	71
Total Xylenes	0 009	0 009	0 009	0 05	4,5	25	5	0 2	0 2	0 0	0 0	N	N	5

Notes
1 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for earthworms
2 Efroymson, R A et al 1997b Oak Ridge National Laboratory, toxicological banchmarks for plants
3 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for microorganisms
4 Ministry of Housing, Spatial Planning and Environment, 1994 optimum soil quality standards
5 Beyer, W N 1990 U S Fish and Wildlife Service Dutch background
6 Crommenttuijn, T et al , 1997 RIVM Report No 601501002

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TABLE 26-12

Constituents of Potential Concern in Screening Site 77 - Surface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
5	77	SS	MG/KG	ANTIMONY	10	2	0.19	7.3	1.3	7.4	4.4	7	3.1	5	Yes	A
5	77	SS	MG/KG	ARSENIC	10	10	0.16	2.6	5.1	23	12	20	0.43	29	Yes	A
5	77	SS	MG/KG	BENZO(a)ANTHRACENE	10	5	0.39	38	0.086	26	6	0.71	0.87	2	Yes	A
5	77	SS	MG/KG	BENZO(a)PYRENE	10	5	0.39	38	0.11	26	6.1	0.96	0.087	8	Yes	A
5	77	SS	MG/KG	BENZO(b)FLUORANTHENE	10	5	0.39	38	0.13	26	6.1	0.9	0.87	5	Yes	A
5	77	SS	MG/KG	BENZO(k)FLUORANTHENE	10	5	0.39	38	0.11	20	4.8	0.78	8.7	49	Yes	A
5	77	SS	MG/KG	CARBAZOLE	7	3	0.39	38	0.12	4	1.4	0.067	32	0.6	Yes	A
5	77	SS	MG/KG	CHRYSENE	10	5	0.39	38	0.12	30	7	0.94	87	160	Yes	G
5	77	SS	MG/KG	DIELDRIN	7	2	0.004	0.38	0.032	0.26	0.15	0.086	0.04	0.004	Yes	A
5	77	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	10	4	0.39	38	0.093	17	4.6	0.7	0.87	14	Yes	A
5	77	SS	MG/KG	PENTACHLOROPHENOL	7	1	0.2	19	0.32	0.32	0.32		5.3	0.03	Yes	A

Note Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 26-13

Constituents of Potential Concern in Screening Site 77 - Subsurface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
5	77	SB	MG/KG	ARSENIC	4	4	2 5	2 6	9	18	13	17	29	Yes	H
5	77	SB	MG/KG	COPPER	4	4	2 5	2 6	19	33	29	33		Yes	D

Note Data evaluated include field duplicates and normal samples (2 feet and below)

A Exceeds Criteria
B Does not exceed Criteria
C Does not exceed Background
D No Criteria available & exceeds Background, or no Criteria or Background available
E Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G Chemical is a member of a chemical class that contains other COPCs
H Chemical is a surface soil COPC

TABLE 26-14
Summary of Exposure Pathways to be Quantified at Screening Site 77
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0-10' bgs)	Yes	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be shorter exposure duration (less than 1 year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper.
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Evaluated for comparison purposes only.

TABLE 26-15

Exposure Point Concentrations for Screening Site 77 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	9	2	2.4	7.4	3.9	10	7.4
MG/KG	ARSENIC	9	9	11	19	14	15	19
MG/KG	DIELDRIN	6	2	0.083	0.26	0.18	187	0.26
MG/KG	BENZO(a)ANTHRACENE	9	5	5.6	26	12	403	26
MG/KG	BENZO(a)PYRENE	9	5	5.6	26	12	344	26
MG/KG	BENZO(b)FLUORANTHENE	9	5	5.6	26	12	297	26
MG/KG	BENZO(k)FLUORANTHENE	9	5	4.9	20	10	253	20
MG/KG	CARBAZOLE	6	3	1.1	4	2.4	61	4
MG/KG	CHRYSENE	9	5	6.1	30	13	394	30
MG/KG	INDENO(1,2,3-c,d)PYRENE	9	4	4.4	17	9.2	197	17
MG/KG	PENTACHLOROPHENOL	6	1	0.9	0.32	2.1	67	0.32

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation.

TABLE 26-16

Exposure Point Concentrations for Screening Site 77 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	13	2	2 9	7 4	3 8	7.2	7.2
MG/KG	ARSENIC	13	13	12	19	14	14	14
MG/KG	COPPER	13	13	26	52	31	34	34
MG/KG	DIELDRIN	10	2	0 051	0 26	0 11	1 6	0 26
MG/KG	BENZO(a)ANTHRACENE	13	5	3.9	26	8 1	31	26
MG/KG	BENZO(a)PYRENE	13	5	4	26	8 1	30	26
MG/KG	BENZO(b)FLUORANTHENE	13	5	4	26	8 1	29	26
MG/KG	BENZO(k)FLUORANTHENE	13	5	3 4	20	7	23	20
MG/KG	CARBAZOLE	10	3	0 75	4	1 5	2 3	2 3
MG/KG	CHRYSENE	13	5	4 3	30	8 9	35	30
MG/KG	INDENO(1,2,3-c,d)PYRENE	13	4	3 1	17	6 4	18	17
MG/KG	PENTACHLOROPHENOL	10	1	0 58	0 32	1 3	2 2	0 32

Note: Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet

TABLE 26-17

Carcinogenic Risks and Noncarcinogenic Hazards of Screening Site 77

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Surface Soil (0-2ft)		8E-05	0 05	*Arsenic, PAHs*
	Soil Column (0-10ft)[1]		7E-05	0 04	*Arsenic, PAHs*
		Total[2]	***8E-05***	***0.05***	***Arsenic, PAHs***
Utility Worker					
	Soil Column (0-10ft)		1E-05	0 005	*Benzo(a)pyrene*
		Total	***1E-05***	***0.005***	***Benzo(a)pyrene***

Notes

[1] *Soil Column includes surface and subsurface soil, therefore, it cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

PAHs = Polynuclear aromatic hydrocarbons

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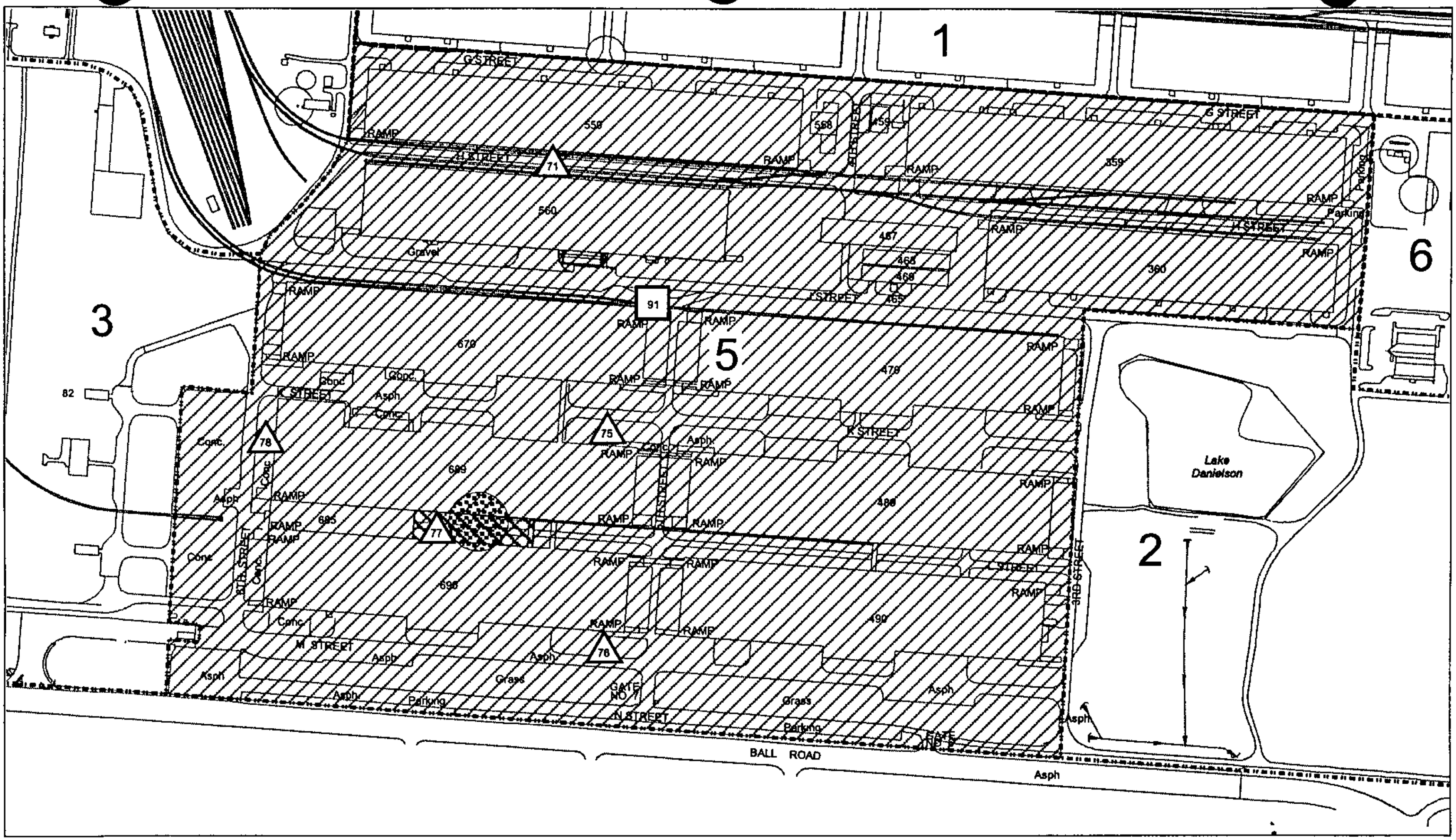

FIGURE 26-1

DIFFERENT EXPOSURE UNITS FOR BASELINE RISK ASSESSMENT WITHIN FUNCTIONAL UNIT 5

MEMPHIS DEPOT MAIN INSTALLATION RI

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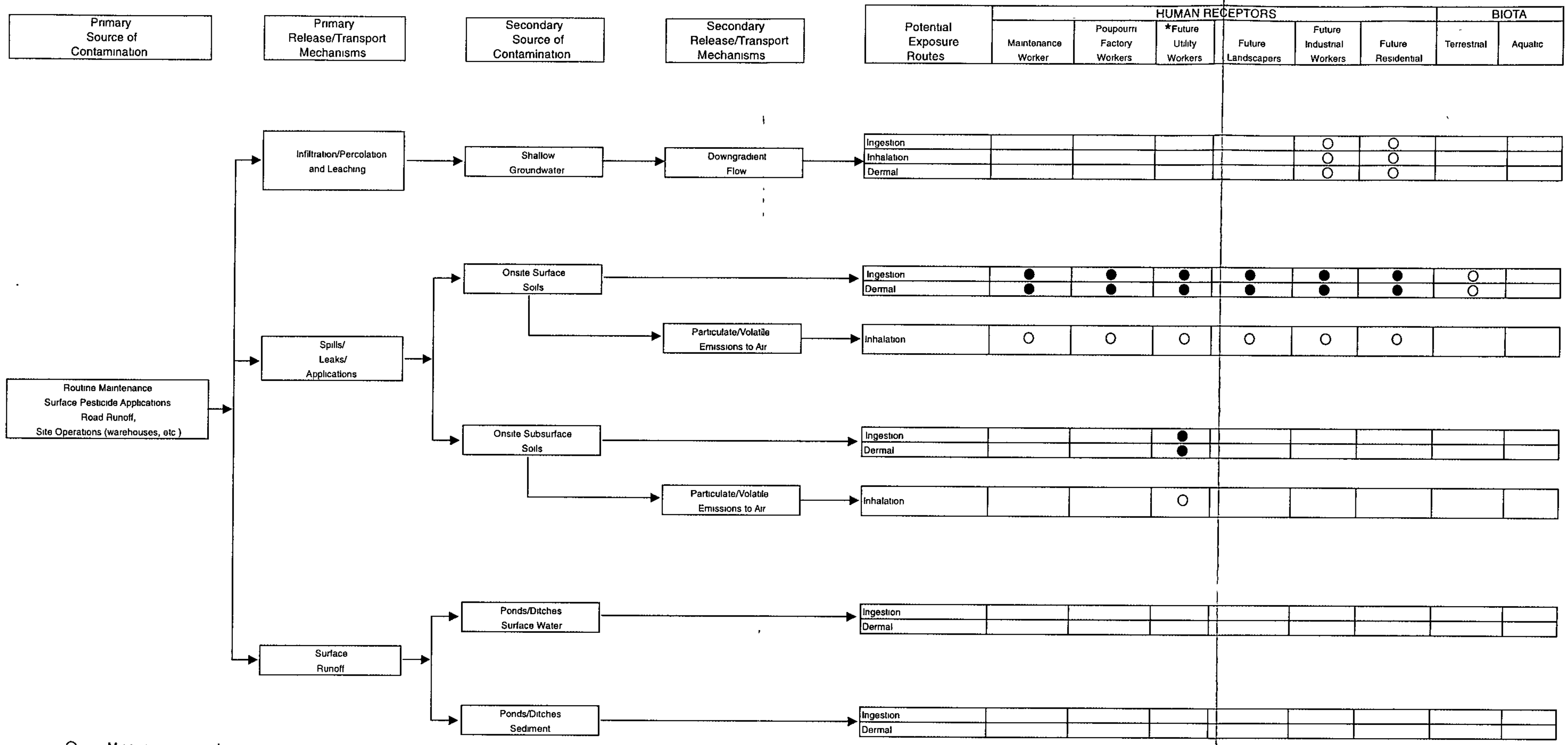

Secondary Source of Contamination	Potential Exposure Routes	Maintenance Worker	Poupourri Factory Workers	*Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Shallow Groundwater (Downgradient Flow)	Ingestion					○	○		
	Inhalation					○	○		
	Dermal					○	○		
Onsite Surface Soils	Ingestion	●	●	●	●	●	●	○	
	Dermal	●	●	●	●	●	●	○	
Onsite Surface Soils (Particulate/Volatile Emissions to Air)	Inhalation	○	○	○	○	○	○		
Onsite Subsurface Soils	Ingestion			●					
	Dermal			●					
Onsite Subsurface Soils (Particulate/Volatile Emissions to Air)	Inhalation			○					
Ponds/Ditches Surface Water	Ingestion								
	Dermal								
Ponds/Ditches Sediment	Ingestion								
	Dermal								

○ = Minor exposure route

= Primary exposure route

* = This pathway is conservatively quantitated under Surrogate site exposure unit

FIGURE 26-2
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: FUNCTIONAL UNIT 5
MEMPHIS DEPOT MAIN INSTALLATION RI

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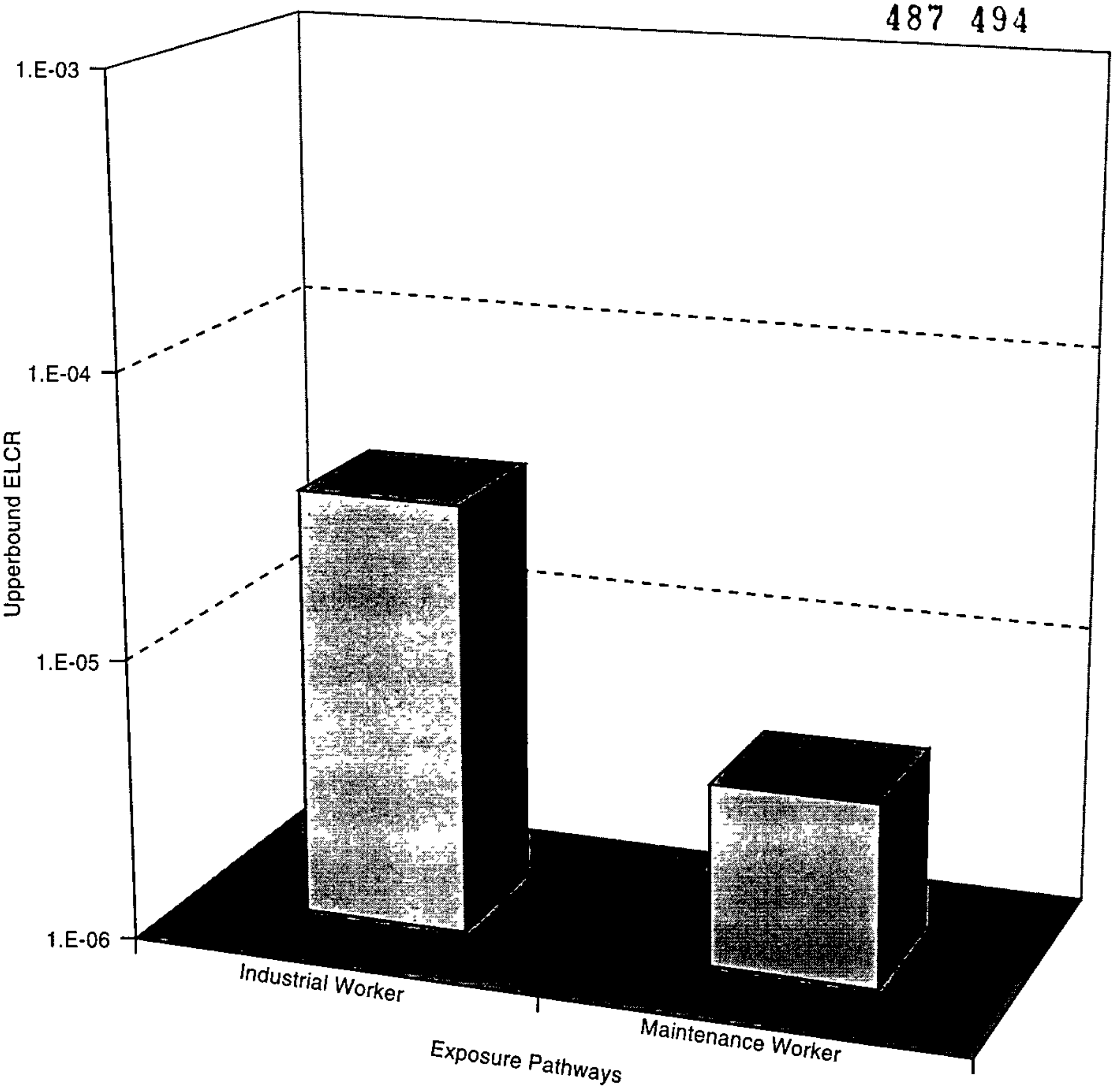

☐ Total ELCR (accepted range of 10-4 to 10-6)

Note·
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 26-3
TOTAL EXCESS LIFETIME CANCER RISKS
FOR TOTAL SOIL EXPOSURE AT FUNCTIONAL UNIT 5
MEMPHIS DEPOT MAIN INSTALLATION RI

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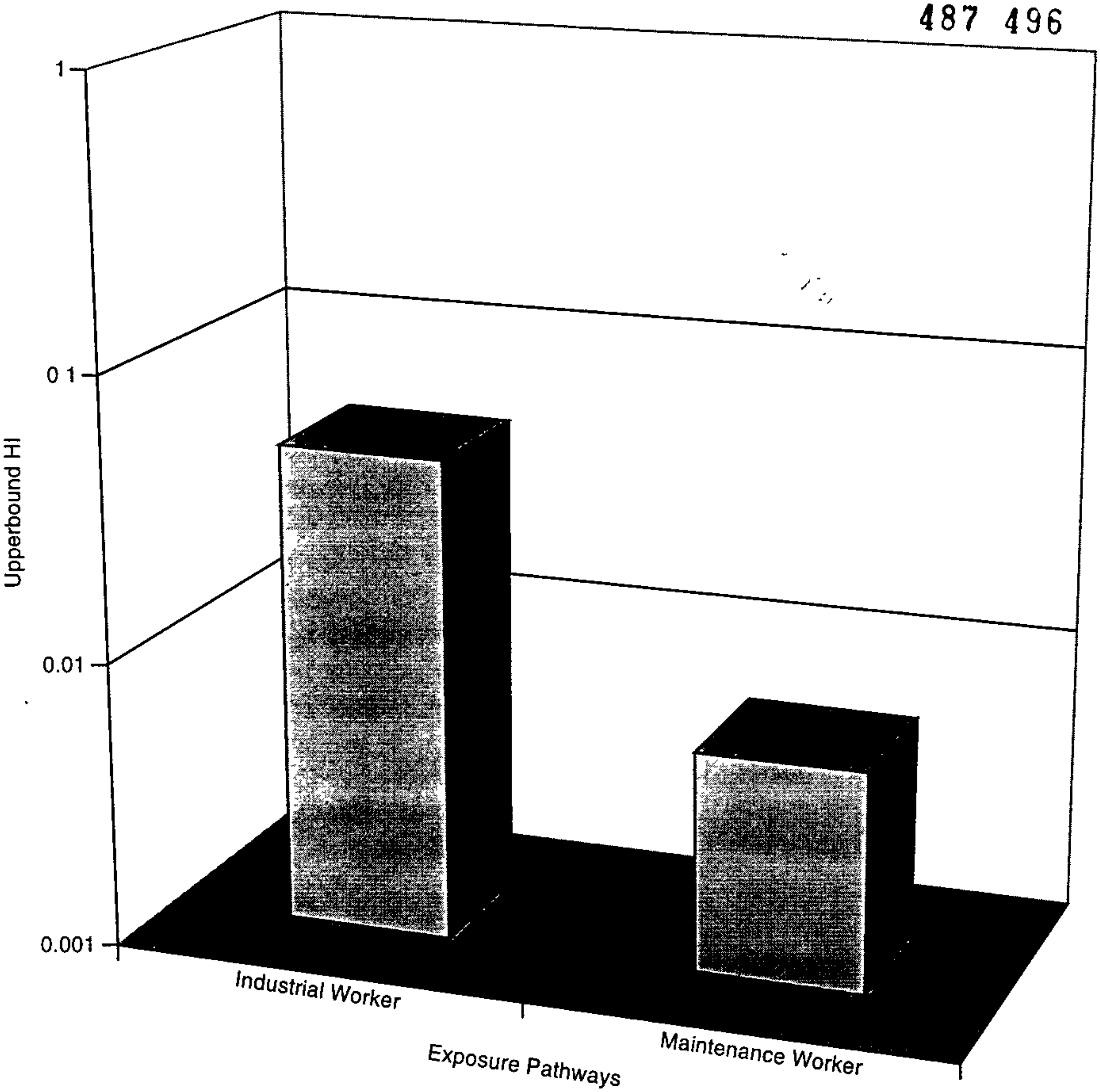

☐ Total HI (threshold of 1.0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 26-4
TOTAL HAZARD INDICES FOR TOTAL SOIL EXPOSURE AT FUNCTIONAL UNIT 5
MEMPHIS DEPOT MAIN INSTALLATION RI

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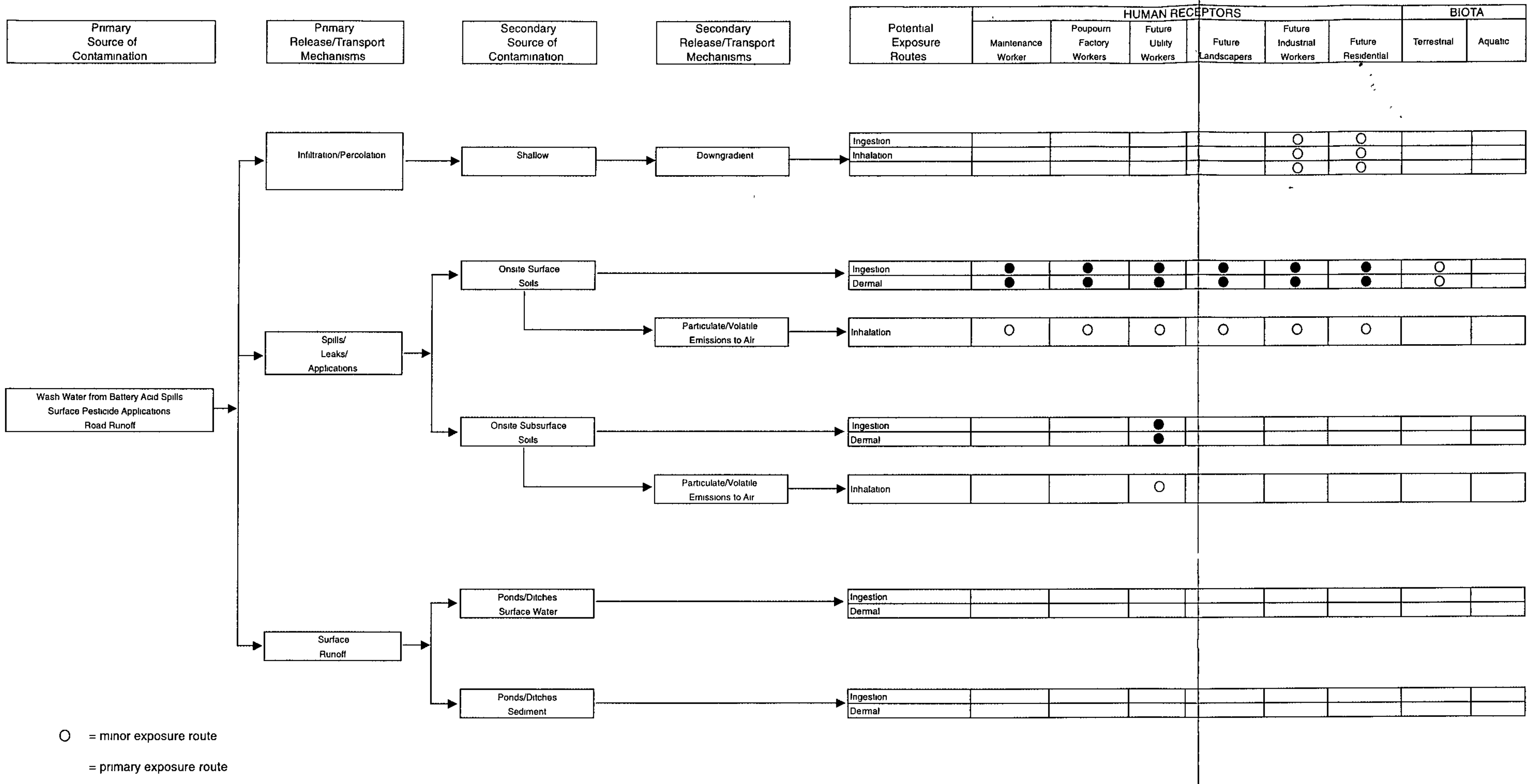

FIGURE 26-5
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: SITE 77
MEMPHIS DEPOT MAIN INSTALLATION RI

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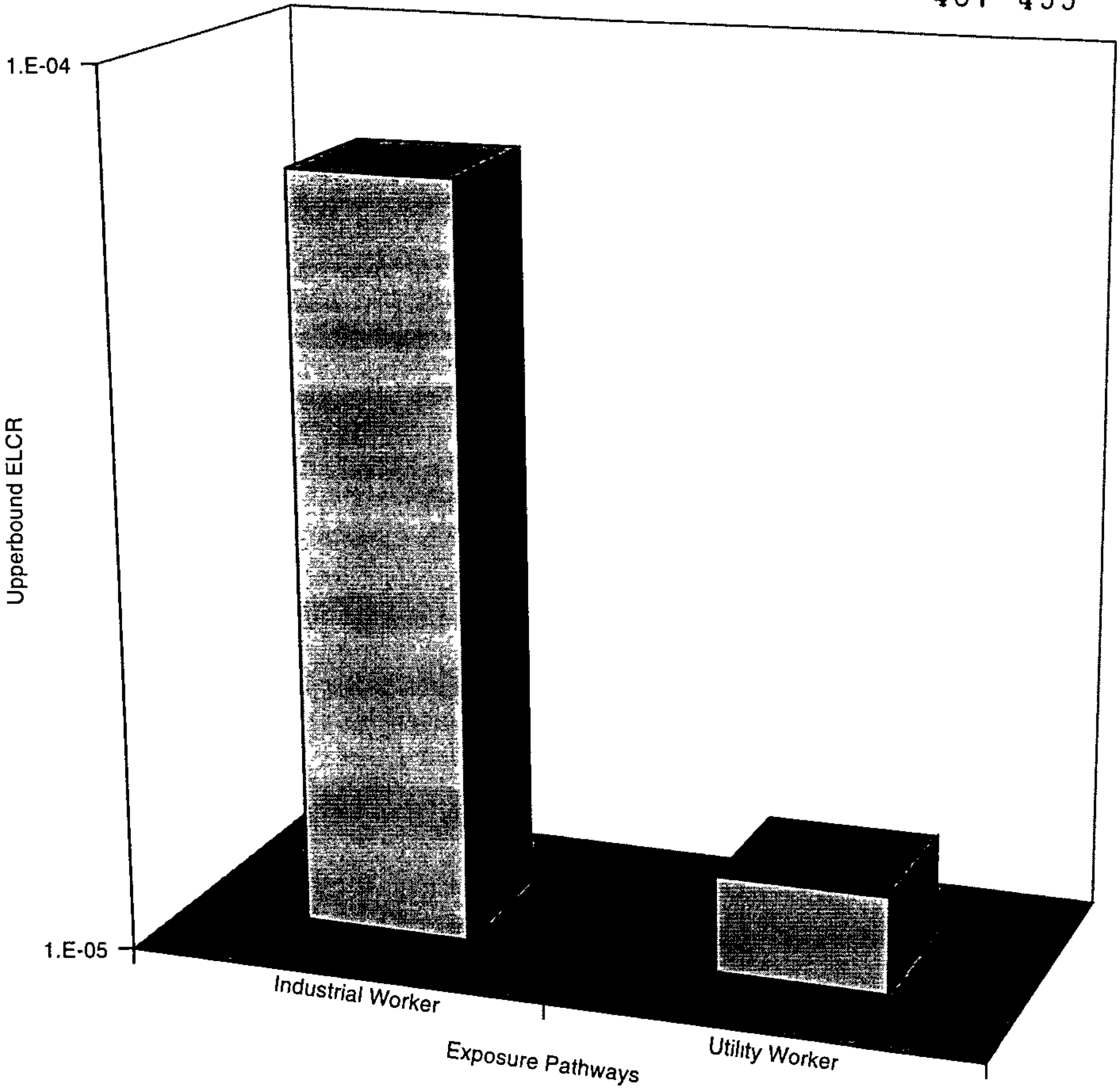

☐ Total ELCR (accepted range of 1E-4 to 1E-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 26-6
TOTAL EXCESS LIFETIME CANCER RISKS FOR SOIL EXPOSURE AT SITE 77
MEMPHIS DEPOT MAIN INSTALLATION RI

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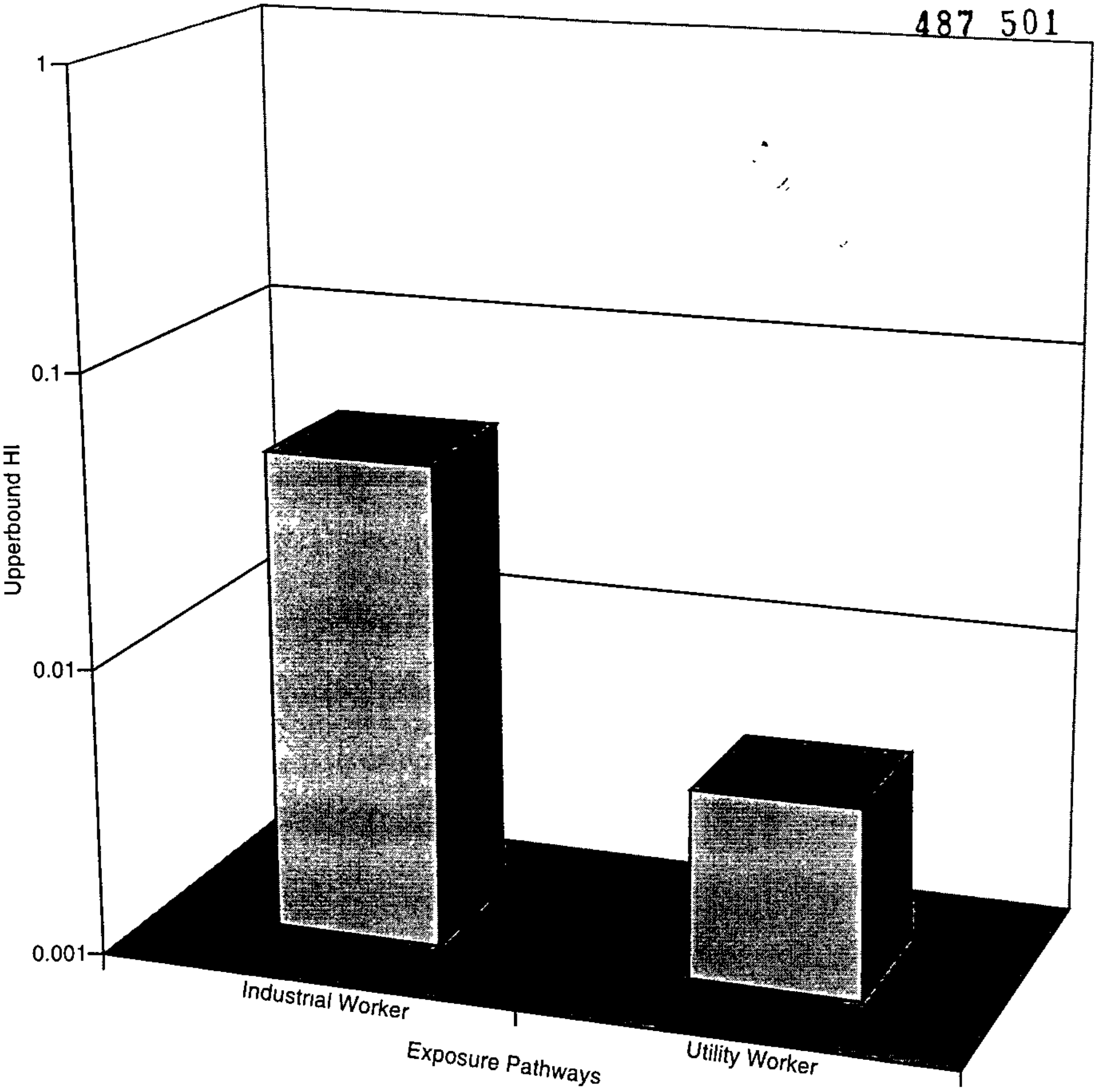

☐ Total HI (threshold of 1.0)

Note.
HI = Hazard Index
HI is dimensionless

FIGURE 26-7
TOTAL HAZARD INDICES FOR SOIL EXPOSURE AT SITE 77
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 27

TAB

27. Summary and Conclusions for FUS

27.0 Summary and Conclusions for FU5

27.1 Summary

27.1.1 Nature and Extent of Contamination

Data were collected for surface and subsurface soil to assess the nature and extent of contamination within FU5.

27.1.1.1 Soil

Metals, PAHs (and several other SVOCs), pesticides, dioxins, and VOCs were detected in the soils across FU5. Some of these contaminants were detected at concentrations above background values in areas that may have contributed to contamination, based on past operations. These areas include the following:

- Screening Site 75–unknown wastes near Building 689;
- Screening Site 76–unknown wastes near Building 690;
- Screening Site 77–unknown wastes near Buildings 689 and 690; and
- Screening Site 78–alcohol, acetone, toluene, naphtha, and hydrofluoric acid spill (Building 689).

Most elevated concentrations in FU5 related to SVOCs, pesticides, dioxins, and VOCs were detected in the surface soils. Concentrations of contaminants detected in the subsurface soil were generally below (or near) background values.

Metals. The primary metals of concern (those with detected concentrations routinely above the background value) were arsenic, total chromium, copper, lead, nickel, and zinc. These constituents exceed background values in surface soil at a number of areas throughout FU5.

Elevated arsenic concentrations were located primarily at Screening Site 78 for both surface and subsurface soil samples. Arsenic is present in low concentrations throughout the Depot, probably because of site-wide pesticide application and natural soil conditions. Half of the elevated chromium surface concentrations and nearly one third of the elevated subsurface concentrations were observed in Screening Site 76.

Elevated lead concentrations were located primarily in the surface soil at Screening Site 77 and in the subsurface soil at Screening Site 78. These sites (77 and 78) also were the only areas affected by elevated copper concentrations. Nickel concentrations in both the surface and subsurface soils were dispersed throughout FU5.

The distributed metals of concern (those with detected concentrations infrequently above the background value) were antimony, beryllium, cadmium, manganese, and selenium Naturally occurring metals (those associated with natural soil conditions with detected concentrations infrequently above the background value) in FU5 were identified as calcium and potassium. Aluminum, barium, cobalt, iron, magnesium, and vanadium were not detected in concentrations above background values.

With the exception of elevated total chromium concentrations in the surface and subsurface soil at Screening Site 76, elevated metal concentrations in surface soil exceeding background levels were detected in samples from Screening Sites 77 and 78.

Subsurface soil samples do not indicate downward migration of metals within FU5.

Pesticides. A total of six pesticides were detected in the surface soil samples at FU5: alpha-chlordane, DDT, DDE, DDD, dieldrin, and gamma-chlordane. The three general areas affected in FU5 are Screening Sites 75, 76, and 77 (all associated with Buildings 689 and 690). DDT and dieldrin each exceeded background values in five samples, and alpha-chlordane exceeded the background value in six samples.

Pesticides were analyzed for in 13 subsurface soil samples. DDE, DDT, and dieldrin were each detected once, with the DDE concentration exceeding the background value. The concentrations were found in sample TEC91A.

Pesticides have not been detected in groundwater samples taken across the Main Installation, so the transfer of pesticides to groundwater from subsurface soil contamination is not evident. The GWP values for DDT and DDE were not exceeded. The dieldrin concentration exceeded the GWP value of 0.004 mg/kg, but was still below the background value.

SVOCs. PAH compounds were the primary SVOCs of concern in the surface soil at FU5. PAHs were detected throughout the Main Installation, with the highest concentrations in proximity to the railroad tracks. PAH compounds can originate from the seepage of creosote from railroad ties, from historical railcar leaks, or from PCP/used oil mixtures such as those historically applied for weed control along the tracks. Twenty-two surface soil samples contained detectable concentrations of total PAHs located primarily in Screening Sites 75 and 77.

It has not been established that the elevated PAH concentrations result entirely from hazardous waste operations or emissions associated with transport in and out of the buildings. PAH concentrations at Sites 57 and 65 (both in FU1) are considered outliers relative to the distribution of PAH concentrations across the Main Installation. On the basis of these outliers, the elevated concentrations may result from hazardous material handling at these locations.

PAHs were not detected frequently in the subsurface soil samples. Six concentrations were detected in the 32 samples analyzed. None of the detected concentrations were detected below 6 ft.

VOCs. The majority of the surface and subsurface soil sampling results for VOCs within FU5 indicate no detected concentrations or no detected concentrations above background. However, there were three VOCs with concentrations detected above background in the surface soil within FU5:

- MEK was detected five times, all at elevated concentrations, throughout the FU;
- Toluene was detected above the background value at sample TEC91A, at the northwestern corner of Building 670; and

- Carbon disulfide was detected at 0.037 mg/kg at BRAC sample point A(20.6), between Building 489 and Building 490.

Volatilization at the surface probably led to the finding that detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations. The subsurface soil areas with VOCs are identified below:

- 2-Hexanone, benzene, bromomethane, carbon dilsulfide, ethyl benzene, toluene, and total xylenes were not detected in any subsurface soil sample within FU5, yet each was noted in at least one surface sample;
- Chlorobenzene, PCE, total 1,2-Dichloroethene, TCE, and methylene chloride were detected in the subsurface soil at FU5, but not the surface soil; and
- The area around Screening Site 78 had two samples with TCE and PCE concentrations underneath the concrete pad. One of the TCE concentrations at 11 mg/kg in boring SB78B (18 to 20 ft) could be a potential continuing source for low level groundwater contamination. This aspect is further evaluated in the FU7 sections (Sections 32.0 through 35.0).

Dioxins and Furans. Dibenzofuran was the only dioxin detected in FU5. The surface soil was sampled 21 times, with 3 concentrations exceeding the background value of 0.647 mg/kg The subsurface soil was sampled 32 times, with no concentrations of dibenzofuran detected.

27.1.1.2 Sediment

No sediment samples were taken in FU5 because there are no surface water bodies or drainage ditches present.

27.1.2 Fate and Transport

27.1.2.1 Migration Pathways

FU5 is an entirely industrialized area, covered mostly with coarse gravel, some grass, paved roads, railroad tracks, and large warehouses (closed) (see Figures 24-1 and 2-16). Potential pathways for migration at FU5 are surface runoff, leaching, and dust emission. Because of the ground cover, significant leaching and volatilization are not anticipated.

Surface runoff migrates from roads, grassy strips, and concrete- or gravel-covered areas around the warehouse buildings and the grassy areas located near the FU boundaries. Leaching may occur in the open contaminated areas because of the percolation of rainwater, and dust emissions may be generated from the grass- and gravel-covered areas if soils are disturbed within FU5. However, dust emissions are relatively minor because they are likely to be associated with grass-cutting types of activities within grass- and gravel-covered areas rather than in the paved areas within FU5.

There are no drainage ditches or bodies of water within FU5. The surface is relatively flat with a slight slope to the north. Surface water runoff within FU5 flows to the south and discharges to an open drainage ditch in FU2. The stormwater from this area eventually flows to the Nonconnah Creek.

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27.1.2.2 Contaminant Persistence and Migration

Metals, PAHs, and pesticides were the most frequently detected contaminants at FU5. Metals are persistent in the environment and are naturally occurring. Emissions of metals to the ambient air would be in the form of particulate emissions. PAHs are not very volatile and are likely to degrade with time because of exposures to sunlight and air. The pesticides degrade slowly; thus, they are expected to remain bound to the soil and are likely to be released through dust.

The surface runoff pathway is not important because of the lack of significant flow through surface drainage features within this FU. Runoff within FU5 is routed to stormwater drainage systems and discharged to a concrete-lined drainage ditch, which extends into FU2 and ultimately discharges into Nonconnah Creek. Low levels of arsenic, antimony, PAHs, and pesticides that are COPCs for FU5 were detected in samples collected from Screening Sites 75, 77, and 78 and Parcel 20. Off-site migration is not considered a significant concern for FU5.

Leaching from surface soil contamination migration to groundwater is a potential pathway at Screening Site 78, because the TCE concentrations in the deeper soils above shallow groundwater exceeded the leachability criteria. Regional groundwater has CVOCs, which are addressed as part of the groundwater FU.

27.1.3 Risk Assessment

27.1.3.1 Summary and Conclusions of Risk Assessment for FU5

The human health RA for FU5 included all of the data collected within this physical unit The primary conclusions of this RA are as follows:

- The following chemicals were detected in surface soils above background and RBC values and therefore were included as COPCs: antimony, arsenic, PAHs, dieldrin, carbazole, PCP, and 4-Methylphenol;
- Antimony, arsenic, cadmium, chromium, copper, manganese, PAHs, dieldrin, carbazole, PCP, 4-Methylphenol, 1,2-DCE (total), and TCE were detected in the subsurface soils above the background and RBC values. For the evaluation of the exposures to a soil column (zero to 10 ft), the COPCs detected in the surface soil were used in addition to subsurface soil COPCs to account for potential future mixing of surface and subsurface soils during excavations;
- Overall human health risks and noncarcinogenic hazards to workers in FU5 are within acceptable risk limits. Potential risks from the surrogate site (Screening Site 77) are negligible for the industrial and utility workers. The identified COPCs for Screening Site 77 are a subset of those found in FU5. Overall risks to various receptors were within acceptable levels, considering that assumptions are overly conservative; and
- Overall human health noncarcinogenic hazards to residents in FU5 also are within acceptable risk limits. The carcinogenic risks under a hypothetical residential scenario estimated for a single data point were above the upper-bound acceptable limits for carcinogenic risk of the 1 in 10,000 (10^{-4}) level, primarily from the arsenic and PAHs detected in the sample. The sample was collected from Screening Site 77, adjacent to

Building 689. Overall risks to residential receptors were acceptable, considering that the assumptions are overly conservative and industrial land use is expected to continue in this area.

27.1.3.2 Summary and Conclusions of Ecological Risk Assessment for FU5

A screening level ERA was conducted for the entire FU5 to evaluate the extent to which contaminant concentrations could adversely affect ecological receptors. Although the ecological habitat at FU5 is limited to a few maintained grassed areas, the ERA was conducted in accordance with EPA guidance, which recommends little or no risk management input in the screening assessment. The screening assessment (Steps 1 and 2) identified a number of COPCs for consideration in Step 3. The refinement process in Step 3 reduced the number of preliminary COPCs; however, further consideration of site-specific ecological exposure pathways indicated that current and future exposure pathways at this site are incomplete. There is adequate information to conclude that the ecological risk at FU5 is negligible, and there is no need for remediation based on ecological risk.

27.1.3.3 Summary and Conclusions for Screening Site 77

The conclusions specific to the surrogate site RA performed at Screening Site 77 are presented below:

- Screening Site 77 was selected as the surrogate site to represent the potential RME areas within FU5, based on the results of the PRE presented in Section 7.0;
- A human health RA was conducted for this site because it was assigned the highest human health risk ratio during the PRE An ERA was not conducted at this site because it is an industrial site and not a suitable habitat for terrestrial receptors;
- Surface soil samples indicated the presence of antimony, arsenic, copper, dieldrin, PCP, and PAHs above screening criteria and/or background values; these were selected as COPCs. Arsenic and copper were selected in subsurface soil based on the exceedance of background or criteria values;
- Deep soil risk evaluations included the soil column from the surface to a 10-ft depth. Nine surface soil (zero to 1 ft) and 13 deeper samples (greater than 1 to 10 ft) were included in this data set. The COPCs for the evaluation of the soil column included those selected for surface soil;
- Risks and noncarcinogenic hazards estimated for workers under various exposure scenarios represent risks within the 1 to 100 in one million range (10^{-6} to 10^{-4}) and HIs below a target value of 1.0;
- The total risks are represented by the higher of the surface and deeper soil risk estimates; and
- Screening Site 77 does not pose a significant human health concern for future industrial land use at FU5, even under high-end exposure assumptions.

27.2 Conclusions

27.2.1 Data Limitations and Recommendations for Future Work

The nature and extent of the chemical constituents in surface and subsurface soil have been defined both vertically and horizontally in FU5. In general, surface soil samples with concentrations attributable to source areas within FU5 were surrounded by sampling locations that had concentrations more representative of background levels.

The subsurface soils at most of the screening sites were investigated. Similarly, subsurface soil samples with elevated concentrations generally were located in borings that contained deeper samples with concentrations below background values. The CVOCs detected near Screening Site 78 may need further investigation as part of the groundwater source area identification.

27.2.2 Recommended Remedial Action Objectives

As shown in the baseline RA detailed in Section 26.0, overall human health risks and noncarcinogenic hazards associated with exposure to soil and sediment are within acceptable risk limits. Groundwater risks are further discussed in Section 34.0. No additional soil remedial actions are recommended for FU5.

TAB

Section 28

TAB

28. Nature and Extent of Contamination
at FUE

28.0 Nature and Extent of Contamination at FU6

This section addresses the nature and extent of contamination within FU6, the Administrative and Residential Areas of the Main Installation. The subsections below provide a description of how FU6 was defined, discuss the probable sources of contamination that exist within FU6, and identify the nature and extent of contamination at FU6 by identifying the distribution and location of widespread contaminants in the surface and subsurface soil and in the sediment in FU6. Groundwater contamination beneath the FU is addressed in Section 32.0.

As described in the following subsections, FU6 contains CERCLA sites identified in the original RI activities prior to 1990, as well as screening sites and TEC sites identified by CH2M HILL. These sites were investigated as possible sources of contaminant releases to the environment. Areas not associated with a specific site were sampled as part of the BRAC characterization program. This section discusses the nature and extent of contamination within the entire FU area by evaluating the combined CERCLA and BRAC data.

28.1 Functional Unit Background

28.1.1 FU6 Description

FU6 is the Administrative and Residential Areas, consisting of BRAC Parcels 1, 2, 4, and 5 (see Figure 1-1). As discussed in Section 1.1, FU6 was established based on similar operational activities in the far eastern portion of the Main Installation, which included buildings for residences and administrative activities.

28.1.2 FU6 History

Most of the land cover within FU6 consists of asphalt parking areas and a few administrative buildings. There is also some grass cover within FU6 in the residential area. The eastern portion of this FU contains Gate 1, which provides an entrance into the Main Installation directly off of Airways Boulevard.

The administrative area faces Airways Boulevard and consists of two major buildings built in the early 1940s, waiting shelters, and sentry gates. The largest building is the 13,500-square-ft administrative building (Building 144). South of the administrative area is the residential housing area, where residential housing and detached garages were built in 1948. The houses remain residential, but the detached garages have been used for automotive storage and maintenance.

Numerous buildings behind the southern parking lot are used primarily for maintenance and automotive activities. Activities include those associated with vehicle maintenance shops, service station, vehicle storage and maintenance, heating fuel storage, a vehicle grease rack, and a gas station. This FU also includes a former building location used for storing and mixing pesticides and herbicides. Other miscellaneous building uses include a thrift shop, former pro shop, and facility installation services building.

28.2 Summary of Remedial Investigations at FU6

28.2.1 Historical Remedial Investigations

Initial sampling of surface soil occurred at FU6 as part of the 1990 RI conducted by Law Environmental (Law Environmental, 1990a). Two surface soil samples were collected at RI Site 48 (Former PCB Transformer Storage Area) and RI Site 58 (Pad 267) in areas where spills may have occurred. General types of chemicals detected at these sites during the 1990 Law Environmental investigation included PAHs and pesticides.

28.2.2 Summary of Key Findings from Past Remedial Investigations

The results of the surface soil sample data collected during the 1990 RI investigation indicated the following:

- The soil was contaminated with PAHs and pesticides; and
- Although RI Site 48 was a former PCB Transformer Storage Area, no PCBs were detected.

On the basis of the fate and transport analysis, the pesticides and PAHs were determined to be relatively immobile, and it was concluded that these compounds were detected at locations near their original sources of contamination–in grassy areas (pesticides) and from asphalt (PAHs).

The extent of contamination from the constituents detected was not defined by Law Environmental. Results from the 1990 Law Environmental RI were used to evaluate potential problem areas within FU6 and to provide the basis for additional sampling. Additional sampling was conducted for areas where data gaps existed and where sampling and analyses were required to characterize the nature and extent of contaminants from past activities of the site.

28.2.3 Current Remedial Investigations

The RI and screening sites within this FU initially were investigated by CH2M HILL from December 1996 through January 1997. At that time, the surface soil was sampled to assess the nature and horizontal extent of contamination at these sites, and the subsurface soil was sampled at most of these sites to assess the vertical extent of contamination. A single BRAC sediment sample was collected from the sump located beneath a floor drain toward the southern end of Building 251 and another single BRAC sediment sample was collected from the sump located beneath a floor drain toward the eastern side of Building 265. No surface water bodies exist at FU6, so no surface water data were collected.

Additional investigations of RI and screening sites were conducted from September 1998 through October 1998. Additional surface and subsurface soil sample data were needed to accomplish the following:

- Further characterize the nature and extent of contamination;
- Collect a sufficient number of data points to perform an RA;
- Confirm the absence of contamination at some screening sites based on initial (1996-1997) screening results;
- Assess the extent of groundwater contamination; and
- Collect feasibility samples where remedial activities are likely.

No additional sampling of dieldrin in the grassy areas surrounding the administration buildings was proposed. There are 23 surface soil samples within FU6 analyzed for dieldrin. The maximum concentration over this area is 0.73 ppm with an average of 0.18 ppm. Although not discussed in the RI report, there are two background samples taken along the eastern perimeter of the Main Installation: BS05 off the southeastern corner and BS06 off the northeastern corner of the Administration Building. The results of these samples are within the range observed throughout FU6; 0.11 and 0.36 ppm, respectively. Because the application mode of dieldrin should not have changed across this area of the Depot, it is reasonable to accept the consistency in dieldrin concentration across FU6 and the administrative area as demonstrated by these perimeter background samples. Therefore the risks to industrial (10^{-5}) and maintenance workers (10^{-6}) is applicable to the administrative area.

The sites investigated within FU6 and the sampling rationale for each site are presented in Table 28-1. Figure 28-1 shows the location of these sites. The basis for the 1996 sampling rationale was the same for each site identified at the time: (1) to collect soil samples that were representative of site conditions; (2) to compare the detected concentrations to background and screening levels; and (3) to develop appropriate recommendations. The 1998 sampling rationale was developed based on the recommendations from the 1996-1997 sampling event. Information regarding specific activities that occurred at the FU6 sites is discussed in Section 28.3.

28.3 Potential Sources of Contamination

Because hazardous materials were handled and stored at a few buildings within FU6, there was the potential for spills of hazardous materials to soil surrounding the buildings. Furthermore, soil may have been contaminated with pesticides or petroleum products from the vehicle maintenance and servicing activities. Other areas of concern within FU6 (and also throughout the Main Installation) include releases associated with transport along railroad tracks and pesticide/herbicide applications in grassy areas. The following paragraphs provide a description of operations that have taken place at these sites, plus other areas of concern within FU6.

28.3.1 Former PCB Transformer Storage Area (RI Site 48)

RI Site 48 was the former storage location of at least two electrical transformers. The transformers were discovered during the Installation Assessment conducted in March 1981 (U.S. Army Toxic and Hazardous Materials Agency, July 1982). Tests of the fluid from the transformers indicated less than 50 ppm of PCBs. This is the current location of Building 274 ("J" Street Cafeteria), which measures 13,500 square ft and was constructed in 1989 after transformer storage had ceased. The August 1997 BCT approved the early removal of surface soils at this site, which was completed in 1998 (Memphis Depot Caretaker, 1998).

Two surface soil samples (SS30 and SS31) were collected at this site during the 1990 RI (Law Environmental, 1990). In these samples, PAHs and pesticides were detected, but there were no PCB concentrations detected.

28.3.2 Pad 267 (RI Site 58)

RI Site 58–Pad 267 refers to the area that was formerly the site of Building T-267, the Pesticide Shop. This 150-ft by 200-ft building previously was located north of the current Building 274. The building was demolished in 1987 and the area is now a paved parking lot.

Building T-267 formerly was used for the storage and mixing of pesticides and herbicides that were applied to the Depot grounds by Depot Entomology Division personnel. The shop is believed to have operated from the 1940s until the mid-1980s.

The Installation Assessment (U.S. Army Toxic and Hazardous Materials Agency, 1982) documented that rinse water from pesticide and herbicide spraying operations was disposed of on the ground near the facility until 1980. The specific location where rinse water was disposed of is unknown. After that time, the rinse water was held for the mixing of later batches. Past pesticide and herbicide spray operations at the Depot generally included 2,4-Dichlorophenoxyacetic acid (2,4-D) on grassy areas, Monuron on railroad track areas, pyrethrum in textile warehouses, Hy-Var-X in gravel areas, and phostoxin (aluminum phosphide) for stack and transit fumigation (USATHMA, 1982).

28.3.3 POL Building 253 (Screening Site 66)

This vehicle maintenance shop, measuring approximately 50 ft by 125 ft, was located in the facility engineering maintenance yard. The shop has been demolished. Operations at Building 253 consisted mainly of motor pool services (minor maintenance, oil changes, steam cleaning, cold-solvent degreasing, washing, and lubrication). Additionally, a 5,000-gallon UST containing No. 4 fuel oil was installed at this site in 1952 and was removed in July 1996.

During the RI (CH2M HILL, May 1997), one surface soil and three soil boring locations were sampled. Three biased soil borings were used to evaluate whether potential contaminants exist at the site, and samples were collected to 40 ft. A boring depth of 40 ft was selected because of releases that may have occurred from the UST previously located at the site.

28.3.4 Installation Gas Station, Building 257 (Screening Site 67)

Since 1942, fuel dispensing and storage have been ongoing at Building 257 (Screening Site 67). Antifreeze also has been stored in this building. The four original steel USTs, installed in 1942 and 1951, were removed in 1986 (three tanks, two 12,000- and one 20,000-gallon tank) and in 1989 (one 2,580-gallon tank) and replaced with 18,000- to 20,000-gallon fiberglass tanks. All tanks stored gasoline (leaded and unleaded). Additionally, two formerly active 1,000-gallon ASTs, one for gasoline and one for diesel, were located at this site (Woodward-Clyde, 1996), but are now inactive and have been moved during construction of the main entrance corridor (Personal Communication, Denise Cooper, 2000).

Building 257 was east of Building 359 at the intersection of G and 2nd Streets, but has been demolished.

According to the *Remedial Investigation at DDMT, Final Report* (Law Environmental, 1990), one surface soil sample (SS25) taken west of Building 257 indicated the presence of PAHs, dieldrin, and metals (see Table B-7 and Figure 4-17 in the *Screening Sites Field Sampling Plan*, CH2M HILL, September 1995e). These sample locations were chosen based on previous sampling results and fuel-dispensing activities conducted at vehicle fueling areas and UST filling areas within the site.

Two 40-ft borings and additional surface soil samples were taken as part of this RI.

28.3.5 POL Building 263 (Screening Site 68)

Building 263 has been used as an attendants' room for the dispensing of POL to vehicles since the 1940s. The site is located 500 ft southwest of Gate 1 and west of Building 260. Building 263 measures approximately 20 ft by 40 ft and is surrounded by a large expanse of asphalt pavement.

The site historically was used to store small containers of POLs. These materials were dispensed to the POL staff and were not used in the Building 263 area. There is little potential for contamination resulting from past practices at this site because the materials were stored inside, the building is surrounded by asphalt pavement, and no releases are known to have occurred.

28.3.6 All Grassed Areas (Screening Site 73)

Grassed areas throughout the Main Installation were treated as one screening site during the investigation. The historical application of pesticides such as dieldrin on grassy areas was cause to consider areas as a potential source of contamination.

28.3.7 BRAC Parcels

Environmental sampling was performed at BRAC property parcels to assess if the property was suitable for transfer or lease Sampling was conducted to assess whether chemicals existed in the surface and subsurface soils in concentrations that might present a concern for industrial, an din some portions of the Main Installation, residential uses.

28.4 Nature and Extent of Soil and Subsurface Soil Contamination

To characterize the nature and extent of contaminants within FU6, surface and subsurface soil samples were collected and analyzed for VOCs, SVOCs, total metals, PAHs, petroleum hydrocarbons, organochlorine pesticides, herbicides, and PCBs. Figure 28-2 shows the sample locations for FU6, and Table 28-2 lists the parameters analyzed for at each site. Appendix Q provides a list of all detected parameters in the surface and subsurface soil samples collected at FU6 and compares them to screening and background values. The nature and extent of the contaminants detected above background values at the FU are discussed below.

28.4.1 Nature and Extent of Metal Contamination

Several metals were detected throughout FU6 at concentrations above background values. The results of the analyses are presented in Table 28-3. The metals that exceeded background values were divided into three categories based on the number of sample concentrations that exceeded background values and the relative importance of the metal as a potential contaminant. Each metal that exceeded a background value was classified as a primary metal of concern, a distributed metal, or a naturally occurring metal:

- Primary metals of concern were those detected above background values in some samples and may indicate a release from source areas in FU6;
- Distributed metals were those detected above background values in a relatively small and insignificant number of samples; and
- Naturally occurring metals were those associated with the natural soil conditions that were detected above background levels.

A fourth category of metals was those that were detected frequently, but never above background values. These metals are briefly discussed in Section 28.4.1.4.

28.4.1.1 Primary Metals of Concern

On the basis of the results of the surface and subsurface soil sampling, lead, copper, and selenium were designated as the primary metals of concern throughout FU6. The soil samples that exceeded the background values for these constituents are shown on Figures 28-3 through 28-6. These constituents were designated as primary metals of concern primarily because they exceeded background levels in a number of areas throughout FU6.

Lead. Of the 13 surface soil samples analyzed for lead (including 2 duplicates), 6 samples contained lead concentrations that exceeded the background value of 30 mg/kg. As shown on Figure 28-3, the elevated lead values were concentrated in the southwestern corner of the FU, near Building 257 (Screening Site 67), Building 253 (Screening Site 66), and Pad 267 (RI Site 58). The highest exceedance was found at SB58B, in the zero- to 1-ft interval, at a concentration of 136 mg/kg. One other exceedance, 67.1J mg/kg in SS66A, was more than twice the background value of 30 mg/kg.

None of the lead concentrations in the 14 subsurface samples (taken to depths of 40 ft) exceeded the background value of 23.9 mg/kg. Detected values ranged from 4 to 19.3 mg/kg.

Overall, lead was detected in concentrations above background values in surface soil in one main area of the FU–the southwestern corner. However, lead does not appear to be leaching to the subsurface, because no subsurface samples contained lead concentrations that exceeded 23.9 mg/kg.

Copper. Copper concentrations in 5 of the 13 surface soil samples, including 2 duplicates, exceeded the background value of 33.5 mg/kg. As shown on Figure 28-4, four of the five elevated copper values were concentrated near Building 257 (Screening Site 67). The highest detected concentration (50.7 mg/kg) was also detected in SS67B. None of the 13 copper concentrations exceeded twice the background limit.

Of the 14 subsurface soil samples analyzed for copper, only one contained copper concentrations that exceeded the background value of 32.7 mg/kg. The elevated copper concentration was found in the 8- to 10-ft depth of SB67B, at a level of 33.9 mg/kg. The copper concentrations in the other borings in FU6 at that depth interval ranged from 8.8 to 11.9 mg/kg. Copper concentrations with depth show no clear pattern and with the one exception described above, did not exceed background values.

Copper concentrations that exceeded the background value were concentrated near Building 257 (Screening Site 67). However, these concentrations were relatively low. In addition, elevated copper concentrations appeared only once in the subsurface.

Selenium. Selenium concentrations in 2 of the 13 surface soil samples, including 2 duplicates, exceeded the background value of 0.8 mg/kg. The elevated selenium concentrations of 0.89 mg/kg (at SB58A) and 0.86 mg/kg (at SB68C) are just slightly above the background concentrations of 0.8 mg/kg for surface soils.

All detected concentrations of selenium in the subsurface exceeded background values. Five of the 14 subsurface soil samples contained selenium concentrations that exceeded the background value of 0.6 mg/kg. Four of the 5 elevated selenium concentrations were found at Pad 267 (RI Site 58), as shown on Figures 28-5 and 28-6, ranging from 1.2 to 1.7 mg/kg, while the fifth exceedance (1 mg/kg) was found at Site 68, at a depth of 8 to 10 ft.

Selenium was barely elevated in the two surface locations (Screening Site 68 and RI Site 58) at which subsurface concentrations exceeded background values. These locations are colocated in the west-central part of FU6. Subsurface soil concentrations of selenium exceeded background values more than surface soil concentrations.

28.4.1.2 Distributed Metals

Nickel, chromium, zinc, and arsenic were detected at concentrations that exceeded background values. However, the elevated concentrations of these constituents occurred infrequently (see Table 28-3) and were widely dispersed. As a result, the elevated concentrations of these constituents were not considered indicative of a release from a source area in FU6 and these constituents were classified as distributed metals.

Nickel. Four nickel concentrations, including 2 duplicates, exceeded the background value of 30 mg/kg in the 13 surface soil samples analyzed for nickel at FU6. The two sample locations with exceedances were SS67A and SB67A, with the values of 37.8 mg/kg at SS67A and 41.1 mg/kg at SB67A. However, these nickel concentrations did not significantly exceed the background limit, and were not greater than two times the background value of 30 mg/kg.

One of 13 subsurface soil samples contained nickel concentrations that exceeded the background value of 36.6 mg/kg. The elevated nickel concentration (41.7 mg/kg) was detected in a sample from the 8- to 10-ft interval of SB67B.

Building 257 (Screening Site 67) is the only location in FU6 with nickel exceedances. The nickel concentrations in both the surface and subsurface do not significantly exceed the background values.

Zinc. Four of the 13 surface soil samples analyzed for zinc, including 1 duplicate, contained a zinc concentration that exceeded the background value of 126 mg/kg. The elevated zinc values were concentrated near Building 253 (Screening Site 66) and Building 257 (Screening Site 67). The highest zinc concentration of 541J was found at SS66A, to the northwest of Building 253. The remaining 3 exceedances were barely above background values, with the highest being 193 mg/kg at SS67B.

Zinc was detected in all 14 subsurface samples for which it was analyzed, but no concentrations exceeded the background value of 114 mg/kg.

Overall, slightly elevated zinc concentrations were observed in the surface soil only at Screening Site 66 and Screening Site 67 in this FU. However, zinc was not detected above the background value in the subsurface.

Chromium. Three total chromium concentrations, including 1 duplicate, exceeded the background value of 24.8 mg/kg in the 13 surface soil samples analyzed for chromium at FU6. The chromium concentrations that exceeded the background value were detected in samples collected from SS67A and SB67A. Concentrations were barely above the background value, with the highest value of 27.2 mg/kg occurring at SS67A. The detected concentrations ranged from 11.3 mg/kg to 27.2 mg/kg.

Chromium concentrations in 3 of the 14 subsurface soil samples barely exceeded the background value of 26.4 mg/kg. The elevated chromium concentrations were found only at Screening Site 67 (Building 257) and were located in or above the 6- to 10-ft interval. In SB67B, elevated chromium values were found in both the 3- to 5-ft interval (26.7 mg/kg) and in the 8- to 10-ft interval (27 4 mg/kg); both concentrations were barely above the background value. In SB67A, only the 4- to 6-ft interval had an exceedance above the background value (27.6 mg/kg). No chromium concentrations exceeded the background value at a depth greater than 18 ft.

Chromium was present in surface and subsurface soil samples at concentrations that barely exceeded the background value. These exceedances occurred only near Building 257 (Screening Site 67).

Arsenic. Thirteen surface soil samples, including 2 duplicates, were analyzed for arsenic in FU6. Each sample contained a detected concentration of arsenic, although SS67A was the only location with a concentration above the background value of 20 mg/kg. SS67A contained a concentration of 29.2 mg/kg. The remaining locations contained concentrations ranging from 3.6J mg/kg in SS66A to 17.2 mg/kg in the duplicate of SB67A. No significant cluster of elevated arsenic concentrations was noted that might indicate a release from a specific source.

Of the 14 subsurface soil samples analyzed for arsenic, 1 contained an arsenic concentration that exceeded the background value of 17 mg/kg. The 8- to 10-ft interval of SB67B contained a concentration of 17.3 mg/kg. The concentrations detected at levels below the background value in the remaining 13 samples ranged from 1.2 mg/kg to 13.1 mg/kg. Sample locations SB67A and SB67B contained concentrations in both of their 18- to 20-ft and 38- to 40-ft intervals, but the concentrations were below the background value.

As described above, the arsenic concentrations were detected in both the surface and subsurface soil throughout FU6. Except for two instances, the concentrations of arsenic did not exceed the background value. The highest surface or subsurface concentration of arsenic was only 29.2 mg/kg. Arsenic is present in low concentrations throughout the Depot, probably because of site-wide pesticide management activities.

28.4.1.3 Naturally Occurring Metals

Various samples collected throughout FU6 contained concentrations of calcium and potassium that exceeded background values However, these metals frequently occur in the natural clay soils beneath the site. Specifically, every soil sample analyzed for these constituents at FU6 contained a detected concentration of calcium and potassium. In addition, these metals do not pose significant health risks and generally are not indicative of a release from source areas in FU6. Therefore, the following constituents were classified as naturally occurring metals.

Potassium. Potassium concentrations in five surface soil samples (out of eight total samples) exceeded the background value of 1,820 mg/kg. These elevated potassium concentrations were detected throughout FU6, but no exceedances were greater than twice the background value. Potassium concentrations in five out of seven subsurface soil samples exceeded the background value of 1,800 mg/kg. The elevated potassium concentrations were below twice the background value, and were found throughout the FU.

Calcium. Calcium concentrations in one surface soil sample exceeded the background value of 5,840 mg/kg. The surface soil sample with elevated calcium concentrations (SS66A at 33,800 mg/kg) was located to the northwest of Building 253. No calcium concentrations in subsurface soil samples exceeded the background value of 2,432 mg/kg. Calcium was detected in all eight surface soil samples and all seven subsurface soil samples.

28.4.1.4 Metals below Background Values

Aluminum, barium, cobalt, iron, magnesium, manganese, and vanadium were detected in each of the eight surface soil samples analyzed for these constituents. However, no concentrations of these constituents exceeded the background values of any of these metals.

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Antimony, beryllium, cadmium, and mercury were detected some of the time in the surface soil, but the detected concentrations never exceeded the background values.

Metals that were always detected in the subsurface soil, but never at concentrations exceeding background levels, include aluminum, barium, calcium, cobalt, iron, lead, magnesium, manganese, vanadium, and zinc. Those that were detected some of the time, but never above background levels (if a background value was established), include antimony, beryllium, cadmium, mercury, nickel, selenium, and sodium.

28.4.2 Nature and Extent of SVOC Contamination

28.4.2.1 Surface Soil

On the basis of soil sample results for FU6, the primary SVOCs of concern in the surface soil were determined to be PAHs. As shown on Figure 28-7 and Table 28-4, 7 out of 14 surface sample locations contained detectable concentrations of total PAHs. The total PAH concentrations were detected throughout FU6 in RI Sites 48 and 58, Screening Sites 66 and 68, and BRAC sample SS1A. The detected total PAH concentrations ranged from 0.2J mg/kg in SB66B to 81.4 mg/kg in SS66A.

The 11 individual PAHs that comprised the total PAH data (shown in Table 28-4) were detected above their respective background values in one sample, SS66A. This sample was collected in the nearest stormwater drain northwest of Building 253 to attain a sample representative of the motor pool activities. Four additional samples were taken north of SS66A to evaluate whether the adjacent asphalt was the primary reason for the elevated PAH concentrations. No detected PAH concentrations were observed above background values in any of the four samples.

Concentrations of anthracene (a PAH), BEHP, and di-n-butylphthlate (both SVOCs) were detected in surface soil samples. Anthracene was detected in SB58A and SB58B, but did not exceed the background value of 0.096 mg/kg. No background values were established for comparison against detected concentrations of the two remaining SVOC constituents.

28.4.2.2 Subsurface Soil

As shown in Table 28-4, total PAHs were rarely detected in subsurface soil samples. Total PAH concentrations were detected in only 1 out of the 24 subsurface soil samples. The 3- to 5-ft interval of SS66A contained a total PAH concentration of 0.179 mg/kg.

Fluoranthene, phenanthrene, and pyrene were the three constituents comprising the total PAH data. The fluoranthene concentration of 0.061 mg/kg exceeded the background value of 0 045 mg/kg and the pyrene concentration of 0.066 mg/kg exceeded the background value of 0.042 mg/kg.

Concentrations of BEHP and di-n-butylphthlate (both SVOCs) also were detected in FU6. No background values were established for comparison against detected concentrations for these constituents.

PAHs were the most common VOCs detected throughout FU6 above background values, and they were usually detected in the surface soil. The highest total PAH concentrations were detected primarily around the POL Building 253 (Screening Site 66). SVOCs, including PAHs, were rarely detected in the subsurface soils.

28.4.3 Nature and Extent of Pesticide Contamination

A total of six pesticides were detected in 32 pesticide surface soil samples at FU6. The pesticides were DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin. Table 28-5 lists these pesticides, the number of times they were analyzed, and the minimum and maximum concentrations detected.

In the majority of the sample locations analyzed for pesticides within FU6, the results indicated that pesticides were not present or that the detected concentrations are below background values. However, each pesticide was detected above background values in at least one sample location.

DDT was detected in 19 of the 32 surface soil sample locations, with 14 concentrations, including 3 duplicate samples, above its background value of 0.074 mg/kg (see Table 28-5). Most elevated concentrations of DDT were detected in RI Sites 48 and 58 (Figure 28-8). Elevated concentrations ranged from 0.18 mg/kg to 0.6 mg/kg in four locations in RI Site 48. BRAC sample A(5.1), located in this area, contained a concentration of 0.25 mg/kg One additional location in Site 48 contained a concentration below the background value Elevated concentrations ranged from 0 15 mg/kg to 1.8 mg/kg in two locations in RI Site 58. Two additional locations in Site 58 contained concentrations below the background value. The four remaining locations with elevated concentrations were detected throughout FU6.

Dieldrin was detected throughout the Main Installation and is not associated with known sources of contamination at FU6. It was sprayed routinely on grassy areas and around warehouses. Within FU6, dieldrin was detected in 17 of the 32 surface soil samples and exceeded its background concentration of 0.086 mg/kg in ten samples, which were taken in grassy areas. All 17 detected concentrations were above the GWP value of 0.004 mg/kg. The highest elevated concentrations were located in Parcel 2. BRAC samples A(2.7), B(2 7), and C(2.7) contained concentrations of 5.5J mg/kg, 0.72J mg/kg, and 0.98J mg/kg, respectively (Figure 28-9).

DDE concentrations were observed in 18 of the 32 surface soil samples. Five samples, including one duplicate, contained concentrations above the background value of 0.16 mg/kg (Figure 28-10). The elevated concentrations in the four sample locations ranged from 0.026J mg/kg to 2.3J mg/kg. The locations were dispersed throughout FU6.

DDD concentrations were observed in seven of the 32 surface soil samples. Six samples, including two duplicates, contained concentrations above the background value of 0.0067 mg/kg (Figure 28-11). The elevated concentrations in the four sample locations ranged from 0.026J mg/kg to 0.13J mg/kg. The locations were dispersed throughout FU6.

Alpha-chlordane and gamma-chlordane were each detected in nine out of the 32 surface soil samples. Each pesticide was detected at a concentration above the background value in two locations. SS58I contained an alpha-chlordane concentration of 0.049J mg/kg and a gamma-chlordane concentration of 0.055J mg/kg. BRAC sample D(2.7) contained an alpha-chlordane concentration of 1.2J mg/kg and a gamma-chlordane concentration of 1.1J mg/kg.

28.4.3.1 Pesticides in Subsurface Soil

Seven subsurface soil samples were analyzed for pesticides in FU6. The samples showed no detected concentrations of pesticides in the subsurface soil.

In summary, most of the samples analyzed within FU6 indicate that pesticides were not present or that the detected concentrations were below background values. DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin were the only pesticides detected above background levels in surface soil at FU6. Dieldrin was the only pesticide detected at concentrations above the GWP value. The pesticides were dispersed throughout FU6.

Because the pesticides are distributed throughout FU6, their detection probably is attributable to site-wide application rather than to site-specific, activity-related releases at these specific waste management sites. No pesticides were detected in the subsurface soil above background values.

28.4.4 Nature and Extent of Dioxin and Furan Contamination

Dioxins are ubiquitous in the urban environment and have been detected in the background samples. However, dioxins were not analyzed for in surface soil and subsurface soil in FU6 because records of past activities did not indicate the need to analyze for these parameters in this portion of the Depot.

28.4.5 Nature and Extent of VOCs in Surface and Subsurface Soil

28.4.5.1 VOCs in Surface Soil

A total of 15 VOCs were detected in the 22 surface soil samples analyzed for VOCs throughout FU6. The VOCs are 2-Hexanone, acetone, benzene, bromomethane, carbon disulfide, chloroform, chloromethane, ethyl benzene, MEK, MIBK, methylene chloride, PCE, toluene, total xylenes, and TCE. Table 28-6 presents a list of these compounds, the number of times they were detected, the number of times background values were exceeded (where applicable), and the minimum and maximum concentrations detected.

The majority of the surface soil sample results for VOCs within FU6 indicate no detected concentrations. However, one isolated area contained detected concentrations of VOCs. SB58B contained concentrations of eight VOCs, six of which were only located in this sample location: carbon disulfide, chloromethane, ethyl benzene, toluene, total xylenes, and TCE.

28.4.5.2 VOCs in Subsurface Soil

A total of 28 subsurface soil samples were analyzed for VOCs. The same VOCs detected in surface soil–minus 2-Hexanone, carbon disulfide, chloromethane, MIBK, and PCE–were detected in the subsurface soils (see Table 28-6). Most subsurface soil results showed no concentrations detected. Total xylenes was the only constituent with a background value established for comparison to detected concentrations.

Total xylenes were detected in nine of the 28 subsurface soil samples and exceeded the background value of 0.002 mg/kg in five samples, including one duplicate. The elevated concentrations were all found in Screening Site 67 SB67A had concentrations of 0.4 mg/kg and 0.22 mg/kg in the 4- to 6-ft and 8- to 10-ft intervals. SB67C contained concentrations of 0.57J mg/kg and 0.49J mg/kg in the 8- to 10-ft and 16- to 18-ft intervals.

Probably because of volatilization at the surface, detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations:

- SB58B contained only three VOCs in the subsurface samples. Bromomethane, total xylenes, and TCE were the only detected parameters, compared to the six VOCs detected in the surface samples; and
- Benzene and methylene chloride were detected in four additional sample locations in the subsurface samples. The benzene concentrations were observed in locations where the surface samples showed no presence of benzene. Methylene chloride was observed in three additional locations in Screening Site 66.

Benzene, methylene chloride, and total xylenes were the only VOCs to exceed their respective GWP values. The GWP values for the VOCs detected in the subsurface soil are 16 mg/kg (acetone), 0.03 mg/kg (benzene), 0.2 mg/kg (bromomethane), 0.07 mg/kg (carbon tetrachloride), 0.6 mg/kg (chloroform), 13 mg/kg (ethyl benzene), 17 mg/kg (MEK), 0.02 mg/kg (methylene chloride), 12 mg/kg (toluene), 0.2 mg/kg (total xylenes), and 0.06 mg/kg (TCE).

Benzene was detected in six samples, including one duplicate, and exceeded the GWP value in each instance. Concentrations of benzene ranged from 0.17 mg/kg to 2.0 mg/kg. Each sample was located in Screening Site 67. Methylene chloride was detected in seven locations and exceeded the GWP value once. SB67C contained a concentration of 0.069J mg/kg in the 16- to 18-ft interval. The GWP values for total xylenes were exceeded only in the samples that also exceeded the background value.

In summary, Screening Site 58 (Building 267, Pesticides and Herbicides) is the primary area with VOCs detected in the surface soil and Screening Site 67 (Installation Gas Station, Building 257) is the primary area with VOCs detected in the subsurface soil. Carbon disulfide, chloromethane, ethyl benzene, toluene, total xylenes, and TCE were detected above background in the surface soil at Screening Site 58. Benzene, methylene chloride, and total xylenes were detected above background in the subsurface soil at Screening Site 67. Elevated concentrations of VOCs in subsurface soils probably are not collocated with elevated surface soil concentrations because of volatilization at the surface.

28.5 Nature and Extent of Surface Water Contamination

Stormwater collected in the western third of FU6 is transported to the underground pipe system that empties in the concrete-lined ditch below Lake Danielson, and ultimately discharges off-site to an unnamed tributary south of N Street that discharges into Nonconnah Creek (Black & Veatch, 1999). Stormwater in the central part of FU6 flows through drop inlets to the underground pipe system that discharges either into the pond or into the concrete-lined ditch (Site 52) below the pond. The ditch discharges into an unnamed tributary south of N Street (Outfall 12) that eventually discharges to Nonconnah Creek. Stormwater from the southern portion of FU6 flows via the underground pipe system and discharges to the city's stormwater drainage system south of the community club complex.

Stormwater collected from FU1 passes through FU6 and is discharged off-site to the city's system along Airways Boulevard.

28.6 Nature and Extent of Sediment Contamination

To evaluate the environmental conditions within Building 251 and Building 265, two BRAC sediment samples, A(4.12) and A(4.13), were collected. Sample A(4.12) was collected from a sump beneath a floor drain in the southern end of Building 251 (a thrift shop used for storage and repair). Sample A(4.13) was collected from a sump beneath a floor drain on the eastern side of Building 265 (facility engineer maintenance shop). Contaminants detected in the sump sediment at the two buildings are listed in Tables 28-7, 28-8, and 28-9 and include metals, SVOCs, and petroleum hydrocarbons. These sediments are beneath a grate and are not subject to direct surface water transportation because they are within a covered building. Therefore, the sediments do not present a direct exposure to humans or aquatic organisms. Additionally, Building 251 has been demolished since these samples were taken.

TABLE 28-1
Sampling Rationale at FU6
Memphis Depot Main Installation RI

Site Number and Name	1996-1997 Sampling Rationale	1998 Sampling Rationale	Number of Samples Collected by Media*
RI Site 48 Former PCB Transformer Storage Area	Evaluate whether releases have occurred to surface soil.	No additional environmental sampling was necessary	5 Surface Soil
RI Site 58 Pesticides, Herbicides (Pad 267)	Evaluate whether releases have occurred to surface soil from the past pesticide and herbicide storage/uses	Characterize the vertical extent of contamination at the site	11Surface Soil 4 Subsurface Soil
Screening Site 66 Petroleum, Oil, and Lubricants (POL) Building 253	Evaluate whether releases have occurred to surface soils and subsurface soils.	Provide a confirmation sample for elevated PAH concentrations detected north of the asphalt.	5 Surface Soil 13 Subsurface Soil
Screening Site 67 Installation Gas Station, Building 257	Evaluate whether releases have occurred to surface soils and subsurface soils.	Evaluate whether there has been an effect on groundwater from benzene in subsurface soil. Feasibility Study Information	4 Surface Soil 10 Subsurface Soil
Screening Site 68 POL Building 263	Evaluate whether releases have occurred to subsurface soils	Further characterize the site and provide a consistent data set indicative of current conditions	1 Surface Soil 5 Subsurface Soil
Screening Site 73 All Grassed Areas	Evaluate whether releases have occurred to surface soil from past pesticide use.	No additional environmental sampling was necessary	1 Surface Soil
BRAC–Parcels 1, 2, and 4	Assess the environmental condition of soil in Parcels 1, 2, and 4.	Assess the presence of contaminants (other than pesticides and PCBs) to further characterize the soils in these parcels.	10 Surface Soil 2 Sediment

Notes:
BRAC–Baseline Realignment and Closure Site
PAH–Polynuclear Aromatic Hydrocarbon
PCB–Polychlorinated Biphenyl
RI–Remedial Investigation Site
Surface Soil–Surface Soil Sample
Subsurface Soil–Subsurface Soil Sample
Sediment–Sediment Sample
SW–Surface Water Sample
* Groundwater samples were collected throughout the Main Installation and are identified under FU7, which is discussed in Section 32.0

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TABLE 28-2
Analytes Investigated for FU6
Memphis Depot Main Installation RI

Functional Unit	Site	Matrix[1]	Event	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	Pesticides	Pesticides, TCLP	Pesticides/PCB	Pesticides/PCBs	PAHs	Pet_ Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
6	48	SS	RI							X				X				X		X
6	58	SB	MAINRIFS							X	X							X		X
6	58	SS	MAINRIFS							X	X							X		X
6	58	SS	RI				X			X				X				X		X
6	66	SB	SS							X				X				X		X
6	66	SS	SS							X				X				X		X
6	67	SB	MAINRIFS																	X
6	67	SB	SS							X				X				X		X
6	67	SS	SS							X				X				X		X
6	68	SB	MAINRIFS							X	X							X		X
6	68	SB	SS												X					
6	68	SS	MAINRIFS							X	X							X		X
6	69	SS	SS												X					
6	BRAC	SE	BRAC							X						X		X		
6	BRAC	SS	BRAC											X						
6	BRAC	SS	MAINRIFS							X	X							X		X

Notes
[1]Matrix GW-groundwater, SB-subsurface soil, SS-surface soil, SE-sump sediment
[2]GW Groundwater sampled in March 1996, March 1997, September 1997, June 1998, and October 1998
[3]MAINRIFS Additional samples for RI, BRAC and Screening Sites (and initial investigations for TEC sites) collected in September and October 1998
[4]RI RI Sites sampled in December 1996 and January 1997
[5]SS Screening Sites sampled in December 1996 and January 1997
BRAC Base Realignment and Closure

TABLE 28-3

Frequency of Metals Detections in Surface and Subsurface Soil at FU6

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALUMINUM	8	8	5 12E+03	=	1 37E+04	=	2 38E+04	0
SS	ANTIMONY	12	4	7 00E-01	J	2 90E+00	J	7 00E+00	0
SS	ARSENIC	13	13	3 60E+00	J	2 92E+01	=	2 00E+01	2
SS	BARIUM	8	8	8 65E+01	=	1 68E+02	=	2 34E+02	0
SS	BERYLLIUM	13	7	2 30E-01	J	5 30E-01	J	1 10E+00	0
SS	CADMIUM	13	6	4 00E-02	J	6 20E-01	=	1 40E+00	0
SS	CALCIUM	8	8	9 54E+02	=	3 38E+04	=	5 84E+03	1
SS	CHROMIUM, TOTAL	13	13	1 13E+01	=	2 77E+01	=	2 48E+01	3
SS	COBALT	8	8	4 60E+00	J	1 71E+01	=	1 83E+01	0
SS	COPPER	13	13	1 21E+01	=	5 07E+01	=	3 35E+01	5
SS	IRON	8	8	1 47E+04	=	2 47E+04	=	3 70E+04	0
SS	LEAD	13	13	9 50E+00	=	1 36E+02	=	3 00E+01	6
SS	MAGNESIUM	8	8	1 48E+03	=	3 63E+03	=	4 60E+03	0
SS	MANGANESE	8	8	2 42E+02	J	6 01E+02	=	1 30E+03	0
SS	MERCURY	13	3	2 00E-02	J	3 00E-02	J	4 00E-01	0
SS	NICKEL	13	13	1 19E+01	=	4 11E+01	=	3 00E+01	4
SS	POTASSIUM	8	8	4 01E+02	J	3 09E+03	=	1 82E+03	5
SS	SELENIUM	13	3	6 60E-01	=	8 90E-01	=	8 00E-01	2
SS	SODIUM	8	1	1 52E+02	J	1 52E+02	J		
SS	VANADIUM	8	8	2 00E+01	=	3 20E+01	=	4 84E+01	0
SS	ZINC	13	13	4 04E+01	=	5 41E+02	J	1 26E+02	4
Subsurface Soil									
SB	ALUMINUM	7	7	8 86E+03	=	1 42E+04	=	2 18E+04	0
SB	ANTIMONY	14	5	4 20E-01	J	7 90E-01	J		
SB	ARSENIC	14	14	1 20E+00	=	1 73E+01	=	1 70E+01	1
SB	BARIUM	7	7	7 81E+01	=	1 54E+02	=	3 00E+02	0
SB	BERYLLIUM	14	9	2 60E-01	J	1 20E+00	=	1 20E+00	0
SB	CADMIUM	14	5	1 60E-01	J	2 90E-01	J	1 40E+00	0
SB	CALCIUM	7	7	1 34E+03	=	1 92E+03	=	2 43E+03	0
SB	CHROMIUM TOTAL	14	14	1 07E+01	=	2 76E+01	=	2 64E+01	3
SB	COBALT	7	7	5 00E+00	J	8 80E+00	=	2 04E+01	0
SB	COPPER	14	14	5 30E+00	=	3 39E+01	=	3 27E+01	1
SB	IRON	7	7	9 19E+03	J	1 75E+04	=	3 85E+04	0
SB	LEAD	14	14	4 00E+00	=	1 93E+01	=	2 39E+01	0
SB	MAGNESIUM	7	7	1 75E+03	=	2 40E+03	=	4 90E+03	0
SB	MANGANESE	7	7	4 94E+01	=	6 81E+02	=	1 54E+03	0
SB	MERCURY	14	1	4 00E-02	J	4 00E-02	J	2 00E-01	0
SB	NICKEL	14	13	5 00E+00	=	4 17E+01	=	3 66E+01	1
SB	POTASSIUM	7	7	6 63E+02	=	2 74E+03	=	1 80E+03	5
SB	SELENIUM	14	5	1 00E+00	=	1 70E+00	=	6 00E-01	5
SB	SODIUM	7	1	2 74E+02	J	2 74E+02	J		
SB	VANADIUM	7	7	1 65E+01	=	3 22E+01	=	5 13E+01	0
SB	ZINC	14	14	1 36E+01	=	1 12E+02	=	1 14E+02	0

Notes

All units are mg/kg

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TABLE 28-4

Frequency of SVOCs Detections in Surface and Subsurface Soil at FU6

Memphis Depot Main Installation RI

Matrix	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil										
SS	PAH	ANTHRACENE	14	2	3 80E-02	J	4 70E-02	J	9 60E-02	0
SS	PAH	BENZO(a)ANTHRACENE	14	6	4 50E-02	J	5 40E+00	J	7 10E-01	1
SS	PAH	BENZO(a)PYRENE	14	6	5 20E-02	J	6 30E+00	J	9 60E-01	1
SS	PAH	BENZO(b)FLUORANTHENE	14	5	6 00E-02	J	8 10E+00	J	9 00E-01	1
SS	PAH	BENZO(g h i)PERYLENE	14	6	4 40E-02	J	6 80E+00	J	8 20E-01	1
SS	PAH	BENZO(k)FLUORANTHENE	14	5	6 60E-02	J	7 40E+00	J	7 80E-01	1
SS	PAH	CARBAZOLE	13	2	6 30E-02	J	1 50E+00	J	6 70E-02	1
SS	PAH	CHRYSENE	14	6	6 80E-02	J	9 20E+00	J	9 40E-01	1
SS	PAH	FLUORANTHENE	14	7	7 80E 02	J	1 40E+01	=	1 60E+00	1
SS	PAH	INDENO(1 2 3-c d)PYRENE	14	5	4 20E 02	J	6 20E+00	J	7 00E 01	1
SS	PAH	PHENANTHRENE	14	5	4 80E-02	J	6 00E+00	J	6 10E 01	1
SS	PAH	PYRENE	14	7	4 40E-02	J	1 20E+01	=	1 50E+00	1
SS	PAH	Total Polynuclear Aromatic Hydrocarbons	14	7	2 00E 01	J	8 14E+01	=		
SS	SVOC	bis(2 ETHYLHEXYL) PHTHALATE	13	1	1 40E 01	J	1 40E-01	J		
SS	SVOC	DI-n BUTYL PHTHALATE	13	1	4 40E 02	J	4 40E-02	J		
Subsurface Soil										
SB	PAH	FLUORANTHENE	24	1	6 10E 02	J	6 10E-02	J	4 50E 02	1
SB	PAH	PHENANTHRENE	24	1	5 20E 02	J	5 20E-02	J		
SB	PAH	PYRENE	24	1	6 60E 02	J	6 60E-02	J	4 20E 02	1
SB	PAH	Total Polynuclear Aromatic Hydrocarbons	24	1	1 79E 01	J	1 79E-01	J		
SB	SVOC	bis(2-ETHYLHEXYL) PHTHALATE	19	6	4 60E 02	J	5 30E+00	=		
SB	SVOC	DI n-BUTYL PHTHALATE	19	1	7 70E-02	J	7 70E 02	J		

Notes

All units are mg/kg

TABLE 28-5
Frequency of Pesticides Detections in Surface Soil at FU6
Memphis Depot Main Installation Ri

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	ALPHA-CHLORDANE	32	9	3 20E-03	J	1 20E+00	J	2 90E-02	3
SS	DDD	32	7	5 60E-03	=	1 30E-01	J	6 70E-03	6
SS	DDE	32	18	8 60E-03	=	2 30E+00	J	1 60E-01	5
SS	DDT	32	19	6 80E-03	=	3 50E+00	J	7 40E-02	14
SS	DIELDRIN	32	17	1 30E-02	J	5 50E+00	J	8 60E-02	10
SS	GAMMA-CHLORDANE	32	9	3 70E-03	J	1 10E+00	J	2 60E-02	3

Notes
All units are mg/kg

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TABLE 28-6

Frequency of VOC Detections in Surface and Subsurface Soil at FU6

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Surface Soil									
SS	2-HEXANONE	22	3	2.00E-03	J	4.00E-03	J		
SS	ACETONE	22	5	5.00E-03	J	3.30E-02	=		
SS	BENZENE	22	2	1.00E-03	J	1.00E-03	J		
SS	BROMOMETHANE	22	2	2.00E-03	J	4.00E-03	J		
SS	CARBON DISULFIDE	22	1	8.00E-03	J	8.00E-03	J	2.00E-03	1
SS	CHLOROFORM	22	2	4.00E-03	J	5.00E-03	J		
SS	CHLOROMETHANE	22	1	2.00E-03	J	2.00E-03	J		
SS	ETHYLBENZENE	22	1	1.00E-03	J	1.00E-03	J		
SS	METHYL ETHYL KETONE (2-BUTANONE)	22	3	1.60E-02	J	3.40E-02	=	2.00E-03	3
SS	METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	22	1	6.00E-03	J	6.00E-03	J		
SS	METHYLENE CHLORIDE	22	3	3.00E-03	J	5.00E-03	J		
SS	TETRACHLOROETHYLENE(PCE)	22	2	4.00E-03	J	1.30E-02	=		
SS	TOLUENE	22	1	4.00E-03	J	4.00E-03	J	2.00E-03	1
SS	Total Xylenes	22	1	3.00E-03	J	3.00E-03	J	9.00E-03	0
SS	TRICHLOROETHYLENE (TCE)	22	1	2.00E-03	J	2.00E-03	J		
Subsurface Soil									
SB	ACETONE	28	6	4.00E-03	J	3.50E-01	J		
SB	BENZENE	28	6	8.20E-02	=	2.00E+00	=		
SB	BROMOMETHANE	28	2	1.00E-03	J	4.00E-03	J		
SB	CARBON TETRACHLORIDE	28	2	1.10E-02	J	1.90E-02	=		
SB	CHLOROFORM	28	3	2.00E-03	J	4.30E-02	=		
SB	ETHYLBENZENE	28	4	7.00E-02	J	3.60E-01	J		
SB	METHYL ETHYL KETONE (2-BUTANONE)	28	3	1.60E-02	J	3.80E-01	J		
SB	METHYLENE CHLORIDE	28	7	1.00E-03	J	6.90E-02	J		
SB	TOLUENE	28	1	6.80E-01	=	6.80E-01	=		
SB	Total Xylenes	28	9	1.00E-03	J	5.70E-01	J	2.00E-03	5
SB	TRICHLOROETHYLENE (TCE)	28	1	2.00E-03	J	2.00E-03	J		

Notes

All units are mg/kg

TABLE 28-7

Frequency of Metals Detections in Sediment Soil at FU6

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Sediment Soil									
SE	ALUMINUM	2	2	3 27E+03	J	8 21E+03	J	1 01E+04	0
SE	ANTIMONY	2	2	1 54E+02	J	1 21E+03	J	7 60E+00	2
SE	ARSENIC	2	1	5 30E+00	J	5 30E+00	J	1 20E+01	0
SE	BARIUM	2	2	3 63E+03	J	3 65E+03	J	1 18E+02	2
SE	BERYLLIUM	2	1	3 30E-01	J	3 30E-01	J	1 30E+00	0
SE	CADMIUM	2	2	2 72E+01	=	3 25E+01	=	2 89E+01	1
SE	CALCIUM	2	2	3 08E+04	=	7 91E+04	=	1 49E+04	2
SE	CHROMIUM, TOTAL	2	2	1 58E+02	J	2 57E+02	J	2 00E+01	2
SE	COBALT	2	2	6 54E+01	J	9 09E+01	J	1 36E+01	2
SE	COPPER	2	2	2 50E+03	J	1 42E+04	J	5 80E+01	2
SE	IRON	2	2	9 59E+04	J	1 33E+05	J	2 31E+04	2
SE	LEAD	2	2	3 11E+03	J	3 57E+03	J	3 52E+01	2
SE	MAGNESIUM	2	2	1 16E+04	=	1 70E+04	=	2 44E+03	2
SE	MANGANESE	2	2	5 05E+02	J	7 39E+02	J	8 71E+02	0
SE	MERCURY	2	1	6 70E-01	=	6 70E-01	=	4 00E+00	0
SE	NICKEL	2	2	8 25E+01	=	1 39E+02	=	3 05E+01	2
SE	POTASSIUM	2	2	1 05E+03	=	1 40E+03	=	1 56E+03	0
SE	SELENIUM	2	2	4 99E+01	J	1 82E+02	J	1 70E+00	2
SE	SILVER	2	1	4 90E+01	=	4 90E+01	=	1 80E+00	1
SE	SODIUM	2	2	8 04E+02	J	1 75E+03	J	2 40E+02	2
SE	THALLIUM	2	1	2 10E+01	J	2 10E+01	J	1 10E+00	1
SE	VANADIUM	2	2	1 15E+01	J	1 54E+01	J	3 00E+01	0
SE	ZINC	2	2	4 98E+03	J	5 57E+03	J	7 97E+02	2

Notes

All units are mg/kg

TABLE 28-8
Frequency of SVOCs Detections in Sediment Soil at FU6
Memphis Depot Main Installation RI

Matrix	ChemGroup	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Sediment Soil										
SE	PAH	ACENAPHTHENE	2	1	5 60E-01	J	5 60E-01	J	7 70E-01	0
SE	PAH	ANTHRACENE	2	1	1 20E+00	J	1 20E+00	J	1 60E+00	0
SE	PAH	BENZO(a)ANTHRACENE	2	2	3 00E+00	J	6 50E+00	=	2 90E+00	2
SE	PAH	BENZO(a)PYRENE	2	2	3 00E+00	J	5 40E+00	=	2 50E+00	2
SE	PAH	BENZO(b)FLUORANTHENE	2	2	4 70E+00	J	8 70E+00	=	2 22E+00	2
SE	PAH	BENZO(g h i)PERYLENE	2	2	3 90E-01	J	2 30E+00	J	1 80E+00	1
SE	PAH	BENZO(k)FLUORANTHENE	2	1	3 30E+00	J	3 30E+00	J	2 30E+00	1
SE	PAH	CARBAZOLE	2	1	8 30E-01	J	8 30E-01	J	1 10E+00	0
SE	PAH	CHRYSENE	2	2	5 00E+00	J	9 80E+00	J	3 20E+00	2
SE	PAH	DIBENZ(a,h)ANTHRACENE	2	1	8 60E-01	J	8 60E-01	J	7 00E 01	1
SE	PAH	FLUORANTHENE	2	2	3 10E+00	J	9 00E+00	=	7 10E+00	1
SE	PAH	FLUORENE	2	1	6 00E-01	J	6 00E-01	J	8 70E 01	0
SE	PAH	INDENO(1 2 3-c d)PYRENE	2	1	2 20E+00	J	2 20E+00	J	1 70E+00	1
SE	PAH	PHENANTHRENE	2	2	1 90E+00	J	6 70E+00	=	6 90E+00	0
SE	PAH	PYRENE	2	2	5 60E+00	J	9 70E+00	J	2 88E+00	2
SE	PAH	Total Polynuclear Aromatic Hydrocarbons	2	2	3 41E+01	J	5 94E+01	=		
SE	SVOC	4 METHYLPHENOL (p CRESOL)	2	1	5 10E+00	J	5 10E+00	J		
SE	SVOC	bis(2 ETHYLHEXYL) PHTHALATE	2	2	7 50E+00	=	1 30E+01	J	4 80E-01	2
SE	SVOC	PHENOL	2	1	7 60E-01	J	7 60E-01	J	2 00E-01	1

Notes
All units are mg/kg

TABLE 28-9

Frequency of Other Organics Detections in Sediment Soil at FU6

Memphis Depot Main Installation RI

Matrix	Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Background Value	Number Background Exceedances
Sediment Soil									
SE	PETROLEUM HYDROCARBONS	2	2	1 41E+03	*	1 46E+03	*		
Notes									
All units are mg/kg									

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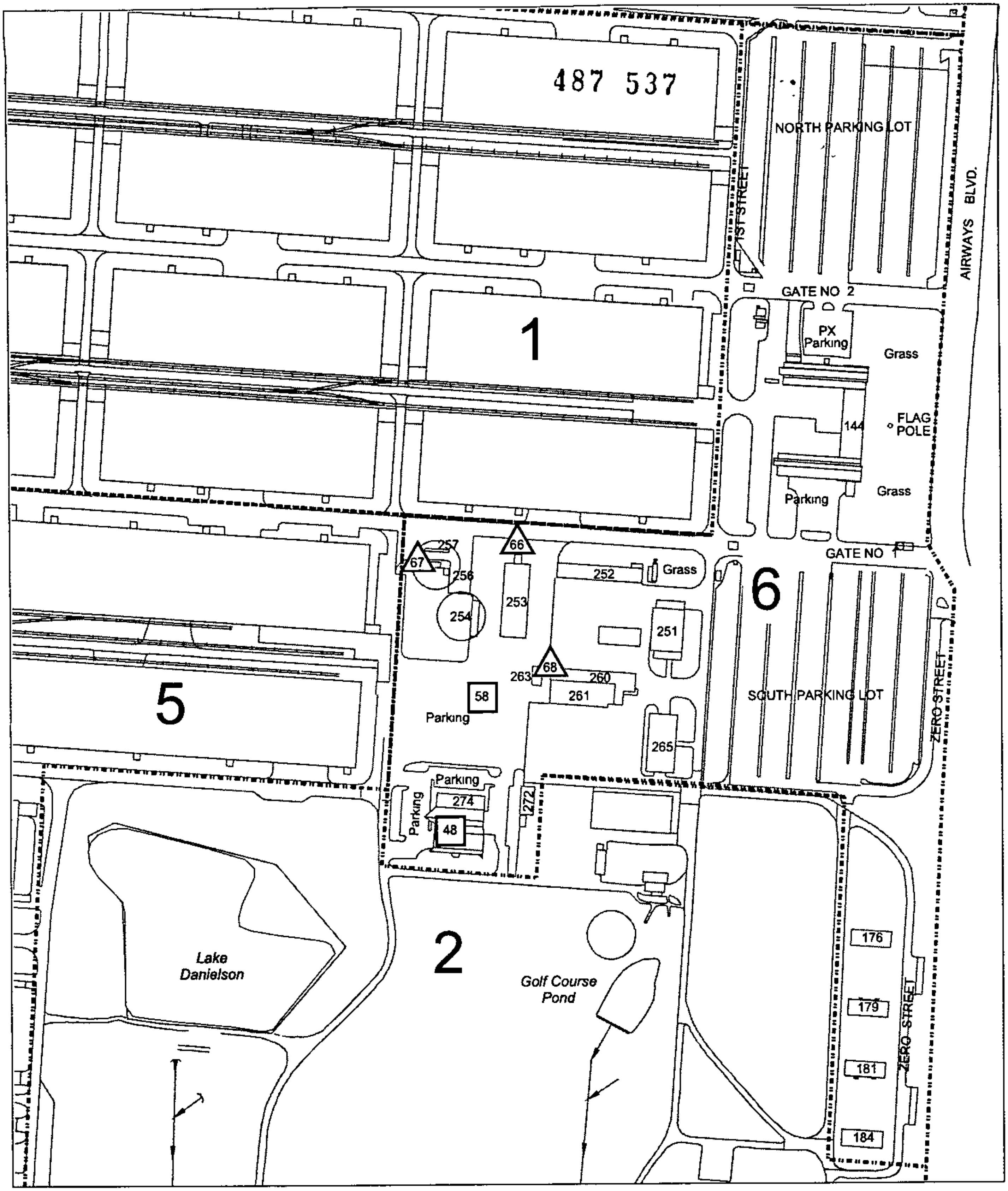

FIGURE 28-1
FU6 LAND COVER AND SITE LOCATIONS
MEMPHIS DEPOT MAIN INSTALLATION RI

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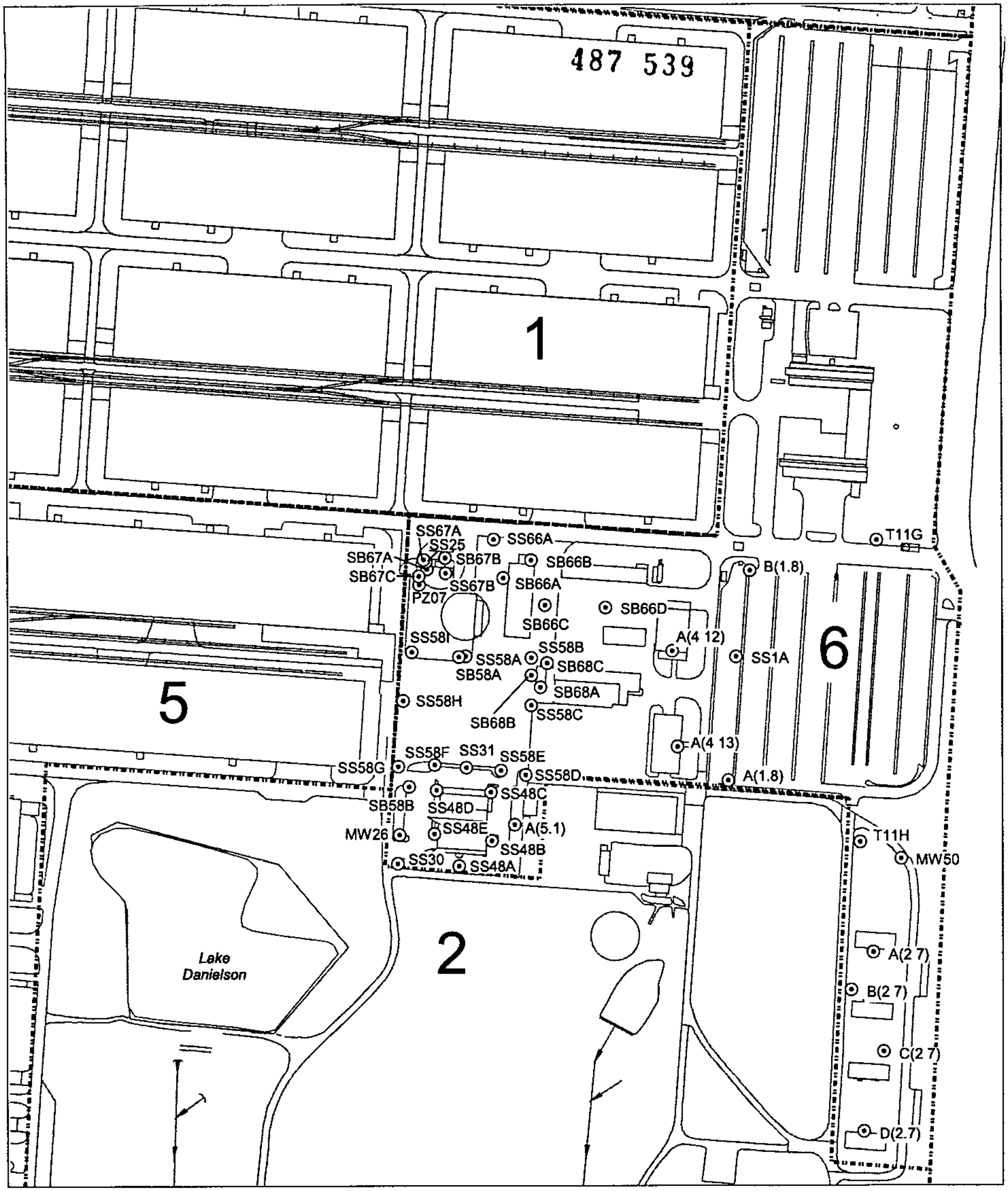

⊙ Sample Locations
Functional Unit Boundary
Surface Water Body
Base Features
Buildings

N

0 150 300 Feet
SCALE IS APPROXIMATE

FIGURE 28-2
SAMPLE LOCATIONS IN FU6
MEMPHIS DEPOT MAIN INSTALLATION RI

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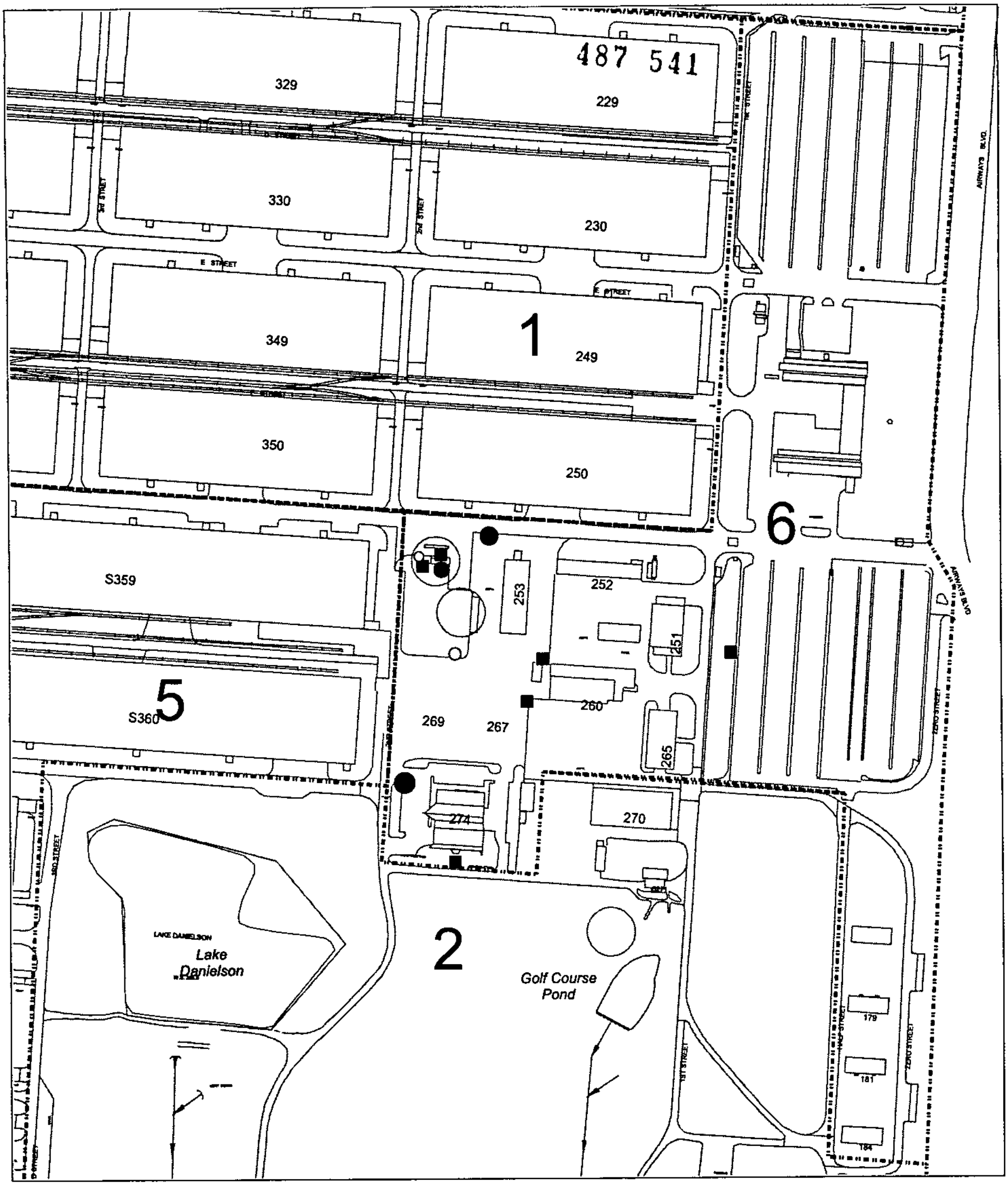

Lead Concentrations
○ 38 4 MG\KG
○ 41 4 MG\KG
51 9 MG\KG
67 1 MG\KG
● 136 MG\KG

■ Concentrations Detected\Below Background (< 30 0 MG\KG)
Text Building Numbers and Road Names
Functional Unit Boundary
Surface Water Body
Base Features
Buildings

N

0 150 300 Feet
SCALE IS APPROXIMATE

FIGURE 28-3
LEAD CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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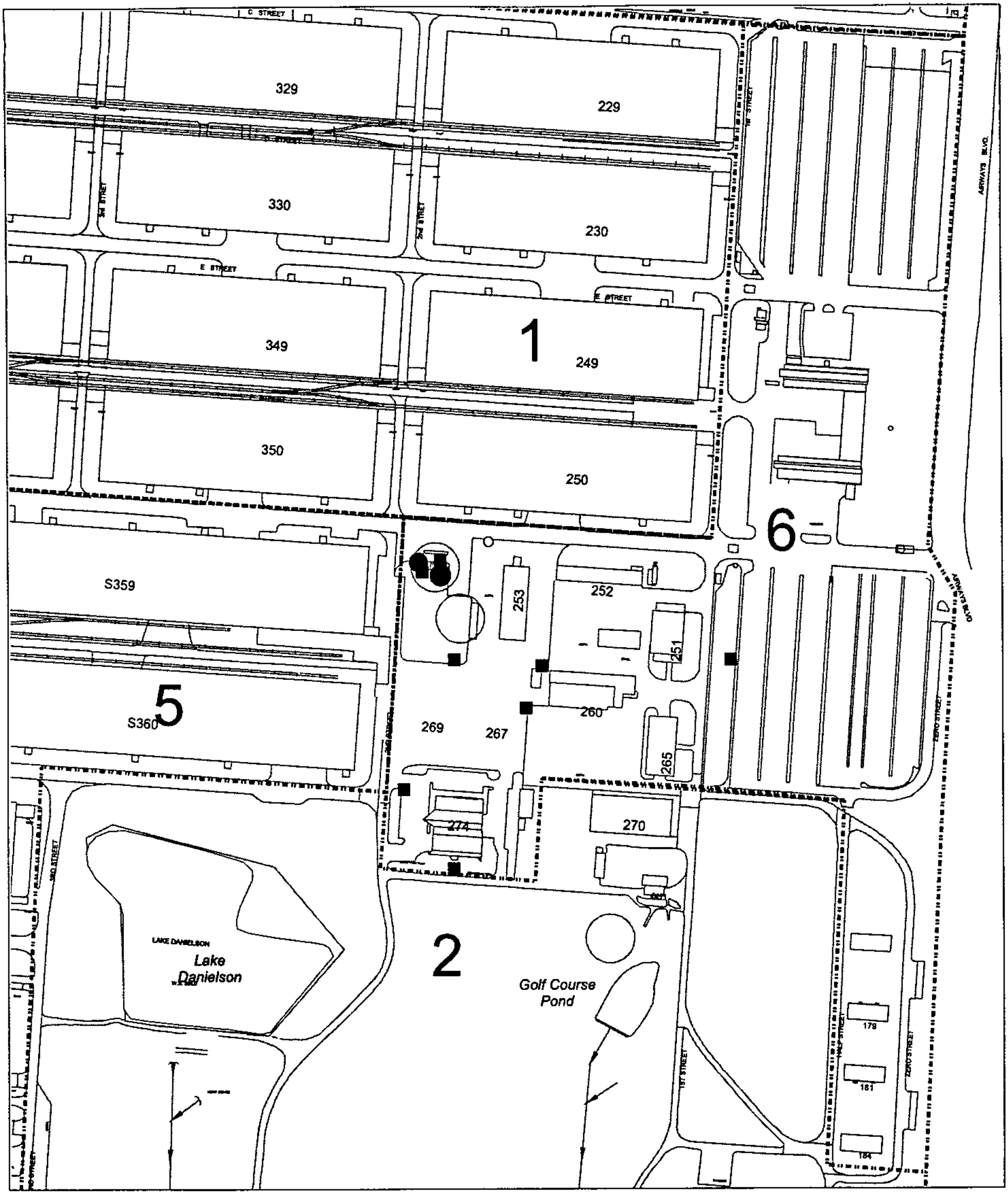

Copper Concentrations
○ 39 1 MG\KG
● 40 1 MG\KG
50 7 MG\KG

■ Concentrations Detected\Below Background (< 33 5 MG\KG)
Text Building Numbers and Road Names
Functional Unit Boundary
Surface Water Body
Base Features
Buildings

N

0 150 300 Feet
SCALE IS APPROXIMATE

FIGURE 28-4
COPPER CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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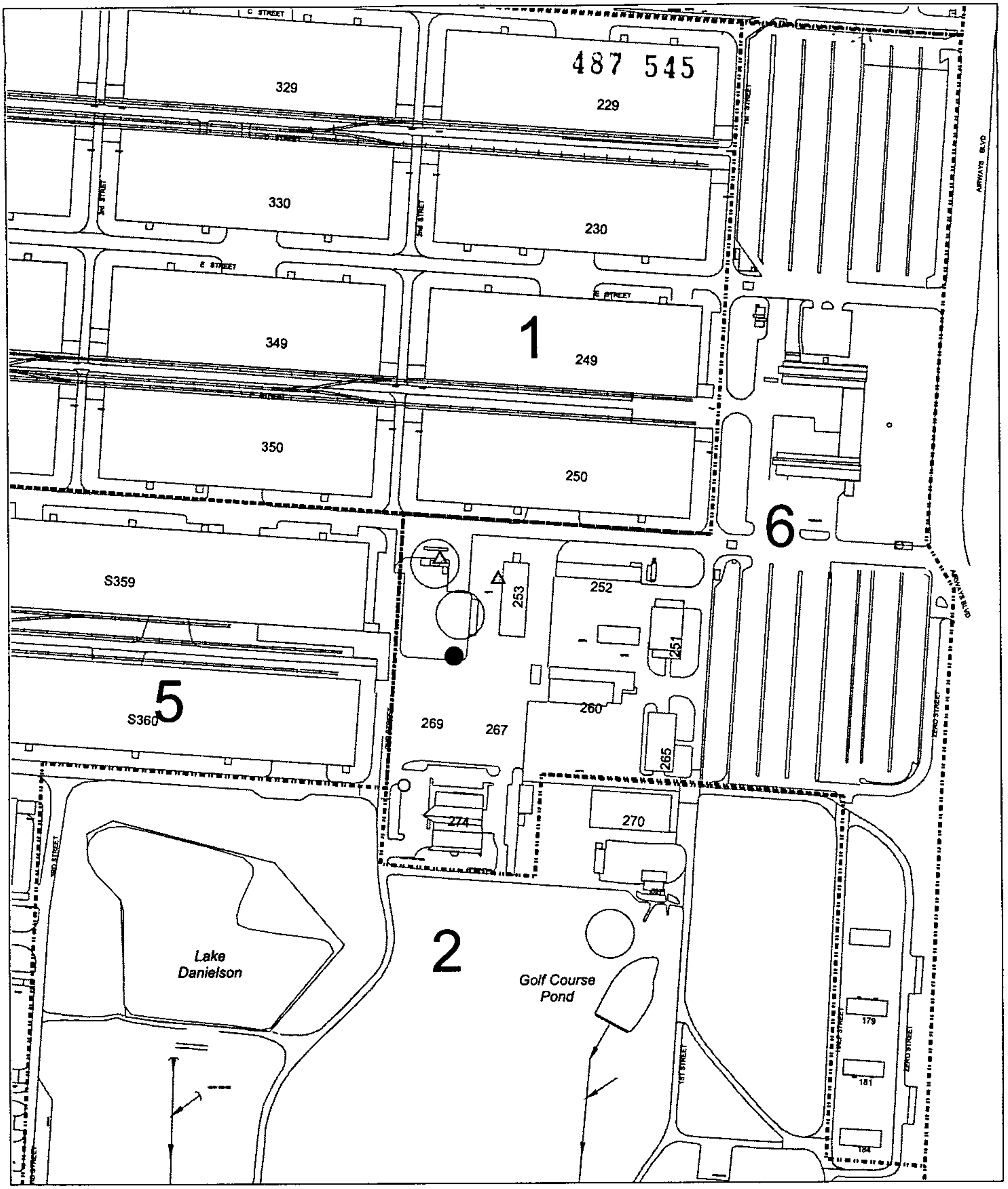

Selenium Concentrations in Depths 3 - 5 Feet

○ 1.3 MG\KG

● 1 7 MG\KG

△ Non-detected

Functional Unit Boundary

Surface Water Body

Text Building Numbers and Road Names

Base Features

Buildings

N

0 150 300 Feet

SCALE IS APPROXIMATE

FIGURE 28-5
SELENIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 3-5 FEET

MEMPHIS DEPOT MAIN INSTALLATION RI

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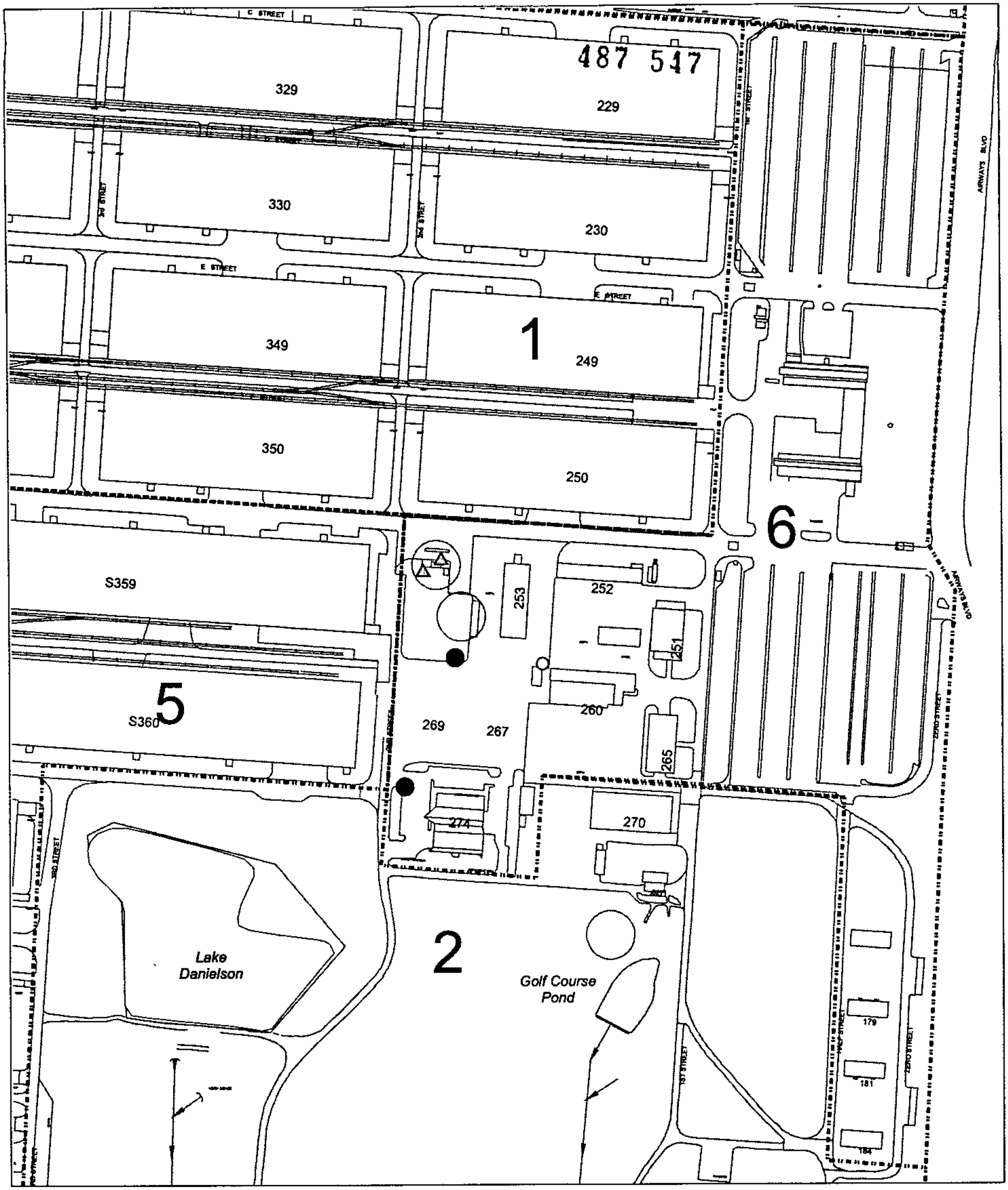

Selenium Concentrations in Depths 8 - 10 Feet

- ○ 1 MG\KG
- ● 1 2 MG\KG
- △ Non-detected
- Functional Unit Boundary
- Surface Water Body
- Text Building Numbers and Road Names
- Base Features
- Buildings

N

0 150 300 Feet

SCALE IS APPROXIMATE

FIGURE 28-6
SELENIUM CONCENTRATIONS IN SUBSURFACE SOIL - DEPTH 8-10 FEET
MEMPHIS DEPOT MAIN INSTALLATION RI

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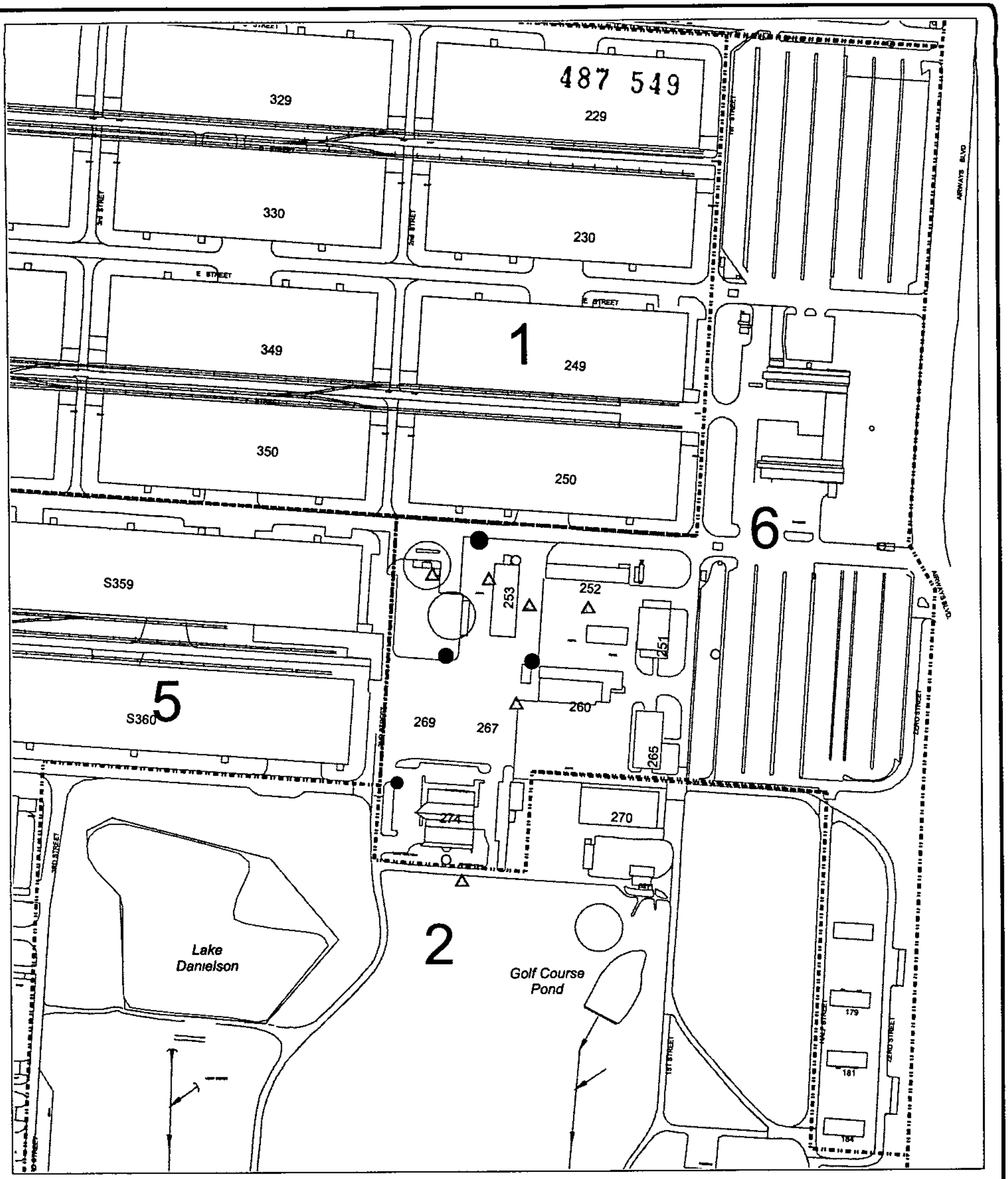

FIGURE 28-7
TOTAL PAH CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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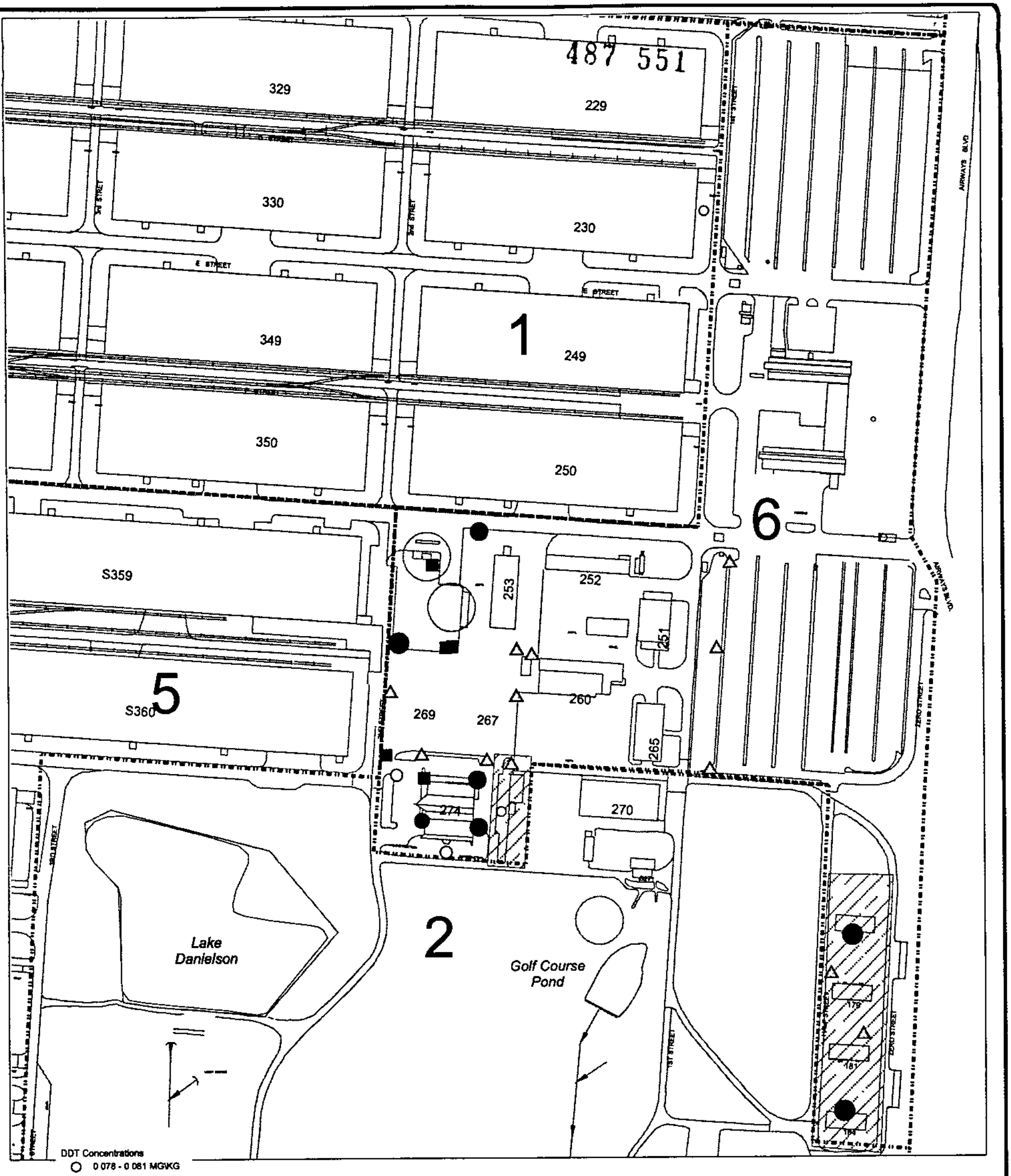

FIGURE 28-8
DDT CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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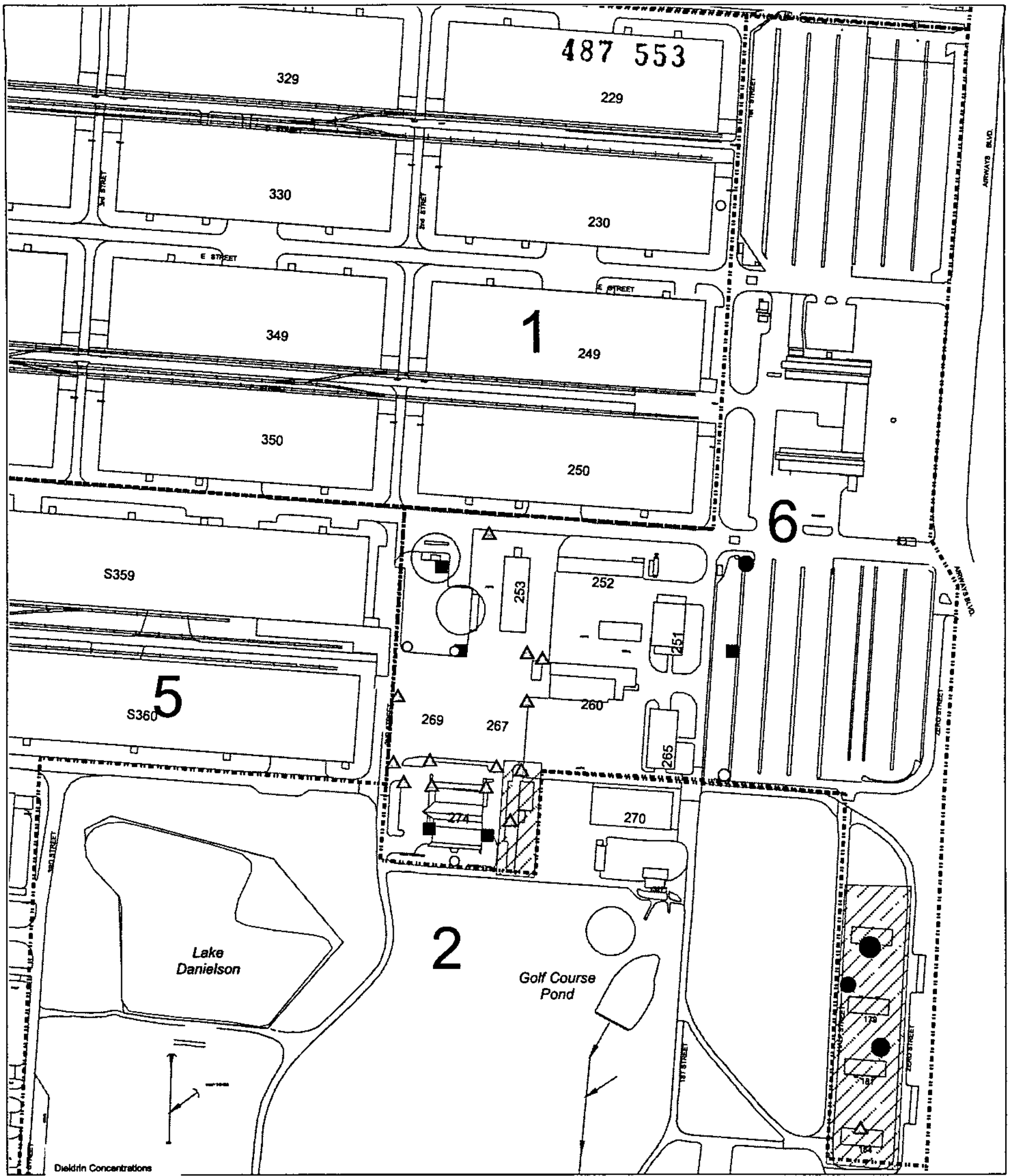

FIGURE 28-9
DIELDRIN CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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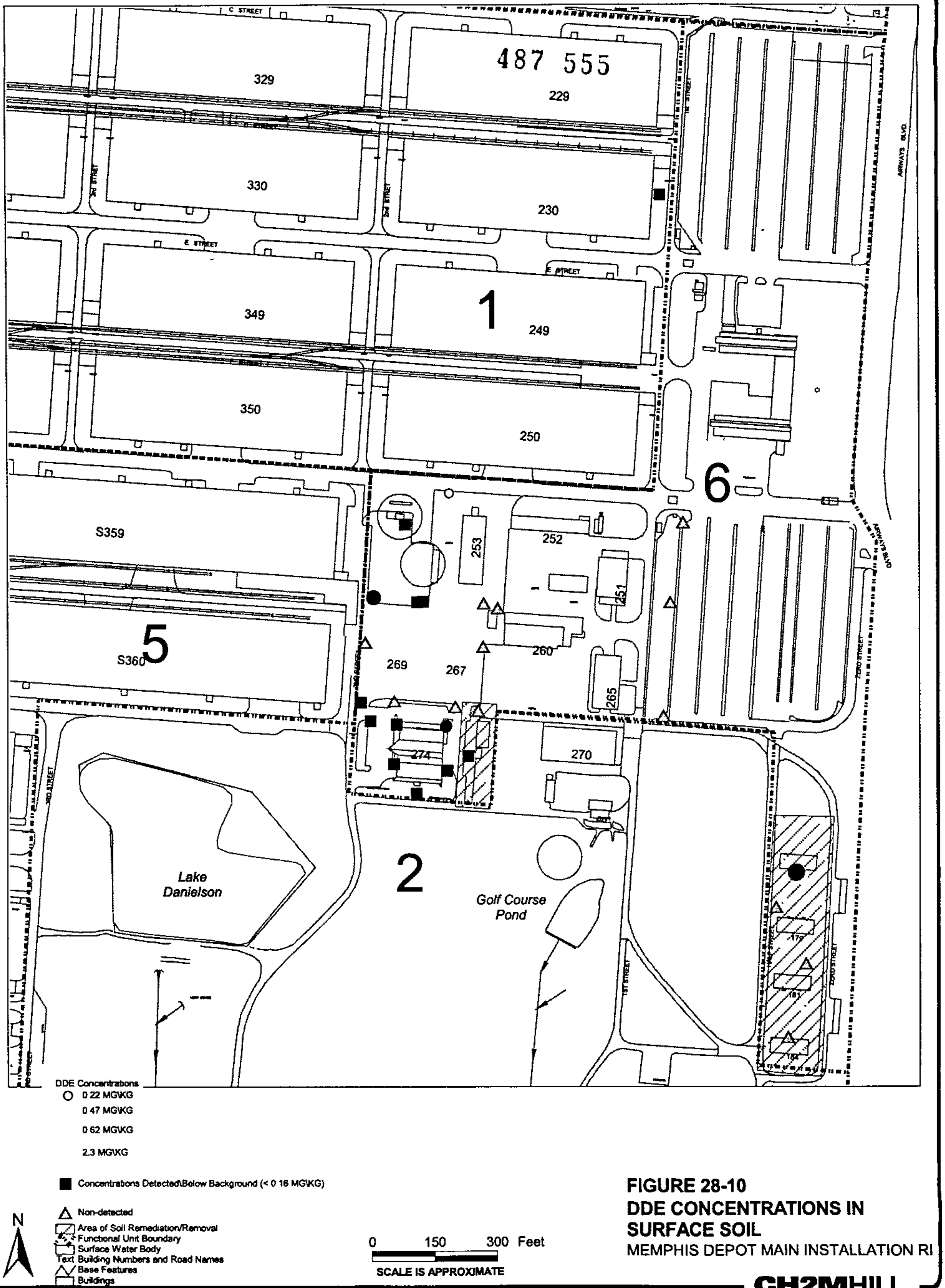

FIGURE 28-10
DDE CONCENTRATIONS IN SURFACE SOIL
MEMPHIS DEPOT MAIN INSTALLATION RI

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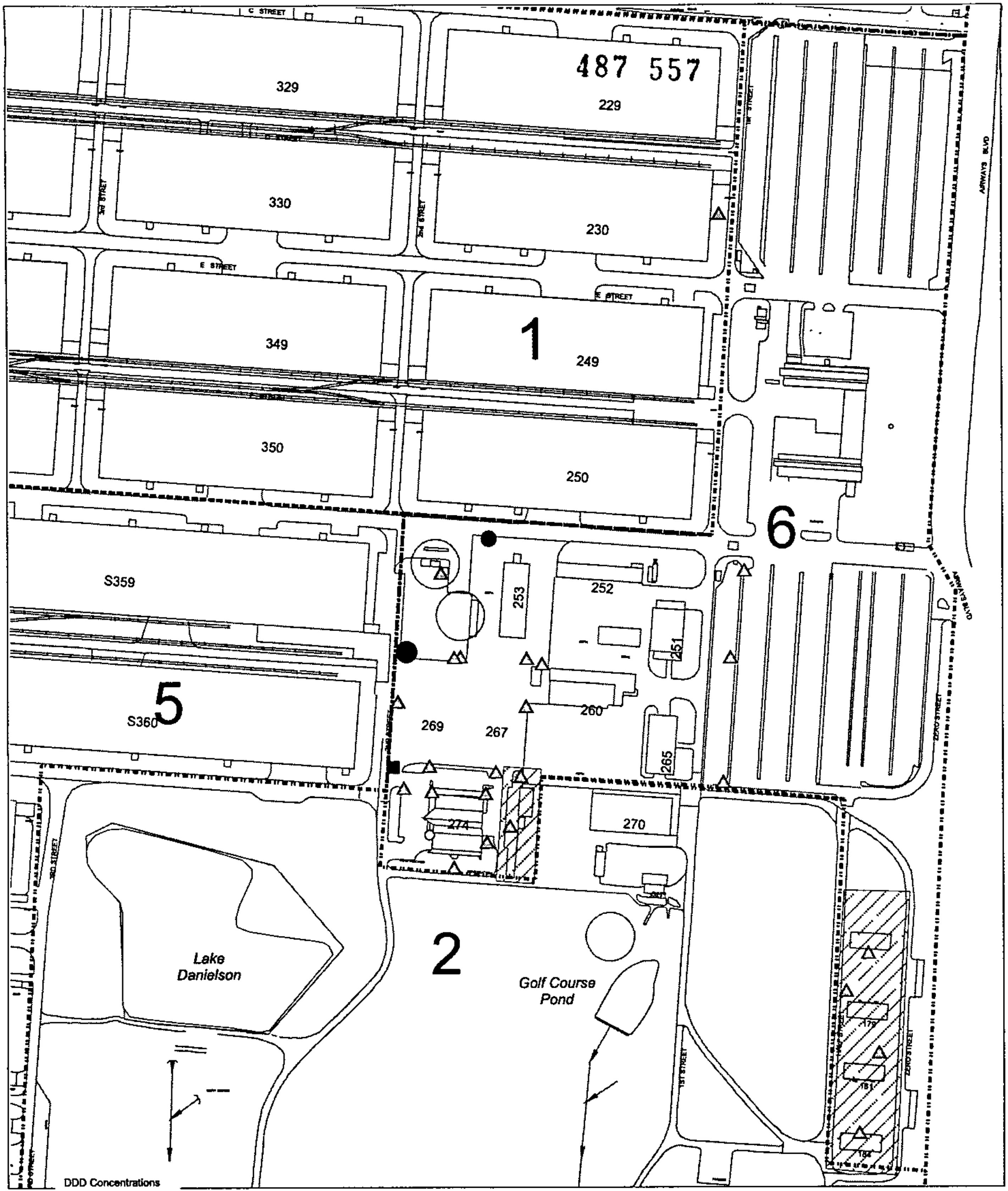

FIGURE 28-11
DDD CONCENTRATIONS IN SURFACE SOIL

MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 29

TAB

29. Fate and Transport for FUle

29.0 Fate and Transport for FU6

The overall fate and transport discussion was included in Section 6.0. This section covers information specific to FU6 and Site 66. The CSM for FU6 is presented on Figure 30-2.

29.1 Fate and Transport for FU6

A summary of site conditions influencing the fate and transport of site contamination is presented in this discussion. Figures 2-16 and 28-1 show the land cover types within FU6.

Source Area Characterization: FU6 consists of the main administration building (Building 144), large parking lots, a police station, a gasoline filling station, a housing area, and several smaller buildings. Building 274 is the new cafeteria building. Most of the surface area in FU6 is covered by asphalt for parking lots and roadways, or concrete-paved roads, with small grassy strips between the roads and the parking lots or surrounding buildings. The complex that includes Buildings 260, 263, 265, and 270 currently is being used as a police station. The area surrounding the old housing buildings and the cafeteria has been replaced with clean soil and fresh sod and the roadway adjacent to the housing buildings has been covered with new asphalt.

Because of the flat surface topography, there is no preferred direction of surface water runoff within FU6. Similar to other areas within the Main Installation, surface water runoff from paved areas is collected in the stormwater drainage system, which in turn drains to concrete-lined open ditches leading off-site from the surface impoundments in FU2 (Parcel 3), and flows east and southeast along Ball Road. The stormwater drainage open ditch system eventually discharges to Nonconnah Creek, located further south approximately 0.6 mile from the Depot. The western portion of the stormwater drainage system drains either to the Golf Course Pond or to the concrete-lined drainage ditches from the pond and Lake Danielson (Sites 51 and 52). These conduits contain water only during rain events. These ditches also join the open drainage ditch, which ultimately reaches Nonconnah Creek.

Tables 6-4 and 30-1 list the COPCs for FU6 surface soils, which were arsenic, PAHs, DDE, DDT, dieldrin, and Aroclor-1260. Arsenic was detected (29 mg/kg) only slightly above the background value (20 mg/kg) in surface soil. Surface soil also had PAHs, mostly along the asphalt roads at concentrations similar to those detected across the Depot. The highest concentration of PAHs was detected near Site 66. Several of the samples had residual chlorinated organic pesticides, at concentrations similar to other areas of the Depot, that are thought to be from historical applications. Subsurface soils at the site had low levels of petroleum hydrocarbons (benzene and xylene) and methylene chloride in a few locations.

Potential Contaminant Migration, Persistence, and Exposure Points: The potential transport and migration pathways at FU6 are considered to be surface runoff, percolation/leaching, and dust emission/volatilization. These pathways are likely to occur mostly in the areas without an impervious cover, which are limited to the strips of grass-covered areas around the warehouse buildings.

Surface Runoff Pathway: The surface runoff pathway is not considered important based on the relatively flat gradient around the various buildings and housing units; surface runoff from the grassy areas is not anticipated. Most of the contamination is associated with grass-covered areas that typically are surrounded by raised roadways, railroad tracks, and buildings, and therefore, are not likely to contribute to off-site runoff. Stormwater from the site is expected to percolate through open areas; in paved areas, stormwater is collected in a stormwater drainage system that flows to the Golf Course Pond within Parcel 3, or the drainage ditches downstream from the ponds. Thus, direct surface runoff from contaminated soils to adjacent FUs or release to surface water features is not a significant pathway of concern for FU6. The off-site drainage ditches were sampled during historical investigations, the results of which indicated that site contaminants were not reaching the off-site drainage ditches (CH2M HILL, 1996). Potential release to an off-site surface water body (i.e., Nonconnah Creek) is therefore not a likely pathway, considering the historical nature of the site operations.

The off-site area to the east of the site is a main road (Airways Boulevard), so any potential off-site migration beyond the property boundary to the east is not likely to reach other properties.

Air/Dust Emission Pathway: The surface soil COPCs did not include any VOCs. The other COPCs are likely to remain bound to the soil, so dust-borne air emissions are somewhat important. Therefore, the potential exposure to dust has been evaluated in the RAs using EPA-recommended dust emission assumptions (PEF = 1.3×10^9 m^3/kg).

The subsurface soils had VOCs, related to petroleum hydrocarbons (e.g., benzene and xylene), that could become airborne through volatilization from subsurface soil or during excavation activities. Thus, exposure to airborne volatiles from shallower subsurface is a potential migration and exposure pathway. Therefore, VOCs were included for inhalation exposure through volatilization using conservative exposure assumptions (see Section 30.0 and Appendix G).

Migration to Groundwater Pathway: Leaching to groundwater is not an issue for any of the surface soil COPCs within FU6, because these chemicals are not readily soluble (see Table 6-2). As a result, they are less mobile for leaching and, except for one occurrence of arsenic that exceeded background, were not detected in the subsurface soil or regional groundwater. Considering the time that has elapsed since the releases occurred, migration may have occurred by now.

The VOCs detected in the subsurface soil are very soluble, are considered mobile, and could reach the groundwater, although they are not distributed widely (6 detected concentrations among 28 samples analyzed). The groundwater underneath FU6 did not have detectable levels of BTEX-related contamination. The nature and extent of contamination at the screening sites were discussed in the *Final Screening Sites Letter Reports* (CH2M HILL, 1998a). Petroleum hydrocarbon constituents (mostly BTEX) were detected in subsurface soils near Site 67 at 4- to 20-ft depths in two samples (SB67A and SB67C). The highest detected concentrations of benzene, ethyl benzene, and xylenes were in samples from 8- to 10-ft depths. The deeper samples had lower concentrations (see Appendix Q). Groundwater may continue to receive some of these VOCs over time, although at very low levels.

The BTEX compounds detected in the deep soils (4 to 10 ft) could volatilize (as indicated by their high vapor pressure) with time into the soil vadose zone and could migrate to the deeper soils and possibly to groundwater. However, all three compounds have short half-lives in groundwater, depending on aerobic and anaerobic conditions, ranging from days to months. The following chart provides half-life values for the BTEX constituents detected in Site 67, based on technical literature (Howard et al., 1991).

Compound	Aerobic	Anaerobic
Benzene	5-16 days	16 weeks-2 years
Toluene	4-22 days	8-30 weeks
Ethyl Benzene	3-10 days	176-288 days
Xylenes	1-4 weeks	6-12 months

The groundwater at Site 67 and in the areas immediately downgradient is not monitored. However, because of the common natural attenuation processes associated with low-level BTEX compounds, these constituents are not expected to be present in groundwater at measurable levels. Groundwater at the site migrates west and northwest to the center of the Main Installation, so off-site migration of the FU6 contamination is not likely to occur. Fluvial aquifer groundwater beneath the Depot in general has been affected by CVOCs, primarily TCE and PCE. Although TCE was detected in one subsurface soil sample at 3J µg/L, this occurrence does not indicate the presence of a significant source of TCE potentially migration to the fluvial aquifer. Groundwater at FU6 flows to the west onto the Depot, so contamination in the groundwater is likely to remain within the site. The potential effects on groundwater are addressed as part of Sections 32.0 to 35.0.

29.2 Fate and Transport for Screening Site 66

The following is a brief summary of the site features that could influence the fate and transport of the contaminants in the site media. Screening Site 66 is located in Building 253, north of the gasoline filling station, in Parcel 4. It consists of the old vehicle maintenance shop within Building 253. Because of the lack of open areas immediately surrounding Building 253, grassy areas across G Street and immediately south of Building 250 were investigated. The site is about 0.22 acre. Building 253 was built in the 1950s and measures 9,600 ft^2. This facility historically has stored 55-gallon drums of petroleum products (hydraulic oil), antifreeze, and a Safety-Kleen unit. Operations consisted mainly of motor pool vehicle services (minor maintenance, oil changes, steam cleaning, cold-solvent degreasing, washing, and lubrication) (CH2M HILL, 1998a). On the basis of this historical site use, constituents expected to be present at this site are petroleum products and PAHs. Figure 28-2 shows the surface and subsurface soil sampling locations.

The surface soils COPCs included PAHs. There were no exceedances of criteria in subsurface soil.

The CSM for Site 66 is identical to the one for FU6 and is presented on Figure 30-5. Primary release mechanisms include historical spills and storage activities. The PAHs detected could be attributable to the asphalt roads and paved areas. Secondary sources of contamination are the site soils with PAHs.

Contaminants could be transported through surface runoff, suspension of entrained dust particles, volatilization into ambient air, and infiltration and leaching from soil to shallow groundwater. Potential off-site migration pathways include surface runoff and dust emissions.

Surface Runoff Pathway: There are no significant drainage features at or near Site 66, which is located in Building 253, leaving limited potential for direct runoff. The entire area surrounding the building is asphalt-paved and the runoff is collected in the stormwater drainage system. The Depot stormwater is collected in a stormwater drainage pipeline, which eventually discharges to the open ditch located along the southern boundary of the property through the ditch at Site 51. Some of these downstream locations were sampled during earlier investigations. These ditches are found to have low-level chlorinated pesticides such as DDT and DDE (CH2M HILL, 1995a). Thus, no site-specific COPCs have reached these off-site areas.

Dust/Air Pathway: Because of the presence of asphalt cover on the soils, dust generation is not an important emission pathway for the site COPCs. However, for conservative risk estimation purposes, it was assumed that the site consists of open area and that the soil COPCs could become airborne. In the risk calculations, EPA's default dust emission assumptions were used (PEF of 1.32 x 10^9 m^3/kg).

Groundwater Migration Pathway: Potential migration to the subsurface soil is not indicated at this site because the site has impervious cover and no surface soil constituents in the deeper soil column. The detected COPCs are relatively insoluble (see Table 6-2) and therefore are not mobile. As a result, the site is not likely to affect the regional groundwater, based on the detected COPCs in the site soils and the lack of exposed surface area.

TAB

Section 30

TAB

30. Baseline Risk Assessment for FU6

30.0 Baseline Risk Assessment for FU6

30.1 Human Health Evaluation for FU6

A RA was conducted for FU6, which includes BRAC parcels and screening sites previously used for administration, vehicle repair maintenance shops, a cafeteria, the old housing area, and parking lots. A surrogate site approach was implemented to conservatively assess potential human health risks in lieu of completing individual RAs at each parcel and site within FU6.. The selection of the surrogate site and the worst-case representative sample point for the future hypothetical residential evaluations was based on exposure units designed according to predicted receptor behavior within an identified site. The approach was described in detail in Section 7.1 and Table 7-1.

The RA for the FU6 sites and parcels included three data groupings, depending on the receptor. First, an FU-wide RA was performed for a current and future industrial land use scenario. In this case, the exposure unit is the entire area of FU6 because a maintenance worker is assumed to work across the entire site. All samples across the FU were used in the exposure and risk calculations. Second, the site with the highest PRE ratio within FU6 was selected as the surrogate site and an industrial exposure scenario was applied for risk estimates to represent an RME scenario. The industrial worker is assumed to work in a limited exposure unit represented by the surrogate site. Finally, a worst-case risk PRE ratio data point within the FU-wide data set (including data from BRAC parcels) was evaluated for the future hypothetical residential scenario. An exposure unit for a resident is assumed be a 0.5-acre lot, represented by the highest PRE data point within FU6. Figure 30-1 presents the various hypothetical exposure units within FU6. The PRE results used as the basis for the surrogate site and the highest PRE data-point selection are presented in Appendix E. Appendix F provides an analysis of exposure levels for various receptors, and provides justification for selection of the most conservative representative exposure scenario for this RA.

FU6 consists of the main administration building (Building 144), large parking lots, a police station, a gasoline filling station, a housing area, and several smaller buildings. Building 274 is the new cafeteria building. Most of the surface area within FU2 is covered by asphalt for parking lots and roadways, or by concrete-paved roads with small grassy strips. The building complex, including Buildings 260, 263, 265, and 270, currently is being used as a police station. The housing buildings are completely surrounded by fresh sod and an asphalt drive. The *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997) proposes to maintain the isolated buildings independently and to convert the housing area into a homeless shelter. A community center is planned for the parking lot area south of the existing administrative building, Building 144. Building 144 is planned for use as training center in the future.

This RA was conducted using data collected as part of the BRAC sampling program (from BRAC Parcels 1, 2, 4, and 5), data from the RI (RI Sites 48 and 58), and data from the screening site investigations (Sites 66, 67, 68, and 73). Screening Site 66, located within

Building 253 east of the gasoline filling station, is an old vehicle maintenance shop. Screening Site 66 is on the southern side of G Street along the southern border of Building 250. The site covers about 0.22 acre.

Data were collected from biased locations within known historical site activity areas to evaluate the maximum possible contamination levels within a site and parcel. When contamination was identified in a sample, the extent of contamination was further defined around that sample in the next phase of sampling. In general, several surface and subsurface soil samples were collected within each site to assess the nature and extent of chemical distributions. A summary of the number of samples collected within an FU and the surrogate site, and the frequency of detection for the detected chemicals, are included in Tables 30-1 to 30-4 and 30-14. Two areas within FU6 were remediated during interim removal actions–the area around the cafeteria, Building 274, and the grass-covered area around the old housing units. Therefore, data collected before the removal actions from these two areas are not included in this RA.

Screening Site 66, the surrogate site for FU6, was selected following the methodology presented in Section 7.1 (see Table 7-1 and Appendix E). This site had the highest PRE ratio in FU6. A separate human health RA was conducted at Site 66. A future utility worker exposure was evaluated for this site. The RGOs are to be calculated for COPCs that present risks for an industrial worker, if the risks and HIs are above the upper limit of the acceptable risk range of 10^{-6} to 10^{-4} at FU6 and/or Site 66. If no excessive risks are observed, no RGOs will be calculated.

30.1.1 Selection of COPCs for FU6

As previously stated, surface and subsurface soil data collected from the BRAC parcels and from the RI and screening sites were used for this RA. Soil COPC selection was based on samples collected from the grassy areas adjacent to paved roadways or parking lots near the buildings within FU6.

Soil samples collected from the housing area and the cafeteria area were excluded because sample locations were eliminated during interim actions. Contaminated surface soils were removed and the excavations refilled with clean soils in both areas. Specifically, samples SS48A, SS48B, SS48C, SS48D, SS48E, A(2.7), B(2.7), C(2.7), D(2.7), and E(2.7) were excluded from the analysis because they were collected from the excavated area before remediation. Residual soil samples collected during the removal actions indicated that contamination was below detection and/or target concentrations in the area (OHM, 1999).

Sump sediment samples at FU6 were collected from Buildings 251 (thrift shop and a small engine and equipment repair shop) and 265 (engine maintenance shop) at sampling stations A(4.12) and A(4.13), respectively. These two samples were included for the COPC selection.

Most of the initial soil samples were analyzed for the TCL/TAL compounds. However, only the detected group of compounds (pesticides) was analyzed in later investigations. As a result, the number of soil samples analyzed differed between chemical groups. Sediment samples were analyzed for metals, SVOCs, and petroleum hydrocarbons. The total number of samples included in the RA ranged from 11 to 23 for surface soil samples and from 7 to 29 for subsurface soil samples; there were 2 samples for sump sediments These data were used to select COPCs to evaluate current and future industrial worker exposure scenarios.

A description of the COPC selection methodology was provided in Section 7.0. Chemicals detected above background values and the RBCs were selected as COPCs for surface and subsurface soil and for sump sediment. A list of COPCs was selected for FU6 by comparing the detected chemical maximum concentration with the background values and health-based criteria (RBC), as presented in Tables 30-1 through 30-4. A table showing human health screening criteria by medium and the results of the COPC selection screening is provided in Appendix D.

The COPCs were selected separately for the FU-wide RA, Site 66 (surrogate site), and the single sample point used for the residential RA. COPCs for FU6 surface soil are arsenic, DDE, DDT, dieldrin, Aroclor-1260, and PAHs. COPCs for FU6 subsurface soil (zero to 10 ft) are arsenic, copper, DDE, DDT, dieldrin, Aroclor-1260, PAHs, benzene, methylene chloride, and total xylenes. For a conservative assessment of risks during excavation types of exposures, all of the surface soil COPCs were included as subsurface soil to account for exposure across the zero- to 10-ft depth range by commercial or industrial workers. This estimation represents a conservative risk analysis for future commercial or industrial worker exposures.

COPCs for the FU6 sump sediment are antimony, barium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc, PAHs, 4-Methylphenol, and petroleum hydrocarbons. Lead levels in the two samples are 3,570 and 3,110 mg/kg in the two sumps from Buildings 251 and 265.

COPCs for surface soil at the highest PRE data point, SS66A, evaluated for residential exposure-related risk estimations are PAHs. The RA for Site 66 is discussed in Section 30.3.

30.1.2 Exposure Assessment for FU6

The regional land use within a 3-mile radius of the Depot is presented on Figure 2-15. Historically, operations in FU6 included administration, cafeteria operations, gasoline filling station, and vehicle repair and maintenance. The housing area was used to house military officers and their families. All of these uses have been discontinued. However, future redevelopment plans recommend using these buildings for other purposes. The building complex, including Buildings 260, 263, 265, and 270, is expected to continue being used as a police station. The main administrative building (Building 144) and the cafeteria building (Building 274) may potentially be used as training centers, and a new community center is planned in the southern parking area. The following text presents a CSM for FU6 and the potentially exposed human receptors within FU6 under current and future land use scenarios.

30.1.2.1 Conceptual Site Model and Fate and Transport Overview

Figure 30-2 presents the exposure CSM for FU6. Each of the components of a CSM is discussed below, including the primary and secondary sources of contamination, primary and secondary release pathways, mechanisms, potential receptors, and routes of exposure.

No hazardous waste handling operations were identified within a large part of FU6. Buildings used for vehicle and small engine maintenance may have left residual wastes in the sump and runoff areas. Other potential sources of soil contamination include routine pesticide applications at the Depot. As noted in the fate and transport discussion in

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Section 6.0, primary release mechanisms include historical spills and leaks from chemical storage areas and the gasoline filling station, and surface application of pesticides, herbicides, and waste oil. Contaminated soils could become secondary sources of contamination. Over time, surface soils could leach more mobile constituents to subsurface soil and eventually to shallow groundwater, if conditions are favorable. "Favorable conditions" can be described as the presence of shallow groundwater under soils that are very porous, high precipitation conditions, and the presence of very mobile chemicals. Most of these conditions do not exist at the Main Installation. The depth to groundwater averages more than 85 ft bgs, with a maximum depth of 132 ft bgs in the northwestern portion (MW-38) to a minimum depth of more than 55 ft bgs. Surficial soils are clayey and relatively impervious, and there are no highly mobile organic COPCs. Therefore, contaminant migration to groundwater is expected to be negligible.

Other potential migration pathways for contaminants could include suspension of entrained dust particles and chemical volatilization into ambient air. On the basis of the chemical and physical characteristics of the COPCs, volatilization is not an important migration pathway because there are no significant concentrations of volatile constituents within FU6. Most of the COPCs are naturally occurring inorganic chemicals, pesticides, and semivolatile constituents. Migration of these chemicals could occur via surface runoff and/or dust-borne emissions.

The nature and extent of the screening sites investigations were included in the *Screening Sites Letter Reports* (CH2M HILL, 1998a). Petroleum hydrocarbon constituents (mostly BTEX) were detected in subsurface soils near Site 67 at 4- to 20-ft depths in two samples (SB67A and SB67C). The highest detected benzene, ethyl benzene, and xylene were at 8- to 10-ft depths. The deeper samples had lower concentrations (see Appendix Q). Groundwater may receive some of these VOCs over time, though at very low levels. Groundwater at the site migrates west and north-west to the center of Main Installation; thus, off-site migration of the FU6 contamination is not likely to occur.

Potential exposure points on-site include areas where human activities and/or ecological receptor occurrences are likely and could result in physical contact with one or more contaminated media. Most of the FU is inactive, with human activity currently limited to the police station and administration buildings (Buildings 270 and 144, respectively) and to the surrounding areas. Most of the current human activity within FU6 is limited to indoor office workers and outdoor facility maintenance workers. The primary activity of interest, maintenance work, typically involves routine activities such as lawn mowing and weed cutting. Future activities may involve construction activities (such as building the community center) for new buildings within FU6.

The potential for direct human exposure depends on the presence of exposed contaminated soil and the types of activities within the contaminated areas. Direct human exposure is limited by pavement and grass cover (Figure 2-16). Much of the surface area at FU6 is covered by grass, concrete, or pavement, thus limiting the potential exposure to soils during maintenance activities. However, for the purposes of this risk evaluation, exposures were assumed to be unlimited. Future exposures were evaluated assuming unrestricted land use. Future land uses are therefore assumed to be maintenance-related work and industrial and residential activities for the entire FU. The exposure units assumed for the various scenarios are identified on Figure 30-1. SS66A is located to the northwest of Building 253 and to the northeast of areas 257 and 256, where buildings once stood. This station is located south of G Street and east of 2nd Street. This area is not likely to be used as a residential area in the future, thus providing a worst-case scenario for future residents. The utility worker can work anywhere in the FU and therefore can be exposed to the larger exposure unit. However, Screening Site 66 was used as a surrogate, potential RME site to evaluate both the industrial and utility workers' exposures. These theoretical assumptions were included to evaluate the site under conservative exposure assumptions.

On the basis of the good functional condition of the warehouse buildings in the area and the planned reuse activities described in the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), the site is likely to remain commercial/industrial, with the addition of a community center and use of housing buildings as a homeless shelter, as previously stated. The future land use plans indicate a need to demolish some of the older buildings to provide adequate parking space for future industrial use. Potential exposure routes for the maintenance worker include incidental ingestion and dermal contact with surface soil and inhalation of particulate emissions via dust from surface soil. Because of the presence of pavement, concrete, and grassy land cover over FU6, dust generation is anticipated to be limited.

30.1.2.2 Potentially Exposed Population and Identification of Complete Exposure Pathways

Currently, most of the buildings in FU6, including the housing area, are not used and the facility is inactive. The potentially exposed population under current conditions includes maintenance workers occasionally cutting grass between the buildings and houses and alongside the roads and parking lots. This area seemed to be under routine maintenance during the site visit. Grassy areas adjacent to the housing buildings and the abandoned cafeteria have been resodded and are under routine maintenance.

Under foreseeable future conditions, potential receptors could include maintenance workers, similar to those identified under current land use. The site is not likely to be used for residential land use because of its physical attributes and historical use; additionally, the site conditions indicate that the buildings, warehouses, and surrounding Depot property could be employed for light industrial use that would provide economic benefits to the surrounding community. The administrative building (Building 144) and the new cafeteria (Building 274) could conceivably be used as a training center to stimulate and support future job growth in the area, but no final decisions on their future uses have been made. Construction activities could occur in the south parking area to build a community center for local community residents. Most of the future activities will be performed indoors, except for construction and maintenance. Therefore, exposure units and receptors identified for other FUs are likely to be representative, yet conservative, surrogate receptors.

However, it has been proposed that the housing area located within FU6 function as a homeless shelter in the future, which may introduce transient residents to the area. Because this is a proposed use and because the future transient residents are likely to be indoors, no yard work or other outdoor activities are likely to occur. Therefore, the future hypothetical residential scenario will conservatively evaluate the transient residential exposure at FU6. Even if these future transient residents are outdoors, the soils around the housing units have been remediated to remove the pesticides detected in soils and have been covered with clean soils and new grass. Thus, the exposure pathways for the users of the housing units are incomplete because of the lack of contamination.

The exposure scenario of a trespasser across the unfenced area around the administration building was not included for quantitation. The Depot is likely to remain light industrial and housing units that may be used for transient residents. If a trespasser/recreational visitor were to be exposed to the administrative area of the FU6 in the future, that receptor exposure is likely to be lower than a future industrial worker exposure. This is because a recreational visitor is likely to have shorter duration and less frequent visits compared to a default industrial worker. Most of the site is occupied by asphalt-paved areas of FU6 rather than the much smaller area of the grass strips, which is where direct exposures are likely to occur. Thus future industrial worker scenario is a conservative representative of a future recreational trespasser scenario. For FU6, both the default worker and the resident scenarios were used as conservative evaluation scenarios for this FU.

For conservative risk estimation purposes, future workers are assumed to contact soils around buildings routinely on a daily basis, during their entire exposure duration (25 years).

A general description of activities to be performed by a maintenance worker within the Depot was provided in Section 7.0. On the basis of occupational duties, it is assumed that a maintenance worker spends half-a-day (4 hours) out of an 8-hour workday, once per week (excluding vacation), 50 days per year for 25 years, cutting grass or weeds around the warehouses in the grass-covered areas around FU6. These are conservative assumptions considering the small size of the grass- and gravel-covered surface soil area in FU6 Exposure of these workers is assumed to occur via incidental ingestion of soil (50 mg/day). The skin surface area accessible for dermal exposure is assumed to include face (1/2 of head area), hands, and forearms. About 4 hours of the 8-hour maintenance workday is assumed to be spent in contaminated areas of the FU, so half of the total incidentally ingested soil is assumed to come from the contaminated soil. Thus, the FI or ET term of the dose estimates is 0.5. The adherence factors used were estimated as documented in Appendix G. Most of the other exposure factors used are default assumptions from the *Exposure Factors Handbook* (EPA, 1997b). Site-specific factors used for EF and ED, as discussed above (½ work-day), are based on best professional judgment. Exposure factors and the rationale for their selection are included in the tables in Appendix G.

As noted previously, future base redevelopment is expected to focus on light manufacturing and warehouse uses, so site activities will remain industrial. Therefore, future potentially exposed populations are expected to be the same as the current human receptors for the site. However, in the interest of conservatism in the risk estimations, it was assumed that the site would be converted to an alternate industrial facility that requires workers to spend more time on the site, with a higher frequency of visits to the contaminated soil areas. This represents the RME scenario for industrial land use. Routes of exposure are identical to those for a maintenance worker, which include incidental ingestion, dermal contact, and inhalation of dust from surface soils.

Future industrial worker exposures were assumed to occur from the surface soil and from subsurface soil in the event the Depot undergoes construction or excavation and subsurface soils become surface soils. Thus, a future industrial worker's long-term exposure to subsurface soil was evaluated. Exposure factors used were the default values for industrial

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workers from the *Exposure Factors Handbook* (EPA, 1997b) and other published sources, as referenced in Appendix G. Under these assumptions, this hypothetical receptor category would represent the maximum or most conservative degree of exposure that would be associated with this site. However, an exception in default EF has been made because of the reality of exposure to sump sediments. It has been estimated that an industrial worker may be exposed to sump sediments 1 hour a week, every week (excluding vacations) for a total of 50 days per year.

Selected areas of the Depot will be landscaped for aesthetic purposes. For example, the northern parking lot will receive landscape work if the redevelopment plan is implemented as proposed. Also, a community center may be built on the southern parking lot. The potential exposure to workers in this area will be conservatively evaluated at the surrogate site, where higher levels of contamination have been identified. Also, there are no Depot activities or other contaminated areas close to the planned community center area. Therefore, future land use alterations and the potential exposure of landscaping workers to surface soil (zero to 2 ft bgs) via direct contact and inhalation of particulate emissions during future redevelopment activities are a likely exposure scenario. This potential future receptor would be expected to have a short ED (1 year or less). Because this scenario results in relatively lower exposure levels compared to those of a maintenance worker, this scenario was not included for quantitation (see Appendix F for relative exposure comparisons).

On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), future residential use of FU6 is unlikely, other than as temporary residence in the planned homeless shelter. However, temporary shelter is distinctly different from permanent housing. Also, the residential area has been remediated, making this an incomplete exposure pathway to potential residents of the housing units. A hypothetical future residential receptor was evaluated in this baseline RA for comparison purposes only. There are no residents within the Main Installation or FU6 under current land use conditions. The nearest off-site residential areas in the vicinity of FU6 are located to the east across Airways Boulevard and to the south beyond the southern border of FU2, south of Ball Road. The only potentially complete exposure pathway for off-site residents is inhalation of particulate emissions from surface soil. Evaluation of the inhalation pathway for a hypothetical future on-site resident is protective against potential off-site residential exposure, because dust generated from on-site areas probably will dissipate to a large extent before reaching off-site areas. Thus, exposures to an off-site receptor are likely to be lower than the potential exposure to an on-site receptor. The risk characterization below includes a comparison of the dust inhalation pathway results to an off-site resident dust inhalation.

Table 30-5 summarizes potential current and future exposure pathways for FU6 and identifies the pathways that were evaluated quantitatively in this RA. Receptors were conservatively selected to be protective of other relatively lower exposure receptors for quantitative risk evaluation for this FU. Appendix F compares each potential receptor to the selected representative exposure scenarios to ensure that selected exposure scenarios are protective against all potential current and future exposures. Under these assumed conditions for exposure under current and future land use, the receptor groups that were considered in deriving estimates of exposure and health risks for FU6 were as follows:

- Current on-site maintenance worker;
- Hypothetical future on-site commercial or industrial worker; and
- Hypothetical future on-site resident–adult and child (for comparison purposes only).

The EPCs were the estimated UCL 95% concentrations for surface and subsurface soils in FU6. EPCs for a maintenance worker and a future industrial worker are either the UCL 95% estimates or the maximum concentrations of the COPCs detected in the surface soil. The EPCs for subsurface soil for the UCL 95% were estimated by combining samples collected from zero- to 10-ft depths (assuming future soil conditions if surface and subsurface soils are mixed during construction and excavation activities). A description of the UCL 95% calculation is provided in Appendix H.

The EPCs for the future residential scenario are the maximum PRE sampling location concentrations for all chemicals detected in that particular sample (e.g., sample SS66A). The estimated EPCs are listed in Tables 30-6 through 30-9. The dose (intake) was estimated for each of the complete exposure pathways (Appendix I).

30.1.3 Toxicity Assessment for FU6

Table 30-8 presents the toxicity factors for COPCs and the WoE classifications for each. Detailed information regarding the basis for the toxicity classification and the uncertainty associated with the listed toxicity factors, based on the EPA toxicity database, is included in the master toxicity tables located in Section 7.0 (Tables 7-7 and 7-8).

The detected carcinogenic chemicals in site soils and sediments were either Class A or B2 carcinogens (see Table 30-10). Oral CSFs are available for arsenic, DDE, DDT, dieldrin, Aroclor-1260, PAHs, carbazole, benzene, and methylene chloride. An inhalation CSF is available for the same constituents with the exception of carbazole and DDE. The individual CSFs for the PAHs were derived using TEFs compared to the BaP CSF. TEFs are available in Table 7-9.

Oral RfD values are available for arsenic, copper, Aroclor-1260, DDT, dieldrin, methylene chloride, and total xylenes. An inhalation RfD was available for methylene chloride only. Oral toxicity factors were adjusted by the gastrointestinal ABS_{GI} factors for comparisons with dermal intake estimates. These values are presented in Table 7-10.

Lead was detected in the sump bottom grit samples grouped as sediments located within Buildings 251 and 265. The concentrations are above the target concentration estimated using TRW's adult lead model (EPA, 1996) of 1,530 mg/kg, which is protective of a worker (see Table 7-16).

30.1.4 Risk Characterization for FU6

Section 7.0 provides the methodology used to calculate risk and HI values; Appendix I provides the actual calculations. The carcinogenic risks and noncarcinogenic HI results from Appendix I are summarized in Table 30-11. A set of histograms of the risks and HIs is presented on Figures 30-3 and 30-4. FU6 was evaluated as one exposure unit. Workers and residents were assumed to have uniform exposures and the EPCs were assumed to be present over the entire surface area of the FU. These are conservative assumptions, because most soil is covered by pavement or grass (Figures 2-16 and 28-1), which restricts direct contact with soil.

The ELCR from surface soil to a maintenance worker from FU6 is estimated at 3 x 10^{-6}, because of arsenic and BaP. The carcinogenic risks are within the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}). The noncarcinogenic HI for the maintenance worker is estimated at 0.007, below the target value of 1.0. The ELCR from sump sediment to a maintenance worker from FU6 is estimated at 1 x 10^{-6}. The carcinogenic risks are at the lower limit of the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}). The noncarcinogenic HI for the maintenance worker is estimated at 0.1, below the target value of 1.0.

Carcinogenic and noncarcinogenic risk estimates for both media are within the acceptable limits. Total surface media risks and hazards were 4 x 10^{-6} and 0.1, respectively. Thus, maintenance worker exposure to the site soils and sediments is not a concern, given that the risks and HIs are within acceptable limits.

The estimated ELCR to an industrial worker from surface soil is 3 x 10^{-5} and subsurface soil mixed with surface soil presents an ELCR of 1 x 10^{-5}, both of which are within the acceptable risk limit range of 10^{-6} to 10^{-4}. Cancer risks were due to arsenic, dieldrin, BaP, and Aroclor-1260 for both surface and subsurface soil estimates. The noncarcinogenic hazards from surface soil and from the soil column (surface and subsurface together) are 0.06 and 0.05, respectively, both of which are below 1.0. The ELCR from sump sediment to an industrial worker from FU6 is estimated at 3 x 10^{-6} and the noncarcinogenic HI for the industrial worker is estimated at 0.4. The carcinogenic risks are within the acceptable range of 1 to 100 in one million (10^{-6} to 10^{-4}) and the HI is below the threshold value of 1.0. Total surface media risks and hazards were 3 x 10^{-5} and 0.5, respectively. Thus, the FU6 soils and sump sediments do not pose a health threat to future industrial workers, despite the conservative exposure assumptions used.

The single point (sample SS66A) specific risk estimate for the residential receptor resulted in an ELCR of 1 x 10^{-4}. Cancer risks were at the upper limit of the acceptable risk range of 10^{-} to 10^{-4}, because of PAHs. Noncarcinogenic hazards were not estimated because no RfDs were identified for these COPCs. This worst-case scenario is included as a hypothetical conservative evaluation scenario, although the site is unlikely to be used for residential purposes. The cumulative inhalation risks to a future on-site adult are at the 6 x 10^{-10} level (see Table I7-4b in Appendix I), which are below the lower end of the acceptable limits. The off-site receptor exposures from airborne, site-related exposures are likely to be lower than these levels. Thus, exposures of off-site residents to on-site contamination are negligible.

There currently are no groundwater exposures for these receptors and none are likely in the foreseeable future because of the established water use patterns in the area and because water is provided from the public water supply system. The groundwater underneath FU6 (MW-50 and PZ-07) did not have detectable levels of organic contamination. Also, the groundwater flow is toward the center of the Main Installation. Therefore, future potential exposures to on-site receptors and immediate off-site receptors are primarily from soils at the site.

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The site-specific risk evaluations under current land use conditions do not present excess risk (risks above the 10^{-4} level) to a future industrial worker. The future potential use of FU6 for industrial purposes does not pose a human health risk concern, because the risks and the HIs to a future industrial worker are within acceptable limits. Therefore, RGOs were not developed for COPCs, because none presented excessive risks or HIs.

Lead concentrations in the sediment (sump bottom grit) samples from inside Buildings 251 and 265 are elevated above the target concentration of 1,536 mg/kg. However, direct exposure to these sediments is expected to be limited, so risks from direct exposures are not likely to be significant. For long-term prevention of direct exposures and potential release to the subsurface environment, the sump grit lead has been eliminated and the sumps have been grouted. Building 251 also has been demolished.

30.1.4.1 Uncertainty Analysis

Section 7.0 presents the general concepts and sources of uncertainty at a given site. The following are some of the major points pertaining to FU6.

30.1.4.2 Constituents of Potential Concern

Data were collected from 1996 to 1998. Many of the COPCs, such as PAHs and metals, also were detected in background soils. Several of the PAHs were detected at higher concentrations along the railroad tracks within the Depot. Operations at several of the sites did not involve PAHs as potential source constituents. Pesticides and the PCB Aroclor-1260 were not used in the storage-related operations. Pesticides may have been applied during routine maintenance of the storage facilities. Likewise, site-wide statistical evaluations indicated that most of the inorganic chemicals and some of the organic contaminants (PAHs, DDT, DDE, and dieldrin) were similarly distributed in the background samples. Some of the inorganic COPCs were selected based on their exceedance of the GWP criteria. These chemicals are not a direct exposure concern. However, their inclusion contributes to the conservatism of the risk estimation.

Subsurface soil organic COPCs are the same as the surface soil COPCs, although most of the organic chemicals were not detected in the deeper soils below 1 ft within FU6 because they tend to remain within the first few inches of the surface. Surface soils in this data set were defined as those from zero to 2 ft, whereas deeper soil was evaluated from zero to 10 ft. EPA defines a "surface soil" as being in the zero- to 1-ft range. Some of the surface soil samples were collected from within the first 1 ft bgs; however, to obtain a large enough data set for statistical evaluations, samples collected from slightly deeper areas were included in the surface soil group. Individual depths of the samples are included in Appendix Q.

Exposure Assessment. There are no exposures under current conditions except for occasional maintenance of the grounds. Most of the area within FU6 is paved or grass-covered. Some of the samples collected were from paved areas; however, they were assumed to be readily available for exposure. There are no human receptors in FU6, except in the administration buildings and police station, as mentioned previously. This site is highly unlikely to be used for residential purposes without significant structural changes to the existing buildings. The housing area is the only area within the FU or the Depot where residents could be expected in the future. The area has been remediated for the organochlorine pesticides detected in surface soil and has been resodded. Thus, the future exposure pathway is incomplete because of a lack of contamination. This area is separated from the rest of the Depot by a fence. Future land use considerations for the Depot include various small industrial uses; thus, land use is likely to remain industrial or commercial. Under future land use, also, indoor office workers are rarely in contact with the grass strips around the warehouses. Much of the direct exposure is limited because of the presence of paved roads and walkways around the buildings. Utility and future industrial worker exposure to subsurface soil that becomes surface soil through excavation types of activities is a conservative risk estimation scenario.

Most of the quantitative exposure values such as EF and ED are assumed values, and the true likely exposure of a receptor is not known. Most of the uncertainty within RAs is attributable to this exposure quantitation step.

Toxicity Assessment. The toxicity criteria used are those recommended by EPA through the toxicity databases; therefore, the uncertainty associated with the toxicity factors is predetermined by the methods used and the studies selected by EPA in calculating these toxicity factors. The quantitative UFs associated with toxicity factors are included in the master toxicity factors tables (Tables 7-7 and 7-8). Some of the primary sources of uncertainty are listed there. Most of the toxicity factors are based on studies from animals extrapolated to humans using arbitrary assumptions (e.g. UF, or MF), which introduces a major uncertainty. In extrapolating to the low carcinogenic dose levels for the slope factor estimation, no threshold for toxicity is assumed. Some of the metal toxicity factors are based on evidence of toxicity from occupational exposures (e.g., chromium) involving a high level of exposures to fumes and airborne particles. The applicability of these data to environmental exposures requires close scrutiny.

Risk Characterization. As noted previously, the assumptions used to estimate risks and hazards in this assessment are conservative. Several scenarios were evaluated to simulate possible alternative future land uses at FU6. The fact that samples were collected from biased locations within suspected past activity and spill areas near warehouses adds to the conservatism of the estimates. Thus, the areas represented by each sample in the combined assessment at the FU6 level represent the areas of highest contamination within the site and FU.

30.1.4.3 Remedial Goal Options

Quantitative RGOs were not calculated for any of the surface media at the site because exposures did not result in excessive risks associated with the soils and other surface media. Also, there are no human health protection-based ARARs for soils. A general list of RGOs for some of the primary COPCs detected across the Depot is included in Section 7.0.

RGOs are developed only for the chemicals that are detected at the site at concentrations either above the applicable state or federal standards or that present risks or HIs above the acceptable levels. "Acceptable" risks are defined as risk levels above 100 in one million (10^{-4}) or HI above 1.0, for either current or future exposure pathways for a worker analyzed in the RA. The risk evaluations under future land use conditions included potential exposures of maintenance, industrial, and utility workers within FU6 based on activities observed to be applicable to the site. Hypothetical future scenarios included residential land use.

The groundwater within the area is addressed as part of the groundwater FU (see Section 34.0). The site groundwater currently is not used within the Depot. Shallow groundwater does not qualify for potable use. There is no contaminated groundwater under FU6, and the groundwater under the facility was addressed as part of FU7 (Sections 32.0 through 35.0).

Lead concentrations in the sediment (sump bottom grit) samples from inside Buildings 351 and 365 are elevated above the target concentration of 1,536 mg/kg. The two lead concentrations are 3,110 mg/kg and 3,570 mg/kg. These may need to be addressed for potential future industrial use.

30.2 Environmental Evaluation for FU6

30.2.1 Introduction

An ERA was conducted at FU6, the Administrative and Residential Areas, to evaluate whether contaminants detected in surface soil potentially pose adverse ecological effects to terrestrial receptors. FU6 is primarily a light industrial area that contains administrative buildings, a small area of residential buildings, and large paved parking lots. A few mowed grass areas occur adjacent to the buildings and roadways, but provide little, if any, ecological habitat for terrestrial plants or animals. The land use at FU6 is expected to remain unchanged in the future. EPA ERA guidance (EPA, 1997d) recommends a screening level ERA for risk management decisions. Although the mowed grass areas within FU6 do not provide a significant habitat, a screening level ERA was initiated to aid in risk management decisions.

This ERA was conducted in accordance with the *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (*Process Document*)(EPA, 1997d). Steps 1, 2, and 3 of the EPA ERA model were completed, as summarized in Section 7.8.

30.2.2 Step 1: Screening Level Problem Formulation and Effects Evaluation

This is the initial step in the ERA and includes all the elements of a problem formulation and ecological effects analysis, but on a screening level. The results of this step support the exposure estimates and risk calculation in Step 2.

30.2.2.1 Environmental Setting and Contaminants at the Site

The environmental setting at the Depot is described in Section 2.0. An ecological assessment checklist was completed as described in the Process Document (EPA, 1997d) and is provided in Appendix S. Site characteristics most relevant to the ERA are discussed here.

Most of FU6 consists of asphalt parking areas and a few administrative buildings. South of the administrative area is the residential housing area, where residential housing and detached garages were built in 1948. The houses remain residential, but the detached garages have been used for automotive storage and maintenance. There is some routinely mowed grass cover within FU6 in the residential area. The eastern portion of this FU contains Gate 1, which provides an entrance into the Main Installation off of Airways Boulevard.

Numerous buildings behind the southern parking lot have purposes largely related to maintenance and automotive activities. These activities include vehicle storage and maintenance shops, heating fuel storage, vehicle grease rack, and a gas station. This FU also includes a former building location used for storing and mixing pesticides and herbicides. Other miscellaneous building uses include a thrift shop, former pro shop, and facility installation services building.

There is no significant ecological habitat at FU6. The limited groundcover consists predominantly of paved roadways, parking lots, and strips of routinely mowed grass and landscape plants along the buildings and within the residential area. There are no on-site aquatic habitats (e.g., ponds or ditches). Potentially occurring wildlife may include tolerant birds such as sparrows, rock doves, grackles, and mockingbirds, and small mammals such as mice, rats, and shrews. There are no on-site aquatic habitats or wetlands, and no state or federally endangered or threatened species are known to inhabit the area of the site (TDEC, 1996; USFWS, 1996; and Appendix T). Overall, the habitat at this site is highly disturbed and of poor quality. The land use of this FU is expected to remain unchanged into the foreseeable future.

Land use in the immediate vicinity of the site primarily consists of industrial areas associated with the Main Installation. A residential community occurs to the east, beyond the fenced property boundary (Figure 2-15).

Surface soil is the only medium sampled at FU6 to which terrestrial ecological receptors could be exposed and is, therefore, the only medium evaluated in this ERA. A list of surface soil COPCs at this FU is provided in Section 26.1.1.

30.2.2.2 Contaminant Fate and Transport

An overview of contaminant fate and transport of chemicals detected at FU6 is provided in Section 24.0 and is not repeated here.

30.2.2.3 Complete Exposure Pathways

For a pathway to be complete, a contaminant must travel from the source medium or media to an ecological receptor and be taken up by the receptor via one or more exposure routes. Although ecological habitats are minimal to non-existent at FU6, a conservative assumption was made that a potentially complete exposure pathway may exist for direct contact of terrestrial plants and invertebrates with contaminants detected in surface soil. There are no other potentially complete exposure pathways at this site.

30.2.2.4 Assessment and Measurement Endpoints

Assessment endpoints are expressions of the environmental value(s) to be protected. The assessment endpoint for FU6 is to sustain soil quality and to achieve COPC concentrations that are below adverse effect thresholds for plants and soil invertebrates. Measurement endpoints are measurable ecological characteristics of the assessment endpoint. In this screening level evaluation, the measurement endpoint is the ratio of surface soil maximum concentrations to conservative screening level soil benchmarks. An exceedance of soil COPC concentrations compared to the benchmarks would be a "measure" of a potential effect If

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an exceedance occurs, it can be inferred that a possible adverse effect may occur to exposed ecological receptors.

30.2.2.5 Screening Level Ecological Effects Evaluation

Conservative thresholds for adverse ecological effects, or screening ecotoxicity values, were used for contaminants detected in surface soil. These values were determined as follows:

- **Surface Soil:** the soil ecological screening values are those recommended by EPA Region IV (1998). The EPA values were obtained from a variety of sources, including the USFWS, the ORNL, the Canadian Council of Ministers of the Environment, the Netherlands Ministry of Housing, and the RIVM.

The screening soil ecotoxicity values are provided in Table 7-14.

30.2.2.6 Uncertainty Assessment

Uncertainty is inherent in each step of the ERA. The following text presents major factors contributing to uncertainty in this assessment.

EPCs were assumed to be maximum soil concentrations. This is a highly conservative assumption that may overestimate risk. Under this assumption, the receptor spends 100 percent of its life cycle at the highest concentration area; although this can be true for plants, most terrestrial wildlife receptors are mobile and can be exposed to the complete range of soil concentrations.

The soil criteria used were obtained from various sources in the literature and may not be representative of actual site conditions. Exposure pathways to terrestrial plants and animals were assumed to be potentially complete, even though the maintained grass habitats do not provide suitable habitat in this industrial setting.

30.2.3 Step 2: Screening Level Exposure Estimate and Risk Calculation

This step includes estimating exposure levels and screening for ecological risks as the last two phases of the screening level ERA. At the end of Step 2, an SMDP will be made to assess whether ecological risks are negligible or whether further evaluation is warranted.

30.2.3.1 Screening Level Exposure Estimate

The maximum concentration of all chemicals detected in surface soil at FU6 was used as the EPC for estimating risk to directly exposed terrestrial organisms.

30.2.3.2 Screening Level Risk Characterization

The quantitative screening level risk estimate was conducted using the HQ approach. This approach divides the EPCs (maximum detected soil value) by the soil screening ecotoxicity values.

Table 30-12 summarizes the results of the surface soil screening level risk calculations. This table provides information regarding the FOD, range of detection, selected soil criteria, and HQs based on a comparison of the maximum concentration to the criteria. An HQ less than 1.0 indicates that the contaminant is unlikely to cause adverse effects and is therefore not considered further in the ERA. Contaminants with HQs greater than or equal to 1.0, or contaminants for which criteria were not available, were identified as COPCs and were carried forward to Step 3.

A total of 12 inorganic and 29 organic compounds were identified as COPCs in surface soil. No screening criteria were available for 8 of the organic compounds.

30.2.3.3 Scientific Management Decision Point

The Step 2 screening information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted. The identified COPCs are to be carried forward to Step 3.

30.2.4 Step 3: Baseline Risk Assessment Problem Formulation

Step 3 refines the problem formulation developed in the screening level assessment. In this step, the results of the screening level assessment and additional site-specific information are used to determine the scope and goals of the baseline ERA.

30.2.4.1 Refinement of COPCs

In Steps 1 and 2, conservative assumptions were used. As a result, some of the COPCs were retained for Step 3, although they may pose only negligible risk. Therefore, in this first phase of Step 3, the assumptions used were further evaluated and other site-specific information was considered to refine the list of COPCs. In this refinement phase, the revised assumptions and site-specific considerations used were as follows:

- Arithmetic mean contaminant concentrations were considered, along with maximum concentrations when a comparison to the benchmarks was conducted,
- Arithmetic average and maximum values were compared to background concentrations,
- Contaminant concentrations were compared to background values,
- The FOD was considered, and
- Less conservative (secondary) soil screening values were considered in addition to the more conservative (primary) screening values used in Step 2.

The secondary benchmarks described above were identified to provide a less conservative benchmark for comparison with site contaminant exposure concentrations. The secondary benchmark selection process focused on identifying the next highest benchmark value among the soil literature references used by EPA Region IV. This was a stepwise process in which the first set of toxicological benchmarks considered was from two ORNL studies (Efroymson et al., 1997). These studies established separate screening benchmarks for soil microorganisms, earthworms, and plants. A secondary screening value was chosen from these three data sets that was the next highest value above the primary EPA Region IV screening value. If no values were available, the selection process proceeded to the Netherlands values (MHSPE, 1994). In addition, if the selected value from ORNL was found to be greater than the highest Netherlands value, then the ORNL value was rejected and the process moved forward to the Netherlands values as a conservative measure.

The Netherlands values included optimum values and action values. When this set of data was considered, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark. If a value was not available, the process proceeded to a final set of data as compiled by the USFWS (Beyer, 1990). The values in this data set represent Dutch background, moderate contamination, and cleanup values. As stated above, the next highest value above the primary EPA Region IV screening value was selected as a secondary benchmark.

In addition, the conservative ecological exposure pathways used in Step 2 were reevaluated based on actual site conditions. All of this information provides a WoE to assess which, if any, contaminants should be recommended for further evaluation in a baseline ERA.

The results of the Step 3 refinement of the COPCs list are summarized in Table 30-13. This table presents the maximum and average EPCs, background concentrations, primary and secondary surface soil screening criteria, range of HQs and background comparisons, and FOD.

On the basis of the WoE presented in Table 30-10, one of the inorganic and several organic COPCs indicated a potential for adverse effects. These included zinc, dieldrin, and several PAHs. These are contaminants for which all HQs were at or above 1.0, and also were above background in all comparisons. Many of the contaminants could be removed from further consideration as a result of some HQs being near or less than 1.0, being less than background, or having an FOD at 5 percent or below. Surface soil criteria for a total of seven contaminants were not available for comparison, so HQs could not be determined, however, three of these contaminants were compared to available background concentrations.

The key consideration in this refinement step is the lack of ecological exposure pathways at FU6. As previously discussed, the screening process in Steps 1 and 2 was conducted as a conservative measure, given that EPA guidance recommends minimal or no risk management considerations in a screening level ERA. FU6 is entirely a light industrial and residential area, and this land use is expected to continue into the future. The on-site habitat is limited to mowed grassy strips adjacent to buildings, roadways, and residential buildings. There are no on-site or near-site natural habitats that could support significant populations of terrestrial wildlife. Given the land use characteristics of FU6 and the lack of suitable on-site habitats, ecological effects are expected to be negligible because complete exposure pathways are not present and are not expected to be present in the foreseeable future.

30.2.4.2 Scientific Management Decision Point

Although several COPCs were identified in the refinement phase of Step 3 as potentially causing adverse ecological effects, the lack of complete ecological exposure pathways at FU6 indicates that current and future ecological effects are negligible. Therefore, no further assessment of ecological risk associated with contaminants at FU6 is warranted.

30.3 Human Health Evaluation for Screening Site 66

Screening Site 66 was selected as the surrogate site for FU6 because it had the highest human health risk ratio among all the sites within FU6 evaluated in the PRE (Appendix E). PAHs in surface soils produced the high risk estimates and HI ratios.

Site 66 formerly was used as a thrift shop and a vehicle repair and maintenance building (CH2M HILL, 1998a). This facility used to be a storage facility for drums containing petroleum products (hydraulic oil), antifreeze, and a Safety-Kleen unit. The building was used as a motor pool vehicle maintenance and service facility for vehicle maintenance, oil changes, steam cleaning, cold-solvent degreasing, washing, and lubrication. A UST was installed in this area in 1952 and was removed in 1996 (CH2M HILL, 1998a).

30.3.1 Selection of COPCs for Screening Site 66

A range of 13 to 32 surface soil (zero to 1 ft deep) samples were included for analysis of SVOCs, and fewer samples were analyzed for other chemical groups at Site 66. The maximum detected chemical concentration within this data group was compared against background concentrations and the RBCs for direct exposure, as well as against the GWP concentrations (SSLs). There were a total of 14 to 28 analyses of subsurface soil (greater than 1 to 10 ft), (duplicate samples included); the maximum detected concentrations were compared with the background concentrations and SSL criteria for COPC selection.

The COPC selection indicated that surface soils at the site had PAHs exceeding the background levels and comparison criteria (see Table 30-14). The PRE indicates PAHs as the primary risk drivers (Appendix E) in surface soil. In the deep soil samples group for utility worker exposure evaluations, soils from 0 to 10 ft are included. The subsurface soils did not have any chemicals that were selected as COPCs.

30.3.2 Exposure Assessment for Screening Site 66

Figure 28-1 depicts the site and its relative location within FU6. Screening Site 66 is located within Building 253. However, some of the samples collected were from further downgradient locations such as the grassy areas south of Building 250, because there are no open surface areas immediately adjacent to Building 253. Figure 30-5 presents the exposure CSM for Site 66.

30.3.3 Potentially Exposed Human Population and Identification of Potentially Complete Exposure Pathways

The site has been inactive since the closure of the Depot. There are no potentially exposed populations under current conditions specific to this site. Maintenance workers for the Depot involved in weed control and other maintenance-related activities could be present for limited periods of time. Maintenance worker exposure at Site 66 was not quantitatively evaluated because of the small area of the site. A maintenance worker exposure scenario was quantified for FU6, including Site 66 data. Other potential receptors evaluated qualitatively for surface soil exposure at this site were landscapers.

Potentially exposed populations under future land use are unknown at this time. On the basis of the *Memphis Depot Redevelopment Plan* (The Pathfinders et al., 1997), it is likely that Site 66 will be used in the future for light industrial or commercial operations. Under such a scenario, likely future receptors are also site workers. Future residential use of this site is highly unlikely, because of the site's central location within a highly industrial area of the Depot. According to future redevelopment plans, the commercial use of the area and of this site is to be retained. Hypothetical future residential exposures were evaluated for the worst-case scenario for FU6; a separate evaluation for Site 66, therefore, was not performed for this site (see Appendix A). A detailed list of exposure factors and the rationale for their selection are included in tables in Appendix G.

Subsurface soils were evaluated for direct exposure of a future construction/utility worker and an industrial worker. These scenarios are based on the assumption that, in the future, if the contaminated subsurface soil (zero to 10 ft bgs) is disturbed (e.g., for installation or maintenance of underground utilities), exposure to contaminated subsurface soil for utility workers or future industrial workers in the area could become a complete pathway. A summary of exposure pathways for Site 66 is included in Table 30-15.

A UCL 95% concentration was estimated for the EPC for surface soil (zero to 1 ft) and subsurface soil (zero to 10 ft) data for the COPCs identified. These values are listed in Tables 30-16 and 30-17, and the estimation methodology is described in Appendix H. The dose (intake) was estimated for each of the complete exposure pathways. The dose estimates are included in Appendix I.

30.3.3.1 Toxicity Assessment for Screening Site 66

The COPCs for Site 66 are a subset of those previously listed in the FU6 RA section (Section 30.1.1). Table 30-10 includes the toxicity factors for the COPCs identified at Site 66.

30.3.3.2 Risk Characterization for Screening Site 66

The carcinogenic risks and noncarcinogenic HIs are summarized in Table 30-18. HIs could not be estimated because of a lack of toxicity factors for COPCs identified in the site soils. Histograms of the risks calculated are included on Figure 30-6. The ELCRs were estimated for a future industrial worker and utility worker. The carcinogenic risks for industrial worker exposures to Site 66 surface soil resulted in estimated risks of 2×10^{-5}. The carcinogenic risks are from PAHs. The risk associated with deeper soil is 3×10^{-6}. Because deep soils include surface and subsurface soils, the risks are not additive. Thus, total risks are the higher of the two sets of risks estimated for the industrial worker. This worker scenario conservatively assumes a full workday exposure, 250 days per year, for an exposure period of 25 years. The resulting risks are at the upper limit for cancer risks of 1 to 100 in one million. Thus, the overall Site 66 soils do not pose a health threat to future industrial workers.

Exposures of a utility worker assume surface and subsurface soil mixed during excavation Exposure to the utility worker resulted in an ELCR of 5×10^{-7}. Carcinogenic health risks are below the lower end of the acceptable limits of 10^{-6} to 10^{-4}. Thus, excavation-type activities do not pose a health threat to these site workers.

Uncertainties associated with this RA are similar to those listed in the FU6 RA section (Section 30.1.4). RGOs were not calculated for the industrial worker at Site 66 because risks did not exceed acceptable risk criteria.

TABLE 30-1

Constituents of Potential Concern in FU6 - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
6	SS	MG/KG	ARSENIC	13	13	0.15	2.5	3.6	29	14	20	0.43	29	Yes	A
6	SS	MG/KG	BENZO(a)ANTHRACENE	14	6	0.062	12	0.045	5.4	1.1	0.71	0.87	2	Yes	A
6	SS	MG/KG	BENZO(a)PYRENE	14	6	0.062	12	0.052	6.3	1.2	0.96	0.087	8	Yes	A
6	SS	MG/KG	BENZO(b)FLUORANTHENE	14	5	0.062	12	0.06	8.1	1.7	0.9	0.87	5	Yes	A
6	SS	MG/KG	CARBAZOLE	13	2	0.37	12	0.063	1.5	0.78	0.067	32	0.6	Yes	A
6	SS	MG/KG	CHRYSENE	14	6	0.062	12	0.068	9.2	1.7	0.94	87	160	Yes	G
6	SS	MG/KG	DDE	32	18	0.0038	2.3	0.0086	2.3	0.27	0.16	1.9	54	Yes	A
6	SS	MG/KG	DDT	32	19	0.0038	2.3	0.0068	3.5	0.65	0.074	1.9	11	Yes	A
6	SS	MG/KG	DIELDRIN	32	17	0.0038	2.3	0.013	5.5	0.53	0.086	0.04	0.004	Yes	A
6	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	14	5	0.062	12	0.042	6.2	1.3	0.7	0.87	14	Yes	A
6	SS	MG/KG	PCB-1260 (AROCLOR 1260)	23	5	0.039	23	0.026	1.4	0.43	0.11	0.32	17	Yes	A

Note Data evaluated include field duplicates and normal samples (0-2 feet)

Data screened includes pre-remediation data

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background; or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

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TABLE 30-2

Constituents of Potential Concern in FU6 - Subsurface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Subsurface Soil (Leachability)	COPC/BASIS	
6	SB	MG/KG	ARSENIC	14	14	0 17	2 6	1 2	17	7 6	17	29	Yes	H
6	SB	MG/KG	BENZENE	28	6	0 01	0 62	0 082	2	0 74		0 03	Yes	A
6	SB	MG/KG	COPPER	14	14	0 12	2 6	5 3	34	17	33		Yes	D
6	SB	MG/KG	METHYLENE CHLORIDE	28	7	0 01	0 62	0 001	0 069	0 012		0 02	Yes	A
6	SB	MG/KG	Total Xylenes	28	9	0 01	0 62	0 001	0 57	0 22	0 002	0 2	Yes	A

Note Data evaluated include field duplicates and normal samples (2 feet and below)

Data screened includes pre-remediation data

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs
H	Chemical is a surface soil COPC

TABLE 30-3

Constituents of Potential Concern in FU6 - Sediment

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Sediments	Regulatory Criteria for Leachability	COPC/BASIS	
6	SE	MG/KG	4-METHYLPHENOL (p-CRESOL)	2	1	3	3 5	5 1	5 1	5 1		39	0 02	Yes	A
6	SE	MG/KG	ANTIMONY	2	2	0 35	0 35	154	1210	682	7 6	3 1	5	Yes	A
6	SE	MG/KG	BARIUM	2	2	0 038	0 038	3630	3650	3640	118	550	1600	Yes	A
6	SE	MG/KG	BENZO(a)ANTHRACENE	2	2	3	3 5	3	6 5	4 75	2 9	0 87	2	Yes	A
6	SE	MG/KG	BENZO(a)PYRENE	2	2	3	3 5	3	5 4	4 2	2 5	0 087	8	Yes	A
6	SE	MG/KG	BENZO(b)FLUORANTHENE	2	2	3	3 5	4 7	8 7	6 7	2 2	0 87	5	Yes	A
6	SE	MG/KG	CADMIUM	2	2	0 038	0 038	27	33	30	29	7 8	8	Yes	A
6	SE	MG/KG	CHROMIUM TOTAL	2	2	2 1	4 5	158	257	207 5	20	10800	38	Yes	A
6	SE	MG/KG	COPPER	2	2	0 13	0 13	2500	14200	8350	58	310		Yes	A
6	SE	MG/KG	DIBENZ(a,h)ANTHRACENE	2	1	3	3 5	0 86	0 86	0 86	0 7	0 087	2	Yes	A
6	SE	MG/KG	INDENO(1,2,3-c,d)PYRENE	2	1	3	3 5	2 2	2 2	2 2	1 7	0 87	14	Yes	A
6	SE	MG/KG	LEAD	2	2	0 18	0 18	3110	3570	3340	35	400		Yes	A
6	SE	MG/KG	NICKEL	2	2	0 12	0 12	83	139	110 75	31	160	130	Yes	A
6	SE	MG/KG	PETROLEUM HYDROCARBONS	2	2	87	185	1410	1460	1435		34	340	Yes	A
6	SE	MG/KG	SELENIUM	2	2	0 39	0 39	50	182	115 95	1 7	39	5	Yes	A
6	SE	MG/KG	SILVER	2	1	0 085	0 085	49	49	49	1 8	39	34	Yes	A
6	SE	MG/KG	THALLIUM	2	1	0 19	0 19	21	21	21	1 1	0 55	0 7	Yes	A
6	SE	MG/KG	ZINC	2	2	0 38	0 38	4980	5570	5275	797	2300	12000	Yes	A
6	SE	MG/KG	CHRYSENE	2	2	3	3 5	5	9 8	7 4	3 2	87	160	Yes	G

Notes

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 30-4

Constituents of Potential Concern in Residential Point Estimate at Station SS66A - Surface Soil

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Analytical Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
6	SS	MG/KG	BENZO(a)ANTHRACENE	5.4	0.71	0.87	2	Yes	A
6	SS	MG/KG	BENZO(a)PYRENE	6.3	0.96	0.087	8	Yes	A
6	SS	MG/KG	BENZO(b)FLUORANTHENE	8.1	0.9	0.87	5	Yes	A
6	SS	MG/KG	CARBAZOLE	1.5	0.067	32	0.6	Yes	A
6	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	6.2	0.7	0.87	14	Yes	A
6	SS	MG/KG	CHRYSENE	9.2	0.94	87	160	Yes	G

Note: Data evaluated include field duplicates and normal samples (0-2 feet)

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC.
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 30-5

Summary of Exposure Pathways to be Quantified at FU6

Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils, and ingestion and dermal contact with sump sediments	Yes	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil, and cleaning sumps
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils, and ingestion and dermal contact with sump sediments.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0 to 10 feet below ground surface).	No	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil This is evaluated as part of the surrogate site exposure unit
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	No	Landscaper exposure to surface soil would be short exposure duration (less than one year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils	Yes	Evaluated for comparison purposes only

TABLE 30-6

Exposure Point Concentrations for FU6 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ARSENIC	14	14	18	35	23	29	29
MG/KG	DDE	23	13	0.15	1.2	0.24	1.6	1.2
MG/KG	DDT	23	13	0.23	1.8	0.4	3.8	1.8
MG/KG	DIELDRIN	23	12	0.18	0.73	0.26	4.4	0.73
MG/KG	PCB-1260 (AROCLOR 1260)	15	1	1.2	6.3	2	7.6	6.3
MG/KG	BENZO(a)ANTHRACENE	16	6	1.2	7.2	2.1	4.5	4.5
MG/KG	BENZO(a)PYRENE	16	6	1.1	6.3	2	4.4	4.4
MG/KG	BENZO(b)FLUORANTHENE	16	5	1.3	8.1	2.3	6.2	6.2
MG/KG	CARBAZOLE	11	2	0.45	1.5	0.77	1	1
MG/KG	CHRYSENE	16	6	1.5	9.2	2.8	6.3	6.3
MG/KG	INDENO(1,2,3-c,d)PYRENE	16	5	1.1	6.2	1.8	5.3	5.3

Note: Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation

Pre-remediation data has been removed for applicable samples.

TABLE 30-7

Exposure Point Concentrations for FU6 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ARSENIC	24	24	14	35	17	22	22
MG/KG	COPPER	24	24	23	51	26	28	28
MG/KG	DDE	30	13	0.11	1.2	0.19	0.72	0.72
MG/KG	DDT	30	13	0.18	1.8	0.31	1.7	1.7
MG/KG	DIELDRIN	30	12	0.14	0.73	0.21	1.8	0.73
MG/KG	PCB-1260 (AROCLOR 1260)	22	1	0.85	6.3	1.4	6.9	6.3
MG/KG	BENZO(a)ANTHRACENE	33	6	0.69	7.2	1.1	1	1
MG/KG	BENZO(a)PYRENE	33	6	0.69	6.3	1.1	1	1
MG/KG	BENZO(b)FLUORANTHENE	33	5	0.78	8.1	1.3	1.2	1.2
MG/KG	CARBAZOLE	24	2	0.32	1.5	0.46	0.38	0.38
MG/KG	CHRYSENE	33	6	0.86	9.2	1.5	1.2	1.2
MG/KG	INDENO(1,2,3-c,d)PYRENE	33	5	0.66	6.2	1	1.1	1.1
MG/KG	BENZENE	29	5	0.093	2	0.21	0.068	0.068
MG/KG	METHYLENE CHLORIDE	29	6	0.016	0.009	0.034	0.013	0.009
MG/KG	Total Xylenes	29	7	0.046	0.57	0.087	0.047	0.047

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation.

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet.

Pre-remediation data has been removed for applicable samples.

TABLE 30-8

Exposure Point Concentrations for FU6 - Sediment

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	ANTIMONY	2	2	682	1210	4016	1.E+15	1210
MG/KG	BARIUM	2	2	3640	3650	3703	3676	3650
MG/KG	CADMIUM	2	2	30	33	47	43	33
MG/KG	CHROMIUM, TOTAL	2	2	208	257	520	1039	257
MG/KG	COPPER	2	2	8350	14200	45287	5.E+12	14200
MG/KG	NICKEL	2	2	111	139	289	692	139
MG/KG	SELENIUM	2	2	116	182	533	8004619	182
MG/KG	SILVER	2	1	25	49	179	5 E+82	49
MG/KG	THALLIUM	2	1	11	21	75	5 E+34	21
MG/KG	ZINC	2	2	5275	5570	7138	6562	5570
MG/KG	BENZO(a)ANTHRACENE	2	2	4.8	6.5	16	250	6.5
MG/KG	BENZO(a)PYRENE	2	2	4 2	5.4	12	42	5 4
MG/KG	BENZO(b)FLUORANTHENE	2	2	6 7	8 7	19	83	8.7
MG/KG	CHRYSENE	2	2	7 4	10	23	149	10
MG/KG	DIBENZ(a,h)ANTHRACENE	2	1	1 2	0 9	3 2	9 3	0 9
MG/KG	INDENO(1,2,3-c,d)PYRENE	2	1	2	2 2	3 4	3 3	2 2
MG/KG	4-METHYLPHENOL (p-CRESOL)	2	1	3 4	5 1	14	6874	5 1
MG/KG	PETROLEUM HYDROCARBONS	2	2	1435	1460	1593	1535	1460

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation

TABLE 30-9

Exposure Point Concentrations for FU6, Station SS66A - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Parameter	EPC (mg/kg)
BENZO(a)ANTHRACENE	5 4
BENZO(a)PYRENE	6 3
BENZO(b)FLUORANTHENE	8 1
CARBAZOLE	1 5
CHRYSENE	9 2
INDENO(1,2,3-c,d)PYRENE	6 2

Note

Data evaluated include normal samples only.

Field duplicates have been dropped from risk evaluation

EPC values represent the maximum PRE sample within Functional Unit 6 at location SS66A

TABLE 30-10
Toxicity Factors for FU6
Memphis Depot Main Installation RI

Name	Weight-of-Evidence Class	ABS_{GI}	Oral SF kg-day/mg	Dermal SF kg day/mg	Inhal SF kg-day/mg	C Oral RfD mg/kg-day	Dermal RfD mg/kg-day	C Inhal RfD mg/kg-day
Arsenic	A	41%	1 50E+00	3 66E+00	1.51E+01	3.00E-04	1.23E-04	
Benzene	A	97%	2.90E-02	2 99E-02	2 73E-02			
Benzo(a)anthracene	B2	31%	7.30E-01	2.35E+00	3.10E-01			
Benzo(a)pyrene	B2	31%	7 30E+00	2.35E+01	3 10E+00			
Benzo(b)fluoranthene	B2	31%	7.30E-01	2 35E+00	3.10E-01			
Carbazole	B2	70%	2 00E-02	2 86E-02				
Chrysene	B2	31%	7.30E-03	2.35E-02	3.10E-03			
Copper	D	30%				3.70E-02	1 11E-02	
DDE	B2	70%	3 40E-01	4 86E-01				
DDT	B2	70%	3 40E-01	4 86E-01	3 40E-01	5 00E-04	3 50E-04	
Dieldrin	B2	50%	1 60E+01	3 20E+01	1.60E+01	5 00E-05	2.50E-05	
Indeno(1,2,3-c,d)pyrene	B2	31%	7 30E-01	2 35E+00	3 10E-01			
Methylene chloride	B2	95%	7.50E-03	7.89E-03	1 65E-03	6 00E-02	5 70E-02	8.57E-01
PCB-1260 (Aroclor 1260)	B2	90%	2.00E+00	2 22E+00	2 00E+00			
Xylenes (total)	D	92%				2 00E+00	1 84E+00	

Note Master list of toxicity factors, with sources and basis is provided in Section 7.0

TABLE 30-11

Carcinogenic Risks and Noncarcinogenic Hazards of FU6

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways	Total ELCR	Total HI	Chemicals of Concern
Industrial Worker				
	Surface Soil (0-2ft)	3E-05	0.06	*Arsenic, Dieldrin, PCB-1260, BaP*
	Soil Column (0-10 ft)[1]	1E-05	0.05	*Arsenic, Dieldrin, PCB-1260, BaP*
	Sediment	3E-06	0.4	*Benzo(a)pyrene*
	Total[2]	***3E-05***	***0.5***	***Arsenic, Dieldrin, PCB-1260, PAHs***
Maintenance Worker				
	Surface Soil (0-2ft)	3E-06	0.007	*Arsenic, Benzo(a)pyrene*
	Sediment	1E-06	0.1	
	Total	***4E-06***	***0.1***	***Arsenic, Benzo(a)pyrene***
Residential Adult (age-adjusted)				
	Soil point exposure at SS66A	1E-04	N/A	*PAHs*
	Total	***1E-04***	***N/A***	***PAHs***
Residential Child[3]				
	Soil point exposure at SS66A	7E-05	N/A	*PAHs*
	Total	***7E-05***	***N/A***	***PAHs***

Notes

Residential receptors have been included for comparison purposes only

[1] *Soil Column includes surface and subsurface soil, and therefore, cannot be combined with surface soil risks*

[2] *Total Risks presented is the higher of surface and subsurface soils*

[3] *Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media*

N/A = no toxicity factors available for these COPCs

BaP = Benzo(a)pyrene

PAHs = Polynuclear aromatic hydrocarbons

TABLE 30-12
Step 2 Surface Soil Screening Level Risk Calculations for FU6
Ecological Risk Assessment
Memphis Depot Main Installation RI

Parameter	Frequency of Detection Number Analyzed	 Number Detected	Range of Detected Values Minimum (mg/kg)	 Qual.	 Maximum (mg/kg)	 Qual.	Surface Soil Screening Value[1] (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
Inorganics									
ALUMINUM	8	8	5120	=	13700	=	50	**274**	Y
ANTIMONY	12	4	0 7	J	2.9	J	3.5	0 8	N
ARSENIC	13	13	3 6	=	29.2	=	10	**2.9**	Y
BARIUM	8	8	86 5	=	168	=	165	**1.0**	Y
BERYLLIUM	13	7	0 23	J	0 53	J	1 1	0 5	N
CADMIUM	13	6	0.04	J	0.62	=	1 6	0 4	N
CHROMIUM, TOTAL	13	13	11 3	=	27.7	=	0 4	**69**	Y
COBALT	8	8	4 6	J	17 1	=	20	0 9	N
COPPER	13	13	12 1	=	50 7	=	40	**1.3**	Y
IRON	8	8	14700	=	24700	=	200	**124**	Y
LEAD	13	13	9 5	=	136	=	50	**2.7**	Y
MANGANESE	8	8	242	J	601	=	100	**6.0**	Y
MERCURY	13	3	0 02	J	0 03	=	0 1	0 3	N
NICKEL	13	13	11 9	=	41.1	=	30	**1.4**	Y
SELENIUM	13	3	0.66	=	0 89	=	0 81	**1.1**	Y
VANADIUM	8	8	20 00	=	32	=	2	**16**	Y
ZINC	13	13	40	=	541	J	50	**11**	Y
Organics									
2-HEXANONE	22	3	0.002	J	0 004	J		**NA**	Y
ACETONE	22	5	0 005	J	0 033	=		**NA**	Y
ALPHA-CHLORDANE	32	9	0 0032	J	1.2	J	0 1	**12**	Y
ANTHRACENE	14	2	0 038	J	0 047	J	0 1	0 5	N
BENZENE	22	2	0 00	J	0	J	0 05	0 0	N
BENZO(a)ANTHRACENE	14	6	0 05	J	5 4	J	0 1	**54**	Y
BENZO(a)PYRENE	14	6	0 05	J	6.3	=	0 1	**63**	Y
BENZO(b)FLUORANTHENE	14	5	0 06	J	8 1	J	0 1	**81**	Y
BENZO(g,h,i)PERYLENE	14	6	0 044	J	6 8	J	0.1	**68**	Y
BENZO(k)FLUORANTHENE	14	5	0 066	J	7 4	J	0 1	**74**	Y
bis(2-ETHYLHEXYL) PHTHALATE	13	1	0 14	J	0 14	J	0 1	**1.4**	Y
BROMOMETHANE	22	2	0 002	J	0 004	J		**NA**	Y
CARBAZOLE	13	2	0 063	J	1 5	J		**NA**	Y
CARBON DISULFIDE	22	1	0 008	J	0 008	J		**NA**	Y
CHLOROFORM	22	2	0 004	J	0 005	J	0 001	**5.0**	Y
CHLOROMETHANE	22	1	0 002	J	0 002	J	0 1	0 0	N

TABLE 30-12
Step 2 Surface Soil Screening Level Risk Calculations for FU6
Ecological Risk Assessment
Memphis Depot Main Installation RI

	Frequency of Detection		Range of Detected Values						
Parameter	Number Analyzed	Number Detected	Minimum (mg/kg)	Qual.	Maximum (mg/kg)	Qual.	Surface Soil Screening Value^1 (mg/kg)	Hazard Quotient (based on Max. detect)	Retained as a COPC?
CHRYSENE	14	6	0.068	J	9.2	J	0.1	**92**	Y
DDD	32	7	0.0056	=	0.13	J	0.0025	**52**	Y
DDE	32	18	0.0086	=	2.3	=	0.0025	**920**	Y
DDT	32	19	0.0068	=	3.5	J	0.0025	**1400**	Y
DIELDRIN	32	17	0.013	=	5.5	J	0.0005	**11000**	Y
DI-n-BUTYL PHTHALATE	13	1	0.044	J	0.044	J	0.1	0.4	N
ETHYLBENZENE	22	1	0.001	J	0.001	J	0.05	0.0	N
FLUORANTHENE	14	7	0.078	J	14	=	0.1	**140**	Y
GAMMA-CHLORDANE	32	9	0.0037	J	1.1	J	0.1	**11**	Y
INDENO(1,2,3-c,d)PYRENE	14	5	0.042	J	6.2	=	0.1	**62**	Y
METHYL ETHYL KETONE (2-BUTANONE)	22	3	0.016	=	0.034	=		**NA**	Y
METHYL ISOBUTYL KETONE (4-METHYL-	22	1	0.006	J	0.006	J		**NA**	Y
METHYLENE CHLORIDE	22	3	0.003	J	0.005	J	0.1	0.1	N
PCB-1260 (AROCHLOR 1260)	23	5	0.026	J	1.4	=	0.02	**70**	Y
PHENANTHRENE	14	5	0.048	J	6	J	0.1	**60**	Y
PYRENE	14	7	0.044	J	12	=	0.1	**120**	Y
TETRACHLOROETHYLENE(PCE)	22	2	0.004	J	0.013	=	0.01	**1.3**	Y
TOLUENE	22	1	0.004	J	0.00	J	0.05	0.1	N
Total Xylenes	22	1	0.003	J	0.003	J		**NA**	Y
TRICHLOROETHYLENE (TCE)	22	1	0.002	J	0.002	J	0.001	**2.0**	Y

Note. Ca, Mg, K, Na were detected, however these parameters were not evaluated since they are commonly occurring elements

1 = Memorandum, Ecological Risk Assessment at Military Bases Process Consideration, Timing, of Activities, and Inclusion of Stakeholders EPA Region 4, December 22, 1998

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TABLE 30-13
Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU6
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max Compared to Primary	Avg Compared to Primary	Max Compared to Secondary	Avg Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
Inorganics														
ALUMINUM	13700	11003	23810	50	2	600	3	274	220	23	18	N	N	100
ARSENIC	29 2	14 1	20	10	2	29	4	3	1 4	1 0	0 5	Y	N	100
BARIUM	168	117	234	165	9	500	2	1 0	0 7	0 3	0 2	N	N	100
CHROMIUM, TOTAL	27 7	18 8	24 8	0 4	1	1	2	69	47	28	19	Y	N	100
COPPER	50 7	27 5	33 5	40	9	50	2,6	1 3	0 7	1 0	0 6	Y	N	100
IRON	24700	18550	37040	200	3			124	93			N	N	100
LEAD	136	38	30	50	2 5	500	1	3	0 8	0 3	0 1	Y	Y	100
MANGANESE	601	468	1304	100	3	500	2	6	5	1 2	0 9	N	N	100
NICKEL	41 1	22 7	30	30	2	90	3	1 4	0 8	0 5	0 3	Y	N	100
SELENIUM	0 89	0 80	0 8	0 81	6	1	2	1 1	1 0	0 9	0 8	Y	Y	23
VANADIUM	32	25 4	48 4	2	2	20	3	16	13	2	1 3	N	N	100
ZINC	541	129	126	50	2	100	3	11	3	5	1 3	Y	Y	100
Organics														
2-HEXANONE	0 004	0 003										NA	NA	14
ACETONE	0 033	0 013										NA	NA	23
ALPHA-CHLORDANE	1 2	0 152	0 029	0 1	5	0 5	7	12	2	2	0 3	Y	Y	28
BENZO(a)ANTHRACENE	5 4	1 06	0 71	0 1	5	1	7	54	11	5	1 1	Y	Y	43
BENZO(a)PYRENE	6 3	1 21	0 96	0 1	5	1	7	63	12	6	1 2	Y	Y	43
BENZO(b)FLUORANTHENE	8 1	1 7	0 9	0 1	5	1	7	81	17	8	2	Y	Y	36
BENZO(g,h,i)PERYLENE	6 8	1 3	0 82	0 1	5	1	7	68	13	7	1 3	Y	Y	43
BENZO(k)FLUORANTHENE	7 4	1 6	0.78	0 1	5	1	7	74	16	7	2	Y	Y	36
bis(2-ETHYLHEXYL) PHTHALATE	0 14	0 14		0 1	4	100	4	1 4	1 4	0 0	0 0	NA	NA	8
BROMOMETHANE	0 004	0 003										NA	NA	9
CARBAZOLE	1 5	0 782	0 067									Y	Y	15
CARBON DISULFIDE	0 008	0 008	0 002									Y	Y	5
CHLOROFORM	0 005	0 0045		0 001	4	10	5	5	5	0 0	0 0	NA	NA	9
CHRYSENE	9 2	1 75	0 94	0 1	5	1	7	92	17	9	2	Y	Y	43
DDD	0 13	0 0734	0 0067	0 0025	4	4	5	52	29	0 0	0 0	Y	Y	22
DDE	2 3	0 27	0 16	0 0025	4	4	5	920	109	0 6	0 1	Y	Y	56
DDT	3 5	0 647	0 074	0 0025	4	4	5	1400	259	0 9	0 2	Y	Y	59
DIELDRIN	5 5	0 532	0 086	0 0005	4			11000	1064			Y	Y	53
FLUORANTHENE	14	2 3	1 6	0 1	5	10	7	140	23	1 4	0 2	Y	Y	50

TABLE 30-13

Step 3 Refinement of Surface Soil Preliminary Contaminants of Concern for FU6
Ecological Risk Assessment
Memphis Depot Main Installation RI

	COPC Detected Concentrations (mg/kg)			Comparison Criteria (mg/kg)				Hazard Quotients				Background Comparisons		
COPCs	Maximum	Average	Background	Primary Soil Screening Criterion	Basis	Secondary Soil Screening Criterion	Basis	Max Compared to Primary	Avg Compared to Primary	Max Compared to Secondary	Avg Compared to Secondary	Maximum Exceeds Background	Average Exceeds Background	Frequency of Detection (%)
GAMMA-CHLORDANE	1 1	0 141	0 026	0 1	5	0 5	7	11	1 4	2	0 3	Y	Y	28
INDENO(1,2,3-c,d)PYRENE	6 2	1 3	0 7	0 1	5	1	7	62	13	6	1 3	Y	Y	36
METHYL ETHYL KETONE (2-BUTANONE)	0 034	0 022	0 002									Y	Y	14
METHYL ISOBUTYL KETONE (4-METHYL-2-PENTANONE)	0 006	0.006										NA	NA	5
PCB-1260 (AROCHLOR 1260)	1 4	0 426	0 11	0 02	4	1	5	70	21	1 4	0 4	Y	Y	22
PHENANTHRENE	6	1 33	0 61	0 1	5	5	7	60	13	1 2	0 3	Y	Y	36
PYRENE	12	2 0	1 5	0 1	5	10	7	120	20	1 2	0 2	Y	Y	50
TETRACHLOROETHYLENE(PCE)	0 013	0 0085		0 01	4	0 1	6	1 3	0 9	0 1	0 1	NA	NA	9
Total Xylenes	0 003	0 003	0 009	0 05	4,5	25	5	0 1	0 1	0 0	0 0	N	N	5
TRICHLOROETHYLENE (TCE)	0 002	0 002		0 001	4	0 1	6	2	2	0 0	0 0	NA	NA	5

Notes

1 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for earthworms
2 Efroymson, R A et al 1997b Oak Ridge National Laboratory, toxicological banchmarks for plants
3 Efroymson, R A et al 1997a Oak Ridge National Laboratory, toxicological banchmarks for microorganisms
4 Ministry of Housing, Spatial Planning and Environment, 1994 optimum soil quality standards
5 Beyer, W N 1990 US Fish and Wildlife Service Dutch background
6 Crommentuijn, T et al , 1997 RIVM Report No 601501002

TABLE 30-14

Constituents of Potential Concern in Screening Site 66 - Surface Soil

Memphis Depot Main Installation RI

Unit	SiteID	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Surface Soil	Regulatory Criteria for Leachability	COPC/BASIS	
6	66	SS	MG/KG	BENZO(a)ANTHRACENE	6	1	0.39	12	5.4	5.4	5.4	0.71	0.87	2	Yes	A
6	66	SS	MG/KG	BENZO(a)PYRENE	6	1	0.39	12	6.3	6.3	6.3	0.96	0.087	8	Yes	A
6	66	SS	MG/KG	BENZO(b)FLUORANTHENE	6	1	0.39	12	8.1	8.1	8.1	0.9	0.87	5	Yes	A
6	66	SS	MG/KG	CARBAZOLE	6	1	0.39	12	1.5	1.5	1.5	0.067	32	0.6	Yes	A
6	66	SS	MG/KG	INDENO(1,2,3-c,d)PYRENE	6	1	0.39	12	6.2	6.2	6.2	0.7	0.87	14	Yes	A
6	66	SS	MG/KG	CHRYSENE	6	1	0.39	12	9.2	9.2	9.2	0.94	87	160	Yes	G

Note Data evaluated include field duplicates and normal samples (0-2 feet)

A Exceeds Criteria
B Does not exceed Criteria
C Does not exceed Background
D No Criteria available & exceeds Background, or no Criteria or Background available
E Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G Chemical is a member of a chemical class that contains other COPCs

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TABLE 30-15
Summary of Exposure Pathways to be Quantified at Screening Site 66
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Current Land Use			
Onsite Maintenance Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Occasional maintenance work is assumed to involve a worker spending time in the contaminated soil
Future Land Use			
Onsite Industrial Worker	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Onsite Utility Worker	Incidental ingestion, dermal contact, and dust inhalation from the subsurface soils (0-10' bgs)	Yes	A hypothetical future utility worker installing or maintaining underground utilities is assumed to be exposed to contaminated subsurface soil.
Onsite Landscaper	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Landscaper exposure to surface soil would be shorter exposure duration (less than 1 year) during property redevelopment Maintenance worker exposure assumptions are protective of landscaper
Hypothetical Future Onsite Residential	Incidental ingestion, dermal contact, and dust inhalation from the surface soils.	No	Evaluated for comparison purposes only.

TABLE 30-16

Exposure Point Concentrations for Screening Site 66 - Surface Soil (0-2 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	BENZO(a)ANTHRACENE	5	1	1.2	5.4	3.5	183	5.4
MG/KG	BENZO(a)PYRENE	5	1	1.4	6.3	4	337	6.3
MG/KG	BENZO(b)FLUORANTHENE	5	1	1.8	8.1	5.2	965	8.1
MG/KG	CARBAZOLE	5	1	0.47	1.5	1	3.2	1.5
MG/KG	CHRYSENE	5	1	2	9.2	5.8	1690	9.2
MG/KG	INDENO(1,2,3-c,d)PYRENE	5	1	1.4	6.2	4	316	6.2

Note: Data evaluated include normal samples only. Field duplicates have been dropped from risk evaluation.

Table 30-17

Exposure Point Concentrations for Screening Site 66 - Soil Column (0-10 feet)

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Value	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/KG	BENZO(a)ANTHRACENE	12	1	0.64	5.4	1.4	0.94	0.94
MG/KG	BENZO(a)PYRENE	12	1	0.72	6.3	1.6	1.1	1.1
MG/KG	BENZO(b)FLUORANTHENE	12	1	0.87	8.1	2	1.3	1.3
MG/KG	CARBAZOLE	12	1	0.32	1.5	0.51	0.42	0.42
MG/KG	CHRYSENE	12	1	1	9.2	2.3	1.4	1.4
MG/KG	INDENO(1,2,3-c,d)PYRENE	12	1	0.71	6.2	1.6	1	1

Note Data evaluated include normal samples only Field duplicates have been dropped from risk evaluation.

COPCs have been selected from both surface and subsurface soil exceedances, and are limited to detected samples within 0-10 feet.

TABLE 30-18

Carcinogenic Risks and Noncarcinogenic Hazards of Screening Site 66

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Surface Soil (0-2ft)		2E-05	N/A	*PAHs*
	Soil Column (0-10ft)[1]		3E-06	N/A	*Benzo(a)pyrene*
		Total[2]	***2E-05***	***N/A***	***PAHs***
Utility Worker					
	Soil Column (0-10ft)		5E-07	N/A	
		Total	***5E-07***	***N/A***	

Notes

[1] *Soil Column includes surface and subsurface soil, and therefore, cannot be combined with surface soil risks.*

[2] *Total Risks presented is the higher of surface and subsurface soils*

N/A = no toxicity factors available for these COPCs

PAHs = Polynuclear aromatic hydrocarbons

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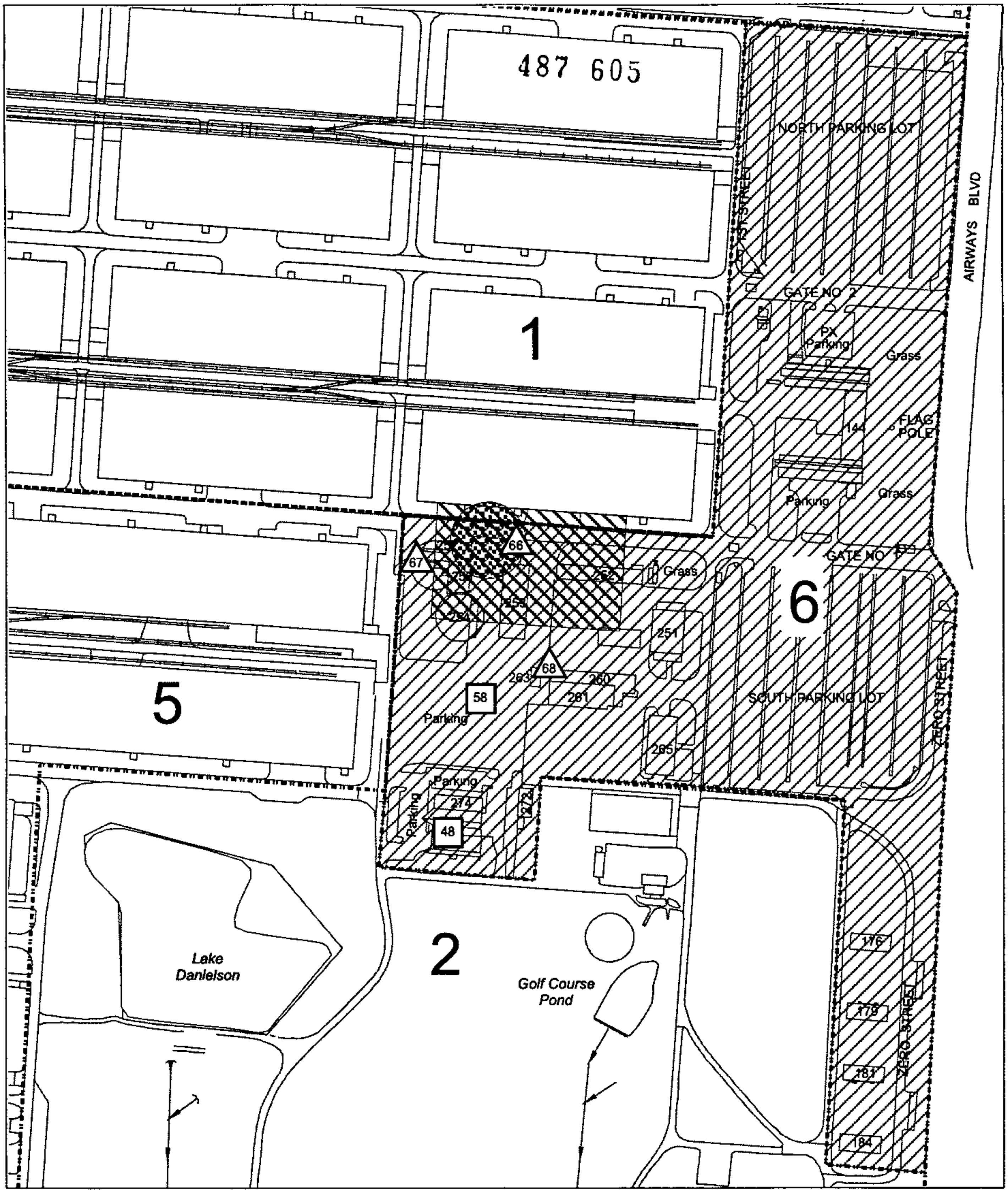

58 Remedial Investigation Site

68 Screening Site

▩ 1\2 acre circle around the highest PRE sample (SS66A) as a hypothetical residential exposure unit

▧ Surrogate site, Site 66, exposure unit for a future industrial and a future utility worker

▨ FU-wide - Exposure Units for current and future maintenance and industrial workers

Functional Unit Boundary

Base Features

☐ Buildings

N

0 150 300 Feet

SCALE IS APPROXIMATE

FIGURE 30-1

DIFFERENT EXPOSURE UNITS FOR BASELINE RISK ASSESSMENT WITHIN FUNCTIONAL UNIT 6

MEMPHIS DEPOT MAIN INSTALLATION RI

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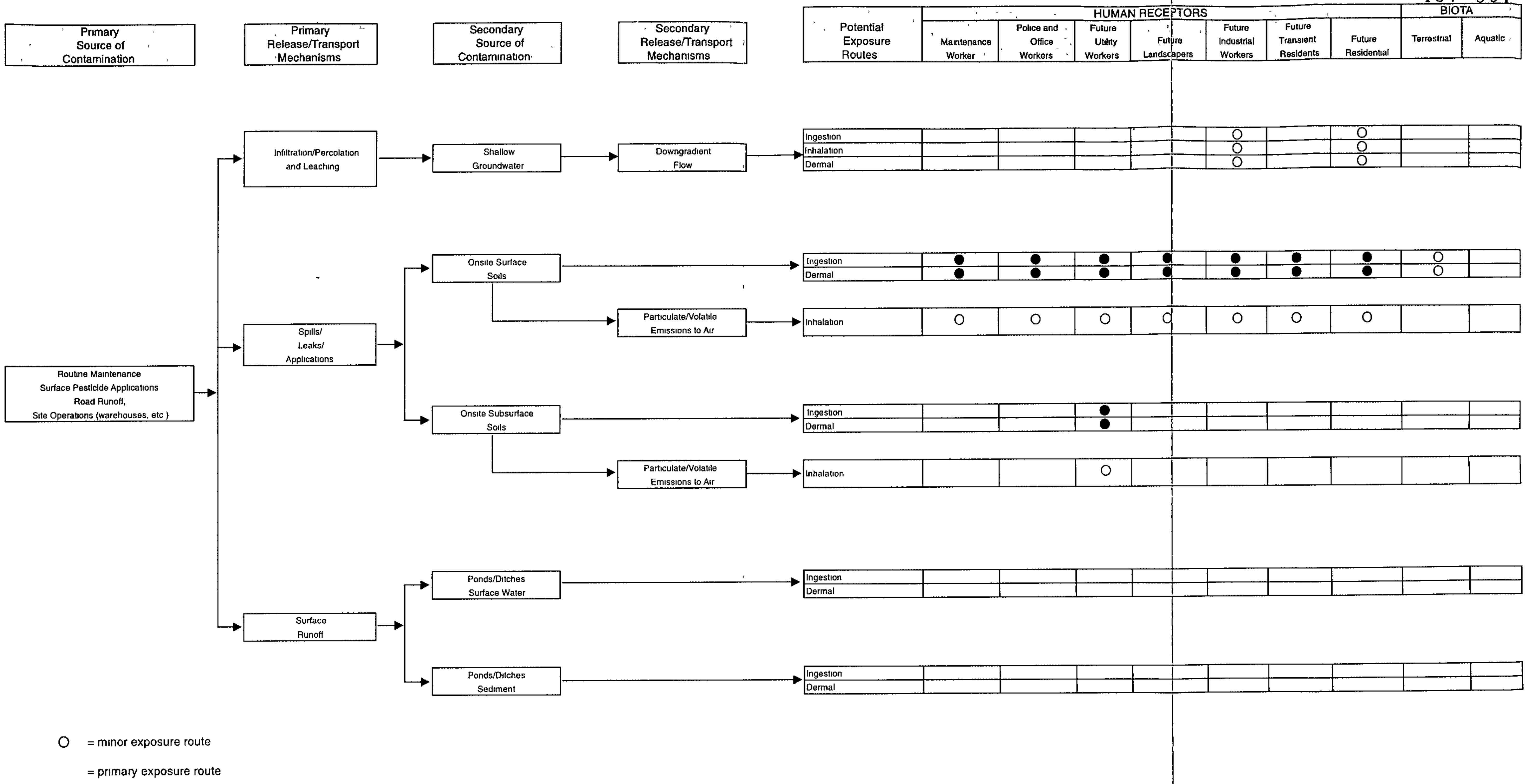

Secondary Source of Contamination	Potential Exposure Routes	Maintenance Worker	Police and Office Workers	Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Transient Residents	Future Residential	Terrestrial	Aquatic
Shallow Groundwater (Downgradient Flow)	Ingestion					○		○		
	Inhalation					○		○		
	Dermal					○		○		
Onsite Surface Soils	Ingestion	●	●	●	●	●	●	●	○	
	Dermal	●	●	●	●	●	●	●	○	
Onsite Surface Soils (Particulate/Volatile Emissions to Air)	Inhalation	○	○	○	○	○	○	○		
Onsite Subsurface Soils	Ingestion			●						
	Dermal			●						
Onsite Subsurface Soils (Particulate/Volatile Emissions to Air)	Inhalation			○						
Ponds/Ditches Surface Water	Ingestion									
	Dermal									
Ponds/Ditches Sediment	Ingestion									
	Dermal									

2972_53 (1/27/00)

FIGURE 30-2
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: FUNCTIONAL UNIT 6
MEMPHIS DEPOT MAIN INSTALLATION RI

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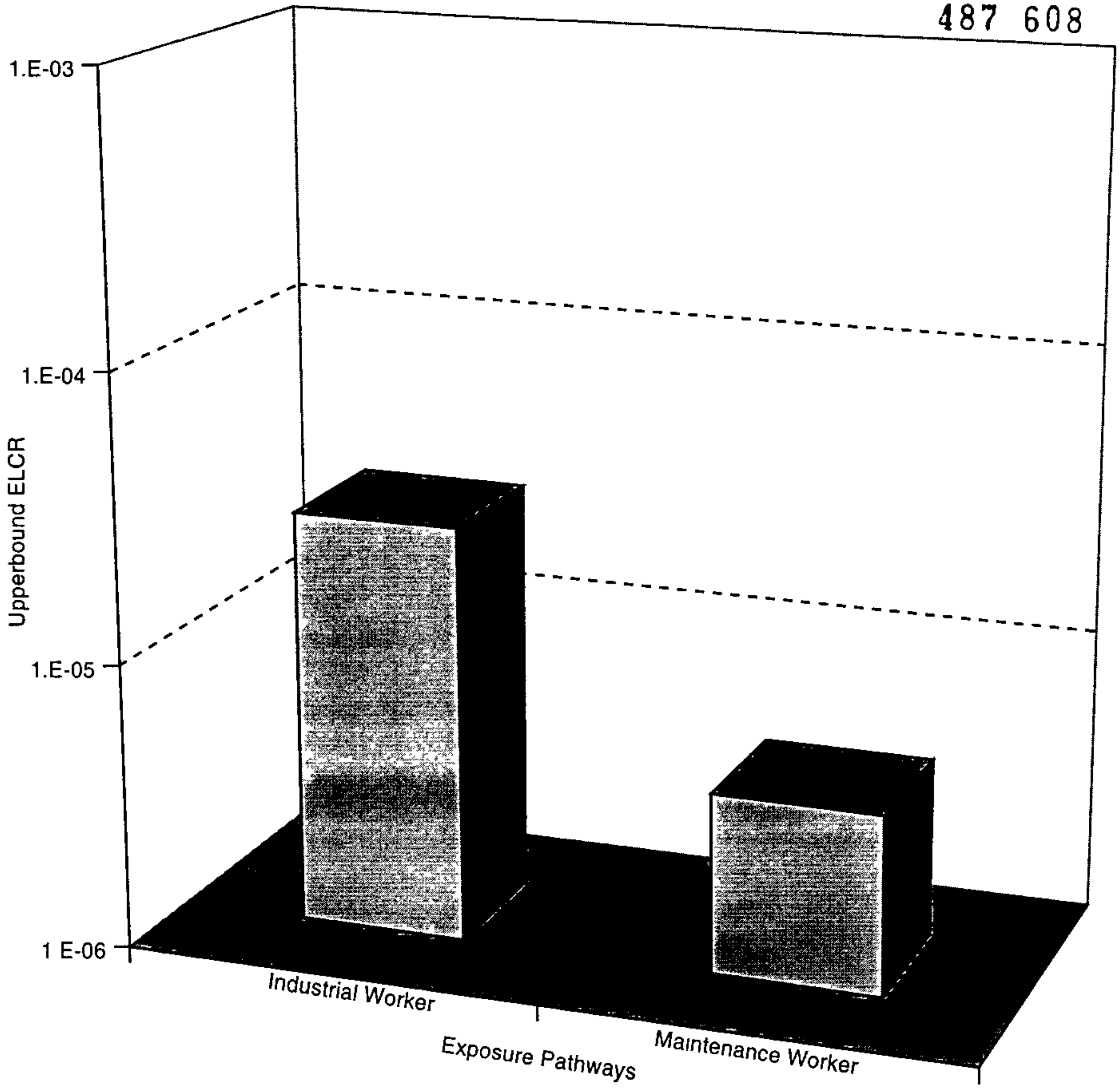

☐ Total ELCR (accepted range of 1E-4 to 1E-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 30-3
TOTAL EXCESS LIFETIME CANCER RISKS FOR TOTAL SOIL EXPOSURE AT FUNCTIONAL UNIT 6
MEMPHIS DEPOT MAIN INSTALLATION RI

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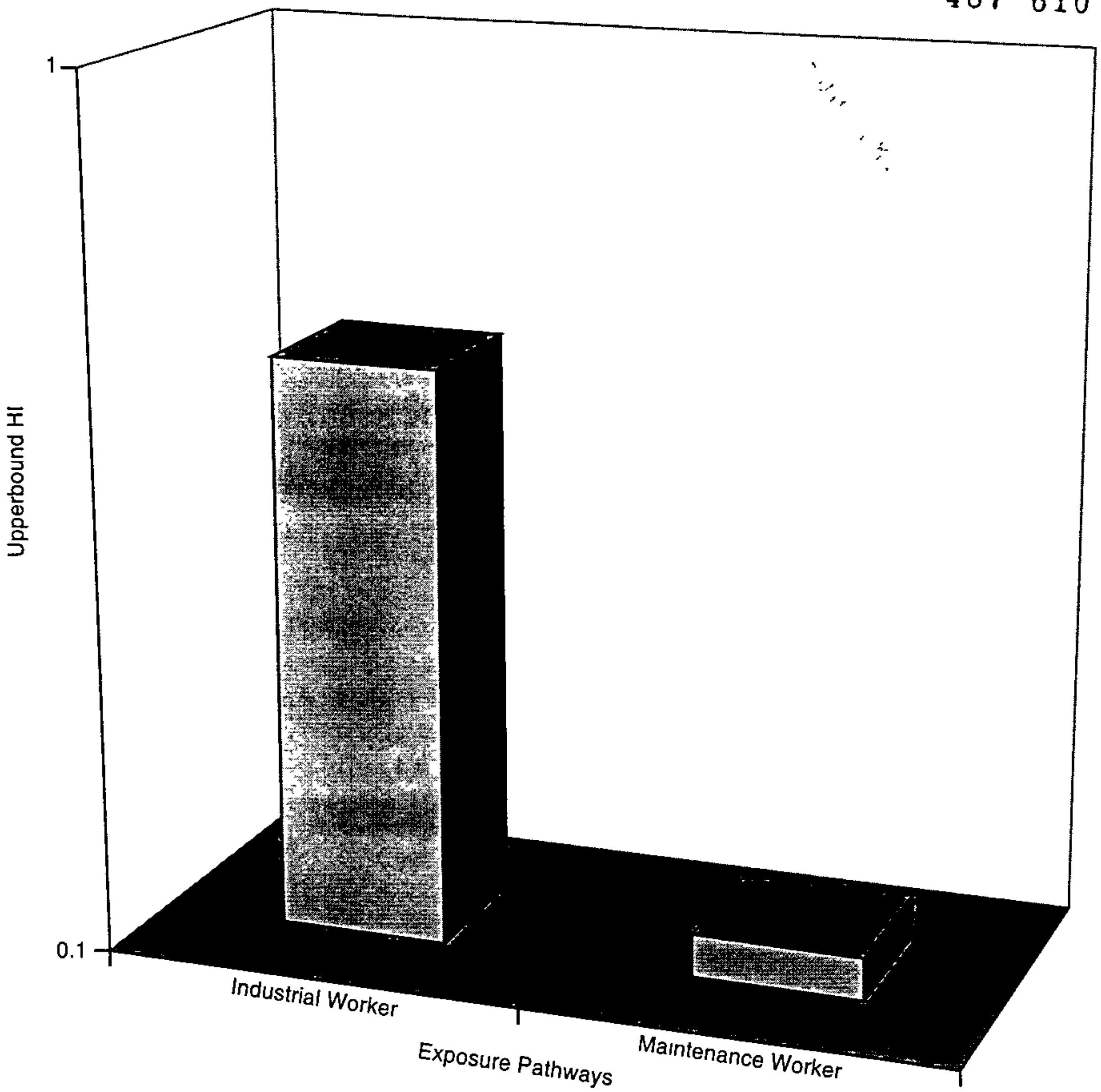

☐ Total HI (threshold of 1.0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 30-4
TOTAL HAZARD INDICES FOR TOTAL SOIL EXPOSURE AT FUNCTIONAL UNIT 6
MEMPHIS DEPOT MAIN INSTALLATION RI

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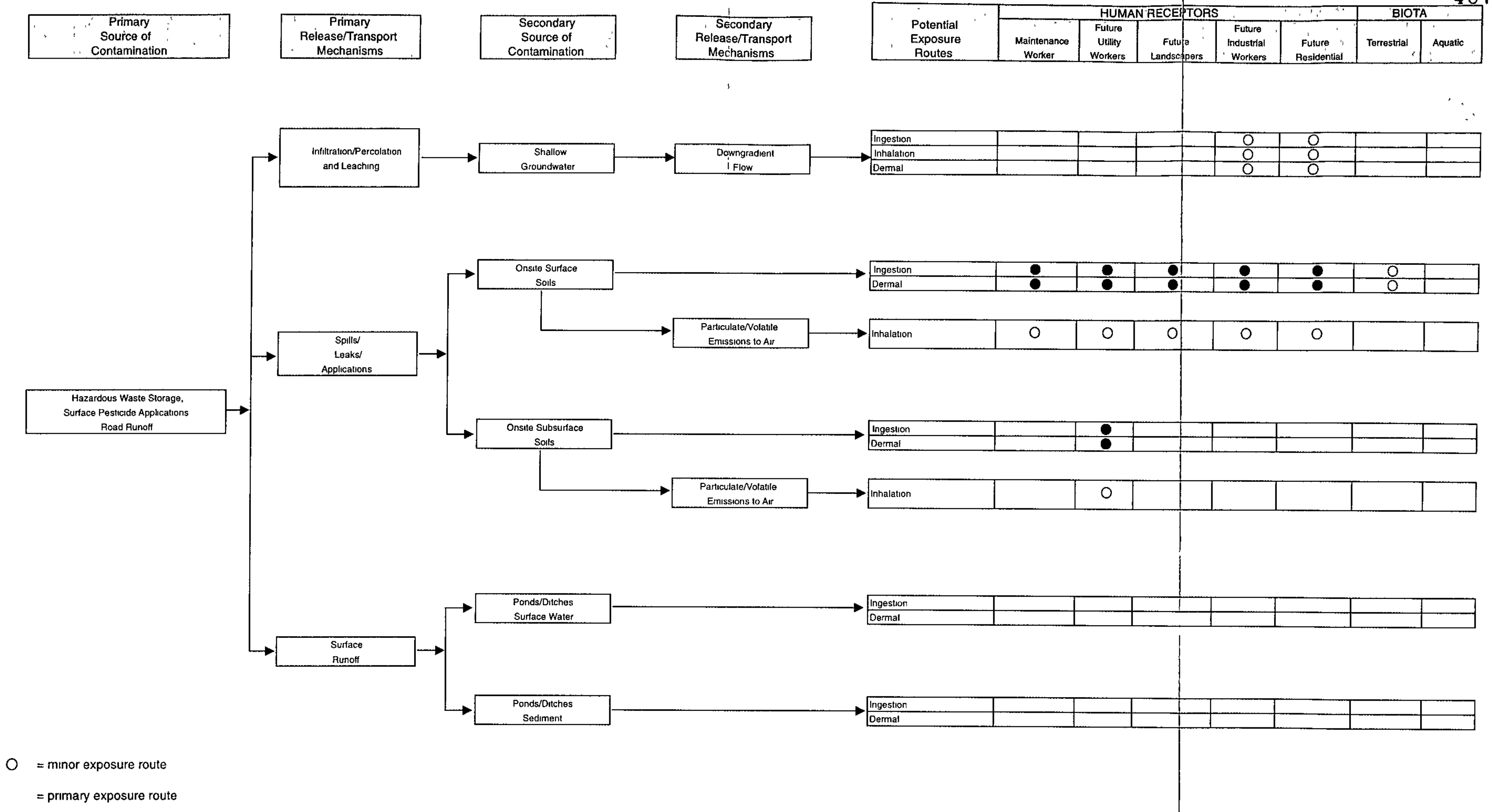

Secondary Source	Potential Exposure Routes	Maintenance Worker	Future Utility Workers	Future Landscapers	Future Industrial Workers	Future Residential	Terrestrial	Aquatic
Shallow Groundwater (Downgradient Flow)	Ingestion				○	○		
	Inhalation				○	○		
	Dermal				○	○		
Onsite Surface Soils	Ingestion	●	●	●	●	●	○	
	Dermal	●	●	●	●	●	○	
Particulate/Volatile Emissions to Air	Inhalation	○	○	○	○	○		
Onsite Subsurface Soils	Ingestion		●					
	Dermal		●					
Particulate/Volatile Emissions to Air	Inhalation		○					
Ponds/Ditches Surface Water	Ingestion							
	Dermal							
Ponds/Ditches Sediment	Ingestion							
	Dermal							

○ = minor exposure route

= primary exposure route

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FIGURE 30-5
CONCEPTUAL SITE MODEL FOR POTENTIAL HUMAN AND ECOLOGICAL EXPOSURES: SITE 66
MEMPHIS DEPOT MAIN INSTALLATION RI

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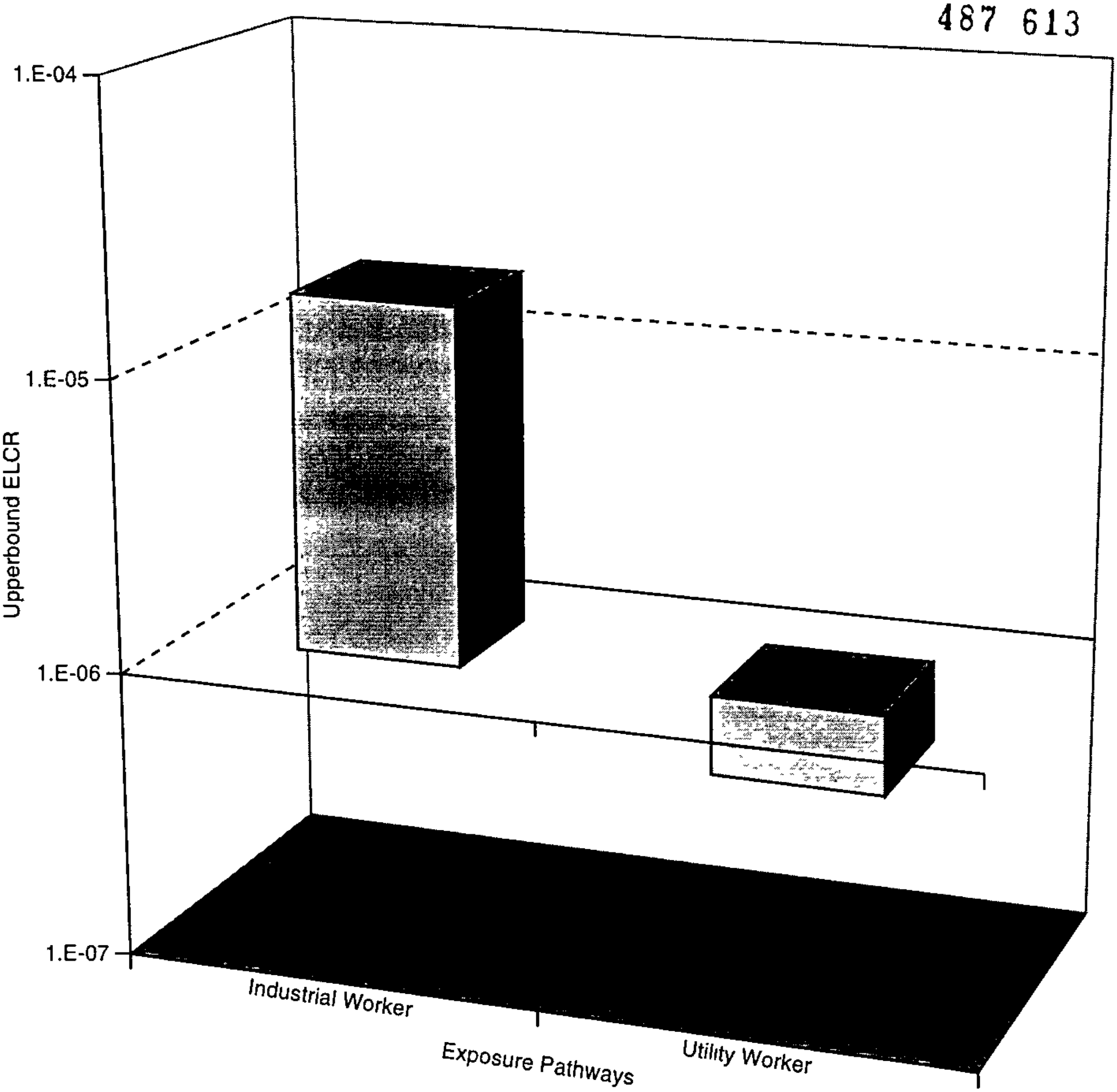

☐ Total ELCR (accepted range of 1E-4 to 1E-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 30-6
TOTAL EXCESS LIFETIME CANCER RISKS FOR SOIL EXPOSURE AT SITE 66
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 31

TAB

31. Summary and Conclusions for FU6

31.0 Summary and Conclusions for FU6

31.1 Summary

31.1.1 Nature and Extent of Contamination

RI data were collected for surface and subsurface soil to assess the nature and extent of contamination at FU6.

31.1.1.1 Soil

Metals, SVOCs, pesticides, and VOCs were detected in the soils across FU6. Some of these contaminants were detected at elevated concentrations (concentrations above background values) in areas that may have contributed to contamination, based on past operations. The following data interpretation associates the detected contamination with the historical site operations:

- Screening Site 58 for metals and VOCs–at Pad 267;
- Screening Site 66 for SVOCs–at Sample SS66A near Building 253; and
- Screening Site 67 for metals and VOCs–at the Installation Gas Station (Building 257).

In addition, the elevated concentrations typically were detected in the surface soils. Contaminants detected in the subsurface soil generally were below (or near) background values, with the exception of total xylenes.

Metals. Lead, copper, and selenium are the primary metals of concern throughout FU6. These metals exceed background values in surface soil at a number of areas throughout FU6.

Elevated lead and copper concentrations in surface soil samples were observed in the southwestern corner of FU1 and near Building 257 (Screening Site 67), respectively. Only one elevated concentration of either metal (a copper concentration in SB67B) was noted in the subsurface soil samples.

Subsurface soil concentrations of selenium exceeded the background value more than did surface soil concentrations.

Nickel, chromium, zinc, and arsenic were identified as the distributed metals. Potassium and calcium were identified as the natural metals, with detected concentrations above background values.

Pesticides. Most of the samples analyzed within FU6 indicate that pesticides were not present or that the detected concentrations were below background values. DDT, DDE, DDD, alpha-chlordane, gamma-chlordane, and dieldrin were the only pesticides detected above background levels in surface soil at FU6. Dieldrin was the only pesticide detected at concentrations above the GWP value. The pesticides were dispersed throughout FU6.

Because the pesticides are distributed throughout FU6, their detection probably is attributable to site-wide application rather than to site-specific, activity-related releases at these specific waste management sites. No concentrations of pesticides were detected in the subsurface soil above background.

SVOCs. The primary SVOCs of concern in the surface soil at FU6 were PAH compounds. PAHs were detected throughout the Main Installation, with the highest concentrations in proximity to the railroad tracks. PAH compounds can originate from the seepage of creosote from railroad ties, from historical railcar leaks, or from PCP/used-oil mixtures historically applied for weed control along the tracks.

The highest concentration of total PAHs was observed in Sample SS66A, taken to be a representative sample of motor pool activities.

SVOCs, including PAHs, rarely were detected in the subsurface soils.

Dioxins. Dioxins were not analyzed for in the surface and subsurface soils in FU6 because records of past activities did not indicate the need to analyze for these parameters.

VOCs and Other Organics. The majority of the surface and subsurface soil sampling results for VOCs within FU6 indicated no detected concentrations. However, there was one isolated area where elevated concentrations of VOCs were detected in the surface soil within FU6. SB58B contained concentrations of eight VOCs, six of which were only located in this sample location: carbon disulfide, chloromethane, ethyl benzene, toluene, total xylenes, and TCE.

Probably because of volatilization at the surface, detected concentrations of VOCs in subsurface soils were not always colocated with elevated surface soil concentrations. These areas are identified below:

- SB58B contained only three VOCs in the subsurface samples. Bromomethane, total xylenes, and TCE were the only detected parameters, compared to the six VOCs detected in the surface samples;
- Benzene, ethyl benzene, and xylene were detected in four additional sample locations in the subsurface samples at Site 67, which is a former gas station. The benzene concentrations were observed in locations where the surface samples showed no presence of benzene; and
- Methylene chloride was observed in three additional locations in Screening Site 66.

Benzene, methylene chloride, and total xylenes were the only VOCs to exceed their respective GWP values.

31.1.1.2 Sediment

Two BRAC sediment samples were collected from sumps beneath floor drains in Buildings 251 and 265. Building 251 is a thrift shop used as a storage and repair facility and Building 265 is the facility engineer maintenance shop. Contaminants detected in the sump sediment included metals, SVOCs, and petroleum hydrocarbons. The sediments are beneath a metal grill and are not subject to direct surface water runoff because they are within an enclosed building. The sediments in both sumps have been removed, and the sumps closed with grout. Building 251 has been demolished.

31.1.2 Fate and Transport

31.1.2.1 Migration Pathways

FU6 consists of the main administration building (Building 144), large parking lots, police station, gasoline filling station, housing area, and several smaller buildings (Buildings 251 through 257, 260, 261, 263, 265, and 270 through 274). Building 274 is the new cafeteria building, which provided food for Depot employees. Most of the surface area within FU6 is covered by asphalt for parking lots and roadways, or concrete-paved roads, with small grassy strips. The building complex, including Buildings 260, 263, 265, and 270, currently is being used as a police station. The area surrounding the housing buildings is completely surrounded by fresh sod and an asphalt drive (Figure 2-16). Potential pathways for migration at FU6 are surface runoff, leaching, and dust emission. Because of the current ground cover, significant leaching and volatization are not anticipated.

Surface runoff will migrate from concrete-, asphalt-, and gravel-covered areas around the buildings and the grassy areas located near the FU boundaries. There are no surface water bodies or drainage ditches within FU6. Surface water runoff within FU6 flows in a general north to south pattern, based on surface topography. Stormwater collected in the western third of FU6 is transported to the underground pipe system that empties in the concrete-lined ditch below Lake Danielson and ultimately discharges off-site to an unnamed tributary south of N Street that discharges into Nonconnah Creek (Black & Veatch, 1999). Stormwater in the central part of FU6 flows through drop inlets to the underground pipe system that discharges either into the pond or into the concrete-lined ditch (Site 52) below the pond. The ditch discharges into an unnamed tributary south of N Street (Outfall 12) that eventually discharges to Nonconnah Creek. Stormwater from the southern portion of FU6 flows via the underground pipe system and discharges to the city's stormwater drainage system south of the community club complex. Stormwater collected from FU1 passes through FU6 and is discharged off-site to the city's system along Airways Boulevard.

The eastern boundary of FU6 also is the Main Installation's site boundaries, which are fenced and covered with grass. The grassy areas outside of the fenced areas were not accessible to site operations-related direct releases. These grassy areas are more than 100 ft wide between the fence and public roads.

Dust emissions could occur from the grass- and gravel-covered areas within FU6. However, dust emissions will be dramatically reduced because of the asphalt cover present as ground cover over a major portion of FU6 (see Figure 2-16). Also, grass-covered areas around the housing units and the cafeteria were remediated and covered with clean soils; thus, dust from these areas is not likely to be associated with site contamination.

31.1.2.2 Contaminant Persistence and Migration

Metals, PAHs, and pesticides were the most frequently detected contaminants at FU6. Metals are persistent in the environment, but are not volatile. Emissions of metals to the ambient air would be in the form of particulate emissions. PAHs are not very volatile and are likely to degrade with time because of exposures to sunlight and air. The pesticides degrade slowly and are expected to remain bound to the soil; thus, they are likely to be released through dust. The surface runoff pathway is not complete because of the lack of significant flow through surface drainage features within this FU; in particular, off-site runoff only occurs along the southeastern and northeastern borders of FU6 through stormwater drainage systems. The remaining runoff is routed to FU2, where concrete-lined stormwater drainages ultimately reach off-site at the southern boundary of FU2. Off-site migration is not considered a significant concern for FU6.

Leaching to groundwater could be a potentially complete migration pathway for the detected petroleum VOCs in subsurface soil. Because of the low levels in the deepest samples (18- to 20-ft depths), the infrequently detected concentrations of these VOCs, and their short half-lives in groundwater, they may not affect the groundwater. However, groundwater at the site is addressed in Sections 32.0 through 35.0.

31.1.3 Risk Assessment

31.1.3.1 Summary and Conclusions of Risk Assessment for FU6

The human health RA for FU6 included all of the data collected within this geographic area. The primary conclusions of this RA are as follows:

- Arsenic, DDE, DDT, dieldrin, Aroclor-1260, and PAHs were detected in surface soils above background and RBC values, and therefore, were included as COPCs. Additionally, benzene, methylene chloride, and xylenes were added as COPCs to the subsurface soils. Sediments from the sumps in Buildings 251 and 265 had inorganics, PAHs, and petroleum hydrocarbons as COPCs;
- The COPCs at Site 66 were a subset of what was detected within FU6, mostly PAHs. There are no exposed soils adjacent to Building 253 where Site 66 is located; therefore, soil samples were collected from an adjacent parcel south of Building 250;
- The potential exists for subsurface VOCs to migrate to groundwater. However, based on the low levels in the deeper samples and short half-lives in water, these chemicals may not be at measurable levels in the regional groundwater;
- Overall human health risks and noncarcinogenic hazards to current maintenance workers, future industrial workers, and utility workers in FU6 are within the acceptable risk limits for carcinogenic and noncarcinogenic end points;
- Potential risks from the surrogate site (Screening Site 66) are negligible. The COPCs identified are a subset of those found in FU6. Overall risks to various receptors were within acceptable levels; and
- Overall human health risks and noncarcinogenic hazards to residents in FU6 also are within acceptable risk limits. The risks under a hypothetical residential scenario estimated for a single data point were above the upperbound acceptable limits for carcinogenic risk of the 1 in 10,000 (10^{-4}) level, primarily because of the PAHs detected in the sample.

31.1.3.2 Summary and Conclusions of Ecological Risk Assessment for FU6

A screening level ERA was conducted for the entire FU6 to evaluate the extent to which contaminant concentrations potentially could adversely affect ecological receptors. Although ecological habitat at FU6 is limited to a few maintained grassed areas, the ERA was conducted in accordance with EPA guidance, which recommends little or no risk management input in the screening assessment. The screening assessment (Steps 1 and 2) identified a number of COPCs for consideration in Step 3. The refinement process in Step 3 reduced the number of preliminary COPCs; however, further consideration of site-specific ecological exposure pathways indicated that current and future exposure pathways at this site are incomplete. There is adequate information to conclude that the ecological risk at FU6 is negligible, and there is no need for remediation based on ecological risk.

31.1.3.3 Summary and Conclusions for Screening Site 66

Conclusions specific to the surrogate site RA performed at Site 66 are presented below:

- Site 66 was selected as the surrogate site to represent the worst-case potential risk areas within FU6, based on the results of the evaluation presented in Section 7.0;
- The site is located at Building 253 (with the UST at the northern end of the building) and there are no exposed soils immediately adjacent to the building;
- A human health RA was conducted for this site because it represents the worst-case exposures to human receptors. An ERA was not conducted at this site because it is an industrial site and not a suitable habitat for terrestrial receptors;
- Surface soil samples indicated the presence of several PAH compounds above screening criteria and/or background values; these were selected as COPCs;
- Risks and noncarcinogenic hazards estimated for workers under various exposure scenarios represent risks within the 1 to 100 in a million range (10^{-6} to 10^{-4}) and HIs below a target value of 1.0. The total risks are represented by the higher of the surface and deeper soil risk estimates; and
- Site 66 does not pose a significant human health concern for future industrial land use at FU6, even under high-end exposure assumptions.

31.2 Conclusions

31.2.1 Data Limitations and Recommendations for Future Work

The nature and extent of the chemical constituents in surface and subsurface soil have been defined both vertically and horizontally in FU6. In general, surface soil samples with concentrations attributable to source areas within FU6 were further investigated until the extent of contamination was been defined. Similarly, subsurface soil samples with elevated concentrations were investigated to shallow groundwater or until contamination was not detected further (below detection limit). Sampling investigations were carried out in several rounds to define the nature and extent around an identified contamination. As a result, no data limitations were identified with respect to the surface or subsurface soil samples collected in FU6. The groundwater under the FU and the Depot is considered as one unit for investigations. Therefore, no additional future work is recommended for FU6.

31.2.2 Recommended Remedial Action Objectives

As shown in the baseline RA detailed in Section 30.0, overall human health risks and noncarcinogenic hazards associated with exposure to soil and sediment are within acceptable risk limits. Groundwater risks are further discussed in Section 34.0. No areas within FU6 require remedial action to facilitate the transfer of property.

TAB

Section 32

TAB

32. Nature and Extent of Contamination at FU7

32.0 Nature and Extent of Contamination at FU7

Current knowledge about the nature and extent of contamination in the FU7 groundwater is based on an evaluation of chemical data that were obtained from groundwater samples collected during five sampling events from January 1996 through November 1998. During this time, groundwater samples were analyzed for herbicides, metals (total), pesticides/PCBs, SVOCs, and VOCs. Samples were collected from wells installed by Law Environmental during the initial 1990 RI activities at the Depot (Law Environmental, 1990a), wells and piezometers installed by CH2M HILL, and push samples collected by CH2M HILL. Locations of wells sampled over the entire Depot are shown in Figure 32-1. All wells within the Main Installation were completed near the base of the fluvial aquifer. Most, but not all, identified the surface of the confining unit clay (see Figures 2-8a and 2-8b). Only analytical data from wells and other groundwater sampling locations identified as Main Installation wells are reported in this document. Groundwater data associated with the Dunn Field wells will be reported in the upcoming Dunn Field RI report.

Table 32-1 identifies the groundwater sampling locations and summarizes the analyses that were conducted on the Main Installation. Of these groups of chemicals, VOCs, SVOCs, and metals (total) were detected. Because of their low mobilities from the surface to depth, herbicides and pesticides/PCBs were not detected in groundwater samples.

The nature and extent of specific chemicals in Main Installation groundwater are discussed in the following subsections.

32.1 VOCs in Groundwater

A total of 20 VOCs were detected in groundwater samples collected since November 1998. Table 32-2 lists these VOCs, along with pertinent statistics. The numbers of detected concentrations are calculated on both normal and duplicate samples.

Of the 20 VOCs detected, only six were determined to warrant detailed discussion based on the frequency of detected concentrations per well and spatial occurrence: carbon tetrachloride, total 1,2-DCE, PCE, TCE, 1,1,1-Trichloroethane (1,1,1-TCA), and chloroform. Three general areas of persistent VOC occurrences are discernible within the Main Installation: the southeastern section, the southwestern section, and the west-central section. The southeastern section includes the golf course, Lake Danielson, the Golf Course Pond, and other sites within the Southeast Golf Course\Recreational Area and Administrative and Residential Area FUs that are the subject of this RI. The southwestern section is characterized by past industrial activity, as is the west-central section. One persistent VOC, 1,1,1-Trichloroethane, was not detected in either of these general areas, but was detected at two locations beyond the western boundary of the Main Installation outside the Depot boundaries. 1,1,1-TCA is a constituent associated with the northern portion of Dunn Field (CH2M HILL, 1997); however, groundwater beyond the western perimeter of the Main Installation is not downgradient of Dunn Field.

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32.1.1 Southeastern Section

The VOCs consistently detected in the southeastern section include PCE, TCE, 1,2-DCE, carbon tetrachloride, and chloroform. PCE and TCE were detected most frequently in groundwater samples. The highest detected concentrations at each well ranged from 0.001J mg/L to 0.016 mg/L PCE, and from 0.001J mg/L to 0.058 mg/L TCE. Figures 32-2 and 32-3 present the distributions of PCE and TCE and show the highest concentrations detected during the RI sampling. The highest concentration of PCE was detected in MW-26, located to the west of Building 274. The spatial distribution of PCE occurrences suggests that a plume may be present that trends northwest to southeast. Concentrations decrease to the north, south, and east from an area of high concentration in the vicinity of MW-26 located west of Building 274, and MW-25 located south of Lake Danielson (Figure 32-2). Groundwater flow directions across the Main Installation support the observed configuration of the plume. Low estimated quantities of PCE have been detected in groundwater samples from wells near the southern boundary, so these wells are considered to be at or near the edge of the southern extent of the plume in the southeastern section of the Main Installation. The potentiometric surface (Figure 2-12) indicates that groundwater flow from this area is toward the southwest and toward a northwest-southeast trending depression in the potentiometric surface in the vicinity of PZ05 and MW-24. Groundwater flowing from the Building 274 area is believed to flow to this depression, then southeastward toward the Main Installation boundary. To date, no PCE has been detected in MW-24, which is the most downgradient well in the south-central depression.

TCE, which may result from anaerobic degradation of PCE, has been detected in wells in the southeastern section of the Main Installation at concentrations and spatial distributions that suggest its presence may be partially unrelated to PCE occurrence. TCE does occur in three (MW-26, MW-64, and HY03) of the five locations where PCE was detected and, except at MW-64 (the northwestern-most well in the southeastern section), concentrations of TCE are lower than those of PCE (Figure 32-3). The occurrence of TCE at these locations might be attributable to the anaerobic degradation of PCE; if so, it originates from the same source. The absence of TCE in groundwater samples collected from MW-25 and MW-52, which are intermediate/upgradient and downgradient of the TCE occurrences, implies that the plume has become diluted.

Other sources of TCE are suggested by occurrences of TCE in groundwater samples from HY04 and PZ05. HY04 is located perpendicular to groundwater flow from MW-26 and the Building 274 area, a potential source area for PCE and TCE. The concentration of TCE detected in a groundwater sample from HY04 was 0.002J mg/L. If there is another source area at this location, the source does not appear to be a significant contributor of TCE to groundwater. Another potential source area for TCE is indicated by the presence of TCE in PZ05, the southernmost sampling location in the southeastern section. This location is oblique to groundwater flow from MW-26 and the Building 274 area. Groundwater samples collected from wells MW-25 and MW-52 contained no TCE. A groundwater sample collected from upgradient well HY04 contained TCE at a lower concentration, 0.002J mg/L, compared to 0.058 mg/L at PZ05. The potentiometric surface indicates that groundwater flow from this area is to the southwest into a northwest-southeast trending depression in the potentiometric surface in the vicinity of PZ05 and MW-24. To date, no TCE has been detected in MW-24, which is the most downgradient well in the south-central depression.

Only a trace quantity of carbon disulfide, at 1 μg/L, has been detected in groundwater samples from MW-24. The elevated concentration of TCE detected in the off-site piezometer PZ05 is anomalous because this location is not directly downgradient of the other wells that show organic contamination on the Main Installation. The industrial facilities records search (Appendix H) identifies a dry cleaning operation and an electrical shop approximately 2,000 ft southwest of the southeastern corner of the Main Installation. TCE could be present in PZ05 as a degradation product of PCE (otherwise known as perchloroethylene, the predominant solvent used in dry cleaning), released from historic or current dry cleaning operations.

Because of its limited areal extent and detection at low concentrations, 1,2-DCE is not considered to be a significant contributor to groundwater contamination at the Main Installation. The VOC 1,2-DCE, which is a degradation product of TCE, was found to occur in groundwater samples from two locations (MW-52 and HY04), as shown on Figure 32-4. The maximum detected concentration was 0.001J mg/L. Groundwater from HY04 was found to contain TCE. Groundwater from MW-52 also was found to contain PCE, although TCE was not detected.

Carbon tetrachloride has been detected in groundwater samples from three locations (MW-25, MW-26, and MW-64) in the southeastern section (Figure 32-5). The highest concentration detected was 0.004J mg/L in a groundwater sample from MW-26. In MW-26, the concentration of carbon tetrachloride detected in groundwater samples has remained at 0.004J mg/L during five sampling events covering first quarter 1996 to fourth quarter 1998. At MW-25, the concentration increased from "not detected" to 0.002J mg/L over the same time period. MW-64 has been sampled only once. The low concentrations of carbon tetrachloride reported are considered estimates, because they were quantified below the detection limit of the analytical method ("J" qualified).

Chloroform has been detected in groundwater samples at low, estimated concentrations from two locations (Figure 32-6). At MW-26, just west of Building 274, chloroform has been detected consistently at 0.001J mg/L to 0.002J mg/L during RI sampling. Only during the third quarter 1997 sampling event was it not detected. At MW-64, located northwest of MW-26 and obliquely downgradient, chloroform was detected at 0.001J mg/L in a groundwater sample. This well was installed in October 1998 and has been sampled only once. Chloroform is a degradation product of carbon tetrachloride, so detected concentrations in MW-26 and MW-64 may be associated with the carbon tetrachloride found in these wells.

32.1.2 Southwestern Section

The persistent VOCs detected in the southwestern section of the Main Installation include PCE, TCE, and 1,2-DCE. The maximum concentrations detected ranged from 0.001J mg/L to 0.120 mg/L of PCE, 0.004J to 0.031 of TCE, and 0.002J mg/L to 0.009J mg/L of 1,2-DCE, as shown on Figures 32-2, 32-3, and 32-4, respectively. PCE was detected at its highest concentration (0.120 mg/L) in a groundwater sample collected from MW-21 during the fourth quarter of 1998. Figure 32-2 shows the areal distribution of the maximum concentrations of PCE detected during the RI sampling. As further discussed in Section 32.1.6, the concentration of PCE in groundwater samples from this location has been increasing since RI sampling began during the first quarter of 1996. This increase in concentration is accompanied by an increase in groundwater level of approximately 1 ft at this location. The increase in concentration over time may be related to the increase in recharge the aquifer has received, resulting in more PCE being leached from the vadose zone to the aquifer.

A similarly high concentration of 0.11 mg/L of PCE was detected in a groundwater sample from PZ04 located beyond the Main Installation boundary to the southwest of MW-21. PZ04 is directly upgradient from MW-21. Groundwater flow is from the southwest onto the Main Installation area, suggesting the possibility of an off-site source of PCE. To the southeast of locations PZ04 and MW-21, groundwater from MW-47 has been affected by PCE, but to a lesser degree. Concentrations have fluctuated from 0.023 mg/L detected during the first quarter of 1996 to 0.001J mg/L detected during fourth quarter 1998 sampling.

PCE also has been detected in groundwater samples collected at two downgradient locations (MW-39 and PZ03, located in the central section of the plant and discussed below) to the east of MW-21 toward the eastern boundary of FU3, Concentrations have been estimated below 0.010 mg/L. Although these locations are downgradient from the occurrences of PCE in the southwestern section, groundwater converges from the southeast with that from the southwest into the central portion of the Main Installation. The central section of the Main Installation area could be receiving PCE via transport from the southwestern and southeastern sections.

TCE has been detected at maximum concentrations ranging from 0.004 mg/L to 0.031 mg/L in the southwestern section of the Main Installation. TCE was detected, as a possible degradation product of PCE, in groundwater samples from MW-21, MW-22, and MW-47 (Figure 32-3). 1,2-DCE was detected in groundwater samples from two locations (MW-21 and MW-47), both of which contained PCE and TCE. The maximum concentration detected, 0.009J mg/L at MW-47, occurred during first quarter 1998 sampling. Fourth quarter 1998 sampling results showed 0.001J mg/L.

Appendix A identifies an abandoned dry cleaning operation about 1,200 ft south of the southwestern corner of the Main Installation, just southeast of the PZ08 location. This location was suspected to be a possible source of the PCE and degradation products found in groundwater in the southwestern section of the Main Installation. However, no organic compounds have been detected in PZ08, located between MW-47 and the dry cleaner location, nor is the dry cleaner oriented within the upgradient flow path, as currently depicted, of the elevated organic concentrations in PZ04 and MW-21. Therefore, it is unlikely that this facility is contributing organic chemicals to the Main Installation plume. An unidentified off-site source of PCE to the southwest of PZ04 and MW-21 continues to be a possibility. It is also possible that the source of PCE is on the Main Installation and has migrated off-site because of the topography of the confining clay unit, which is observed to dip toward the south and southwest (Figure 2-9) and because of the relatively flat groundwater gradient.

32.1.3 Central Section

Persistent VOCs have been detected in groundwater samples at some locations in the central section of the Main Installation, including PCE, TCE, chloroform, and carbon tetrachloride. The potentiometric surface indicates that groundwater flow converges from the southeast, the south, and the southwest to the central portion of the Main Installation area. These VOCs have been detected at locations upgradient from the central section.

PCE has been detected in groundwater samples from MW-39 and PZ03, which are downgradient from the southeastern and southwestern sections of the Main Installation, where PCE also has been detected (Figure 32-2). PCE has been detected in four samples from MW-39, ranging in concentration from 0.003J mg/L to 0.009J mg/L. The suspected source of PCE in groundwater samples from these wells is the upgradient area to the southwest.

PCE has been detected in one of the four groundwater samples collected from MW-34, located in the depressed clay feature in the southwestern corner of Dunn Field. PCE was detected at 0.001J mg/L during the first quarter 1996 sampling event, but was not detected in any subsequent sampling events.

TCE has been detected in four wells in the central section (Figure 32-3). This compound consistently has been detected at concentrations below 0.010J during four sampling events. PCE, TCE's parent compound, also has been detected in groundwater from one of these wells.

The highest concentration of TCE (0.037 mg/L) was detected in a groundwater sample from MW-62 during the fourth quarter 1998 sampling event. No other persistent VOCs have been detected at this location.

Carbon tetrachloride was detected in groundwater samples from MW-34 only once in four sampling events (Figure 32-5). This compound was detected at 0.001J mg/L during the first quarter 1996 sampling event but has not been detected since, and therefore, is not a significant contributor to VOC contamination. Carbon tetrachloride has been detected in groundwater at Dunn Field (CH2M HILL, 1997). MW-34 is in the depressed clay feature in an area where flow from the southern portion of Dunn Field may be converging with flow from the Main Installation. It is possible that this isolated, low-level detection of carbon tetrachloride originated from Dunn Field.

Chloroform was detected in groundwater samples from MW-34 and MW-43 (Figure 32-6), both of which are located within the depressed clay feature. The sample from MW-43 was collected from a temporary well installed below a clay unit, presumably a thinned section of the uppermost clay of the Jackson Formation-Upper Claiborne Group, which was encountered during drilling activities. Chloroform also was detected in a groundwater sample collected from MW-63, located near the southeastern edge of the depressed groundwater surface. MW-34 had the highest chloroform concentration (0.005J mg/L), but this compound was not detected in this well during the fourth quarter 1998 sampling. Like carbon tetrachloride, chloroform was detected in groundwater at Dunn Field, so these low-level, estimated detected concentrations may be attributable to groundwater transport from Dunn Field.

32.1.4 Occurrences Beyond Depot Boundary

The VOC 1,1,1-TCA was detected in groundwater samples from two locations, both of which are beyond the Main Installation boundaries (Figure 32-7). 1,1,1-TCA was detected in MW-66 (west of the Main Installation) in the fourth quarter 1998 sampling at an estimated concentration of 0.001J mg/L. This location is upgradient of the Main Installation. No 1,1,1-TCA was detected in groundwater samples collected from downgradient wells immediately to the east of MW-66 on the Main Installation property.

As discussed in Section 2.5.2.3, the installation of MW-43, clay was encountered between elevations 112.5 and 107.5 ft msl. A temporary well was set below this elevation, screened between 91.7 and 81.7 ft msl, to obtain a water quality sample from the underlying saturated sand. The well was permanently installed, with the screened interval immediately above the clay. In two samples collected from the lower interval, one with the Grundfos pump and one with a bailer, concentrations of 1,1,1-TCE at 0.001J mg/L (pumped) and 0.014 mg/L (bailed) were detected. 1,1,1-TCE also was detected in the upper sample at 0.002J mg/L. In groundwater samples from upgradient wells, 1,1,1-TCA was detected only in MW-66. Numerous Main Installation wells between MW-66 and MW-43 have been sampled, resulting in no detected concentrations of 1,1,1-TCA.

Concentrations of 1,1,1-TCA have been estimated below the MDL in wells at Dunn Field, at concentrations less than 0.01 mg/L. The highest concentration above the detection limit was 0.011 mg/L in PZ02, located beyond the northeastern corner of Dunn Field. Therefore, the 1,1,1-TCE detected in MW-43 may originate from sources at Dunn Field. Additional groundwater sampling is planned and will be documented in the Dunn Field RI report.

32.1.5 Other VOCs

Of the remaining 14 VOCs that were detected (Table 32-2), none was detected more than four times and most were detected only once or twice in 83 total samples. The occurrences are temporally sporadic, indicate no significant effect on the fluvial aquifer by these VOCs, and suggest no significant source area. With the exception of acetone, these VOCs were detected at estimated concentrations not exceeding 0.010 mg/L.

Acetone was detected in groundwater samples from three locations (HY04, MW-41, and MW-43). HY04 was sampled in October and November 1998. Acetone was not detected in the October sampling event, but was detected at 0.024 mg/L in November. Therefore, its presence is uncertain at this time. MW-41 has been sampled five times since 1996. Only in the 1996 sampling episode was it detected. MW-43 was sampled three times in October 1998 and in only one sample was acetone detected. It was sampled again in November 1998 and acetone was not detected. The anomalous occurrences of acetone and the lack of any known source area at HY04 and northwest of the Main Installation, suggest that acetone may be attributable to laboratory contamination. Acetone is a commonly occurring laboratory contaminant (see Section 5.3)

32.1.6 Temporal Trends in Persistent VOC Concentrations

The concentrations of persistent VOCs were plotted over time to evaluate trends at locations with more than one sampling event. No more than five samples were collected and no more than five groundwater levels were measured between January 1996 and November 1998. Only general observations can be made regarding trends and relationships, because the groundwater samples were collected and the groundwater level measurements were recorded during five sampling events over nearly a 3-year time frame

Generally, groundwater levels were observed to fluctuate over an elevation change of approximately 1 ft. Temporal trends in groundwater level fluctuations in the fluvial aquifer beneath the Main Installation are variable, though some patterns between wells are evident. Figure 2-2 shows the trend in actual and average monthly precipitation from January 1996 and the precipitation conditions during each of the groundwater sampling events. The average precipitation data for the Memphis area covers the period from 1961-1990. The actual average precipitation for each month is presented on Figure 2-2. Hydrologic conditions for each sampling event can be summarized as follows:

- 1st Quarter 1996 (February)–This sampling period has historically average precipitation. The preceding month's actual precipitation is higher than average; actual February precipitation lower than average February precipitation.
- 2nd Quarter 1997 (June)–This sampling period has historically below average precipitation. Actual precipitation during the sampling period and the preceding 10 months above average.
- 3rd Quarter 1997 (October)–This sampling period has historically below average precipitation. Actual precipitation in preceding 2 months below average.
- 1st Quarter 1998 (March)–Both historic average and actual precipitation were above average.
- 4th Quarter 1998 (October)–Both historic average and actual precipitation were below average.

For the most part, the degree of groundwater fluctuation is less than 10 percent of the saturated thickness of the aquifer and does not change the general flow directions across the Main Installation. Specific reasons for the variation in groundwater level trends have not been identified; the variation may be an artifact of the limited groundwater elevation data available. Possible reasons for the variation between wells involve the dynamics of surface water runoff across the Main Installation and the local configuration of the confining unit clay.

With a couple of exceptions discussed below, neither positive nor negative correlations of groundwater level with change in concentration are discernible (Figures 32-8a and 32-8b). Concentrations of persistent VOCs at most wells tend to be below the detection limit, so some variation may result from variations in estimating the concentration rather than actual changes in groundwater concentrations. Fluctuations in concentrations are erratic, sometimes increasing or decreasing several times the previous sampling events' concentration. Correlation patterns of VOC concentration levels with groundwater elevations when concentrations tend to be in the vicinity of the detection limit are, at best, speculative.

In contrast, groundwater samples from MW-21 exhibit a significant positive correlation of groundwater level change with concentration, particularly for PCE and TCE. From the first quarter 1996 to the fourth quarter 1998, the concentration of PCE increased from 0.052 mg/L to 0.12 mg/L. TCE also increased in concentration from 0.009J mg/L to 0.031 mg/L. During five sampling events, 1,2-DCE was detected only once, at 0.002J, which is below the detection limit during fourth quarter sampling in 1998. The increase in concentrations of

PCE, TCE, and possibly 1,2-DCE suggests a nearby soil source that is leaching VOCs to groundwater during recharge through the soil column and vadose zone. However, no VOCs have been detected in soil samples collected in this area (Figure 32-9).

Plume geometry during the course of this RI from January 1996 to November 1998 changed only slightly because of changes in concentration. In the southwestern area, PCE was intermittently detected in MW-47. In downgradient MW-23, PCE was detected at low estimated concentrations in the first sampling event, and not at all in subsequent sampling. Fourth quarter 1998 results that show decreasing concentrations of PCE in MW-47 and non-detect levels in MW-23 suggest that the plume is becoming diluted because of rising groundwater levels or that the plume has passed from this point downgradient. No other significant plume geometry changes are evident.

32.1.7 Relationship Between VOCs in Groundwater and Subsurface Soils

To evaluate the potential relationship between VOCs in groundwater and subsurface soil, the concentrations of organic compounds observed in the Main Installation groundwater (PCE, TCE, 1,2-DCE, carbon tetrachloride, and chloroform) that also were detected in subsurface soil were summed and plotted as a function of sampling interval depth. Figure 32-9 shows the distribution of total organic compounds in subsurface soil for the following sampling intervals: 3- to 5-, 7- to 15-, 16- to 30-, and deeper than 30-ft bgs. Because of the varying objectives of subsurface sampling at individual sites, subsurface boring intervals vary across the site. The intervals presented in Figure 32-9 are groupings of intervals that vary within the reported range. Additional discussions of subsurface VOC contamination are presented in the individual FU sections.

Subsurface organic compounds are consistently present throughout the borehole in two locations: the cluster of boreholes associated with Site 36, the DRMO Hazardous Waste Concrete Storage Pad; and two borings near Site 78, the Acetone, Toluene, Naptha, Hydrofluoric Acid Spill Area. A relatively high concentration of TCE, 11 mg/kg, was detected in the 16- to 30-ft subsurface interval at SB78B. However, TCE was not detected in PZ03, adjacent to SB78B, or in surrounding wells MW-23 and MW-24. Likewise, VOCs were not detected in PZ06, located within the boring cluster at Site 36. Isolated subsurface VOC concentrations were detected throughout the central portion of the Main Installation. A correlation between subsurface soil VOC detected concentrations and VOCs in groundwater was not observed, particularly in the centroid of the PCE plume in the southwestern area.

32.2 Semivolatile Organic Compounds in Groundwater

Five SVOCs were detected in groundwater samples collected during the RI activities. These include chrysene, BEHP, diethyl phthalate, di-n-butyl phthalate, and di-n-octylphthalate. The most frequently detected SVOC was BEHP. Among 57 samples, this compound was detected 5 times at concentrations ranging from 0.001J mg/L to 0.019 mg/L and not more than once at any location. The other SVOCs were detected only once. None of the other SVOCs detected in groundwater exceeded an estimated concentration of 0.004J mg/L.

The phthalate compounds are common plasticizers in latex gloves and other common plastic materials used in the sampling and analysis process. Their mobility through the soil column to groundwater is generally quite limited. Their presence in groundwater samples at the Depot, therefore, is probably not attributable to waste management practices at the Main Installation.

32.3 Metals and Other Inorganics in Groundwater

Twenty-two metals and other inorganics were detected in groundwater samples collected from 19 wells on the Main Installation. Seventy-seven samples were collected during five sampling periods from first quarter 1996 to fourth quarter 1998. All reported metal results are total concentrations–no samples were filtered.

During quarterly sampling, metals concentrations were compared with groundwater turbidity measurements to evaluate whether a statistically significant relationship between these two parameters exits. Such an analysis of the 1st quarter 1996 data produced ambiguous results, with correlation coefficients for each metal analyzed ranging from 0.47 for aluminum to –0 81 for silicon. Turbidity ranged from 6 NTUs to 999 NTUs (off the scale of the instrument). The correlation coefficients of subsequent quarterly data of turbidity and metals concentrations suggested moderate (0.32 2nd quarter 1997) to very weak positive correlations (0.13 and 0.14, 3rd quarter 1997 and 1st quarter 1998, respectively).

Because it may not be reasonable to assume that all metals concentrations in groundwater will respond identically to increases in turbidity, two of the more common mineral-forming metals (iron and aluminum) were investigated. Both of these metals were detected commonly above background in groundwater samples from the Main Installation and are discussed in more detail in subsequent paragraphs.

Turbidity values measured during the RI sampling were plotted with the corresponding aluminum and iron concentrations, as shown on Figures 32-10 and 32-11. On both plots several outliers were removed to observe the relationships on a finer scale. At turbidity values less than 10 NTUs, there appears to be little to no relationship between concentration and turbidity. Between NTU values of 10 and 100, the plots begin to show a marginal positive relationship between increasing concentration and turbidity for both aluminum and iron. At turbidity values exceeding 100, the relationship between increasing concentration and turbidity becomes stronger. Therefore, for iron and aluminum, there does appear to be a positive relationship of increasing concentrations with turbidity. The causes of turbidity typically are associated with disturbances to the water column (during sampling) that suspend small particles. During RI sampling, care was taken to minimize disturbances to the water column; however, at some locations, turbid samples were unavoidable. There are several occurrences of elevated iron and aluminum concentrations associated with low turbidity values (10 NTUs or less). These occurrences may reflect the natural variation in the geochemical properties of the aquifer. On the other hand, there are numerous occurrences of high turbidity with non-elevated concentrations of iron and aluminum. Turbidity in this case may be attributable to some factor other than suspended clay and finer material, perhaps organic material in suspension.

The concentrations of metals detected in groundwater samples from the Main Installation area and adjacent off-site locations were compared with background concentrations. The metals antimony, magnesium, and sodium were detected in groundwater samples, but did not exceed background concentrations at any location. The remaining 19 metals exceeded background concentrations, but at different percentages. Table 32-3 summarizes the metals data.

Seven metals were found to occur at frequencies and locations that suggest their occurrences could be related to waste management practices at the Depot. These frequencies and locations were based on temporal distribution in groundwater samples from each well and by spatial distribution. These metals include (from highest to lowest frequency of detection above background) zinc, cadmium, iron, aluminum, vanadium, arsenic, and potassium. In contrast to the plumes of VOCs that underlie a large portion of the Depot, locations where metals exceeded background concentrations are limited to smaller geographic areas, primarily in the southwestern corner of the Depot. There are some scattered and isolated occurrences elsewhere.

As discussed in Section 16.0, chromium, lead, cadmium, copper, nickel, selenium, and zinc concentrations are elevated in the surface soil at the southwestern corner of the Main Installation because of sandblasting and painting operations. Groundwater samples most frequently containing metal concentrations that exceeded background levels also were collected from this area. The following discussion focuses on each of the seven primary metals and is augmented by a discussion on spatial and temporal distribution.

32.3.1 Primarily Occurring Metals and Inorganics

Zinc was detected in groundwater at the Main Installation in concentrations most frequently exceeding background. Figure 32-12 shows the spatial distribution of zinc detected during the fourth quarter 1998 and also the maximum concentration detected during RI sampling. Zinc was analyzed for 76 times and was detected 40 times. In background wells, zinc did not exceed the detection limit. Therefore, occurrences above the detection limit are background exceedances. Significant concentrations of zinc were detected in groundwater samples from wells located in the general vicinity of the sandblasting area located in the southwestern corner of the installation. The maximum concentration of zinc was 0.351 mg/L, detected in a groundwater sample from HY89A during the fourth quarter of 1998. HY89A is located in the southwestern corner of the installation adjacent to the sandblasting area. Other monitoring wells located in the southwestern corner of the Main Installation near the sandblasting area are MW-21 and MW-22. Groundwater samples from both wells contained zinc at concentrations consistently exceeding background.

MW-20, located to the north of the sandblasting area, yielded groundwater samples containing zinc above background concentrations multiple times during RI sampling events. It is unlikely that groundwater in the vicinity of MW-20 has been affected by operations at the sandblasting area because it is perpendicular to the groundwater gradient from the sandblasting area. Another local source is probably the contributor. Other significant concentrations of zinc have been detected in groundwater samples from MW-38, MW-39, and MW-55, located in the western third of the installation. Zinc was detected in groundwater samples from 17 locations, and although there have been other occurrences of zinc in addition to the locations just discussed, the frequency of detection of zinc in groundwater at these locations suggests transient conditions with insignificant effects on groundwater quality.

Cadmium is the second most frequently detected metal in groundwater at the Main Installation. It was analyzed for 76 times and was detected 37 times. Figure 32-13 shows the spatial distribution of cadmium detected during the fourth quarter of 1998 and also the maximum concentration detected during RI sampling. In background wells, cadmium did not exceed the detection limit. Therefore, concentrations above the detection limit are background exceedances. Significant concentrations of cadmium were detected in groundwater samples from MW-22 near the sandblasting area. In contrast with zinc, cadmium was not detected in groundwater samples from MW-21, which is north of MW-22, indicating the limits of the areal extent of cadmium in groundwater above background Other significant concentrations of cadmium in groundwater were detected in samples from the following:

- MW-20, located north of the sandblasting area and west of the P949 area (POL area);
- MW-38, located south of Dunn Field; and
- MW-41, located beyond Depot boundaries to the northwest of the Main Installation.

The maximum concentration of cadmium was 0.0846 mg/L, detected in a groundwater sample collected from MW-20 during the third quarter of 1997. It should be noted that in two subsequent sampling events, the concentration of cadmium in groundwater samples collected at this location decreased more than two orders of magnitude to 0.00036 mg/L and 0.00073 mg/L, implying irregularities in either sample collection or analytical procedures. Cadmium was detected in groundwater samples from 12 locations, and although there have been other occurrences of cadmium in addition to the locations just discussed, the frequency of detection of cadmium in groundwater at these locations suggests transient conditions with insignificant effects on groundwater quality.

Iron was analyzed for 70 times and was detected in 64 samples above the detection limit. The background concentration of 6.73 mg/L was exceeded in 18 samples from 10 locations (Figure 32-14). The highest concentration of iron was 136 mg/L, detected in a third quarter 1997 groundwater sample collected from MW-20. Subsequent concentrations were three to four orders of magnitude lower, at 0.0971 mg/L and 0.182 mg/L, detected in the first and fourth quarters 1998, respectively. Iron was often detected in groundwater samples from MW-22, located in the southwestern area in the southwestern corner of the installation. In five sampling events, iron exceeded background four times. Only during the first quarter of 1998 did the concentration not exceed background. Iron was detected in groundwater samples from MW-21, located north of MW-22; only in the third quarter of 1997 (one sampling event in five) did the concentration exceed background. Although iron was detected in groundwater samples at other locations, the frequencies of detection of iron in groundwater samples at these locations suggest transient conditions with insignificant effects on groundwater quality.

Aluminum was analyzed for 69 times, detected 55 times, and exceeded background 16 times. The background concentration for aluminum is 1.8 mg/L. Aluminum was detected in groundwater samples above the background value at nine locations, as shown on Figure 32-15. The highest concentration of aluminum detected was 126 mg/L in a third quarter 1997 groundwater sample collected from MW-20. As with iron, in groundwater samples collected in the first and fourth quarters of 1998 concentrations diminished three to four orders of magnitude to below background. At MW-22 and MW-55, aluminum was detected exceeding background more often (3 out of 5 sampling events) than at any other locations and included the fourth quarter 1998 sampling event. MW-55 is located within an area of multiple railroad tracks and on a groundwater high, upgradient to other monitoring well stations at the installation.

Vanadium was analyzed for 69 times, detected 48 times, and exceeded the background concentration of 0.006 mg/L 15 times. Vanadium was detected at eight locations exceeding background (Figure 32-16) The highest concentration of vanadium was detected in MW-20 at 0.262 mg/L during third quarter 1997 sampling. The following sampling events resulted in concentrations of vanadium in groundwater samples from MW-20 approximately two orders of magnitude lower than the highest concentration and below background. This was also the case with aluminum, iron, and cadmium in the groundwater samples collected at MW-20. Only at MW-22 was vanadium detected more than twice during RI sampling. Vanadium was detected in groundwater samples at other locations; however, the frequencies of detection of vanadium in groundwater samples at these locations suggest transient conditions with insignificant effects on groundwater quality.

Arsenic was analyzed for 76 times and detected 13 times, all at concentrations greater than background (the detection limit). Arsenic was detected in groundwater samples collected from six locations, as shown on Figure 32-17. The highest concentration was 0.0905 mg/L in the third quarter 1997 groundwater sample collected from MW-20. Subsequent results for the first and fourth quarter 1998 sampling events show decreasing concentrations, with arsenic not being detected in the fourth quarter of 1998. Elsewhere, arsenic concentrations above background have been detected only sporadically. In the southwestern area, where groundwater samples from MW-22 contained other metals exceeding background, arsenic was detected in two of five sampling events, indicating no significant effects. The sporadic occurrence of arsenic in groundwater samples indicates no sustained effects on the fluvial aquifer.

Potassium was analyzed for 69 times, detected 53 times, and exceeded background 11 times. It was detected in groundwater samples collected from five locations (Figure 32-18). The highest concentration of potassium (13.9 mg/L) in the third quarter 1997 sampling event was detected in a sample from MW-20. In the two sampling events that followed in 1998, potassium was detected below the background concentration of 3.50 mg/L. Potassium has been detected in groundwater samples in three of five sampling events, including the fourth quarter 1998 event at MW-22. Elsewhere, detected concentrations have occurred only sporadically.

32.3.2 Infrequently Occurring Metals and Inorganics

The low frequency of detection and the sparse geographic distribution indicate that for some metals their occasional exceedance above background is not generally related to waste management practices at the facility, but rather to statistical outliers in the concentration distribution for that metal when compared to background concentrations. The metals in this category include calcium, copper, selenium, silver, cobalt, mercury, nickel, barium, beryllium, chromium, lead, and manganese. These metals were detected at concentrations exceeding background 11 times or less during RI sampling events. Table 32-4 presents the concentrations, locations, and sampling periods when these analytes were detected in Main Installation wells at concentrations above background.

None of these metals were detected above background more than twice in the same well during the five sampling events at the Main Installation. Additional discussion of temporal trends is provided in the following subsection. Barium, beryllium, total chromium, cobalt, copper, lead, manganese, and nickel were detected in wells MW-20, MW-21, and MW-22, located near the area of elevated metals in surface soil associated with sandblasting and painting operations in the southwestern corner of the Main Installation. Maximum concentrations of barium, beryllium, copper, and lead in the Main Installation groundwater were observed at MW-20. Total chromium, copper, lead, and nickel also are elevated in the overlying surface soil in this area. Although these metals were only sporadically detected in groundwater above background, their presence in the southwestern area groundwater suggests potential effects on groundwater from surface soil contamination.

32.3.3 Temporal Trends in Metals Concentrations

The concentrations of metals in wells that were sampled more than once were plotted over time to evaluate whether any trends were discernible. Groundwater elevations for the same time period also were plotted to observe their relationship, if any, with metals concentrations (Figures 32-19a through 32-19c). Trends in groundwater levels and the response of groundwater to precipitation are discussed in Section 32.1.5.

Generally, metal concentrations at any one location were not consistent over time. Although elevated concentrations were detected at varying times, maximum concentrations occurred predominantly during the second and third quarter 1997 sampling events. Peaks in concentrations observed during the second and third quarters of 1997 were preceded by significant springtime precipitation events. Precipitation amounts of 11 inches, 9 inches, and 8 inches were recorded during March, April, and May, respectively, in 1997 and are above average precipitation amounts for those months (Section 32.1.5). Correspondingly, during this period, groundwater levels rose in 13 of the 18 wells presented in Figure 32-8. Exceptions are wells in the northwestern and northern perimeter of the Depot (MW-34, MW-38, MW-41, MW-53, and MW-55). Concentrations before and after these sampling events were significantly lower. Generally, maximum concentrations were detected for more than just one of the metals. Wells that illustrate this clearly are MW-20, MW-24, MW-25, MW-26, and MW-47. It should be noted that in most of these wells turbidity values were higher during the 1997 sampling events than in 1996 and 1998. Following these peaks, concentrations of metals typically decreased, as did turbidity values. Generally, concentrations decreased between the first and fourth quarter 1998 sampling events.

Exceptions to decreasing trends, evident from fourth quarter 1998 sampling, are indicated for MW-22 and MW-55. MW-22 is located in the southwestern corner of the Depot and south of the sandblasting and painting area. This area is also noted for occurrences of VOCs in groundwater. The results of metals analyses from the fourth quarter 1998 indicate concentrations of metals at their highest values during RI sampling. This is contrasted with the previous quarter's results, in which concentrations were at or near their lowest. It should be noted that the turbidity did not significantly increase from the 1st quarter 1998 (when concentrations were lower than in the 4th quarter 1998) to the 4th quarter 1998. Concentrations of metals in samples from prior sampling events are between these extremes. MW-55 is located in the northwestern corner of the Depot in a gravelly area adjacent to railroad tracks and upgradient to groundwater flow on the Depot. Notable

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increases were detected for vanadium, lead, and cobalt. In the case of MW-55, a very significant increase in turbidity was measured from the 1st quarter 1998 to the 4th quarter 1998.

In some instances, turbidity and water levels increase as concentrations of some metals increase. In other cases, turbidity and water levels appear to have no relationship with either increases or decreases in metals concentrations. The relationships remain ambiguous, particularly in some of the low-yield fluvial wells. No conclusions have been drawn about these apparently anomalous relationships.

TABLE 32-1
Analytes Investigated for FU7
Memphis Depot Main Installation RI

Station	Sample	Date Collected	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	OC Pesticides	OC Pesticides, TCLP	OC Pesticides/PCBs	PAHs	Petroleum Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
HY01	HY015B	10/25/1998																X
HY02	HY025B	10/26/1998																X
HY03	HY035B	11/08/1998																X
HY04	HY045B2	11/07/1998																X
HY04	HY045B	10/28/1998																X
HY07	HY075B	11/03/1998																X
HY09	HY095B	11/04/1998																X
HY-83A	HY83A5	10/24/1998							X									
HY-83A	HY83A5FD	10/24/1998							X									
HY-89A	HY89A5	10/23/1998							X									
MW20	MW205	10/17/1998							X							X		X
MW20	MW205FD	10/17/1998														X		
MW20	MW204	03/25/1998							X							X		X
MW20	MW204D	03/25/1998														X		
MW20	MW203	09/24/1997							X							X		X
MW20	MW203DUP	09/24/1997														X		
MW20	MW202	06/18/1997							X							X		X
MW20	MW201	02/07/1996				X			X			X				X		X
MW21	MW215	10/19/1998		X					X							X		X
MW21	MW214	03/27/1998		X					X							X		X
MW21	MW213ADD	09/28/1997		X					X									
MW21	MW213	09/27/1997							X							X		X
MW21	MW212	06/20/1997							X							X		X
MW21	MW211	02/10/1996				X			X			X				X		X
MW22	MW225	10/19/1998		X					X							X		X
MW22	MW224	03/28/1998		X					X							X		X
MW22	MW223	09/25/1997		X					X							X		X
MW22	MW222	06/19/1997							X							X		X
MW22	MW221	02/10/1996				X			X			X				X		X
MW23	MW235	10/19/1998		X					X							X		X
MW23	MW234	03/26/1998		X					X							X		X
MW23	MW233	09/26/1997		X					X							X		X
MW23	MW232	06/18/1997							X							X		X
MW23	MW231	02/10/1996				X			X			X				X		X
MW25	MW255	10/16/1998							X							X		X
MW25	MW254	03/26/1998							X							X		X
MW25	MW253	09/25/1997							X							X		X
MW25	MW252	06/19/1997							X							X		X
MW25	MW251	02/09/1996				X			X			X				X		X
MW26	MW265	10/20/1998							X									X
MW26	MW264	03/28/1998							X									X
MW26	MW263	09/26/1997							X									X
MW26	MW262	06/20/1997							X									X
MW26	MW261	02/08/1996				X			X			X				X		X
MW34	MW344	03/27/1998		X					X							X		X
MW34	MW344D	03/27/1998																X

TABLE 32-1
Analytes Investigated for FU7
Memphis Depot Main Installation RI

Station	Sample	Date Collected	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	OC Pesticides	OC Pesticides, TCLP	OC Pesticides/PCBs	PAHs	Petroleum Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
MW34	MW343	09/26/1997		X					X							X		X
MW34	MW343DUP	09/26/1997																X
MW34	MW342DUP	06/19/1997																X
MW34	MW342	06/19/1997		X					X							X		X
MW34	MW341	02/09/1996		X		X			X			X				X		X
MW38	MW385	10/17/1998							X							X		X
MW38	MW385FD	10/17/1998							X									
MW38	MW384	03/26/1998							X							X		X
MW38	MW384D	03/26/1998							X									
MW38	MW383	09/25/1997							X							X		X
MW38	MW383DUP	09/25/1997							X									
MW38	MW382	06/19/1997		X					X							X		X
MW38	MW382DUP	06/19/1997							X									
MW38	MW381	02/11/1996		X		X			X			X				X		X
MW39	MW395	10/19/1998							X							X		X
MW39	MW395FD	10/19/1998							X									
MW39	MW394	03/27/1998							X							X		X
MW39	MW394D	03/27/1998							X									
MW39	MW393	09/26/1997							X							X		X
MW39	MW393DUP	09/26/1997							X									
MW39	MW392	06/20/1997							X							X		X
MW39	MW392DUP	06/20/1997							X									
MW39	MW391	02/10/1996				X			X			X				X		X
MW41	MW415	10/16/1998							X									X
MW41	MW414	03/25/1998							X									X
MW41	MW413	09/27/1997							X									X
MW41	MW412	06/17/1997							X									X
MW41	MW41011796	01/17/1996																X
MW43	MW435U	11/08/1998							X							X		X
MW43	MW435B	10/24/1998																X
MW43	MW435	10/23/1998		X					X									X
MW47	MW475	10/19/1998		X					X							X		X
MW47	MW474	03/28/1998		X					X							X		X
MW47	MW473	09/26/1997		X					X							X		X
MW47	MW472	06/22/1997							X							X		X
MW47	MW471	02/09/1996				X			X			X				X		X
MW55	MW555	10/16/1998		X					X							X		X
MW55	MW554	03/25/1998		X					X							X		X
MW55	MW553	09/26/1997		X					X							X		X
MW55	MW552	06/18/1997		X					X							X		X
MW55	MW551	02/10/1996							X									X
MW62	MW625	10/26/1998		X					X									X
MW63	MW635	10/21/1998		X					X							X		X
MW64	MW645	10/25/1998		X					X							X		X
MW66	MW665	11/12/1998							X							X		X
MW66	MW665FD	11/12/1998							X							X		X

TABLE 32-1
Analytes Investigated for FU7
Memphis Depot Main Installation RI

Station	Sample	Date Collected	Dioxins	General Chemistry	Geotechnical	Herbicides	Metals, Dissolved	Metals, TCLP	Metals, Total	OC Pesticides	OC Pesticides, TCLP	OC Pesticides/PCBs	PAHs	Petroleum Hydrocarbons	Phenols	Semivolatiles	Semivolatiles, TCLP	Volatiles
PZ01	HY065B	10/27/1998																X
PZ03	HY78A5	10/29/1998																X
PZ04	HY085B	11/03/1998																X
PZ05	HY055B	11/05/1998																X
PZ06	HY36A5	11/08/1998																X
PZ07	HY67A5	11/09/1998																X
PZ08	HY115B	11/11/1998																X

Notes:
1) All samples taken as part of Delivery Order 4 (DO4)
2) "X" - denotes that consituent was analyzed for in that particular sample

TABLE 32-2

Frequency of VOC Detections in Groundwater

Memphis Depot Main Installation RI

Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Units	Background Value	Number Background Exceedances
Persistent VOCs									
TETRACHLOROETHYLENE(PCE)	83	33	0.0010	J	0.1200	=	MG/L	0.001	30
TRICHLOROETHYLENE (TCE)	83	31	0.0010	J	0.0580	=	MG/L		
TOTAL 1,2-DICHLOROETHENE	83	7	0.0010	J	0.0090	J	MG/L		
1,1,1-TRICHLOROETHANE	83	5	0.0010	J	0.0140	=	MG/L	0.001	2
CARBON TETRACHLORIDE	83	10	0.0010	J	0.0040	J	MG/L		
CHLOROFORM	83	10	0.0010	J	0.0050	J	MG/L		
Sporadic VOCs									
ACETONE	83	3	0.0140	=	0.1900	=	MG/L		
BROMODICHLOROMETHANE	83	2	0.0010	J	0.0020	J	MG/L		
BROMOFORM	83	1	0.0010	J	0.0010	J	MG/L		
CARBON DISULFIDE	83	2	0.0010	J	0.0010	J	MG/L		
BENZENE	84	1	0.0030	J	0.0030	J	MG/L		
CHLOROBENZENE	83	2	0.0010	J	0.0040	J	MG/L		
CHLOROETHANE	83	1	0.0010	J	0.0010	J	MG/L		
CHLOROMETHANE	83	2	0.0010	J	0.0020	J	MG/L		
DIBROMOCHLOROMETHANE	83	2	0.0010	J	0.0020	J	MG/L		
METHYL ETHYL KETONE (2-BUTANONE)	83	4	0.0040	J	0.0090	J	MG/L		
1,1,2,2-TETRACHLOROETHANE	83	2	0.0020	J	0.0040	J	MG/L		
TOLUENE	84	1	0.0020	J	0.0020	J	MG/L		
2-HEXANONE	83	1	0.0050	J	0.0050	J	MG/L		
1,2-DICHLOROETHANE	83	1	0.0010	J	0.0010	J	MG/L		

Notes

"J" - Indicates an estimated value. Refer to Page 5-2 for more detail

"=" - Indicates a detection. Refer to Page 5-2 for more detail

TABLE 32-3
Frequency of Metals Detections in Groundwater
Memphis Depot Main Installation RI

Parameter	Number Analyzed	Number Detected	Minimum Detection	Minimum Detection Qualifier	Maximum Detection	Maximum Detection Qualifier	Units	Background Value	Number Background Exceedances
ALUMINUM	69	55	0 0113	J	126	J	MG/L	1 80	16
ANTIMONY	76	5	0 0017	J	0 0025	J	MG/L	0 034	0
ARSENIC	76	13	0 0016	J	0 091	=	MG/L	**0 01**	13
BARIUM	69	69	0 0309	J	0 393	=	MG/L	0 224	6
BERYLLIUM	76	10	0 0002	J	0 0059	=	MG/L	0 001	6
CADMIUM	76	37	0 0003	J	0 085	=	MG/L	**0.005**	37
CALCIUM	69	69	7 37	=	116	=	MG/L	52 9	1
CHROMIUM, TOTAL	76	49	0 0012	J	0 278	=	MG/L	0 054	7
COBALT	69	37	0 0009	J	0 086	=	MG/L	0 025	4
COPPER	76	36	0 0011	J	0 207	=	MG/L	0 163	1
IRON	70	64	0 0480	J	136	=	MG/L	6 73	18
LEAD	76	41	0 0011	J	0 111	=	MG/L	0 009	11
MAGNESIUM	69	69	2 8000	J	18 7	=	MG/L	26 0	0
MANGANESE	69	61	0 0009	J	2 66	=	MG/L	0 560	7
MERCURY	76	4	0 0001	J	0 0003	=	MG/L	**0 0002**	4
NICKEL	76	40	0 0009	J	0 212	=	MG/L	0 031	5
POTASSIUM	69	53	0 849	J	13 9	=	MG/L	3 50	11
SELENIUM	76	4	0 0041	J	0 0083	=	MG/L	0 006	2
SILVER	76	2	0 0028	J	0 011	=	MG/L	**0 01**	2
SODIUM	69	60	7 04	J	42 6	=	MG/L	107	0
VANADIUM	69	48	0 0003	J	0 262	=	MG/L	0 006	15
ZINC	76	40	0 0027	J	0 351	=	MG/L	**0 02**	40

Note Bold values indicate CRDL (contract-required detection limit) values Background values were not reported above the CRDLs for these metals
The CRDL values were used as background concentrations for the classification of these metals

487 644

Table 32-4

Infrequently Occurring Inorganic Compounds in Main Installation Groundwater

Memphis Depot Main Installation RI

Well	Date Collected	Concentration (mg/L)	Qualifier	Background (mg/L)
		Barium		
MW20	2nd Q, 1997	**0.393**	=	0.2238
MW26	2nd Q, 1997	0.264	=	
MW43	4th Q, 1998	0.297	=	
MW64	*4th Q, 1998*	0.229	=	
MW66	*4th Q, 1998*	0.348	=	
		Beryllium		
MW20	2nd Q, 1997	**0.0059**	=	0.0006
MW20	1st Q, 1996	0.0011	J	
MW22	4th Q, 1998	0.00097	J	
MW26	2nd Q, 1997	0.0012	J	
MW39	1st Q, 1996	0.0016	J	
MW55	1st Q, 1996	0.002	J	
		Calcium		
MW23	2nd Q, 1997	116	=	52.875
		Total Chromium		
MW20	2nd Q, 1997	0.147	=	0.0544
MW21	4th Q, 1998	0.0595	=	
MW22	4th Q, 1998	0.0652	=	
MW38	1st Q, 1996	**0.278**	=	
MW39	1st Q, 1996	0.215	=	
MW47	2nd Q, 1997	0.0686	=	
MW55	1st Q, 1996	0.0967	=	
		Cobalt		
MW20	2nd Q, 1997	0.038	=	0.0248
MW38	1st Q, 1996	0.0378	J	
MW39	1st Q, 1996	0.0525	=	
MW43	4th Q, 1998	**0.0862**	=	
		Copper		
MW20	1st Q, 1996	0.207	=	0.1626

Table 32-4

Infrequently Occurring Inorganic Compounds in Main Installation Groundwater

Memphis Depot Main Installation RI

Well	Date Collected	Concentration (mg/L)	Qualifier	Background (mg/L)
		Lead		
MW20	2nd Q, 1997	**0.111**	=	0.0094
MW22	4th Q, 1998	0.0228	=	
MW25	2nd Q, 1997	0.0104	=	
MW26	2nd Q, 1997	0.0102	J	
MW38	1st Q, 1996	0.0302	=	
MW38	2nd Q, 1997	0.0195	J	
MW39	1st Q, 1996	0.0998	=	
MW39	2nd Q, 1997	0.0608	J	
MW55	1st Q, 1996	0.0204	=	
MW55	4th Q, 1998	0.0116	=	
		Manganese		
MW20	2nd Q, 1997	1.4	=	0.56
MW25	2nd Q, 1997	0.895	=	
MW26	2nd Q, 1997	0.568	=	
MW39	1st Q, 1996	1.72	=	
MW43	4th Q, 1998	**2.66**	=	
MW64	*4th Q, 1998*	1.39	=	
		Nickel		
MW20	2nd Q, 1997	0.0687	=	0.0314
MW21	4th Q, 1998	0.0404	=	
MW38	1st Q, 1996	**0.212**	=	
MW39	1st Q, 1996	0.164	=	
MW55	1st Q, 1996	0.0459	=	
		Selenium		
MW55	4th Q, 1998	0.006	=	0.0058
MW66	*4th Q, 1998*	**0.0083**	=	

Note. 1) Only detections exceeding background are listed
2) 1st Q, 1996 = Sampled in February, 1996
3) 2nd Q, 1997 = Sampled in June, 1997
4) 4th Q, 1998 = Sampled in October-November, 1998
5) Italicized date denotes only sampling event at that well
6) Bold concentration denotes maximum observed concentration

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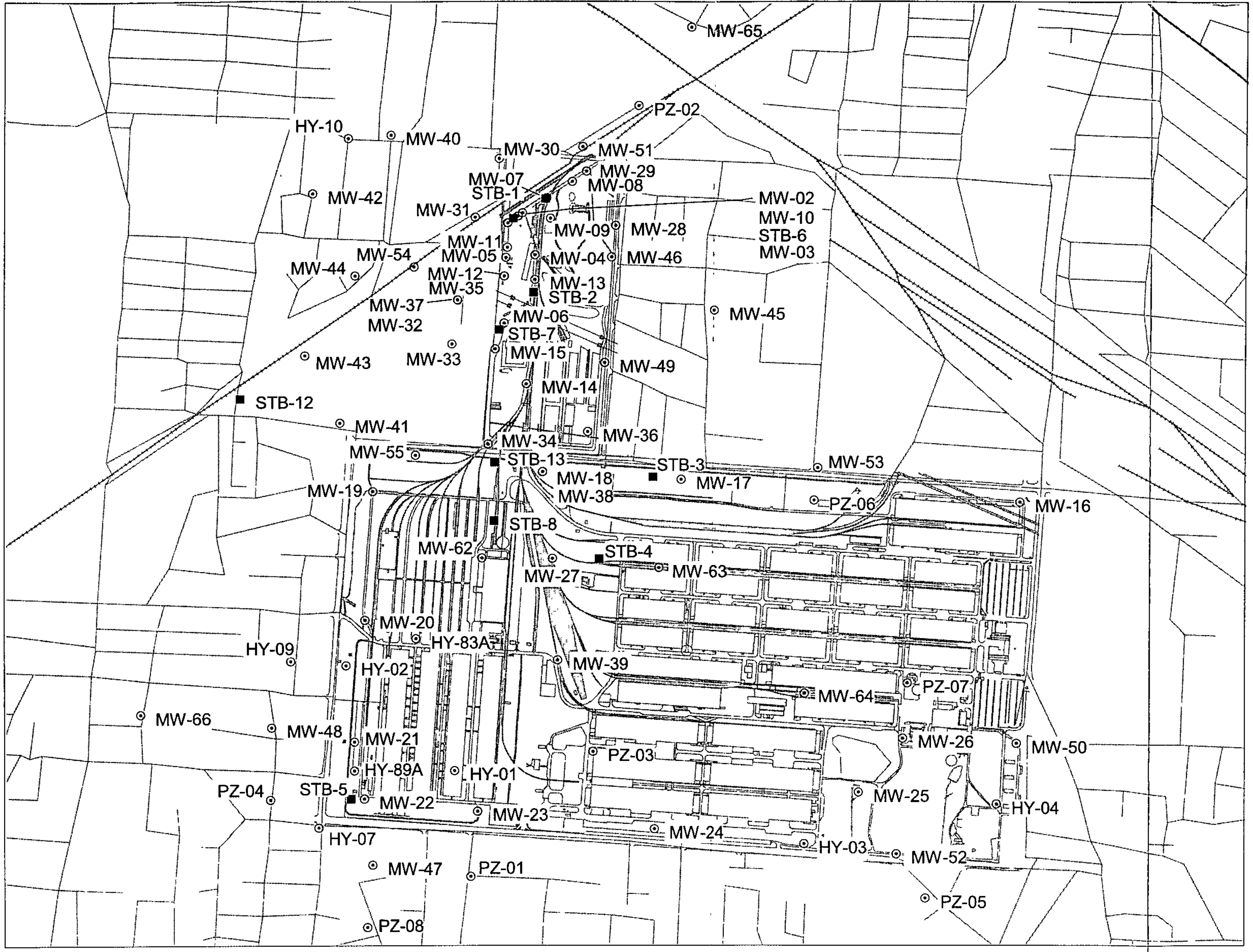

LEGEND

- ⊙ Groundwater Monitoring Well Location
- ◑ Background Groundwater Monitoring Well
- —— Base Features

0 500 1000 Feet

SCALE IS APPROXIMATE

FIGURE 32-1

GROUNDWATER MONITORING WELL LOCATIONS

MEMPHIS DEPOT MAIN INSTALLATION RI

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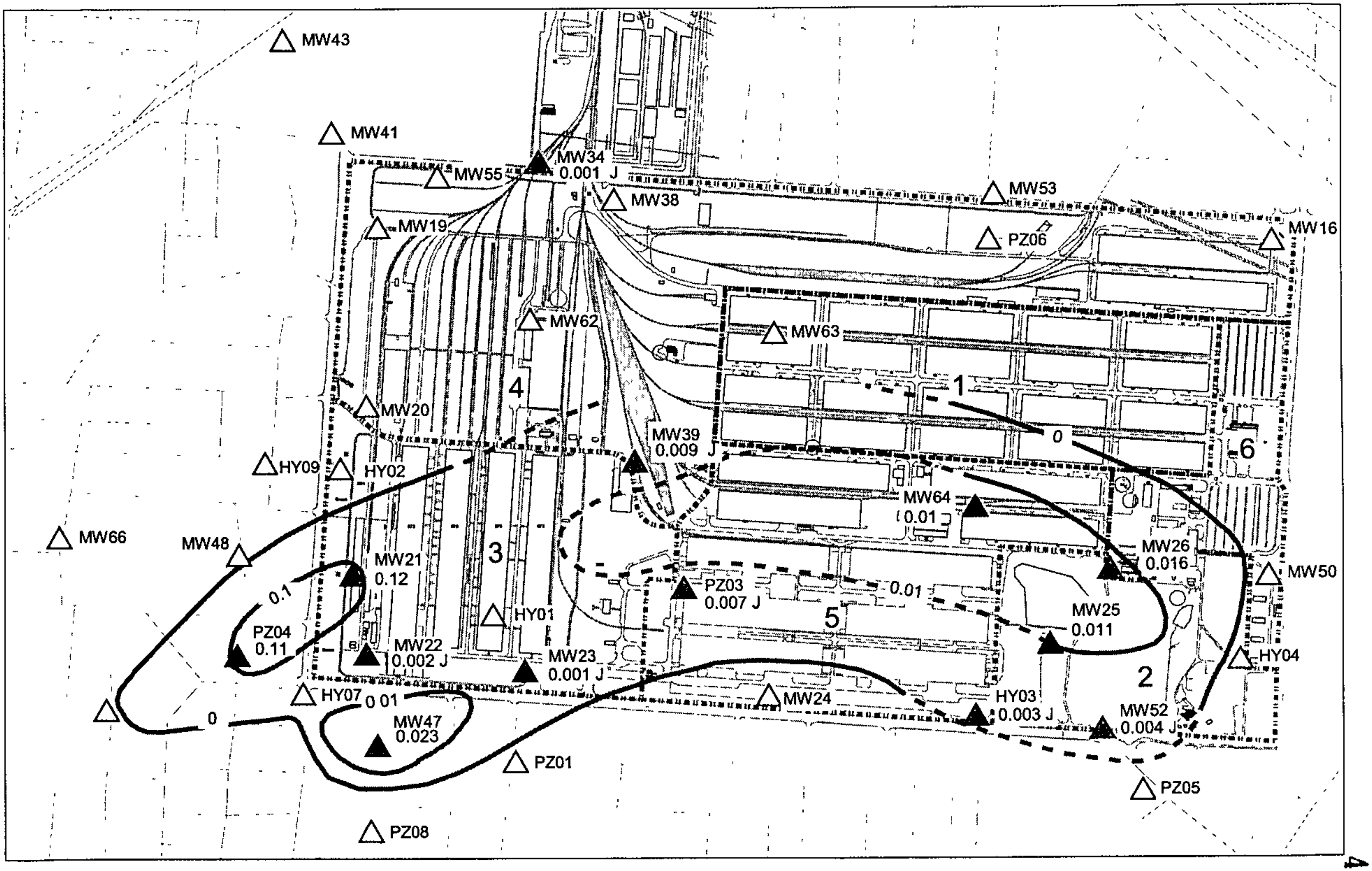

TETRACHLOROETHYLENE (PCE) Concentrations

△ Non-Detected

▲ Detected

Concentration Isopleth
Concentration Contour in Area of Lesser Certainty
Concentration Contour in Area of Greater Certainty
Functional Unit Boundary
Base Features
Roads
Buildings

N

0 500 1000 Feet

SCALE IS APPROXIMATE

Maximum Concentrations Detected During RI Sampling

Units are in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

FIGURE 32-2
TETRACHLOROETHYLENE (PCE) CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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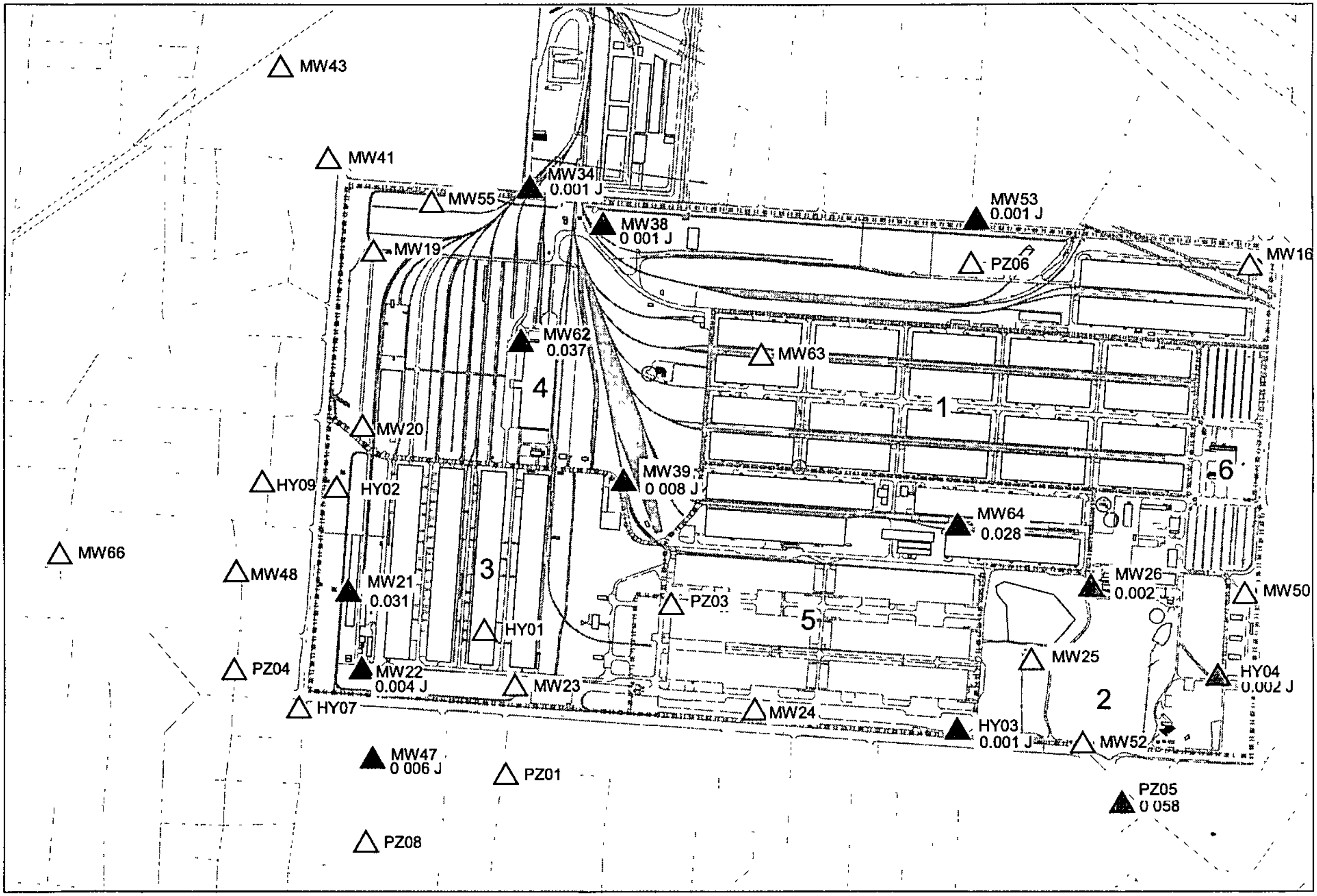

TRICHLOROETHYLENE (TCE) Concentrations

△ Non-Detected

▲ Detected

Functional Unit Boundary
Base Features
Roads
Buildings

N

0 500 1000 Feet

SCALE IS APPROXIMATE

Maximum Concentrations Detected During RI Sampling

Units are in mg/L

J - Estimated, the analyte was present but the reported value may not be accurate or precise

FIGURE 32-3
TRICHLOROETHYLENE (TCE) CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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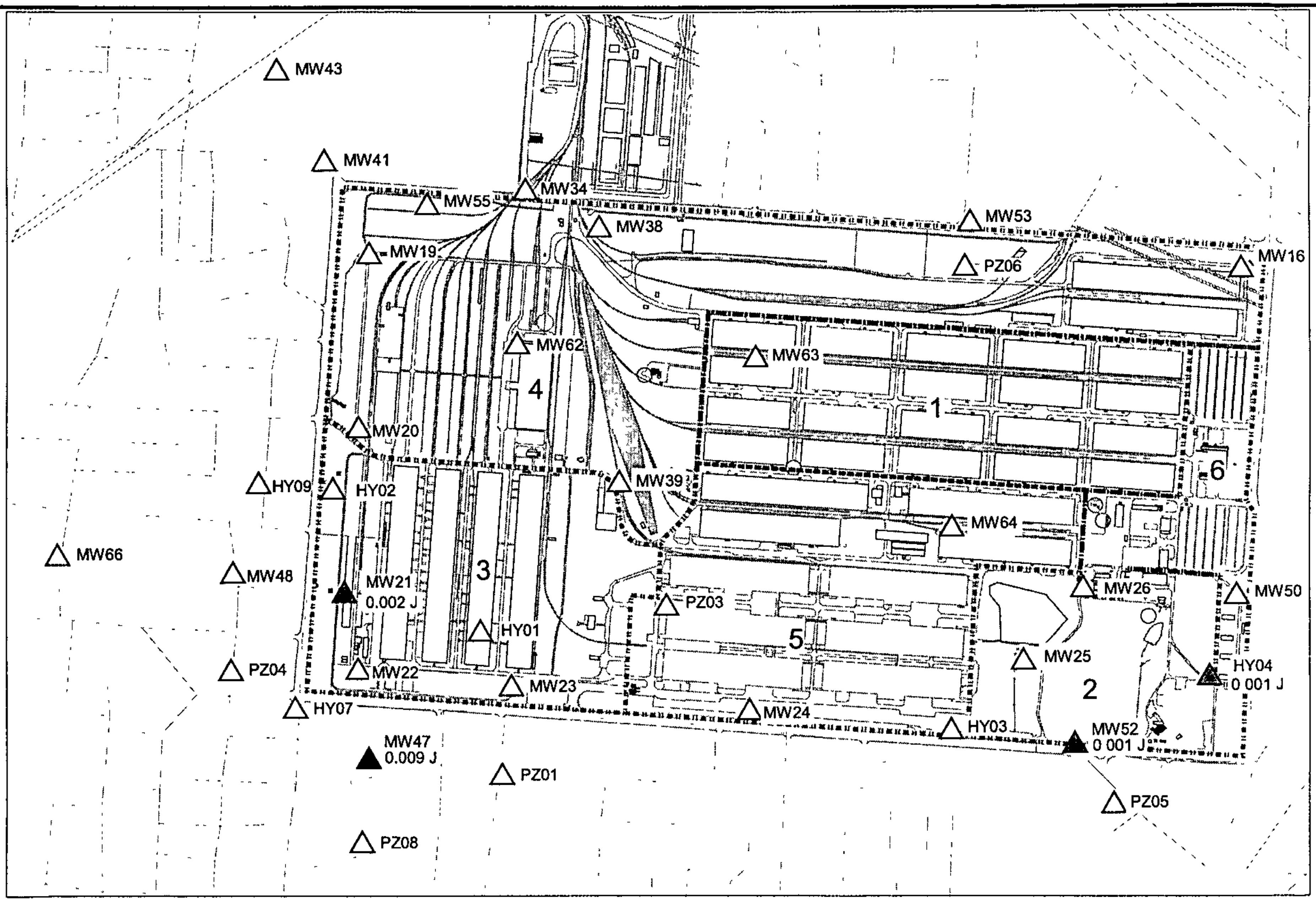

TOTAL 1,2-DICHLOROETHENE Concentrations

△ Non-Detected

▲ Detected

Functional Unit Boundary
Base Features
Roads
Buildings

N

0 500 1000 Feet

SCALE IS APPROXIMATE

Maximum Concentrations Detected During RI Sampling

Units are in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

FIGURE 32-4
TOTAL 1,2-DICHLOROETHENE CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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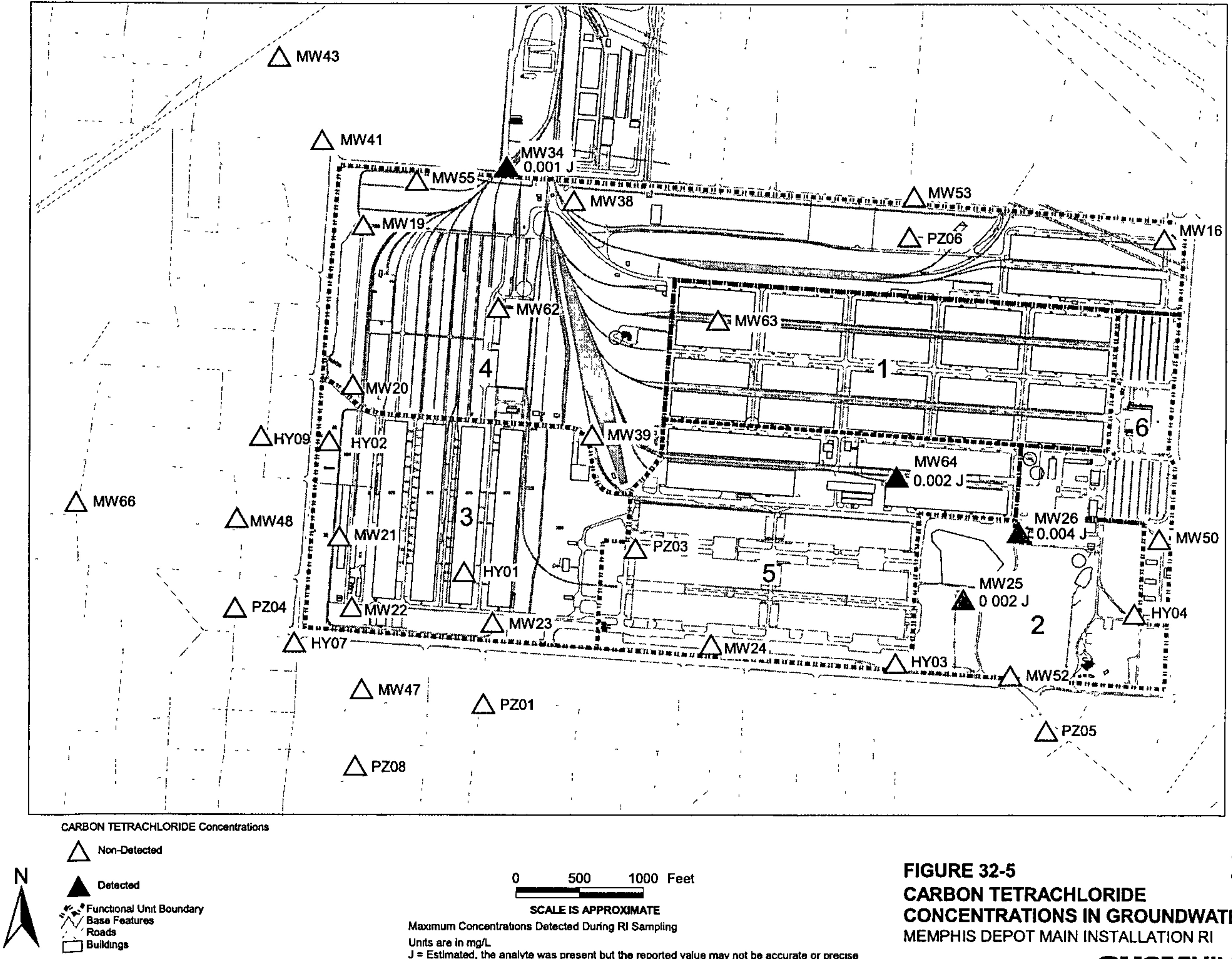

Maximum Concentrations Detected During RI Sampling

Units are in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

FIGURE 32-5
CARBON TETRACHLORIDE
CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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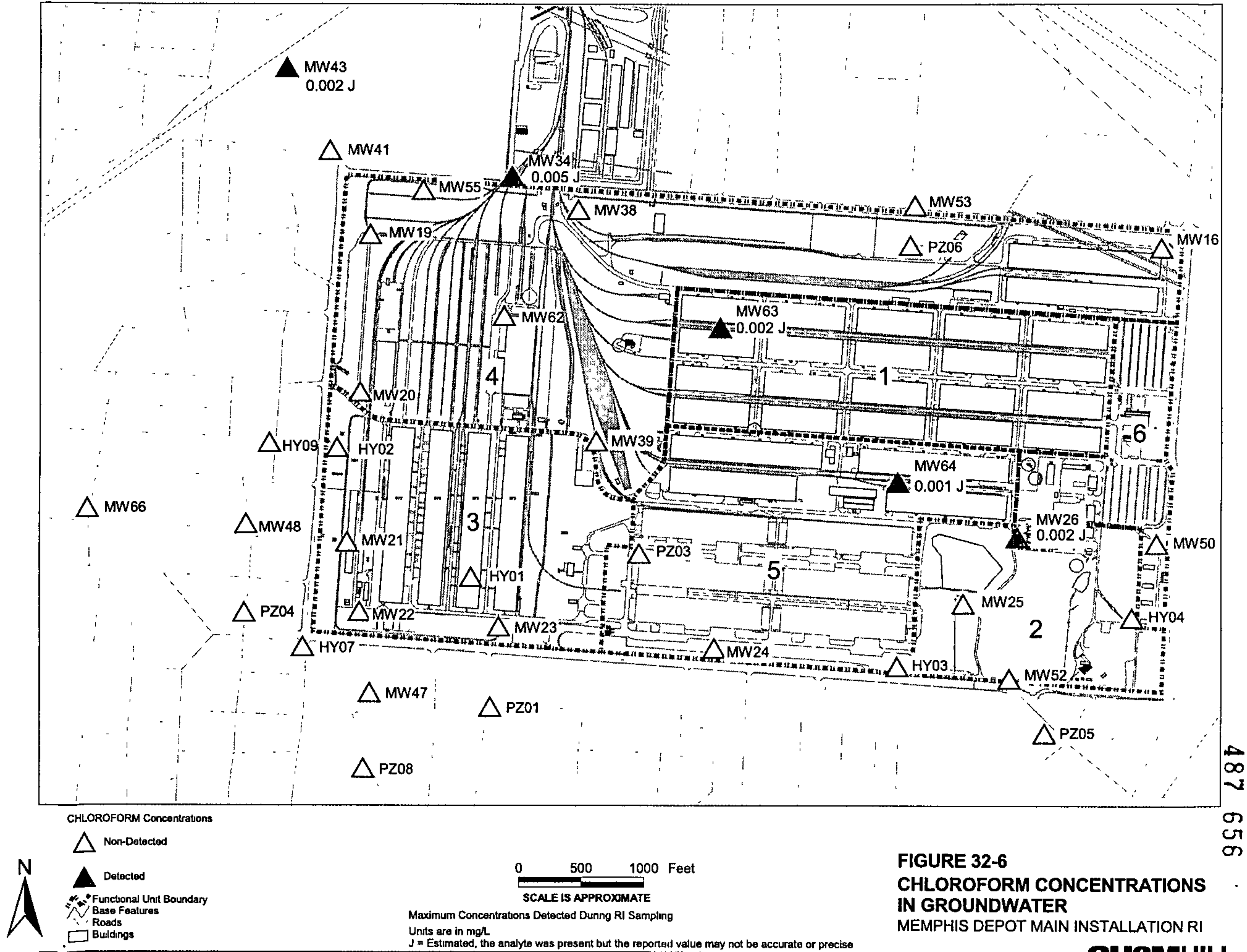

Maximum Concentrations Detected During RI Sampling

Units are in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

FIGURE 32-6
CHLOROFORM CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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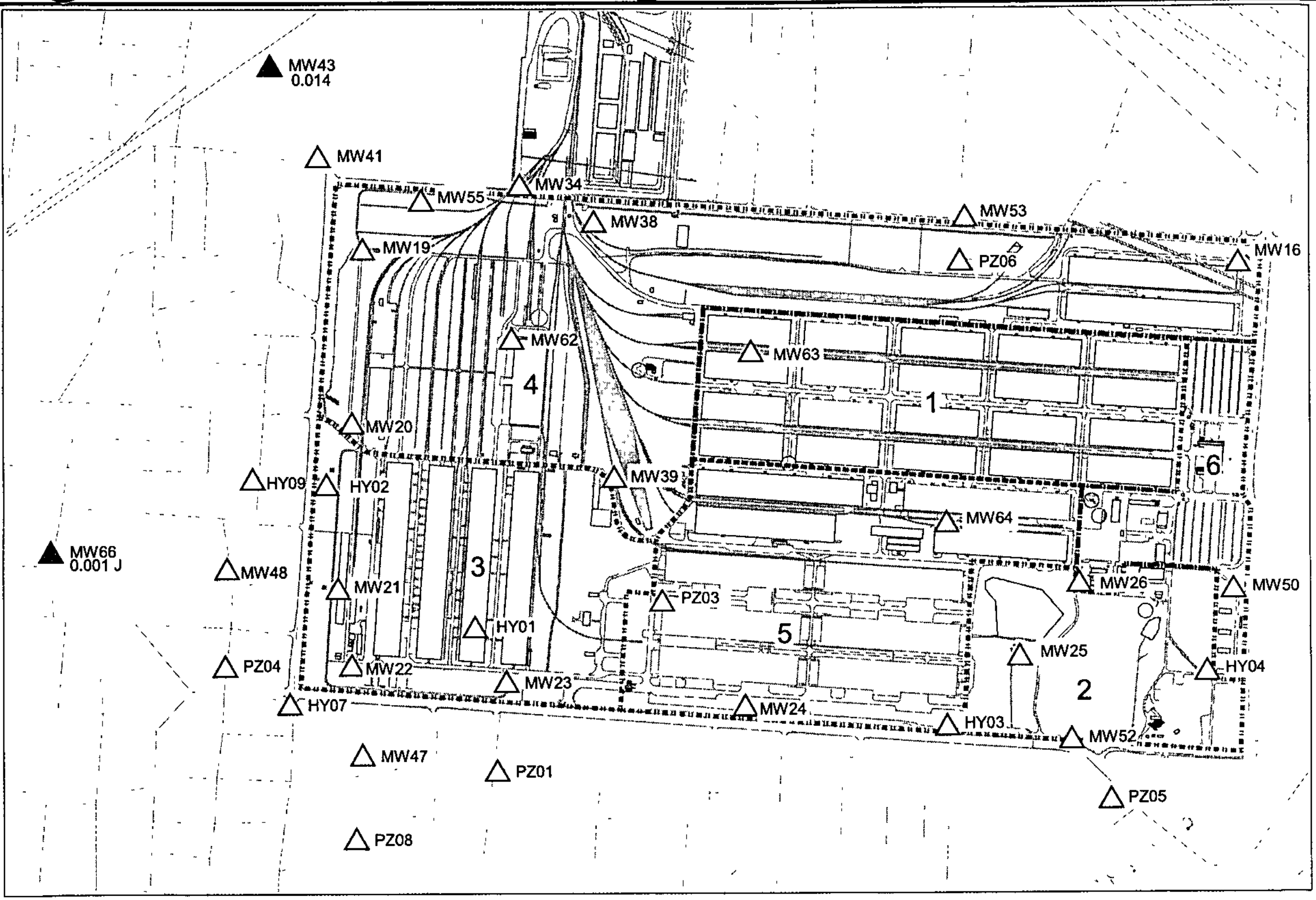

Maximum Concentrations Detected During RI Sampling
Units are in mg/L
J = Estimated, the analyte was present but the reported value may not be accurate or precise
Concentration shown for MW-43 was found in a sample from the lower "confined sand" aquifer

FIGURE 32-7
1,1,1-TRICHLOROETHANE CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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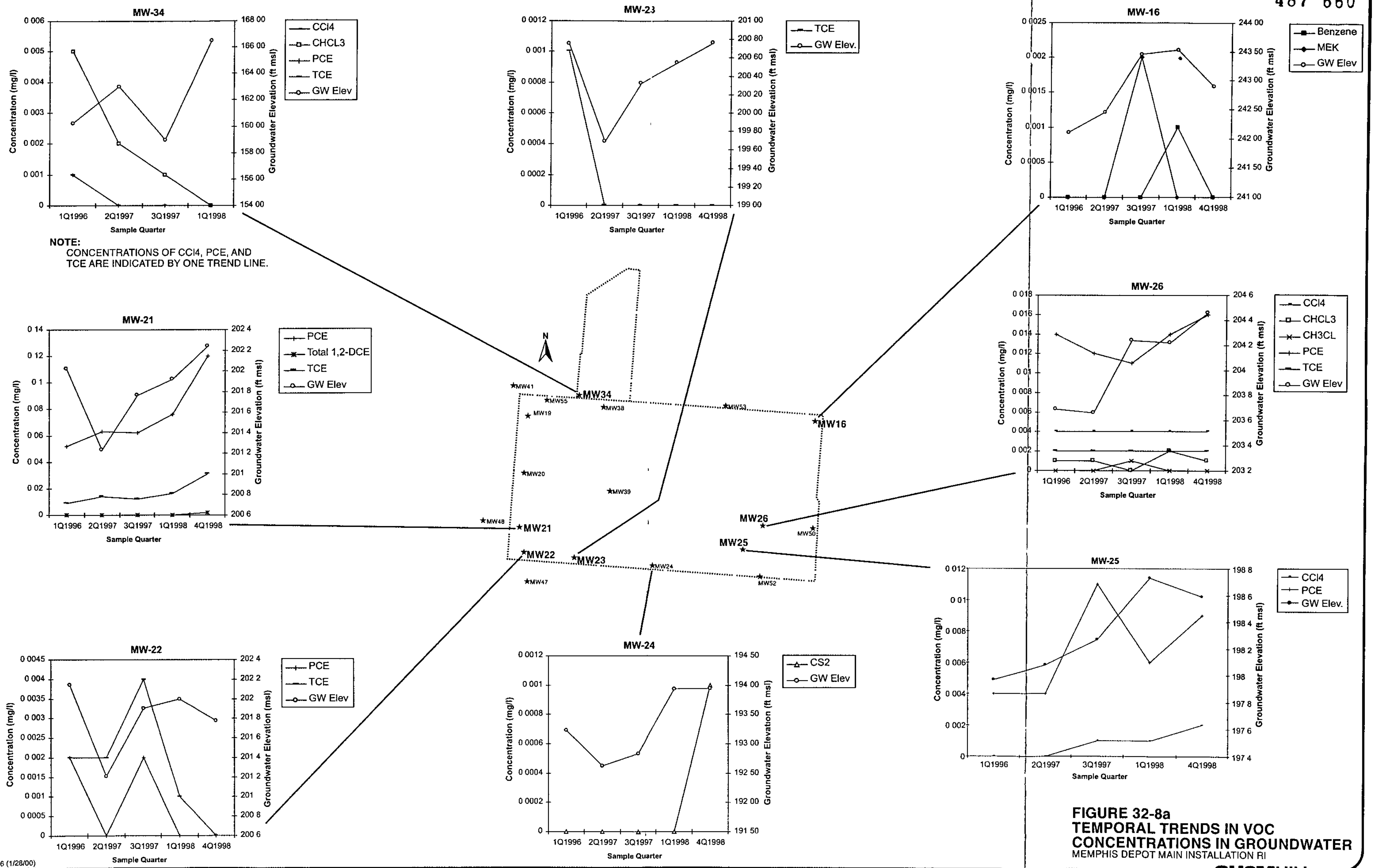

NOTE:
CONCENTRATIONS OF CCl4, PCE, AND TCE ARE INDICATED BY ONE TREND LINE.

FIGURE 32-8a
TEMPORAL TRENDS IN VOC CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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2972_06 (1/28/00)

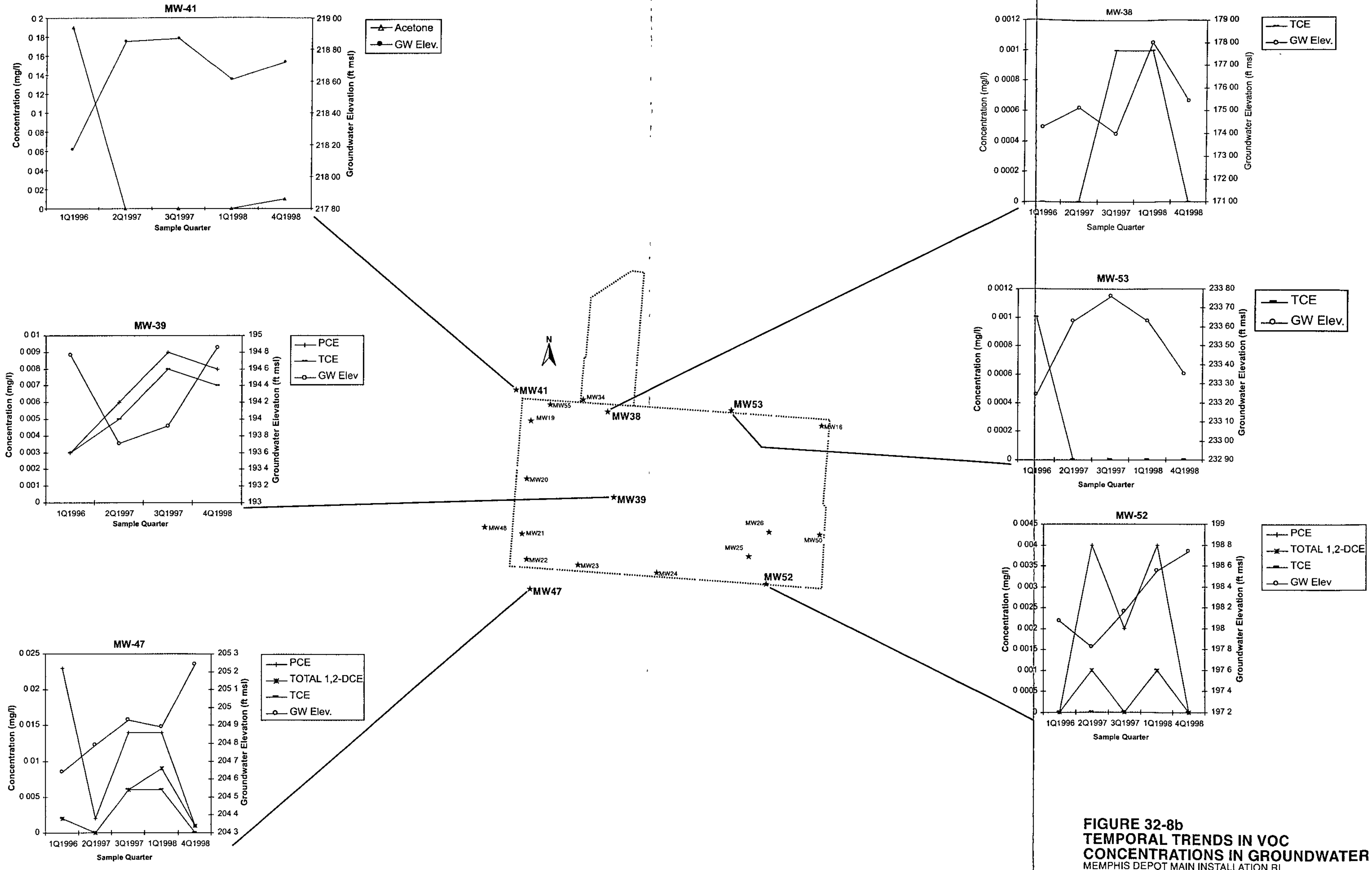

FIGURE 32-8b
TEMPORAL TRENDS IN VOC CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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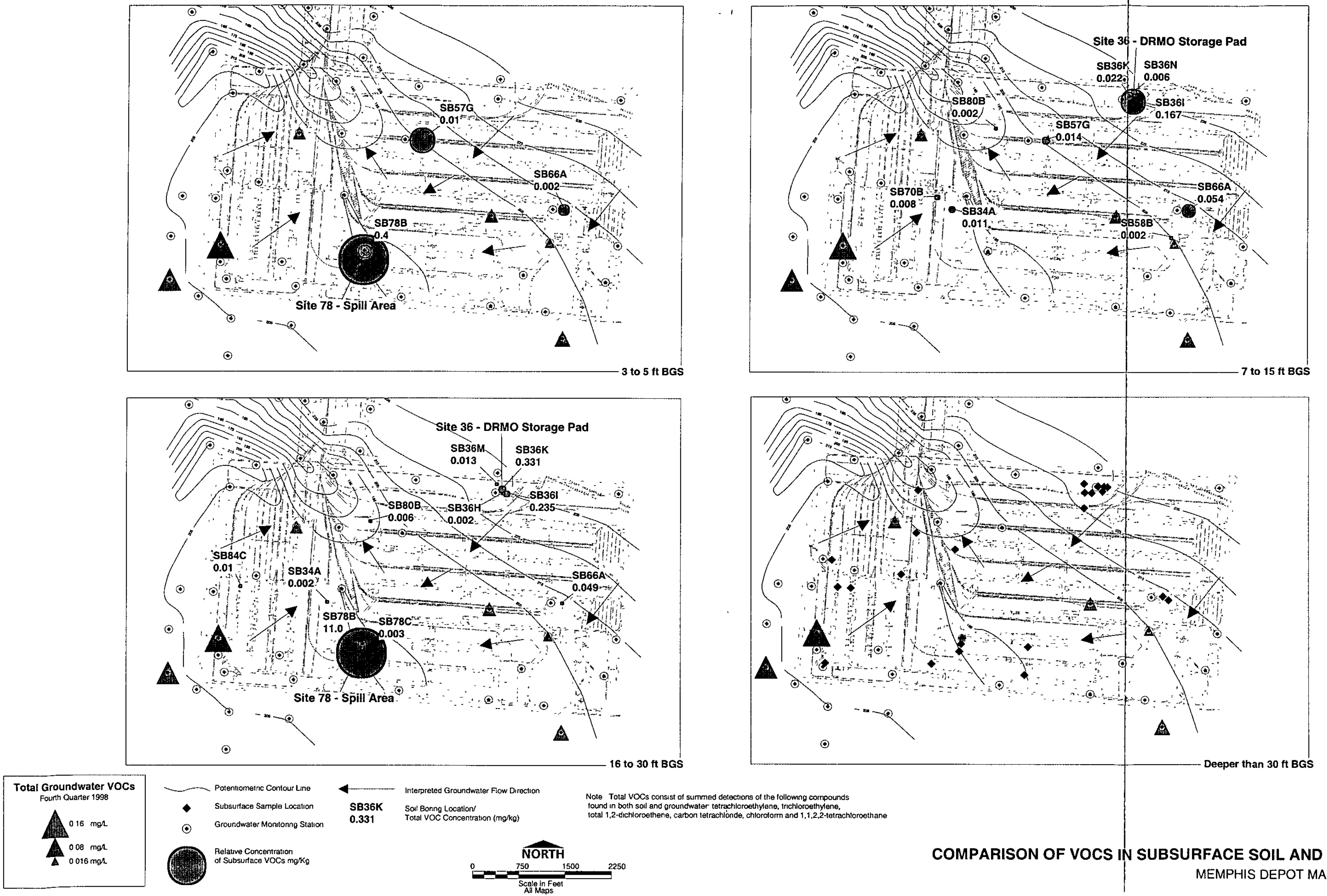

Note Total VOCs consist of summed detections of the following compounds found in both soil and groundwater: tetrachloroethylene, trichloroethylene, total 1,2-dichloroethene, carbon tetrachloride, chloroform and 1,1,2,2-tetrachloroethane

FIGURE 32-9
COMPARISON OF VOCS IN SUBSURFACE SOIL AND GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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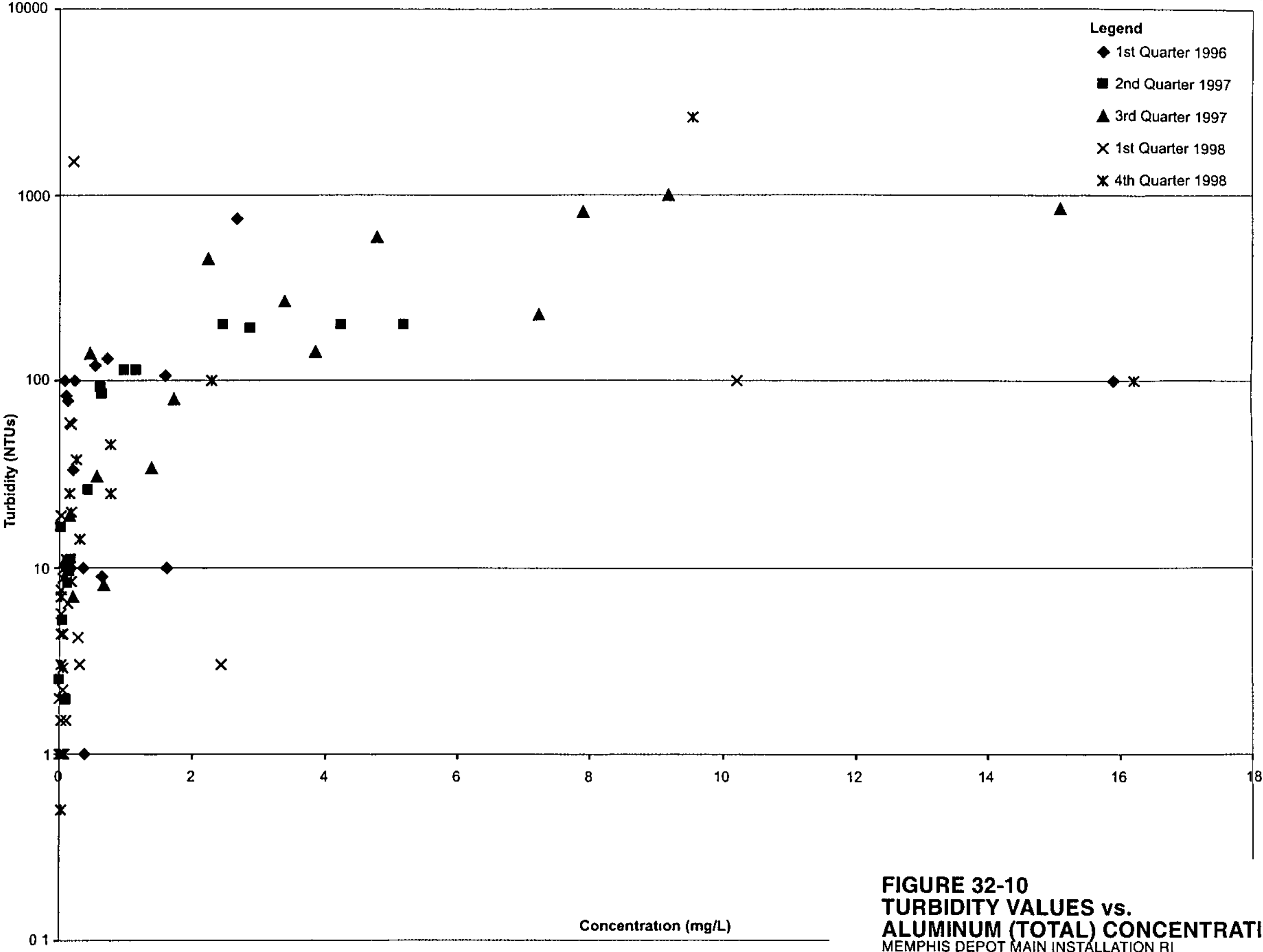

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FIGURE 32-10
TURBIDITY VALUES vs. ALUMINUM (TOTAL) CONCENTRATION

MEMPHIS DEPOT MAIN INSTALLATION RI

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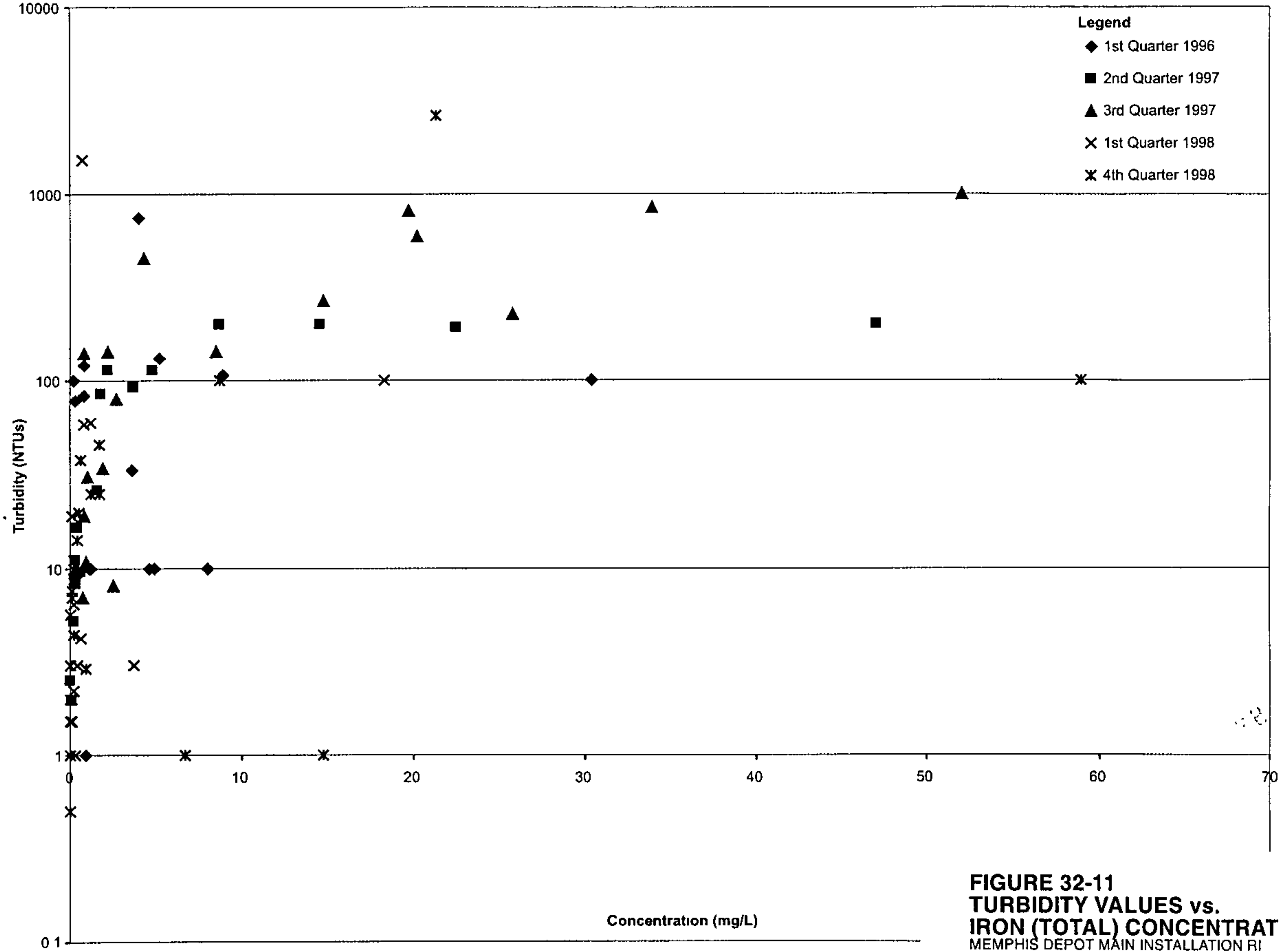

2972_66 (1/28/00)

FIGURE 32-11
TURBIDITY VALUES vs.
IRON (TOTAL) CONCENTRATION
MEMPHIS DEPOT MAIN INSTALLATION RI

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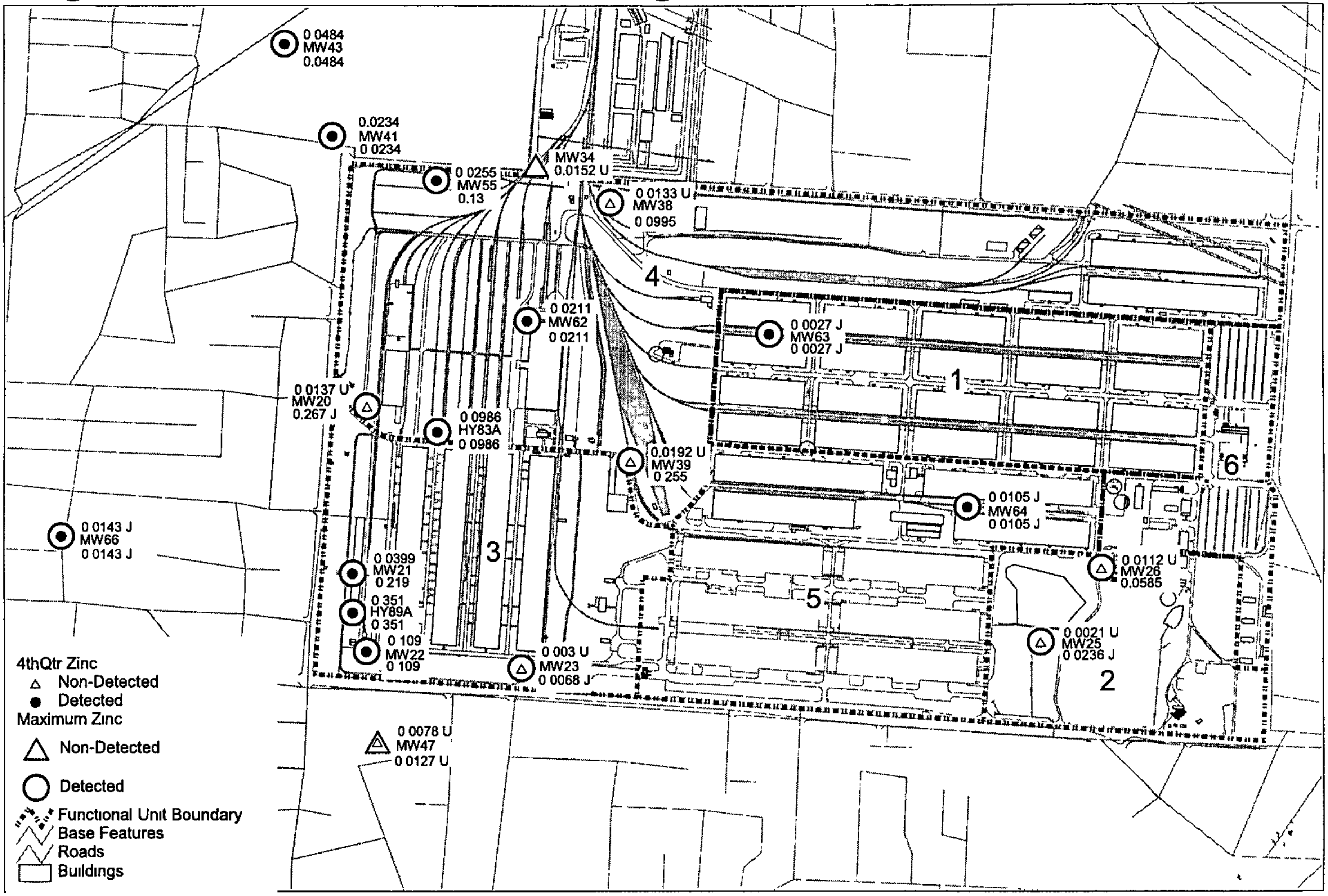

Note:

◉ 4th Qtr 1998 Concentration
Location I D.
Maximum Concentration

Concentrations reported in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration

Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for

FIGURE 32-12
TOTAL ZINC CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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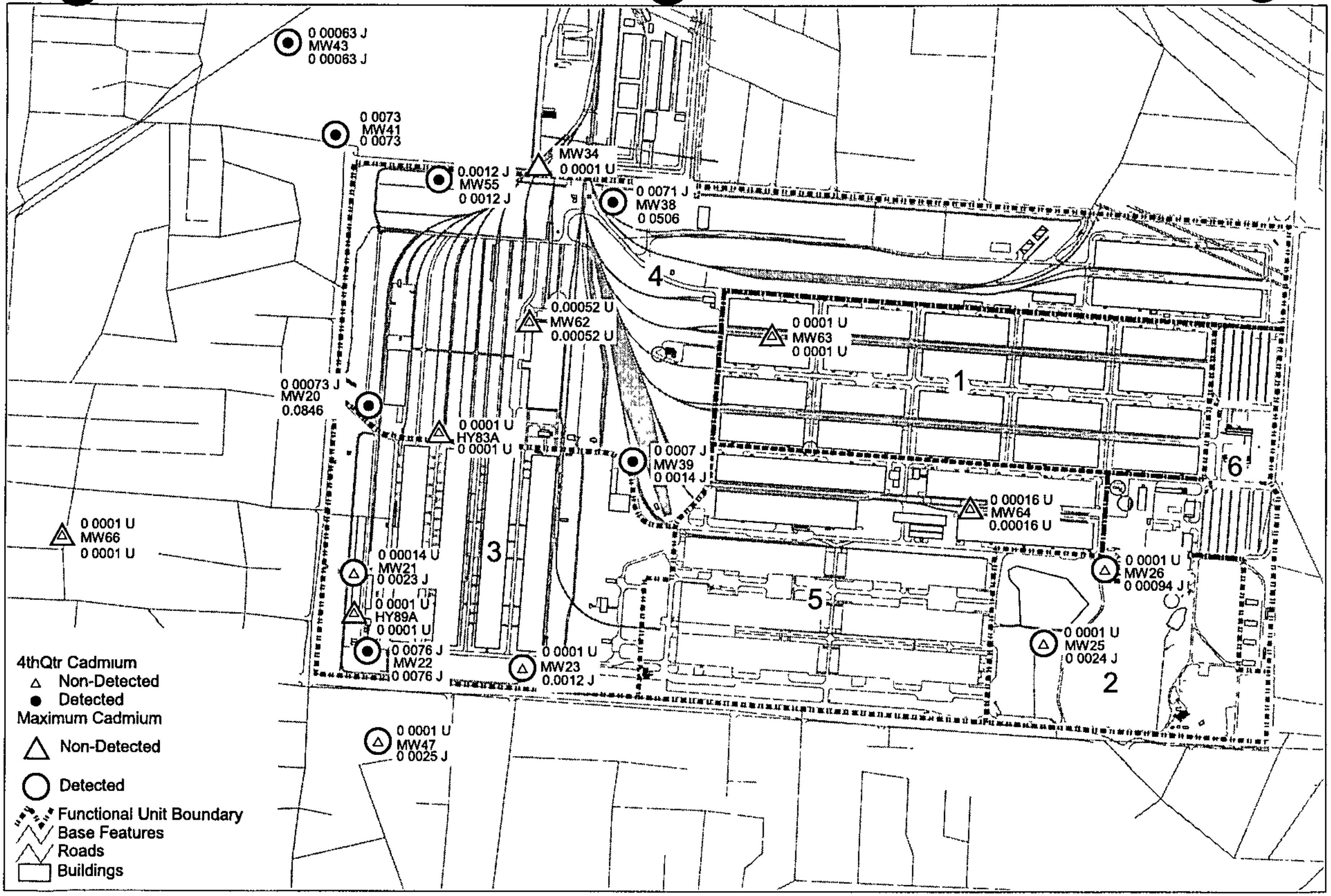

Note
4th Qtr 1998 Concentration
Location I D
Maximum Concentration

Concentrations reported in mg/L
J = Estimated, the analyte was present but the reported value may not be accurate or precise.
U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration
Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for

FIGURE 32-13
TOTAL CADMIUM CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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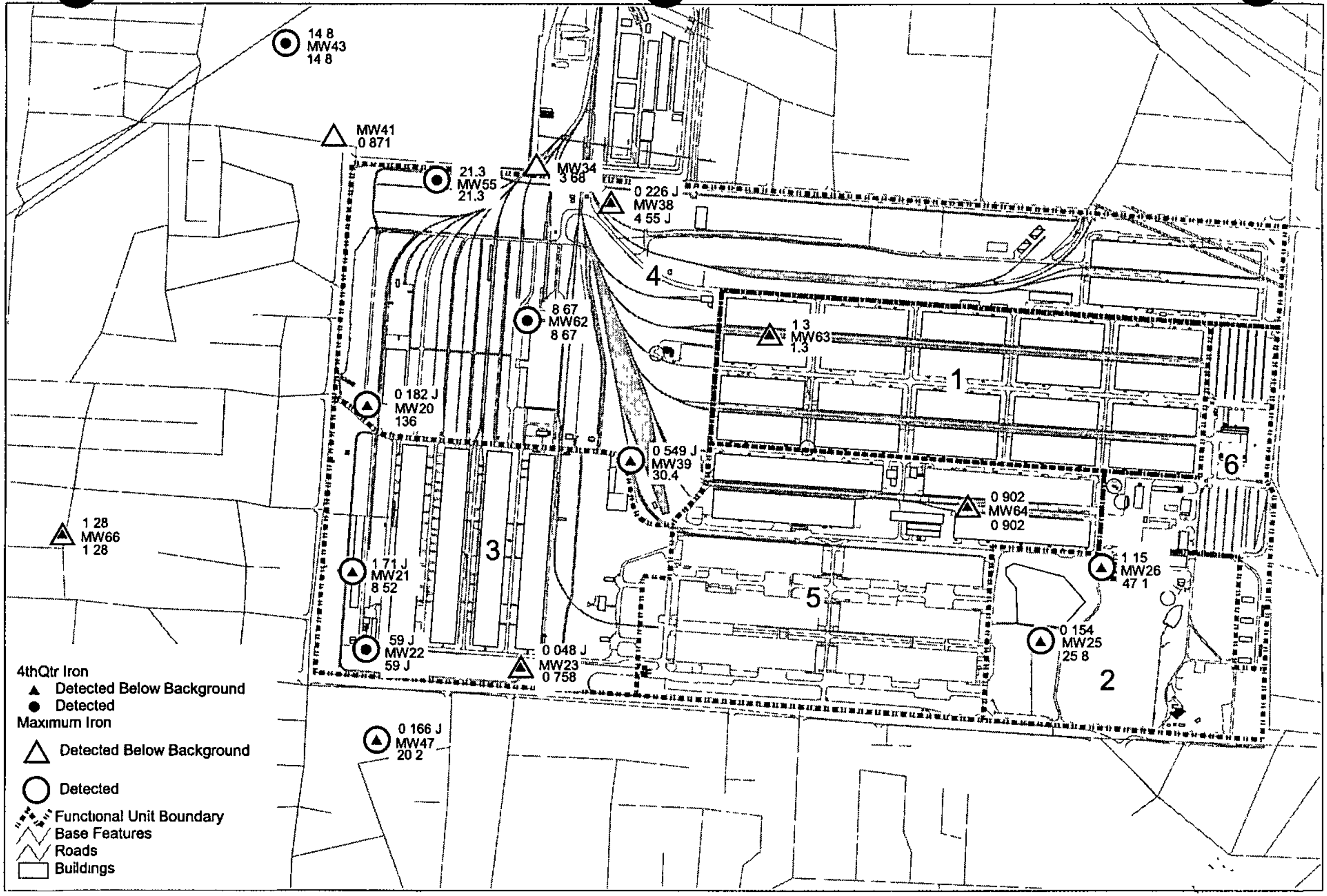
487 671



Note

4th Qtr 1998 Concentration
Location I D
Maximum Concentration

Concentrations reported in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration

Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for

N

0 500 1000 Feet

SCALE IS APPROXIMATE

FIGURE 32-14
TOTAL IRON CONCENTRATIONS IN GROUNDWATER

MEMPHIS DEPOT MAIN INSTALLATION RI

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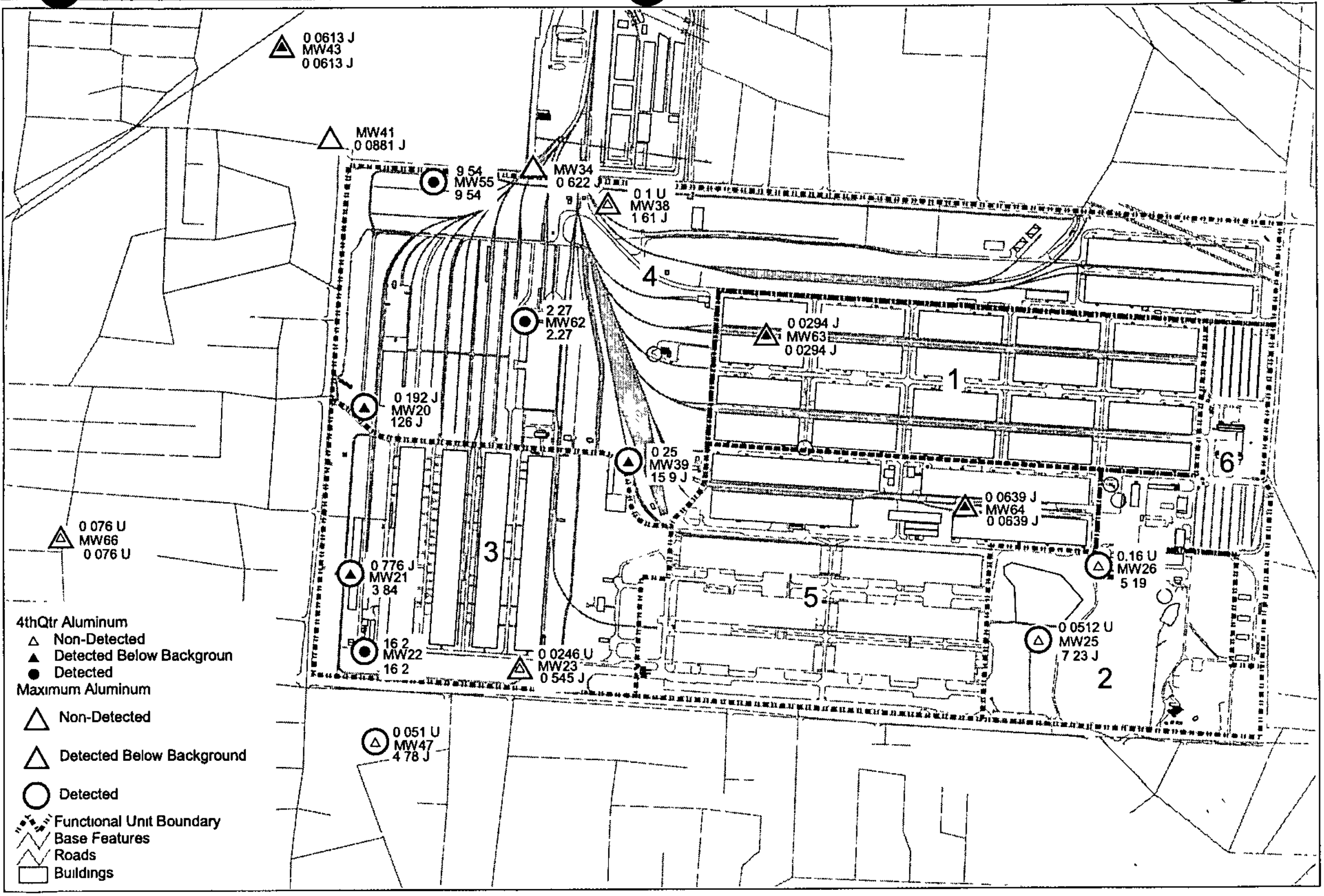

Note

4th Qtr 1998 Concentration
Location I D
Maximum Concentration

Concentrations reported in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise.
U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration
Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for

N

0 500 1000 Feet

SCALE IS APPROXIMATE

FIGURE 32-15
TOTAL ALUMINUM CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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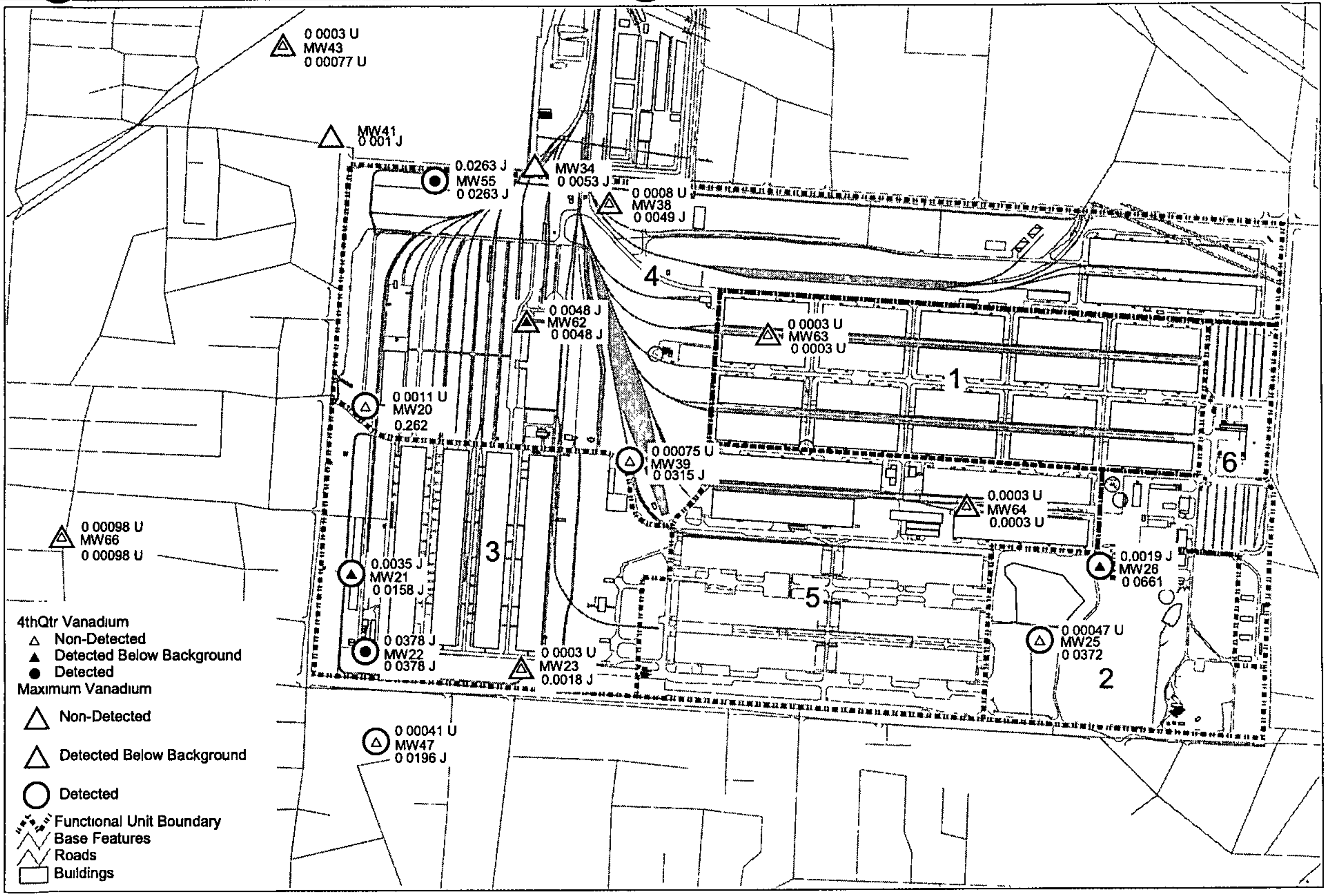

Note:
4th Qtr 1998 Concentration
Location I.D
Maximum Concentration

Concentrations reported in mg/L
J = Estimated, the analyte was present but the reported value may not be accurate or precise.
U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample. The method detection limit is given as the default concentration
Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for.

N

0 500 1000 Feet
SCALE IS APPROXIMATE

FIGURE 32-16
TOTAL VANADIUM CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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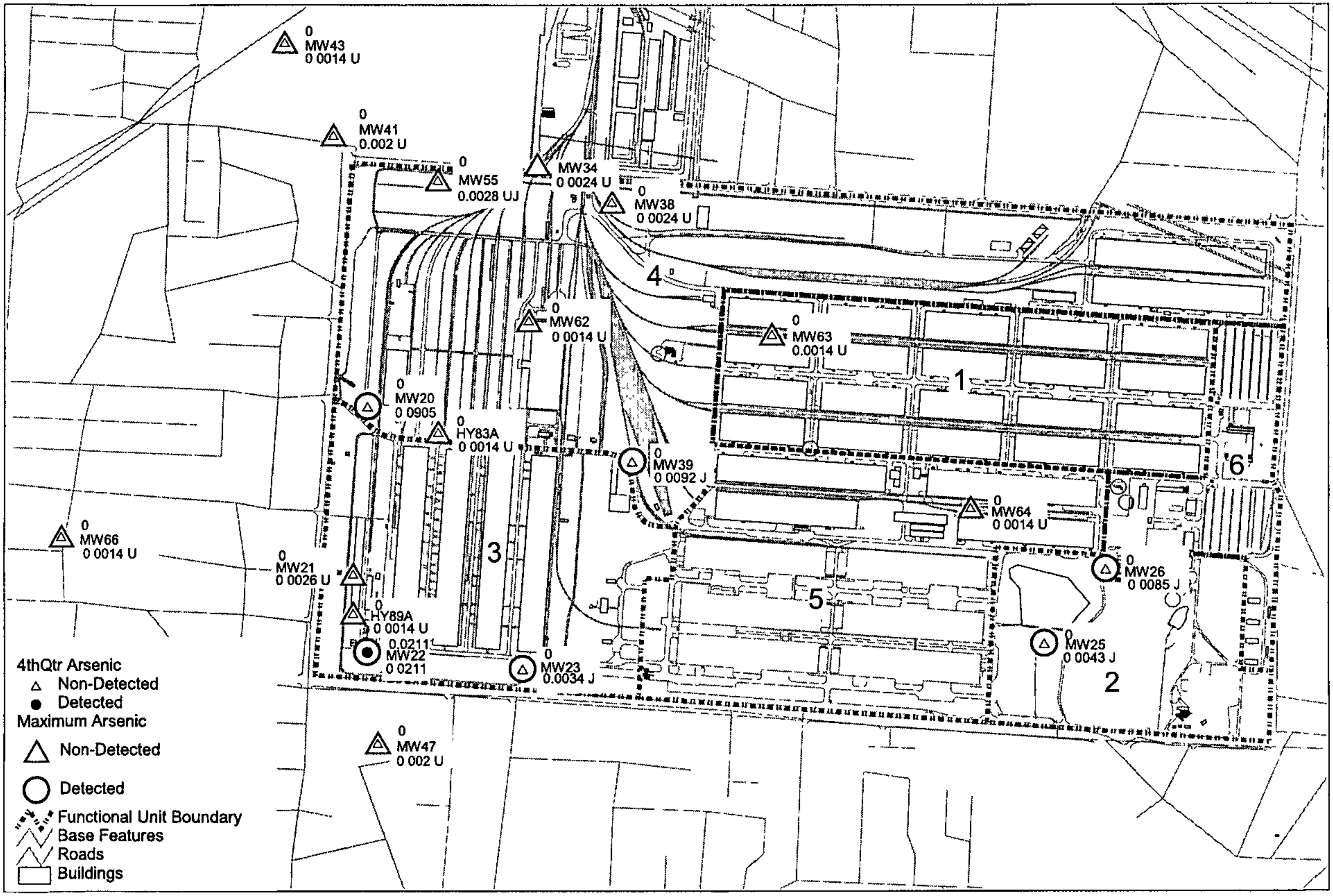

487 677

Note

4th Qtr 1998 Concentration
Location I D
Maximum Concentration

Concentrations reported in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise
U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration
Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for.

N

0 500 1000 Feet

SCALE IS APPROXIMATE

FIGURE 32-17
TOTAL ARSENIC CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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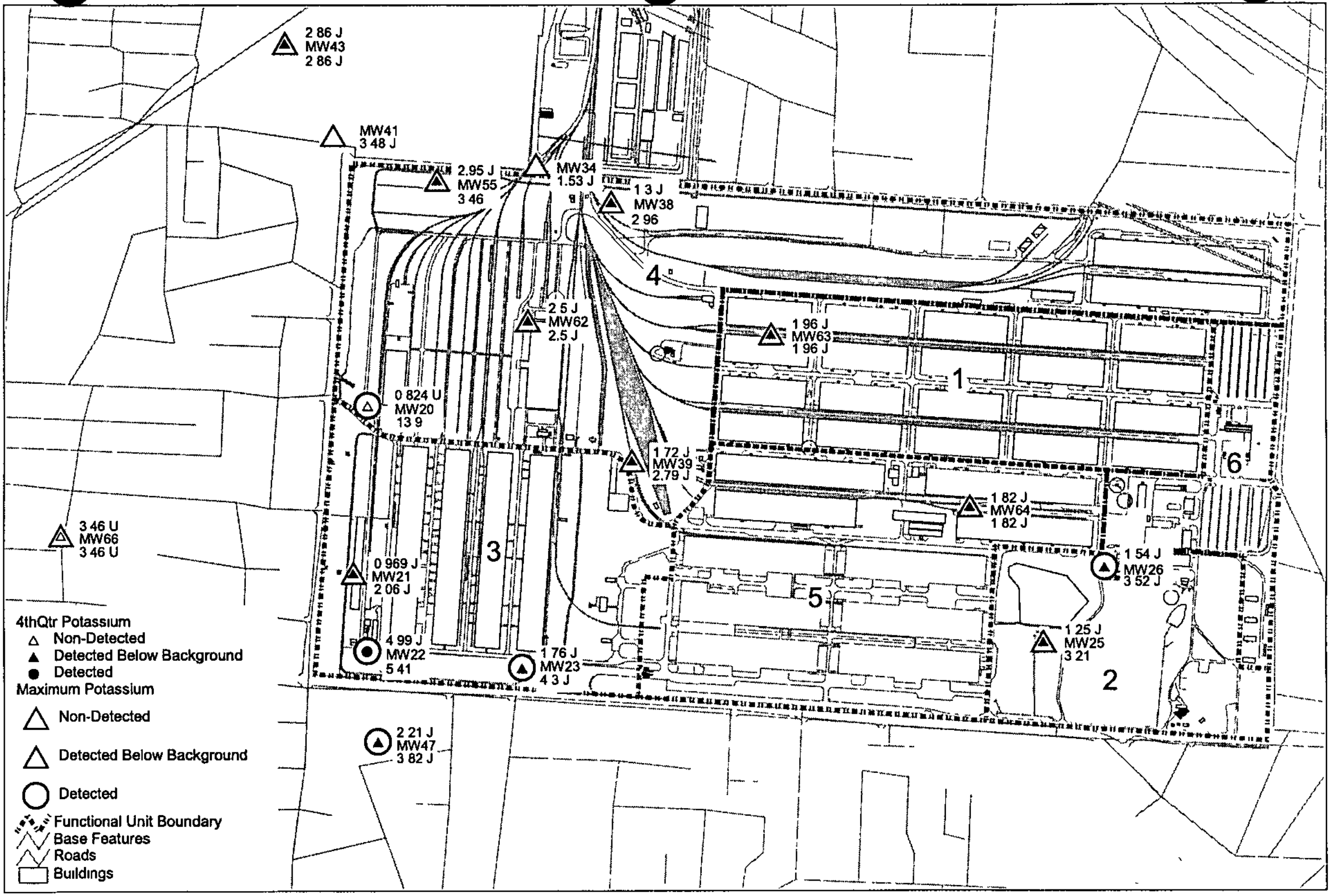

Note.
4th Qtr 1998 Concentration
Location I D
Maximum Concentration

Concentrations reported in mg/L

J = Estimated, the analyte was present but the reported value may not be accurate or precise

U = Undetected, the analyte was analyzed for but not detected above the reported method detection limit for that sample The method detection limit is given as the default concentration

Blank concentration results for 1998 4th quarter sampling means the parameter was not analyzed for

N

0 500 1000 Feet

SCALE IS APPROXIMATE

FIGURE 32-18
TOTAL POTASSIUM CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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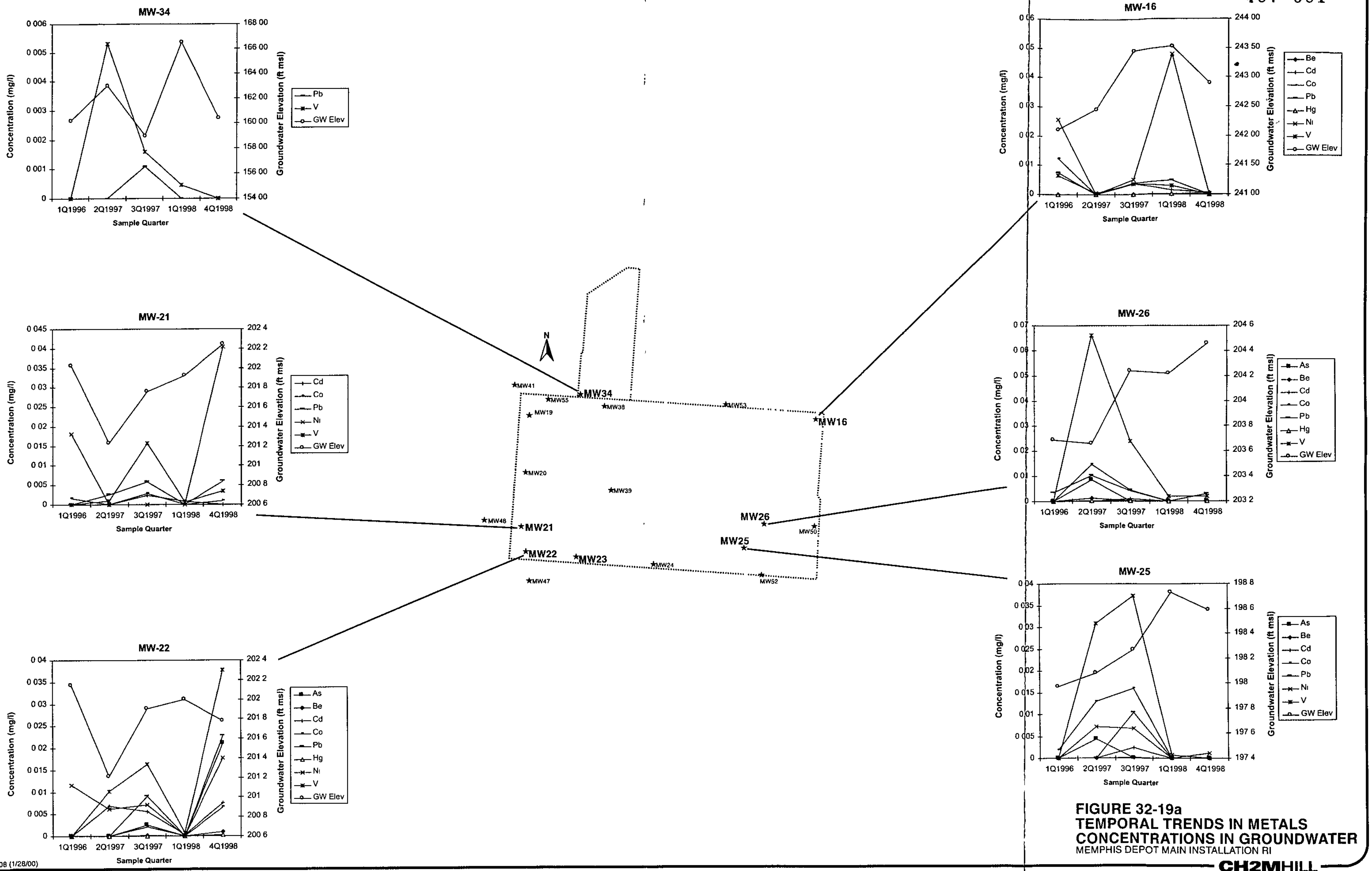

FIGURE 32-19a
TEMPORAL TRENDS IN METALS CONCENTRATIONS IN GROUNDWATER

MEMPHIS DEPOT MAIN INSTALLATION RI

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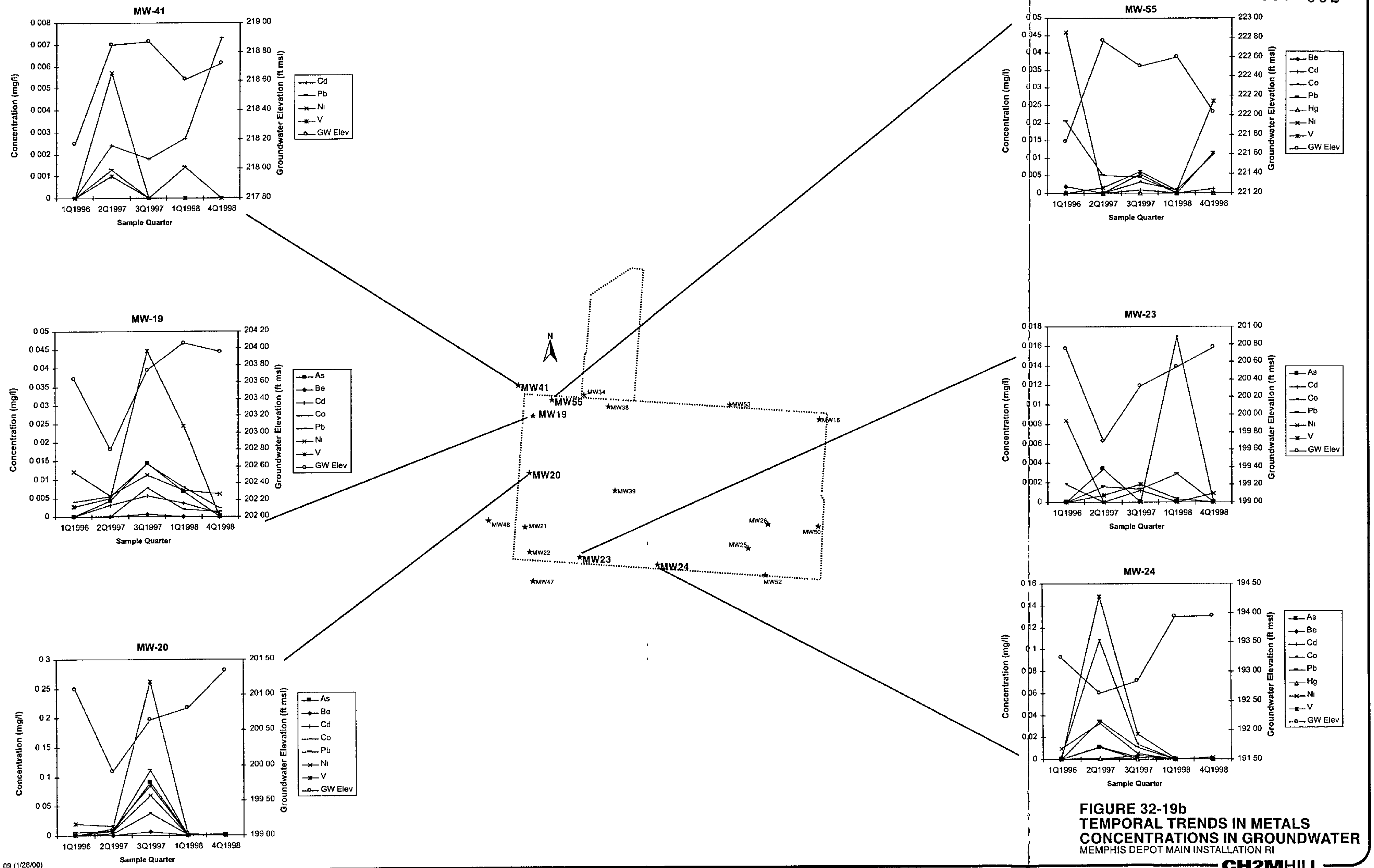

FIGURE 32-19b
TEMPORAL TRENDS IN METALS CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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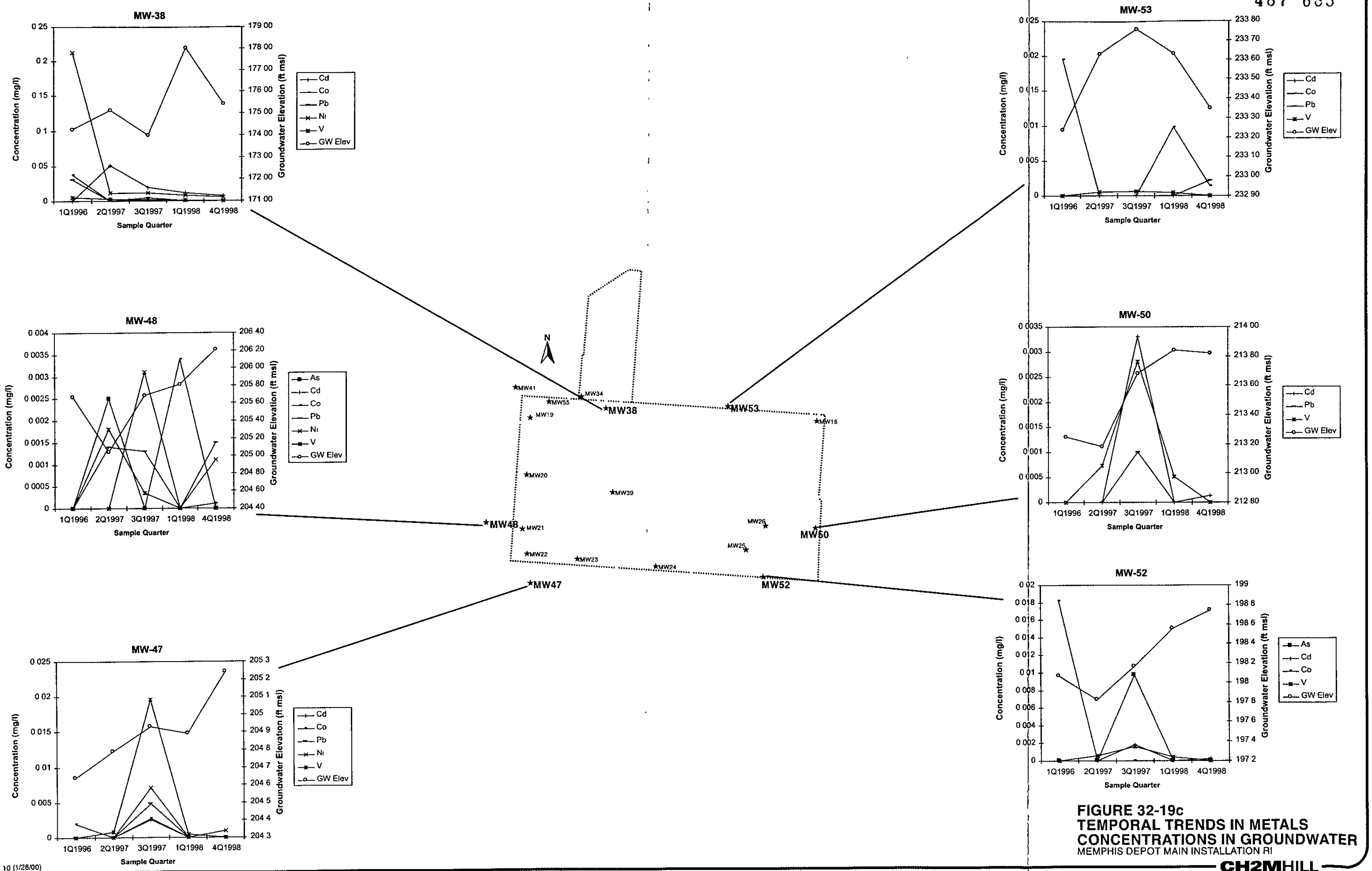

FIGURE 32-19c
TEMPORAL TRENDS IN METALS CONCENTRATIONS IN GROUNDWATER
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 33

TAB

33. Fate and Transport for FU7

33.0 Fate and Transport for FU7

33.1 Introduction

This section provides an overview of the potential migration pathways, mechanisms for transport, and behavior of chemical substances reported in the groundwater at the Main Installation. The fate and transport of site-related contaminants are important in assessing the potential for exposure to these contaminants, as well as the potential changes in concentration or migration if no actions are taken. The potential for direct contact with chemicals in surface soil and for residual constituents in soils to affect groundwater was discussed in previous sections. The risk management decisions also include effects on groundwater and are based in part on the potential for the continued migration of groundwater contaminants to affect downgradient receptors.

Physical, chemical, and biological processes affect the nature and distribution of chemicals in the environment. Because the Main Installation consists of numerous individual sites, migration in groundwater is addressed for the entire portion of the Depot facility south of Dunn Road (i.e., the Main Installation). Although in many instances, the specific chemicals, sources, and concentrations differ across the Main Installation, physical, chemical, and hydrogeologic conditions that affect the migration and fate of contaminants are similar.

This section presents the following:

- Overview of the groundwater CSM, a summary of potential sources, and groundwater transport pathways; and
- Chemical-specific discussions of common constituents at the Main Installation, including the properties that influence migration.

The principles of contaminant fate and transport analysis and the results of modeling (analytical calculations) activities are summarized in this section. Section 33.2 presents a conceptual model for potential contaminant migration pathways at the Main Installation that considers site topography, geology, hydrology, and site-related chemicals. Section 33.3 presents a brief discussion of the persistence of the contaminants in the environment and the physical and chemical properties of the site-related chemicals that were used in the fate and transport analysis. See Section 6.0 for a more detailed discussion of the physical and chemical properties of the detected chemicals. Contaminant release mechanisms and transport media also are described in this section. A summary of the natural attenuation assessment for the Main Installation is presented in Section 33.4. Chemical migration rates for the Main Installation groundwater COPCs are presented in Section 33.5.

33.2 Conceptual Site Model

The CSM developed for the Main Installation is a representation of known site conditions and serves as the framework for quantitative modeling. Site conditions described by the CSM include waste source information, the surrounding geologic and hydrologic conditions, a list of site-related chemicals, and the current spatial distribution of the site-related chemicals. The graphical representation of the CSM for all exposure pathways and environmental media at the Main Installation is shown on Figure 18-1. Figure 33-1a presents a generalized schematic east-west trending cross section through the Main Installation and identifies all transport pathways associated with subsurface transport through soil and groundwater. Figure 33-1b expands the conceptual model into three dimensions and shows groundwater flow directions and transport pathways across the Depot. This information is combined to identify the likely chemical migration pathways. A conceptual model focusing on the transport of VOCs in the southwestern corner of the Main Installation is presented in Figure 33-1c. There are no known offsite sources of VOCs southwest of the Main Installation, so observed concentrations of VOCs at PZ-04 are thought to migrate upgradient of the Main Installation by way of discontinuous lateral transport along thin clay laminae observed in the unsaturated zone. Migration would occur in the dissolved phase during periods of recharge and move laterally in temporary perched zones above the clay laminae.

With the exception of the metals soil contamination delineated in the southwestern portion of the Main Installation, surface and subsurface borehole samples did not indicate any specific contaminant sources that could be linked to the VOC contamination present in the fluvial aquifer. The relatively low concentrations of VOCs in groundwater over most of the Depot and the absence of definitive soil sources suggest that the sources are diffuse and probably are the result of past industrial activity at the Memphis Depot. Data indicate that releases from these sources (on-site or off-site) would directly affect soils below or areas adjacent to the sources. Continuing transport processes also may result in secondary releases, which are likely if all contaminants are site related, that could affect larger areas or additional environmental media. Transport processes likely to be active at the site include vertical infiltration of chemicals into the substrate and lateral and vertical migration in groundwater.

Surface water is a potentially viable exposure pathway for the site because of the risk to ecosystems at or near Lake Danielson. It should be emphasized that because the depth to groundwater at the Main Installation is so great (at least 55 ft bls and typically in excess of 90 ft bls), the potential for groundwater discharge to on-site surface waters does not exist; therefore, this exposure pathway is incomplete.

Off-site and southwest of the Main Installation, the surface waters of Nonconnah Creek are at an approximate elevation of 225 ft above msl (USGS, 1996), an elevation similar to the water table elevation underlying the southern portion of the Main Installation (see Figure 2-12). Given the apparent closeness of the creek and groundwater levels along Nonconnah Creek, it is highly probable that the creek and the fluvial aquifer are hydraulically connected. These conditions would result in a more direct recharge to the fluvial aquifer. In addition, during periods of high water table, the fluvial aquifer recharges the creek and when the reverse condition occurs, the creek recharges the fluvial aquifer.

The majority of runoff from the Main Installation flows into surface ditches, enters the storm sewer system, and eventual discharges into Nonconnah Creek. The result of a walkover survey conducted during the summer of 1997 indicate that there are 130 acres of grass and 145 acres of gravel on the Main Installation–the rest is impermeable asphalt, concrete, and buildings. The Main Installation covers about 590 acres; therefore, only

47 percent (275 acres) is opened to receive direct recharge to the fluvial aquifer. The average annual net recharge in the Memphis area is 9 inches (CH2M HILL, 1995a). Adjusting this average infiltration for the infiltration area at the Main Installation results in an effective infiltration rate of about 4.23 inches per year. Only this amount is available to recharge the fluvial aquifer within the Main Installation area; the remaining 4.77 inches flows as runoff into a series of on-site ditches and storm drains before eventual discharge off-site and into Nonconnah Creek. Recharge across the Main Installation is expected to be variable and concentrated in areas of permeable land cover.

33.2.1 Contaminant Sources, Release Mechanisms, and Migration Pathways

In accordance with historical process knowledge and the findings of sampling and analysis performed at the Main Installation, contaminant sources for metals were identified. As previously mentioned, the presence of organic contaminants in the fluvial aquifer is not directly linked to on-site contaminant or soil sources. Continued release of organics may be from historical releases or possibly off-site industries that use chlorinated hydrocarbon solvents. These industrial facilities may be contributing to the presence of the VOC plume identified in the southeastern corner of the Main Installation. Although specific sources have not been identified, chemicals detected in soil and groundwater confirm the potential for media-specific chemical transport. The migration pathways discussed below appear to be the most viable exposure routes and include the potential for migration of groundwater to downgradient receptors. The primary groundwater receptors are the people who drink water obtained from the public water supply wells of the Allen Well Field, located 1.5 miles to the west of the Main Installation. The Allen Well Field supplies the City of Memphis with a portion of its drinking water. It should be emphasized, as discussed in Section 2.0, that groundwater is pumped from the Memphis aquifer, which over most of the Main Installation is separated from VOCs in the fluvial aquifer by a confining clay layer. In areas where this clay is thinned or potentially absent, groundwater monitoring wells indicate that VOCs are not migrating at detected concentrations downward to the Memphis aquifer.

The suspected contributing sources of metals contamination are primarily the Former Paint Spray Booth (RI Site 31) and the Sandblasting Waste Accumulation Process Area (RI Site 32). Organic contaminants either continue to migrate from undetermined on-site source terms related to past industrial process releases, or are transported advectively by groundwater from off-site sources onto the Main Installation from areas located southeast and southwest of the Main Installation property.

33.2.2 Hydrologic Properties

A description of the site hydrology and hydrogeology is provided in Section 2.0. Four geologic units underlie the Main Installation and control the flow of groundwater and thus contaminant migration. These are, in descending order:

- Loess: discontinuous and variable interfingerings of silt and sand averaging 28 ft thick;
- Fluvial Deposits: sand, silt, and clay deposits with varying thicknesses, averaging 73 ft;
- Jackson, Cockfield, and Cook Mountain Formations (Jackson Formation–Upper Claiborne Group): approximately 90 ft of clay lignitic clay, and sand, which may be

discontinuous in the northwestern portion of the Main Installation near STB-13, MW-34, and MW-18; and

- Memphis Sand Formation: approximately 800 ft of sand and gravely sand.

For analytical modeling purposes, it was assumed that the loess deposits are not perennially saturated, as suggested by the water level data presented in Section 2.8. Instead, it was assumed that groundwater infiltrates and migrates downward to recharge the fluvial aquifer. This is a conservative assumption because, if saturated conditions in the loess were assumed, contaminant transport through it would have been attenuated.

33.2.3 Site-related Chemicals

Site-related chemicals for the Main Installation are identified in Section 32.0. These chemicals were detected frequently and at elevated concentrations in various environmental media. It is important to note that all waste-source chemicals that were detected in groundwater at least once above screening criteria are addressed quantitatively in this fate and transport analysis. The primary groundwater COPCs are as follows:

- VOCs, including PCE and its degradation products (TCE and 1,2-DCE), and carbon tetrachloride, 1,1,1 TCA, chlorobenzene, chloroethane, chloromethane, and 1,1,2,2-tetrachloroethane; and
- Ten metals: aluminum, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, nickel, and vanadium.

33.3 Chemical Properties

The physical and chemical properties of primary chemicals reported in all media at the Main Installation that affect contaminant migration are discussed in Section 6.0 and summarized in Tables 6-1 and 6-2. This section focuses on the COPCs reported in groundwater and summarized in the previous subsection. In general, organic and inorganic chemicals with high solubilities are more mobile in water than those that sorb more strongly to soils. Henry's Law constants are a measure of the partitioning of a chemical between the air phase and the water phase. Because of the abundance of water in the environment, this property is best used to estimate the tendency for organic compounds to volatilize.

The primary parameters used to evaluate the mobility of constituents in groundwater include K_{oc}, K_{ow}, and K_d (Table 6-1). Other properties including pH, conductivity, turbidity, redox, DO, and TOC also were measured and used to assess the mobility of groundwater constituents.

Chemical distributions in both soil and water are more difficult to predict for metals than for organic compounds. A direct relationship between the measured total metal concentration in soil and the extractable aqueous concentration cannot be assumed. The metal may be fixed in the interior of the soil and be unavailable for exchange or release to water, or an exchangeable metal may be present at the surface of the particles.

Published K_d values generally represent the potential relationship between water and exchangeable metal at the surface of the soil, which is as follows:

$$C_{total} = C_{fixed} + C_{absorbed}$$
$$K_d = C_{absorbed}/C_{water}$$

where

C_{total} = total concentration of metal (fixed plus adsorbed)
C_{fixed} = fixed concentration of metal
$C_{absorbed}$ = absorbed concentration of metal
C_{water} = concentration of metal in water

This relationship is useful in determining retardation (the velocity of the chemical to the velocity of groundwater) and the tendency for the metal to sorb to the surface of the soil (K_d) but it does not relate the total metal concentration in the solid to a dissolved concentration.

33.3.1 Metals

Inorganic chemicals released to unsaturated soil become dissolved in soil moisture or adsorbed onto soil particles. Dissolved inorganic analytes detected at the Main Installation are subject to movement by vadose zone water and fluctuations in the elevation of the water table. Aqueous transport mechanics may result in metal migration through the vadose zone to groundwater. Metals, unlike organic compounds, cannot be degraded. However, retarding reactions such as adsorption, surface complexation, and ion-exchange reactions with the soils with which they come into contact can attenuate metals migration Such reactions are affected by pH; oxidation-reduction conditions; and the type and amount of organic matter, clay, and hydrous oxides present.

Once dissolved into groundwater, metals move at a slower rate because of the retardation factor (RF), which describes, numerically, the extent to which the velocity of the contaminant migration is decreased relative to the groundwater velocity, and is largely derived from the partition coefficient (K_d). Table 33-1 presents the K_d values for metals for the sandy-type soils prevalent in the fluvial aquifer underlying the Main Installation. The K_d values of metals vary widely in the same soil type and may vary by orders of magnitude among samples from the same site (EPA, 1996).

Contaminant persistence is a function of physical, chemical, and biological processes that affect the chemical as it moves through water. The mobility of metals is directly related to their solubility in water or other fluids and to pH and redox conditions. In the absence of fluids to mobilize and transport metals, virtually no transport is possible. Even if fluids are present, metals become more mobile only under favorable pH and redox conditions. The pH of the fluvial aquifer water samples ranged from a low of 5.49 (MW-35) to 7.9 (MW-62) and averaged 5.95. In general, a lower pH enhances the process of metals precipitation into solution (Dominico and Schwartz, 1990).

The most persistent and frequent detection of metals throughout the groundwater-monitoring program was observed in MW-21 and MW-22. The highest concentration of metals occurred in these wells during the October 1998 sampling event. Although it has been concluded that the presence of metals in groundwater (MW-21 and MW-22) is due to the release of metals from the sandblasting waste accumulation pile/former paint spray booth, it should be noted that the groundwater samples collected during October 1998 had the highest increase in turbidity over the previous sampling event in March 1998 (see Table 33-2). The turbidity of the groundwater samples collected from monitoring wells MW-21 and MW-22 increased by 38 and 41 nephelometric turbidity units (NTUs), respectively. With the exception of the samples collected from these wells, the turbidity of the groundwater was below 40 NTU.

Given the inconsistent and sporadic occurrence of metals at the Main Installation in MW-21 and MW-22 and the difficulty in achieving acceptable turbidity levels in groundwater samples at these locations, discretion should used in basing risk management decisions on metals chemistry from low-yielding, small-diameter monitoring wells that exhibit large fluctuations in turbidity. It is difficult to achieve acceptable turbidity in these wells and to sample them, because they rarely produce sustainable yields of water. A continuous yield of water is necessary to move soil particulates that cause anomalously high metals concentrations. Low or intermittent yields and higher turbidity have been observed in the groundwater samples collected from monitoring wells MW-21 and MW-22.

Although metals COPCs have been detected in the fluvial aquifer, they are not mobile and have a very low horizontal migration potential.

33.3.1.1 Abundant Metals

A recurring issue in the Main Installation is the ubiquitous presence of abundant, generally non-anthropogenic metals identified in all media. The most common of these are aluminum and iron. It is important to distinguish evidence for release and transport from the natural variability at the site or secondary factors that may alter the solubility. Aluminum and iron are not primary constituents associated with operations performed across the Main Installation, with the exception of sandblasting operations in the southwestern corner of the Main Installation. The patterns of these constituents suggest that they are not related to site activities, based on the following:

- Ten metals occur in the fluvial aquifer above screening levels, and their distribution is relatively random. The random distribution makes it impossible to establish a correlation with process or source areas;
- Aluminum and iron have been identified as groundwater COPCs, and in particular, are the second and third most abundant metals in the earth's crust. These were present in the soil and sediment samples analyzed, as well; and
- The metals reported in groundwater at elevated concentrations form no distinguishable "plume" (pattern of high to lower concentrations). In addition, at some locations, the concentrations are sensitive to turbidity.

33.3.2 Chlorinated VOCs

CVOCs detected at the Main Installation could be related to the use of solvents such as PCE, TCE, or 1,1,1-TCA, which typically are used for degreasing activities. In addition to these solvents, common degradation products were detected, including 1,2-DCE (related to the degradation of PCE or TCE), and 1,1-DCE(related to the degradation of TCE and 1,1,1-TCA). Because the actual source of the chlorinated solvents has not been determined, it is not known if the solvents are directly site-related or if they are migrating onto the Main Installation from off-site areas.

The nature of the release is considered in interpreting constituent patterns. There are two distinct VOC plumes present at the Main Installation. The PCE plume is the largest and most concentrated of the plumes and has two distinct centroids: one is centered at MW-21 (southwestern portion of the Main Installation) with a maximum PCE concentration of 120 µg/L; and the second is centered at MW-26 (southeastern portion of the Main Installation) with a maximum PCE concentration of 16 µg/L. The PCE within both the southwestern and southeastern plumes extends beyond the Main Installation property.

The other major contaminant plume defined on the Main Installation consists of TCE. This plume is thought to be a result of the degradation of PCE (although TCE may also be a source material) and is located in the area formed by the outline of monitoring wells MW-64, MW-21, MW-39, and MW-62. The TCE plume also extends off-site to the southeast to include PZ05, where the highest TCE concentration was reported. The TCE plume is more centrally located within the Main Installation and is hydraulically downgradient from the PCE centroids. On the basis of the biodegradation processes (PCE degrades to TCE), the direction of groundwater gradients, and degradation ratios of PCE to TCE, this interpretation is well supported.

When releases are associated with aqueous discharges that contain trace amounts of solvents, migration is associated with the behavior of the aqueous phase. In some instances, the organic solvent itself could be spilled or released, in which case the migration of the separate organic solvent phase must be considered. The presence of a solvent phase generally is suspected only when high concentrations of CVOCs are reported. The chlorinated solvents detected at the Main Installation were reported at various locations and levels that typically ranged from trace amounts to as high as 120 µg/L. At MW-21, the concentration of PCE was reported at 120 µg/L. EPA (1991) suggests that a groundwater concentration equal to 1 percent effective solubility is a good indicator of DNAPL. On the basis of this criterion and the solubilities reported in Table 6-1, dissolved phase concentrations of 2,000 µg/L PCE and 11,000 µg/L TCE would be necessary to suggest the presence of DNAPL. Maximum concentrations of PCE and TCE in groundwater are orders of magnitude below this criterion, indicting that an active source of DNAPL has not been identified. To put these low concentrations in further perspective, extensive soil testing conducted at other sites in the southeast region indicated that TCE soil concentrations at or above 225,000 micrograms per kilogram (µg/kg) are a reliable indicator of TCE DNAPL (LMES, 1997). VOC concentrations in soil throughout the Main Installation, again, are orders of magnitude lower than this indicator value.

Overall, the levels of PCE and TCE in groundwater at the Main Installation have remained constant (both increasing and decreasing trends have been observed) over the past four sampling events. Dispersion, diffusion, degradation, and water level fluctuations all have contributed to the observed trend.

33.4 Preliminary Screening of Natural Attenuation Potential

After the September 1997 groundwater sampling event, a screening of natural attenuation potential was added to the groundwater monitoring program. Biodegradation and chemical degradation are important considerations in evaluating chlorinated solvents because of the potential formation of COPCs and/or losses of COPCs.

The screening was conducted for the purpose of evaluating whether biological degradation was a dominant physical process in the fluvial aquifer. The sampling strategy and parameter selection for the natural attenuation screening were developed from the September 1997 groundwater sampling and all previously collected groundwater data.

During the March 1998 and October 1998 groundwater monitoring events, selected natural attenuation parameters were measured from wells installed at the Main Installation. In addition to the analysis of VOCs, the protocol listed in the following chart was used for evaluating natural attenuation:

Selected Natural Attenuation Parameters at Main Installation for March 1998 and October 1998 Sampling Events
Oxygen (dissolved)
Iron (II) (expressed as total iron)
Sulfate
Methane, Ethane, and Ethene
Redox Potential
pH
Temperature
Conductivity
TOC (aqueous)
Alkalinity
Ammonium

On the basis of the extent of groundwater contamination, as indicated by the September 1997 groundwater sampling results, the data collection protocol was implemented for wells located upgradient of the source (MW-48), in the dissolved plume downgradient of the source (MW-21 and MW-47), and downgradient of the dissolved plume (MW-20) to evaluate the potential for anaerobic biodegradation. The groundwater samples were collected with a Grundfos (submersible) pump using the lowest flow rate possible, while still allowing for continuous groundwater flow through the YSI multimeter. DO, pH, turbidity, redox potential, temperature, and conductivity were measured with the YSI multimeter. The other natural attenuation parameters were collected in appropriate sample containers and analyzed by the off-site lab.

Aerobic and anaerobic biodegradation are important transformation processes for chlorinated aliphatic compounds in natural water systems and soil. Considerable research has been done on the degradation mechanisms and pathways for this class of compounds. Although several degradation pathways could occur for these constituents, the following patterns have been identified for degradation under anaerobic conditions. The anaerobic degradation pathway is as follows:

PCE-------> TCE-------> DCE------> vinyl chloride ------> ethene ------> ethane

The anaerobic biodegradation of TCE, which initially forms cis-1,2-DCE, occurs under reducing conditions where sulfide- and/or methane-producing conditions exist. Such conditions occur primarily in the presence of other natural or anthropogenic carbon sources. TOC concentrations in soil samples from MW-40 at 89 ft bls, MW-42 at 23 ft bls, and MW-46 at 67 ft bls were 4,760, 2,220, and 56.3 mg/kg, respectively. The three samples yielded an average TOC concentration of 2,345 mg/kg. A higher TOC indicates a greater potential for VOCs to sorb to soil.

DCE (particularly the cis-1,2-DCE isomer), is an indicator for this degradation pathway, because it is not used as a pure product but is found solely as a degradation product. 1,2-DCE may further degrade anaerobically to vinyl chloride, but the rate is slower and the process may require stronger reducing conditions than those required for the reduction of PCE or TCE (Chapel, 1997). Geochemical markers indicate a more oxidizing environment, evidence that the conditions are not optimal to drive the degradation process to vinyl chloride. Only three low-level detected concentrations (1, 1, and 2 µg/L) of 1,2-DCE (conservatively assumed to be the cis-1,2-DCE isomoer) were reported in the October 1998 sampling event and no vinyl chloride was reported above the MDL. Very little DCE in any form and no vinyl chloride, ethene, and ethane were observed in the last 2 years of groundwater data.

TCE, which may occur as a source material or degradation produce of PCE, generally would be expected to persist under aerobic or denitrifying conditions. Denitrifying conditions are indicated when nitrates are present in groundwater but no oxygen is present. Also, with the right microorganisms and the proper concentrations of ammonia, methane, and toluene, TCE can be aerobically degraded. Smaller chlorinated compounds such as DCE are harder to degrade anaerobically, but are easier to aerobically degrade than the more chlorinated solvents such as TCE.

33.4.1 Degradation Ratios

To evaluate the change in chemical mass over time, the molar ratios of the parent to daughter products and to total concentrations (sum total of the parent and daughter products) were calculated. The data collected during the March 1998 and October 1998 sampling events were used to calculate molar ratios of the daughter products to parent products (e.g. TCE to PCE, DCE to TCE) and their molar ratios to the sum total concentration for the Main Installation wells (see Table 33-3). These ratios were used to develop trends that would show the progression and/or accumulation of degradation products in the fluvial aquifer as the groundwater moves downgradient, through the source area, and as a dissolved plume into a clean zone.

In general, the molar ratios calculated for the March 1998 sampling event are consistent with the molar ratios calculated for the October 1998 data. As previously mentioned, the only evidence of biodegradation is the transformation of PCE to TCE. TCE is more prevalent within areas downgradient of the PCE plume, as shown in the contaminant plume maps presented in Section 32.0. The three primary TCE plume wells (MW-39, MW-62, and MW-64) show a sharp reduction or no PCE, and an increase in the levels of TCE and ratios in these wells, with the ratios being the highest in these wells. Within the PCE plume, however, the ratios of TCE to PCE are low, suggesting a slower transformation of PCE to TCE. Well MW-21 did show an increase in concentration of PCE and TCE during the March 1998 to October 1998 time period. Overall, the ratios indicate that the geochemical conditions are adequate to support moderate transformation of PCE to TCE.

33.4.2 Geochemical Markers

Geochemical parameters were measured to assess the extent to which physical conditions in the fluvial aquifer would support natural attenuation of chlorinated solvents. PCE and TCE are present in groundwater at concentrations that range from below MDLs up to 120 and 58 µg/L, respectively. TCE is most widespread within the central portion of the Main

Installation, whereas PCE is concentrated within the southwestern and southeastern portions of the Main Installation. The hydraulic gradient is from the southwest and northeast to the central portion of the Main Installation, where flow converges, and then toward the potentiometric low centered at MW-34.

33.4.2.1 Soluble Chloride Ion

A strong indicator of chlorinated solvent degradation is the simultaneous increase in chloride concentration and the decrease in chlorinated solvent concentrations as the chloride ion is produced during degradation. The chloride concentrations are summarized in Table 33-2. A similar trend was observed in the March 1998 data. Typically, a strong indicator of reductive dehalogenation would be chloride concentrations in the source/dissolved plume greater than two times the background chloride concentrations (Wiedemeier et al., 1996). This trend is not supported by the current data.

33.4.2.2 Dissolved Oxygen

The concentrations of DO must be kept low for anaerobic bacteria to function In general, DO values greater than 7 mg/L are considered to be very high for an aquifer. Outside the dissolved plume, background DO concentrations ranged from 1.01 to 9.52 mg/L. DO values measured in the source and dissolved plume ranged from 4.01 to 8.6 mg/L (Table 33-2). Traversing a path in the direction of groundwater flow from upgradient (MW-47), through the centroid of the plume (MW-21 and MW-39), downgradient from the source within the dissolved plume (MW-20) to a clean zone, the reported DO concentrations were 4.23 mg/L, 4.53 mg/L, 5.7 mg/L, and 9.52 mg/L, respectively. DO concentrations of less than 1 mg/L generally indicate a reductive pathway. These conditions are not evident from the DO data. However, these elevated DO levels are somewhat suspect for groundwater at depths exceeding 70 ft bgs. Additional confirmatory monitoring using in-situ oxygen probes or other appropriate methods is warranted.

33.4.2.3 Redox Potential

Redox potential in the source and dissolved plume range from 57 to 130 millivolts (mV). Beyond the dissolved plume, redox potential ranged from 113 to 219 mV (Table 33-2). Typically, redox potential below 50 mV enhances the potential for reductive dechlorination (Wiedemeier et al., 1996). The probability of a reductive dechlorination pathway is not strongly supported by the redox values. However, as discussed in Section 33.4.2.2, elevated DO levels indicate additional confirmatory monitoring using in-situ redox probes or other appropriate methods is warranted.

33.4.2.4 Total Iron

Total iron concentrations (conservatively assumed to be Fe^{+2}) were measured for wells located within and beyond the contaminant plume. Typically, Fe^{+2} concentrations greater than 1 mg/L (oxygen-deficient) indicate the potential for an anaerobic pathway (Wiedemeier et al., 1996). Total iron concentrations, however, can be used as a preliminary indicator of where the reductive pathway is present. Iron concentrations that were reported in the dissolved plume ranged from 48 to 59,000 µg/L. Eliminating MW-22 (59,000 µg/L) and MW-55 (21,300 µg/L) because of high sample turbidity, iron concentrations ranged 48 to 1,710 µg/L. These values suggest a low probability for a reductive pathway.

33.4.2.5 Sulfate

Sulfate concentrations ranged from 5.7 to 37.2 mg/L. These data indicate a trend where concentrations within the dissolved plume (MW-21 at 5.7 mg/L) generally were lower than those outside of the plume (MW-48 at 37.2 mg/L). Sulfate can drive a reductive pathway when background concentrations exceed 20 mg/L and source/dissolved plume concentrations are less than 20 mg/L (Wiedemeier et al., 1996). When sulfate levels exceed 20 mg/L, sulfate may cause exclusion of dechlorination. If oxygen or nitrate is present at optimum levels, biodegradation can still occur. Current sulfate data indicate limited evidence for a reductive pathway.

33.4.2.6 Total Organic Carbon, Alkalinity (HCO_3), and Ammonium

Limited TOC and ammonium data currently are available. The concentrations of TOC and ammonium suggest conditions that are not optimal to drive a reductive pathway. Without the presence of anthropogenic carbon sources, natural TOC is required to drive anaerobic metabolism of chlorinated solvents. The levels of TOC measured at the Main Installation (below MDL to 2.5 mg/L) indicate limited evidence for a reductive pathway. Only one well was sampled for HCO_3; therefore, no trends for this parameter could be evaluated.

33.4.2.7 Summary of Preliminary Screening for Natural Attenuation

The evaluation of the natural attenuation parameters measured during the past two groundwater sampling events indicates that biodegradation is not a dominant physical process in the fluvial aquifer. Localized observations, such as the presence of PCE and TCE at favorable ratios in MW-21, support the transformation of the parent (PCE) to a daughter (TCE) product. Additional evidence supporting biodegradation is the presence and separation of the TCE plume downgradient of the PCE plume. However, geochemical data show little evidence that a reductive pathway exists at the Main Installation. In addition, the apparent lack of 1,2-DCE and vinyl chloride in the groundwater indicates that the transformation of TCE cannot be supported in the current geochemical environment.

The geochemical data collected to date do not indicate that chemical and biological conditions in the fluvial aquifer are favorable for anaerobic (reductive) dehalogenation of chlorinated hydrocarbons. However, considering the depth to fluvial groundwater over the Main Installation, previous field measurements that indicate high levels of DO and redox are suspect and may result from oxygen being introduced into the sample tubing and pumps. Also, low concentrations of chlorinated hydrocarbons result in significantly lower concentrations of biodegradation products. Additional monitoring using in-situ sampling and measurement methods, as well as sampling and analysis of the full suite of MNA indicator parameters, should be performed to confirm the preliminary evaluation presented in this RI.

33.5 Chemical Migration Rates

Chemicals in soil or groundwater migrate at a velocity slower than that of the water, which is the transport medium. The RF is the relative chemical migration velocity, which is calculated as follows:

$$RF = 1 + (K_d \rho) / \eta$$

where

RF = chemical-specific retardation factor (dimensionless)

ρ = bulk mass density of dry aquifer system skeleton (g/cc)

{1.67 g/cc (Everett, Wilson, and Hoylman, 1984)}

η = total porosity (dimensionless)

{0.40 (Dawson and Istock, 1991)}

K_d = chemical-specific distribution coefficient (cc/g)

The distribution coefficient K_d for organic constituents is estimated as follows:

$K_d = K_{oc} * foc$

where

K_{oc} = chemical-specific organic carbon partition coefficient

foc = fraction of organic carbon

{0.002345 (based on soil samples collected during this RI)}

In general, metals are persistent in the environment. Metals are not typically volatile, so any emissions to ambient air would be in the form of particulate emissions. The chemical migration rates for site-related COPCs are presented in Table 33-1.

33.5.1 Migration Pathways

The COPCs reported in the fluvial aquifer groundwater beneath the Main Installation include the metals aluminum, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, nickel, and vanadium; and VOCs, including: PCE and its degradation products (TCE and 1,2-DCE), carbon tetrachloride, 1,1,1-TCA, chlorobenzene, chloroethane, chloromethane, and 1,1,2,2-Tetrachloroethane. VOCs are the most widespread of the COPCs. The highest concentrations of VOCs were reported in the southwestern portion of the Main Installation at MW-21. On the basis of the October 1998 sampling results, PCE was present in the fluvial aquifer at concentrations ranging from 1 µg/L (MW-47) to 120 µg/L (MW-21). TCE was reported at concentrations ranging from 1 µg/L (MW-22) to 58 µg/L (PZ-05). As noted earlier, TCE is formed from anaerobic biodegradation of PCE. If conditions are optimal, TCE subsequently degrades to DCE, vinyl chloride, and ethene and/or ethane. The current data indicate that anaerobic biodegradation (e.g., PCE to TCE) is occurring, but may not be a major process in the hydrogeological and geochemical environment at the Main Installation.

The ultimate discharge point for groundwater on the Main Installation is the potentiometric low associated with the thinning of the lower Jackson Formation/Claiborne Group clay unit located near STB13, MW-38, and MW-34, 3,600 ft hydraulically downgradient from MW-21.

Once in the groundwater, the COPCs generally move through the fluvial aquifer via advection. Using the hydraulic properties of the fluvial aquifer as a conservative estimate of advective transport, the seepage velocity (advection velocity) at the site was estimated at

0.4 ft/day. Therefore, based on advection alone, it was estimated that contaminants from the site could migrate 149 ft each year.

COPCs spread both horizontally and vertically because of the process of dispersion, while adsorption retards the movement of chemicals in groundwater. Dispersion generally causes chemicals to migrate from 10 to 20 percent farther than migration caused by advection alone. Adsorption, which retards the movement of chemicals, counteracts the advection and dispersion processes. Adsorption generally is described by a chemical's distribution coefficient (K_d). The migration potential for 1 year is calculated for COPCs in accordance with the groundwater flow velocities at that location. These calculations were based on the following equation:

$$V_c = V / R_d$$

where

V_c = chemical horizontal migration velocity in ft per year (ft/yr)

V = site-specific groundwater flow velocity (ft/yr)

R_d = chemical-specific retardation factor (dimensionless)

Calculated horizontal migration velocities are based on advection, retardation, and dispersion, but not on the effects of biodegradation. In accordance with the COPCs identified in Table 33-1, the most mobile constituents include the CVOCs. Other constituents, including metals (such as lead and vanadium), are not readily transported in groundwater.

The maximum extent of contamination confirmed in the fluvial aquifer is due to TCE. Considering that the site began operations approximately 55 years ago, the current horizontal migration potential of TCE from advection, retardation, and dispersion is estimated to be 2,882 ft. This distance is consistent with plume maps developed to evaluate the nature and extent of contamination that show TCE at MW-62, a distance of about 2,800 ft from MW-21. Once at MW-62, groundwater will move under the influence of a higher gradient between MW-62 and MW-34. The 39-ft drop in groundwater levels over the 1,120 ft between MW-62 and MW-34 results in a 0.035 gradient, about three times that assumed over the Main Installation. Chemical migration rates between these wells therefore will be about three times faster. TCE will migrate at a rate of about 130 ft/yr and therefore will reach MW-34 in about 8.5 years. The depressed potentiometric surface at this location suggests downward transport to the underlying confined sand aquifer, which is probably not confined from the overlying fluvial aquifer at this location.

It should be noted that trace concentrations (estimated at less than 5 µg/L) of TCE, carbon tetrachloride, and chloroform have been measured sporadically in MW-18 and MW-34. However, these compounds also are present in the southern portion of Dunn Field, an area that may also be contributing groundwater to the depressed groundwater table monitored at MW-34 and MW-38. Therefore, it is not assumed that the trace levels of VOCs in these wells invalidate the transport calculations.

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TABLE 33-1

Distribution Coefficients and Horizontal Groundwater Migration Potential for Groundwater COPCs

Memphis Depot Main Installation RI

Chemical Name of Groundwater COPC		Distribution Coefficient K_d (cc/g)	Retardation Factor (R_f)	Chemical Migration Rate (ft/year)	Chemical Migration Rate (20% Increase Due to Dispersion) (ft/yr)	Horizontal Migration Potential (Main Installation) (Distance [ft] over 55 years)
Volatile Organic Compounds						
1,1,1 Trichloroethane	135 0	0 3	3 8	39 1	46 9	2579 2
1,2 Dichloroethene	77 5	0 2	3 3	45 8	55 0	3024 8
Bromodichloromethane	107.0	0 3	3 5	42 1	50 5	2778 5
Carbon Tetrachloride	152 0	0 4	4 0	37 4	44 9	2471 6
Chlorobenzene	224 0	0 5	4 7	31 8	38 2	2100 3
Chloroethane	17.0	0 0	2 7	56 0	67 2	3697.5
Chloromethane	5 1	0 0	2 6	58 6	70 3	3865 5
Tetrachloroethene	265 0	0 6	5 1	29 3	35 2	1934 8
Trichloroethene	94 0	0 2	3 4	43 7	52 4	2882 0
Tetrachloroethane, 1,1,2,2-	93.30	0 22	3 41	43 75	52 50	2887 7
Metals						
Aluminum		1500 0	6265 0	0 024	0 029	1 6
Arsenic		25 0	106 9	1 398	1 677	92 2
Beryllium		650 0	2716 3	0 055	0 066	3 6
Cadmium		80 0	336 5	0 444	0 533	29 3
Chromium		35 0	148 6	1 005	1 206	66 3
Lead		270 0	1129 8	0 132	0 159	8 7
Manganese		50 0	211 3	0 707	0 848	46 7
Nickel		400 0	1672 5	0 089	0 107	5 9
Vanadium		1000 0	4177 5	0 036	0 043	2 4
foc (unitless)	0 00234543					
bulk density (g/cm³)	1 67					
total porosity (unitless)	0 4					
effective porosity (unitless)	0 2					
hydraulic conductivity (ft/day)	6 82					
hydraulic gradient (unitless)	0 012					
seepage velocity (ft/day)	0 4092	1 49E+02 ft/year				

TABLE 33-2

Summary of Natural Attenuation Parameters
March & October 1998 Sampling Event
Memphis Depot Main Installation RI

Well No.	Sampling Method	Conductivity (mS/cm)	Turbidity (NTU)	pH	Temp (oC)	DO (mg/L)	Redox (mV)	Nitrate (mg/L)	Sulfate (mg/L)	HCO3 (mg/L)	TOC (mg/L)	NH4 (mg/L)	Fe (µg/L)	Cl (mg/L)	Methane (µg/L)	Ethane (µg/L)	Ethene (µg/L)
Main Installation - October 1998 Sampling Event																	
Dissolved Plume Wells																	
21	p	0.238	45.6	6.48	21 1	4.63	112.8	nc	5.7	nc			1710.0	12.2	1.9		
25	p	0.918	8.8	5.96	19.0	6.22	nc	nc	nc	nc	nc	nc	154 0	nc	nc		
26	p	0.377	25	6.71	22.3	6.29	130.0	nc	nc	nc	nc	nc	1150 0	nc	nc		
39	p	0.327	37.6	5.99	21.1	5.70	nc	nc	nc	nc	nc	nc	549 0	nc	nc		
47	p	0.338	4.4	6.08	19.8	4.23	nc	nc	19.6	nc			166.0	29 9			
52	p	0 991	0	6 00	19 0	4 01	nc	nc	nc	nc	nc	nc		nc	nc		
38	p	0 241	11	5 81	23 0	6 79	117 0	nc	nc	nc	nc	nc	226 0	nc	nc		
22	b	0 499	>100	6 40	17 9	8 60	57 0	nc	20 7	nc	2 6		59000 0	34 3	0 6		
23	p	0 297	3	5 94	19 4	5 20	120 0	nc	17 5	nc			48 0	19 0	2 3		
Control Wells																	
16	p	0 623	14 1	6 26	21 4	1 01	nc	nc	nc	nc	nc	nc	410 0	nc	nc		
19	p	0 166	25	5 7	20 2	8 8	159 0	nc	nc	nc	nc	nc	1700 0	nc	nc		
20	p	0 247	8 4	5 49	19 8	9 52	167.2	nc	nc	nc	nc	nc	182 0	nc	nc		
24	p	0 22	19 8	6 25	19 6	5 97	162 7	nc	nc	nc	nc	nc	483 0	nc	nc		
41	b	0 212	40	7 90	20 5	7 61	113 0	nc	nc	nc	nc	nc	nc	nc	2 6		
48	p	0 272	10	5 86	19 7	6 73	136 0	nc	14 3	nc			170 0	15 7			
50	p	0 858	2	6 00	19 8	2 99	219 0	nc	nc	nc	nc	nc	106 0	nc	nc		
53	p	0 521	6 9	5 92	19 8	1 17	nc	nc	nc	nc	nc	nc	146 0	nc	nc		
55	b	0 277	2610	6 10	23 4	6 75	nc	2 6	37 2	47 0	nc	nc	21300 0	18 7	nc		
Main Installation - March 1998 Sampling Event																	
21	p/b	0 228	7 5	5.81	19.8	6.00	173.3	3.5	5.9	nc			139 0	13 5			
25	p	0.011	2.2	5.93	20.5	10.00	244 7	nc	nc	nc	nc	nc	220J	nc	nc		
26	p	0 376	60	6.09	21.5	6.97	201.5	nc	nc	nc	nc	nc	1180 0	nc	nc		
39	p	0 013	79	6.03	21 7	11.28	158 7	nc	nc	nc	nc	nc	550 0	nc	nc		
47	p	0 328	4 4	6.01	21 1	5.12	134.5	2 1	19.5	nc				31 3	1.0		
52	p/b	0.943	1	5.82	18.6	6.83	82 6	nc	nc	nc	nc	nc		nc	nc		
16	p/b	0 474	3	6 13	20 6	3 09	221 4	nc	nc	nc	nc	nc	430J	nc	nc		
19	b		>100	nc	nc	nc	nc	nc	nc	nc	nc	nc	18300J	nc	nc		
20	p/b	0 272	1 5	5 86	19 0	8 43	206 4	nc	nc	nc	nc	nc	97J	nc	nc		
22	b	0 482	59	6 32	18 6	10 75	115 1	8 4	20 8	nc	2 0		806 0	38 7	2 2		
23	p/b	0 3	5 6	6 12	19 5	5 28	138 5	1 9	15 7	nc				20 4	1 1		
24	b	0 243	1527 7	6 01	17 7	9 33	253 4	nc	nc	nc	nc	nc	738 0	nc	nc		
38	p/b	0 224	4 2	5 93	21 5	7 77	182 3	nc	nc	nc	nc	nc	572J	nc	nc		
41	b	0 197	17	6 37	18 6	7 00	104 3	nc	nc	nc	nc	nc	nc	nc			
48	p/b	0 262	1 5	5 87	20 7	6 67	221 4	5 1	13 9	nc				15 4			
50	p/b	0 916	1	5 70	20 3	5 00	124 7	nc	nc	nc	nc	nc	283 0	nc	nc		
53	p/b	0 506	2	6 00	19 9	1 60	187 7	nc	nc	nc	nc	nc	20 2J	nc	nc		
55	p/b	0 221	5	5 65	20 7	7 43	234 4	nc	28 9	50 0	nc	nc	197 0	13 2	nc		

Notes

Shaded areas represent wells containing concentrations of dissolved VOCs

Blank cells represent undetected parameters

nc = not collected

b = bailed

p = pumped

Wells MW 34 MW 35 and MW-37 are deep wells that are not completed in the fluvial aquifer where the source of VOC contamination has been confirmed

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Table 33-3
Percentages of Degradable VOCS
March and October 1998 Sampling Events
Memphis Depot Main Installation RI

Station ID	TETRACHLOROETHYLENE(PCE)	TRICHLOROETHYLENE (TCE)	1,1-DICHLOROETHENE	TOTAL 1,2-DICHLOROETHENE	Ratio of Trichloroethene to Tetrachloroethene	Ratio of 1,1 Dichloroethene to Trichloroethene	Ratio of 1,2 Dichloroethene to Trichloroethene	Total Concentration (ug/L)	Percent Tetrachloroethene of total	Percent Trichloroethene of total	Percent 1,1 Dichloroethylene of total	Percent 1,2 Dichloroethene of total	Comments
Main Installation Wells - October 1998 Sampling Event													
Source Wells													
MW21	120	31	1	2	25.8%		6.5%	154	77.9%	20.1%		1.3%	Functional Unit 7
MW25	9	1	1	1				12	75.0%				Functional Unit 7
MW26	16	2	1	1	12.5%			20	80.0%	10.0%			Functional Unit 7
Dissolved Plume Wells													Functional Unit 7
HY01	1	1	1	1									Functional Unit 7
HY02	1	1	1	1									Functional Unit 7
HY03	3	1	1	1	33.3%			6	50.0%	16.7%			Functional Unit 7
HY04	1	2	1	1			50.0%	5		40.0%		20.0%	Functional Unit 7
HY07	0.5	0.5	0.5	0.5									Functional Unit 7
HY09	1	1	1	1									Functional Unit 7
MW22	1	1	1	1									Functional Unit 7
MW23	1	1	1	1									Functional Unit 7
MW38	1	1	1	1									Functional Unit 7
MW39	8	7	1	1	87.5%			17	47.1%	41.2%			Functional Unit 7
MW43	1	1	1	1									Functional Unit 7
MW47	1	1	1	1				4	25.0%			25.0%	Functional Unit 7
MW52	1	1	1	1									Background well
MW62	1	37	1	1				40		92.5%			Functional Unit 7
MW63	1	1	1	1									Functional Unit 7
MW64	10	28	1	1	280.0%			40	25.0%	70.0%			Functional Unit 7
MW66	1	1	1	1									Functional Unit 7
PZ01	1	1	1	1									Functional Unit 7
PZ03	7	1	1	1				10	70.0%				Functional Unit 7
PZ04	110	0.5	0.5	0.5				111.5	98.7%				Functional Unit 7
PZ05	1	58	1	1				61		95.1%			Functional Unit 7
PZ06	1	1	1	1									Functional Unit 7
PZ08	1	1	1	1									Functional Unit 7
Control Wells													
MW16	1	1	1	1									Background well
MW19	1	1	1	1									Background well
MW20	1	1	1	1									Functional Unit 7
MW24	1	1	1	1									Background well
MW41	1	1	1	1									Functional Unit 7
MW48	1	1	1	1									Background well
MW50	1	1	1	1									Background well
MW53	1	1	1	1									Background well
MW55	1	1	1	1									Functional Unit 7
Main Installation Wells - March 1998													
Source Wells													
MW21	76	16	1	0.02	21.1%			93.02	81.7%	17.2%			
Dissolved Plume Wells													
MW25	6	1	1	1				9	66.7%				Hot Spot
MW26	14	2	1	1	14.3%			18	77.8%	11.1%			Hot Spot
MW39	8	7	1	1	87.5%			17	47.1%	41.2%			Downgradient of Source Well MW21
MW47	14	6	1	9	42.9%		150.0%	30	46.7%	20.0%		30.0%	
MW52	4	1	1	1	25.0%		100.0%	7	57.1%	14.3%		14.3%	
MW22	1	1	1	1				4		25.0%			
MW38	1	1	1	1				4		25.0%			
MW23	1	1	1	1				4					Downgradient of Source Well MW21
Control Wells													
MW55	1	1	1	1				4					
MW16	1	1	1	1				4					
MW19	1	1	1	1				4					
MW20	1	1	1	1				4					
MW24	1	1	1	1				4					Downgradient of Source Well MW21
MW41	1	1	1	1				4					
MW48	1	1	1	1				4					Upgradient of Source Well MW21
MW50	1	1	1	1				4					
MW53	1	1	1	1				4					

Note Shaded values indicate one-tenth of the method detection limit

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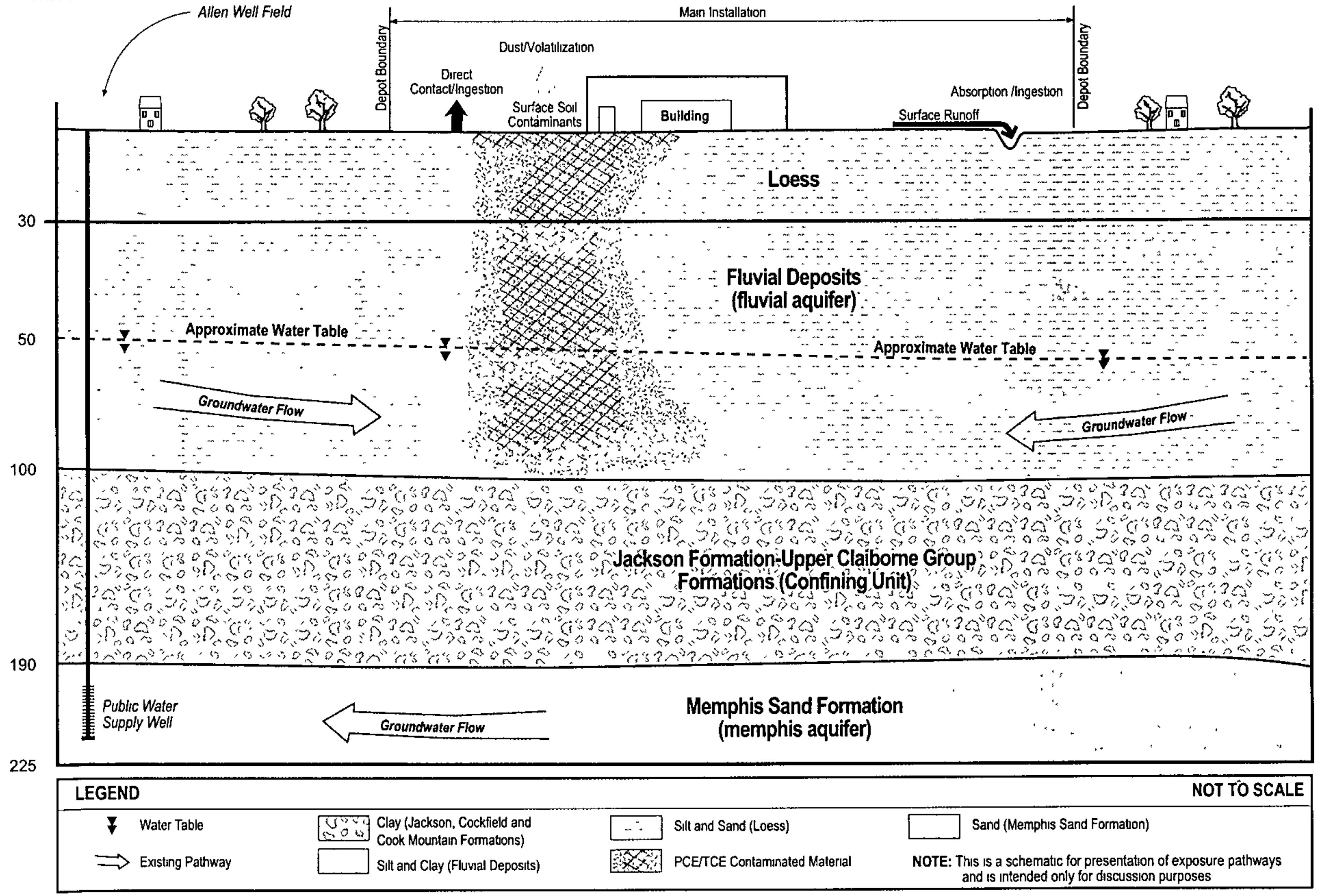

FIGURE 33-1a
CONCEPTUAL MODEL CROSS SECTION
MEMPHIS DEPOT MAIN INSTALLATION RI

CH2MHILL

2972_04 (1/27/00)

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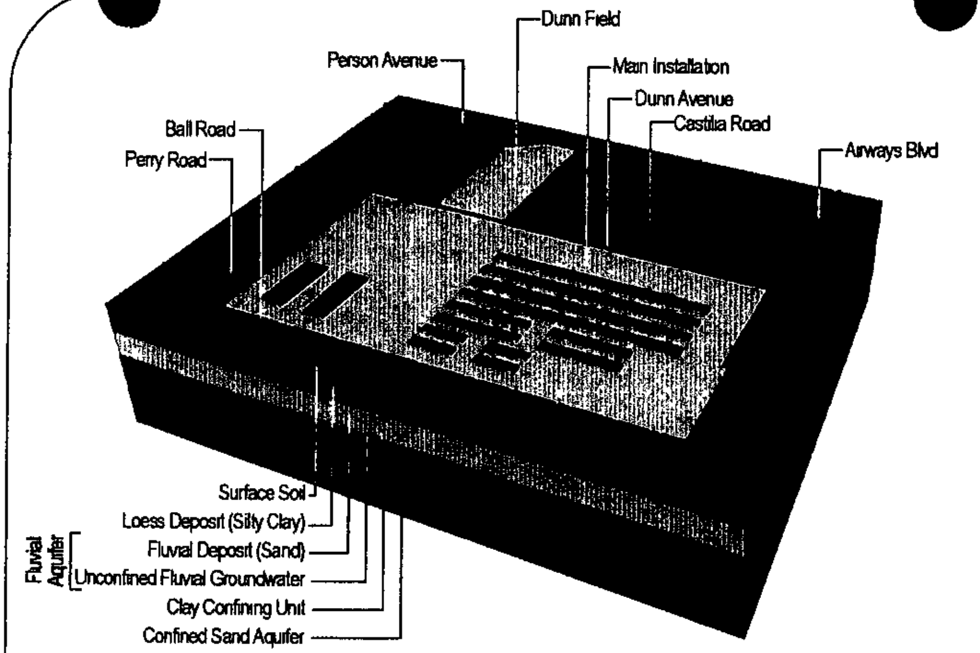
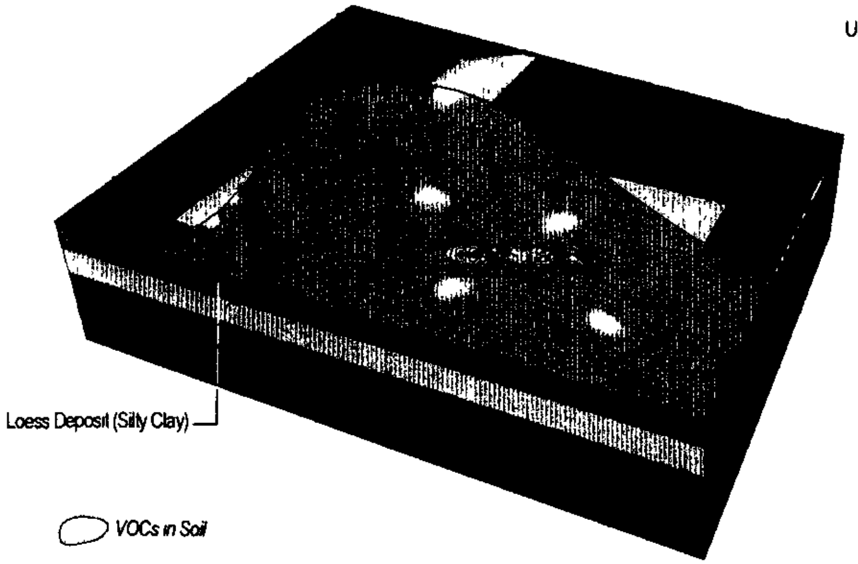
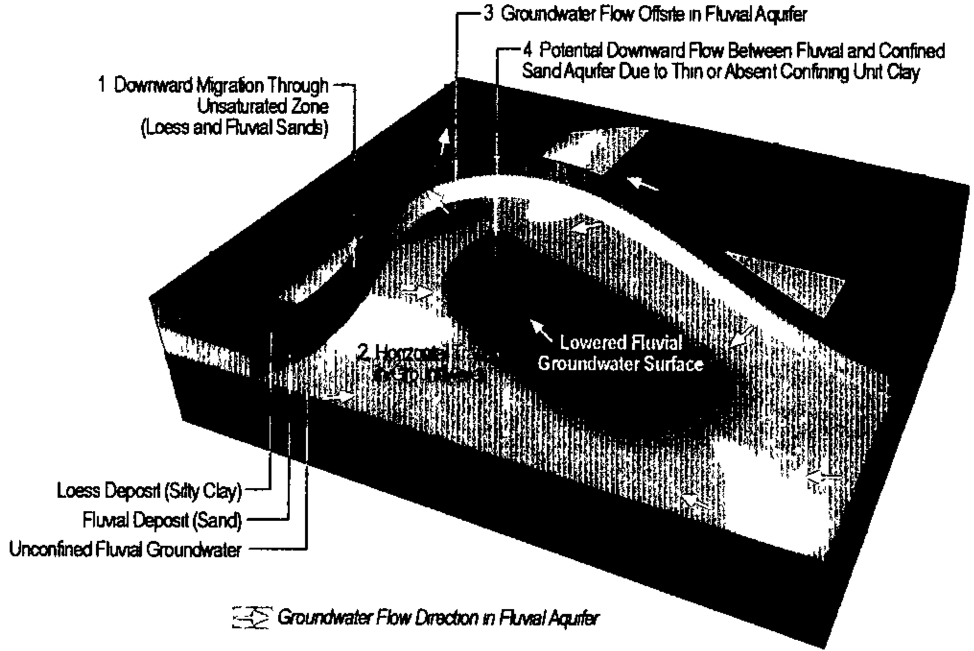


1. Depot Layout and Geologic Strata



2. VOC Releases to Surface and Subsurface Soil



3. Subsurface Migration Pathways

NOT TO SCALE North

FIGURE 33-1b
CONCEPTUAL MODEL:
SUBSURFACE MIGRATION PATHWAYS
MEMPHIS DEPOT MAIN INSTALLATION RI

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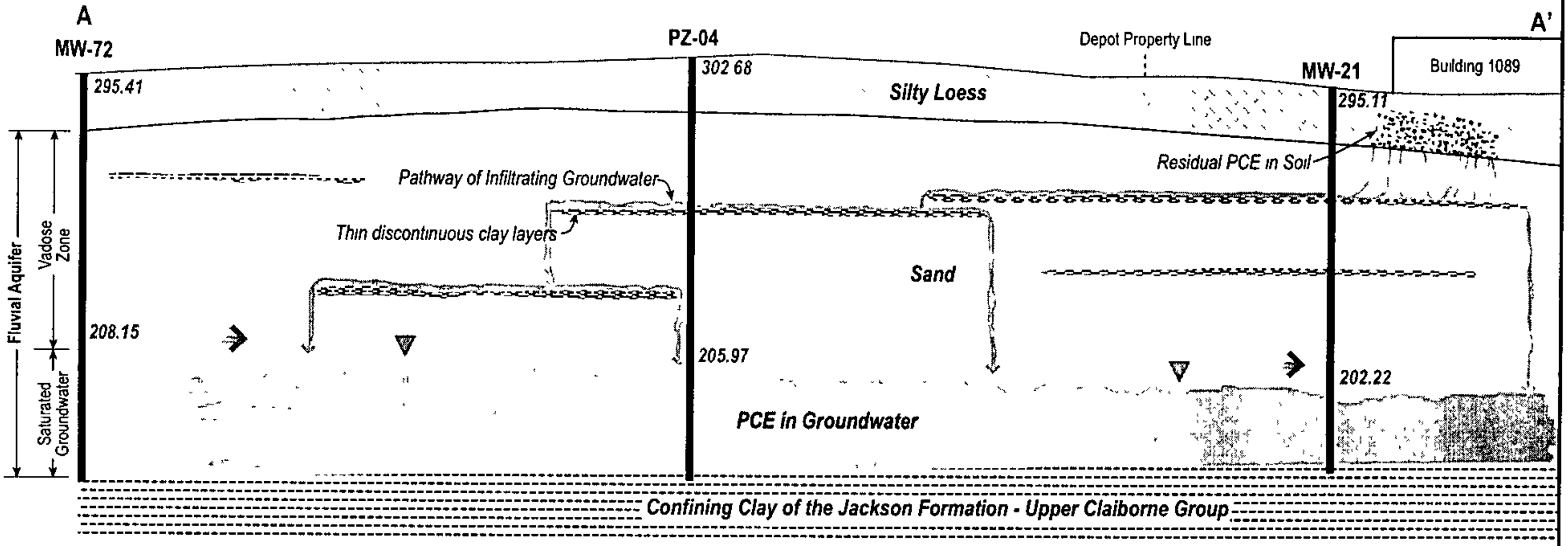

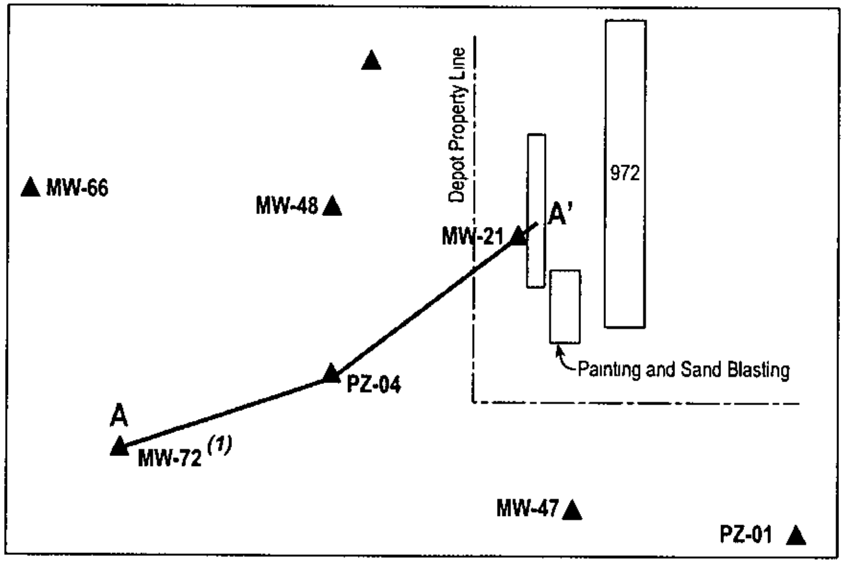

SCALE

Horizontal 1" = 250'

Vertical: 1" = 50'

LEGEND

208.15	Elevation (msl)
➔	Groundwater Flow Direction

NOTE

(1) MW-72 was installed during completion of the Main Installation Final RI Report Additional water level and chemical information is presented in the Main Installation Feasibility Study PCE, TCE, and the other VOCs detected on the Main Installation were not detected in MW-72.

FIGURE 33-1c
CONCEPTUAL MODEL SUBSURFACE PCE MIGRATION PATHWAYS
MEMPHIS DEPOT MAIN INSTALLATION RI

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TAB

Section 34

TAB

34. Baseline Risk Assessment for FU7

34.0 Baseline Risk Assessment for FU7

34.1 Human Health Evaluation

This RA was conducted in accordance with the RA approach presented in Section 7.0 and the agreements reached during meetings with the agencies, which are presented in Appendix A. This section describes each of the four steps of the RA applied to groundwater at the Main Installation, addressed as FU7. Figure 32-1 shows the locations of the groundwater monitoring wells across the Main Installation and immediately off-site of the Depot. The Allen Well Field location and the potentiometric surface map are shown on Figures 2-14 and 2-12, respectively. Monitoring well data collected between 1996 and 1998 were used for this RI/RA. Figures 32-2 to 32-7 present the distribution of CVOCs in the monitoring wells in the Main Installation.

A network of monitoring wells and pizometers was used to evaluate the nature and extent of groundwater contamination at the Main Installation. Low levels of chlorinated organic VOCs were detected in the southeastern, southwestern, and central portions of the Main Installation. No correlation between subsurface soil and groundwater contamination was found. The organic chemicals detected in the southeastern portion of the Main Installation were found to include chlorinated solvents at higher concentrations near the property boundary in the off-site and upgradient location (groundwater flows to the northwest toward the center of Main Installation), indicating a possible off-site source. Similarly, groundwater in the southwestern portion has the chlorinated solvents TCE and PCE, with the highest concentrations in the off-site upgradient location (PZ04). Groundwater from this area also flows to the center in the northeastern portion of the Main Installation. Dry cleaning facilities, which have since been removed, may have been the sources of the PCE and its degradation products.

Potential risks from groundwater use within the Main Installation are estimated for three separate areas represented by a plume in the southwestern area (Plume A), a plume in the southeastern area (Plume B), and a separate more diffuse area (Plume C) in the center of the Main Installation. Each of these plumes for this RA are defined by the monitoring results from the following wells:

- Plume A is represented by temporary and permanent wells HY02, MW-21, MW-22, MW-23, MW-47, and PZ04;
- Plume B is represented by temporary and permanent wells HY03, HY04, MW-25, MW-26, MW-64, and PZ05; and
- Plume C is represented by temporary and permanent wells MW-34, MW-43, MW-38, MW-39, MW-62, MW-63, and PZ03.

As discussed in Section 32.0, inorganic chemicals tend to be commonly and sporadically distributed throughout the Main Installation groundwater (see Table 32-3). Their occurrence also was sporadic during various monitoring periods. For example, arsenic was detected in only one well in the fourth quarter 1998 monitoring (see Figure 32-17). Metals concentrations appear to be slightly elevated in the southwestern corner (two wells, MW-21 and MW-22) near the plating shop. Concentrations were significantly lower during the fourth quarter 1998 monitoring. Groundwater from this area (southwest) moves to the center of the site toward two troughs, one located in the south-central portion of the Main Installation and a second located in the northwestern portion (see Figure 2-12). All of the data from 1996 to 1998 were included in this COPCs selection and the risk estimations.

There currently is no groundwater use within or surrounding the Depot. In the interest of conservatism, a future exposure scenario was assumed whereby industrial and residential receptors are exposed to groundwater via potable use. This section therefore focuses on risk estimations for a hypothetical future groundwater use.

34.1.1 COPC Selection

Chemicals detected in the monitoring wells above background levels and groundwater screening levels were selected as COPCs, as discussed in Section 7.0. Groundwater screening levels are determined by the most conservative of three values: MCLs, MCLGs, and EPA Region III Tap Water RBC values (see Appendix D). To maintain conservatism in this risk analysis, target analytes are sometimes retained as COPCs even though they may be detected below MCLs. Detected compounds analyzed to characterize general aquifer water quality (sodium, chloride, total dissolved solids [TDS], and nitrate/nitrite) or essential nutrients are not important for human health protection and often do not have a toxicity value. Therefore, these general chemistry parameters were not included as COPCs. The COPCs used for the RA for FU7 are shown in Table 34-1.

34.1.2 Exposure Assessment

A CSM for groundwater was discussed briefly in Section 33.2. The primary sources of COPCs in the environmental media within the Main Installation are historical spills and leaks from the storage of chemicals and the surface application of pesticides, herbicides, and waste oil, as well as any unknown buried wastes disposed during Depot operations. Contaminants could be transported through infiltration and leaching to shallow groundwater and subsequently could migrate to downgradient areas.

Section 33.0 presents a fate and transport discussion for the groundwater flow direction, velocity, and contaminant migration pathways. The site groundwater fate and transport can be summarized as follows. Groundwater in the uppermost water-bearing unit, the fluvial aquifer, flows from south, east, and west to lows in the potentiometric surface toward the center of the Main Installation. One low is toward the northwestern portion of the Main Installation and a second is present is the south-central portion. On the basis of the available data, site groundwater is moving at a rate of approximately 149 ft/yr toward the center of the site. Plumes A and B probably are moving to the center of the site toward the two troughs and are potentially co-mingling in the Plume C area. The downgradient-most well in the trough to the northwest of the installation (MW-43, located off the Depot boundary in the downgradient location) has only trace levels of chloroform at 2 µg/L. Contamination is not found to move toward the southern trough in measurable concentrations. No other VOCs, except carbon disulfide at a trace level of 1 µg/L, have been detected in MW-24, which is the downgradient well in the trough in the south-central section of the Main

Installation. Thus, with regard to off-site locations to the south, little or no migration of groundwater contaminants through the trough would occur.

The wells MW-43, MW-34, and MW-38 are in an area of potential vertical migration to the underlying confined sand (possibly the Memphis) aquifer; however additional characterization is being performed at Dunn Field to evaluate whether downward migration is occurring here. Off-site migration is occurring through the depressed clay surface aligned with wells MW-43, MW-34, and MW-38. Small amounts of degradation products were detected in the site groundwater. Some of the more toxic degradation products (such as vinyl chloride), however, were not detected in the site groundwater The potential for volatilization exposures through the ground surface for the CVOCs in groundwater is negligible, because of the impervious nature of surface soils in the area, the depth to groundwater (greater than 50-ft depths), and the low levels of the COPCs detected. Considering the historical nature of VOC releases at the site (55 years), potential migration to off-site areas would have occurred by now. However, estimated chemical-specific migration rates (Table 33-1) indicate the maximum likely distances the CVOCs could reach. The monitoring data for the off-site areas show that the site constituents are not reaching off-site areas in measurable levels.

There is no residential groundwater use on the Depot or in the surrounding community under current or foreseeable future land use conditions. Drinking water is supplied by MLGW pumping wells in the Memphis aquifer. Currently, site groundwater is not being used for industrial use at the Depot. Because of the availability of municipal water supplies, the groundwater is not likely to be used for drinking in the foreseeable future, even if site operations were to be altered to a different industrial use; i.e., redevelopment of the Depot.

Table 34-2 summarizes hypothetical future exposure pathways for FU7 and identifies the pathways that will be evaluated quantitatively in this RA. The potential receptors evaluated for potable water use are:

- Hypothetical future industrial worker; and
- Hypothetical future on-site resident–adult and child (for comparison purposes only).

Maximum and average concentrations were estimated for groundwater from each plume for chemicals that exhibit plume behavior (i.e., CVOCs). For chemicals that do not occur as plumes (i.e., inorganic chemicals), the upperbound exposure concentration was estimated using the UCL 95% concentrations on the mean for all wells associated with the Main Installation. The estimated concentrations, referred to as EPCs, are listed in Tables 34-3 and 34-4. The dose (intake) was estimated for each of the complete exposure pathways and included in Appendix I. The exposure assumptions are standard default factors. For example, ingestion rates of 2 L/day for an adult and 1 L/day for a child and industrial worker were used. Exposure frequency is assumed to be 350 days per year for residential receptors and 250 days per year for industrial receptors. All assumptions are presented in Appendix G.

An oral exposure dose was estimated for organic and inorganic COPCs. The dose estimates are used for comparison with the CSFs and the RfDs to estimate risks and hazards. Inhalation exposure to the CVOCs was assumed equal to the oral dose to estimate intake. Inorganic COPCs were evaluated for oral and dermal doses.

34.1.3 Toxicity Assessment

Table 34-5 presents toxicity values from EPA toxicity factor sources for all of the COPCs at FU7.

Oral CSFs are available for 1,1,2,2-Tetrachloroethane, arsenic, chloroethane, chloromethane, dibromochloromethane, PCE, and TCE. Inhalation CSFs are available for 1,1,2,2-Tetrachloroethane, arsenic, beryllium, cadmium, chloromethane, chromium (total), PCE, and TCE. Chronic oral RfDs are available for aluminum, arsenic, beryllium, cadmium, chlorobenzene, chloroethane, chromium (total), dibromochloromethane, manganese, nickel, PCE, TCE, and vanadium. Inhalation RfDs are available for chlorobenzene, chloroethane, and PCE. Oral toxicity factors were reduced by the gastrointestinal dermal absorption (ABS_{GI}) factors for comparisons with dermal intake estimates. These values can be found in Table 7-10. Ten carcinogenic and five noncarcinogenic inorganic and organic chemicals were identified as COPCs at FU7. All of the chemicals were analyzed for their potential toxicity contribution to represent the combined effect of all site-related chemicals.

34.1.4 Risk Characterization

Estimates of ELCR and noncarcinogenic health hazards are summarized for all of the COPCs on a route- and receptor-specific basis for FU7 in Tables 34-6 (average VOC plume concentrations) and 34-7 (maximum VOC plume concentrations). Appendix I provides detailed risk calculations, along with histograms of the risks and the HIs per receptor group For the chemicals that do not occur as plumes (e.g., inorganic COPCs), the EPC was estimated as the UCL 95% concentration across the Main Installation, and one set of risk and HI values was estimated for the entire Main Installation area. Three sets of risk and HI calculations were performed for organic COPCs for Plumes A, B, and C. The average concentrations within each of the three organic plumes combined with inorganic risks and HIs across the Depot are included in Table 34-6. The maximum concentration within each of the three plumes, combined with inorganic risks and HIs across the Depot, are included in Table 34-7. The ELCR estimates for a future industrial worker exposure to Plumes A, B, or C are 2×10^{-5} each, and the HI is below 1.0. The risk driver within the site-wide inorganics is arsenic. The risk drivers for all organic plumes are PCE and 1,1,2,2-Tetrachloroethane (with the exception of Plume A, which is PCE only). The risks from maximum organic COPC concentrations within Plumes A, B, and C are 4×10^{-5}, 2×10^{-5}, and 2×10^{-5}, respectively. The carcinogenic risks are within the acceptable risk limit range; noncarcinogenic HIs for Plumes A, B, and C, respectively, are 0.6, 0.6, and 0.5, all of which are below 1.0. Figures 34-1 and 34-2 present the risks and HIs for an industrial worker from groundwater use at the Main Installation.

For exposure to site-wide inorganics and organics at average concentrations from either Plume A or B, the ELCR to a future hypothetical residential adult is 9×10^{-5} and the HI is 1.0. Plume C resulted in an ELCR of 7×10^{-5} and an HI of 1.0. The risk driver within the site-wide inorganics is arsenic. The risk drivers for all organic plumes are PCE and TCE, including 1,1,2,2-Tetrachloroethane, for Plumes B and C, and dibromochloromethane for Plume C. The risks to a hypothetical residential adult from exposures to the maximum concentrations estimated from Plumes A, B, and C are 2×10^{-4}, 1×10^{-5}, and 8×10^{-5}, respectively. The risks are either above or near the upper limit of the acceptable risk range, indicating that groundwater within the plume area is unfit for drinking.

For exposure to site-wide inorganics and average concentrations of organics from Plumes A, B, or C, the ELCR to a future hypothetical residential child is 3 x 10^{-5} and the HI is 3.0. The risk driver within the site-wide inorganics is arsenic. The risk drivers for all organic plumes are PCE, TCE, and 1,1,2,2-Tetrachloroethane (with the exception of Plume A, which is PCE only). For exposure to site-wide inorganics and organics at maximum concentrations from Plume A, B, or C, the ELCRs for a future hypothetical residential child are 6 x 10^{-5}, 4 x 10^{-5}, and 3 x 10^{-5}, respectively. The HIs are 4.0 for Plumes A and B and 3.0 for Plume C. The risk driver within the site-wide inorganics is arsenic.

Groundwater is not currently used for potable purposes at the site. Overall, risks to a future industrial worker or hypothetical resident from exposure to average concentrations present risks that are within the 1 to 100 in a million risk range (10^{-6} to 10^{-4}). Risks from maximum concentrations, on the other hand, are slightly above the upper limit of the acceptable risk levels, while the HI is at or below 1.0. Although there is no intent to use groundwater as potable water in the future, any plans for future use would have to be carefully evaluated

In addition to baseline RA results, the following factors also must be considered for future site management decisions:

- Distance to the potential exposure point for the observed plume(s); and
- Time required for the plume(s) to attenuate below MCLs at the identified point of exposure.

There are no residential or industrial groundwater users within the site. The downgradient location of the nearest potential receptor is not clearly known, but in a well survey none were identified between the Depot and the Allen Well Field (see Figure 2-14). A conservative assumption regarding exposure is that fluvial groundwater enters the Memphis aquifer in the northwestern portion of the Depot, where it is eventually pumped and potentially enters the City of Memphis drinking water supply. It should be stressed that this assumption has not been verified in evaluating groundwater at the Depot or in monitoring wells at the Allen Well Field.

As discussed in Section 33.5.1, transport calculations indicate that CVOCs from the southwestern and southeastern portions of the Main Installation are not reaching (in measurable quantities) the low in the potentiometric surface in the vicinity of MW-34. Evaluation of the plume configuration, based on monitoring data, confirms this calculated result. Concentrations of PCE from the southwestern portion of the Main Installation (MW-21) have decreased by about a factor of 50 at the most downgradient well where PCE was detected (MW-39)–a distance of about 2,200 ft (see Figure 32-2). Similar reductions in concentrations would be expected along the 2,000-ft distance from MW-39 to the potentiometric low at MW-34. Additional order-of-magnitude concentration reductions are expected over the approximately 1.5-mile distance from the Depot to the Allen Well Field. Because no TCE or PCE, or their degradation products, were detected in these downgradient wells, future migration in detectable levels is highly unlikely.

The groundwater within areas of organic contamination is not usable for potable purposes because of the presence of CVOCs. Although site groundwater has low-level CVOC contamination, the shallow aquifer is not used for residential or industrial potable use at the Depot or within the surrounding community. Because of this lack of exposure, risks are not considered significant.

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TABLE 34-1

Constituents of Potential Concern in FU7 - Groundwater

Memphis Depot Main Installation RI

Unit	Matrix	Units	Parameter Name	Number Analyzed	Number Detected	Minimum Detection Limit	Maximum Detection Limit	Minimum Detected Concentration	Maximum Detected Concentration	Arithmetic Mean Detected Concentration	Background Concentration	Regulatory Criteria for Groundwater	COPC/BASIS	
7	WG	MG/L	1,1,2,2-TETRACHLOROETHANE	83	2	0.005	0.01	0.002	0.004	0.003		0.000053	Yes	A
7	WG	MG/L	ARSENIC	76	13	0.00068	0.0024	0.0016	0.091	0.013		0.05	Yes	A
7	WG	MG/L	BERYLLIUM	76	10	0.00002	0.00015	0.00018	0.0059	0.0014	0.0006	0.004	Yes	A
7	WG	MG/L	CADMIUM	76	37	0.000085	0.0018	0.0003	0.085	0.009		0.005	Yes	A
7	WG	MG/L	CHLOROBENZENE	83	2	0.005	0.01	0.001	0.004	0.0025		0.0035	Yes	A
7	WG	MG/L	CHLOROMETHANE	83	2	0.01	0.01	0.001	0.002	0.0015		0.0015	Yes	A
7	WG	MG/L	CHROMIUM, TOTAL	76	49	0.00039	0.0022	0.0012	0.28	0.028	0.054	0.11	Yes	A
7	WG	MG/L	DIBROMOCHLOROMETHANE	83	2	0.005	0.01	0.001	0.002	0.0015		0.00013	Yes	A
7	WG	MG/L	LEAD	76	41	0.00099	0.0093	0.0011	0.11	0.014	0.0094	0.015	Yes	A
7	WG	MG/L	MANGANESE	69	61	0.000063	0.00053	0.00092	2.7	0.23	0.56	0.073	Yes	A
7	WG	MG/L	NICKEL	76	40	0.00027	0.0077	0.00085	0.21	0.021	0.031	0.1	Yes	A
7	WG	MG/L	TETRACHLOROETHYLENE(PCE)	83	33	0.005	0.01	0.001	0.12	0.021	0.001	0.005	Yes	A
7	WG	MG/L	TRICHLOROETHYLENE (TCE)	83	31	0.005	0.01	0.001	0.058	0.009		0.005	Yes	A
7	WG	MG/L	VANADIUM	69	48	0.0003	0.0016	0.00031	0.26	0.014	0.006	0.026	Yes	A
7	WG	MG/L	ALUMINUM	69	55	0.0061	0.023	0.011	126	4.3	1.8		Yes	D
7	WG	MG/L	CHLOROETHANE	83	1	0.01	0.01	0.001	0.001	0.001			Yes	D

Notes Data evaluated include field duplicates and normal samples

A full list of all chemicals and their COPC status can be found in Appendix I

A	Exceeds Criteria
B	Does not exceed Criteria
C	Does not exceed Background
D	No Criteria available & exceeds Background, or no Criteria or Background available
E	Chemical is an essential nutrient and professional judgment was used in eliminating it as a COPC
F	Chemical is a common lab contaminant and professional judgment was used in eliminating it as a COPC
G	Chemical is a member of a chemical class that contains other COPCs

TABLE 34-2
Summary of Exposure Pathways to be Quantified at FU7
Memphis Depot Main Installation RI

Potentially Exposed Population	Exposure Route, Medium, and Exposure Point	Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Future Land Use			
On-site Industrial Worker	Incidental ingestion, dermal contact, and inhalation from groundwater.	Yes	Hypothetical future reasonable maximum exposure scenario for future workers
Hypothetical On-site Residential	Incidental ingestion, dermal contact, and inhalation from groundwater	Yes	Worst-case scenario evaluated for comparison purposes only

TABLE 34-3

Exposure Point Concentrations for Inorganic Compounds in FU7 - Groundwater

Memphis Depot Main Installation RI

Units	Parameter	Number of Analyses	Number of Detects	Arithmetic Mean Concentration	Maximum Detected Concentration	UCL95 Normal	UCL95 Lognormal	EPC
MG/L	ALUMINUM	60	48	4 7	126	7 3	9 5	9 5
MG/L	ARSENIC	66	10	0 015	0 091	0 0054	0 0023	0.0023
MG/L	BERYLLIUM	66	10	0.0014	0 0059	0 000415	0 0003	0 0003
MG/L	CADMIUM	66	29	0 0082	0 085	0 0064	0 0081	0 0081
MG/L	CHROMIUM, TOTAL	66	41	0 031	0 28	0 03	0 029	0 029
MG/L	MANGANESE	60	53	0 24	2 7	0 32	1	1
MG/L	NICKEL	66	33	0 022	0 21	0 019	0 022	0 022
MG/L	VANADIUM	60	42	0.016	0 26	0 019	0 019	0 019

Note: Inorganic constituents have been evaluated from site-wide data, and UCL 95% calculations have been used for EPC values

TABLE 34-4
Exposure Point Concentrations for Organic Compounds in FU7 - Groundwater
Memphis Depot Main Installation RI

PlumeID	Parameter	Arithmetic Mean Concentration	Maximum Detected Concentration	Maximum Concentration's Qualifier	Station ID	EPC
A	CHLOROBENZENE Average	0.004	0.004	J	HY02	0.004
A	TETRACHLOROETHYLENE(PCE) Average	0.039	0.12	=	MW21	0.039
A	TRICHLOROETHYLENE (TCE) Average	0.0079	0.031	=	MW21	0.0079
B	1,1,2,2-TETRACHLOROETHANE Average	0.004	0.004	J	MW64	0.004
B	CHLOROBENZENE Average	0.001	0.001	J	PZ05	0.001
B	CHLOROMETHANE Average	0.001	0.001	J	MW26	0.001
B	TETRACHLOROETHYLENE(PCE) Average	0.0094	0.016	=	MW26	0.0094
B	TRICHLOROETHYLENE (TCE) Average	0.0093	0.058	=	PZ05	0.0093
C	1,1,2,2-TETRACHLOROETHANE Average	0.002	0.002	J	MW34	0.002
C	CHLOROETHANE Average	0.001	0.001	J	MW43	0.001
C	CHLOROMETHANE Average	0.002	0.002	J	MW34	0.002
C	DIBROMOCHLOROMETHANE Average	0.0015	0.002	J	MW63	0.0015
C	TETRACHLOROETHYLENE(PCE) Average	0.0055	0.009	J	MW39	0.0055
C	TRICHLOROETHYLENE (TCE) Average	0.0068	0.037	=	MW62	0.0068

Note: Organic constituents have been evaluated from plume-specific data, and arithmetic means have been used for EPC values

All units are mg/L.

Plume A consists of the following wells HY02, MW21, MW22, MW23, MW47 & PZ04

Plume B consists of the following wells HY03, HY04, MW25, MW26, MW64 & PZ05

Plume C consists of the following wells MW34, MW43, MW38, MW39, MW62, MW63 & PZ03

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TABLE 34-5
Toxicity Factors for FU7
Memphis Depot Main Installation RI

Name	Weight-of-Evidence Class	ABS$_{GI}$	Oral SF kg-day/mg	Dermal SF kg-day/mg	Inhal SF kg-day/mg	C Oral RfD mg/kg-day	Dermal RfD mg/kg-day	C Inhal RfD mg/kg-day
1,1,2,2-Tetrachloroethane	C	70%	2 00E-01	2 86E-01	2 03E-01			
Aluminum		10%				1 00E+00	1 00E-01	1 00E+00
Arsenic	A	41%	1 50E+00	3 66E+00	1 51E+01	3 00E-04	1 23E-04	
Beryllium	B1	1%			8 40E+00	2 00E-03	2 00E-05	5 70E-06
Cadmium	B1	1%			6 30E+00	1 00E-03	1 00E-05	
Chlorobenzene	D	31%				2 00E-02	6 20E-03	5 70E-03
Chloroethane		80%	2 90E-03	3 63E-03		4 00E-01	3 20E-01	2 90E+00
Chloromethane	C	80%	1 30E-02	1 63E-02	6 00E-03			
Chromium (total)	A	2%			4 20E+01	3 00E-03	6 00E-05	2 86E-05
Dibromochloromethane	C	60%	8 40E-02	1 40E-01		2 00E-02	1 20E-02	
Manganese	D	4%				1 40E-01	5 60E-03	1 43E-05
Nickel	D	27%				2 00E-02	5 40E-03	
Tetrachloroethene	C-B2	100%	5 20E-02	5 20E-02	2 00E-03	1 00E-02	1 00E-02	1 71E-01
Trichloroethene	B2	15%	1 10E-02	7 33E-02	6 00E-03	6 00E-03	9 00E-04	
Vanadium		1%				7 00E-03	7 00E-05	

Note Master list of toxicity factors, with sources and basis, is provided in Section 7 0

TABLE 34-6

Main Installation Groundwater Risks and Noncarcinogenic Hazards Based on Average Concentrations

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways	Total ELCR	Total HI	Chemicals of Concern
Industrial Worker				
	Groundwater - Site-wide Inorganics	1E-05	0.5	*Arsenic*
	Groundwater - Plume A Organics (Averages)	8E-06	0.06	*PCE*
	Total	***2E-05***	***0.5***	***Arsenic, PCE***
	Groundwater - Site-wide Inorganics	1E-05	0.5	*Arsenic*
	Groundwater - Plume B Organics (Averages)	8E-06	0.03	*1,1,2,2-Tetrachloroethane, PCE*
	Total	***2E-05***	***0.5***	***Arsenic, PCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics	1E-05	0.5	*Arsenic*
	Groundwater - Plume C Organics (Averages)	5E-06	0.02	*1,1,2,2-Tetrachloroethane, PCE*
	Total	***2E-05***	***0.5***	***Arsenic, PCE, 1,1,2,2-Tetrachloroethane***
Residential Adult (age-adjusted)				
	Groundwater - Site-wide Inorganics	5E-05	1	*Arsenic*
	Groundwater - Plume A Organics (Averages)	3E-05	0.2	*PCE, TCE*
	Total	***9E-05***	***1***	***Arsenic, PCE, TCE***
	Groundwater - Site-wide Inorganics	5E-05	1	*Arsenic*
	Groundwater - Plume B Organics (Averages)	3E-05	0.08	*1,1,2,2-Tetrachloroethane, PCE, TCE*
	Total	***9E-05***	***1***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics	5E-05	1	*Arsenic*
	Groundwater - Plume C Organics (Averages)	2E-05	0.05	*1,1,2,2-Tetrachloroethane, PCE, TCE, DBCM*
	Total	***7E-05***	***1***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane, DBCM***
Residential Child[1]				
	Groundwater - Site-wide Inorganics	2E-05	3	*Arsenic*
	Groundwater - Plume A Organics (Averages)	1E-05	0.4	*PCE*
	Total	***3E-05***	***3***	***Arsenic, PCE***
	Groundwater - Site-wide Inorganics	2E-05	3	*Arsenic*
	Groundwater - Plume B Organics (Averages)	1E-05	0.2	*1,1,2,2-Tetrachloroethane, PCE*
	Total	***3E-05***	***3***	***Arsenic, PCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics	2E-05	3	*Arsenic*
	Groundwater - Plume C Organics (Averages)	8E-06	0.1	*1,1,2,2-Tetrachloroethane, PCE*
	Total	***3E-05***	***3***	***Arsenic, PCE, 1,1,2,2-Tetrachloroethane***

Notes

[1] Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media

DBCM = Dibromochloromethane

PCE = Tetrachloroethane

TCE = Trichloroethene

TABLE 34-7

Main Installation Groundwater Risks and Noncarcinogenic Hazards Based on Maximum Concentrations

Memphis Depot Main Installation RI

Exposure Scenarios	Exposure Pathways		Total ELCR	Total HI	Chemicals of Concern
Industrial Worker					
	Groundwater - Site-wide Inorganics		1E-05	0.5	*Arsenic*
	Groundwater - Plume A Organics (Max)		2E-05	0.2	*PCE, TCE*
		Total	***4E-05***	***0.6***	***Arsenic, PCE, TCE***
	Groundwater - Site-wide Inorganics		1E-05	0.5	*Arsenic*
	Groundwater - Plume B Organics Max		1E-05	0.11	*1,1,2,2-Tetrachloroethane, PCE, TCE*
		Total	***2E-05***	***0.6***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics		1E-05	0.5	*Arsenic*
	Groundwater - Plume C Organics Max		7E-06	0.07	*1,1,2,2-Tetrachloroethane, PCE, TCE*
		Total	***2E-05***	***0.5***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***
Residential Adult (age-adjusted)					
	Groundwater - Site-wide Inorganics		5E-05	1	*Arsenic*
	Groundwater - Plume A Organics Max		1E-04	0.5	*PCE, TCE*
		Total	***2E-04***	***2***	***Arsenic, PCE, TCE***
	Groundwater - Site-wide Inorganics		5E-05	1	*Arsenic*
	Groundwater - Plume B Organics Max		5E-05	0.3	*1,1,2,2-Tetrachloroethane, PCE, TCE*
		Total	***1E-04***	***2***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics		5E-05	1	*Arsenic*
	Groundwater - Plume C Organics Max		3E-05	0.2	*1,1,2,2-Tetrachloroethane, PCE, TCE, DBCM*
		Total	***8E-05***	***1***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane, DBCM***
Residential Child[1]					
	Groundwater - Site-wide Inorganics		2E-05	3	*Arsenic*
	Groundwater - Plume A Organics Max		4E-05	1	*PCE, TCE*
		Total	***6E-05***	***4***	***Arsenic, PCE, TCE***
	Groundwater - Site-wide Inorganics		2E-05	3	*Arsenic*
	Groundwater - Plume B Organics Max		2E-05	0.7	*1,1,2,2-Tetrachloroethane, PCE, TCE*
		Total	***4E-05***	***4***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***
	Groundwater - Site-wide Inorganics		2E-05	3	*Arsenic*
	Groundwater - Plume C Organics Max		1E-05	0.5	*1,1,2,2-Tetrachloroethane, PCE, TCE*
		Total	***3E-05***	***3***	***Arsenic, PCE, TCE, 1,1,2,2-Tetrachloroethane***

Notes

[1] Carcinogenic risks for child scenario are optional evaluations & may not have been evaluated for all media

DBCM = Dibromochloromethane

PCE = Tetrachloroethane

TCE = Trichloroethene

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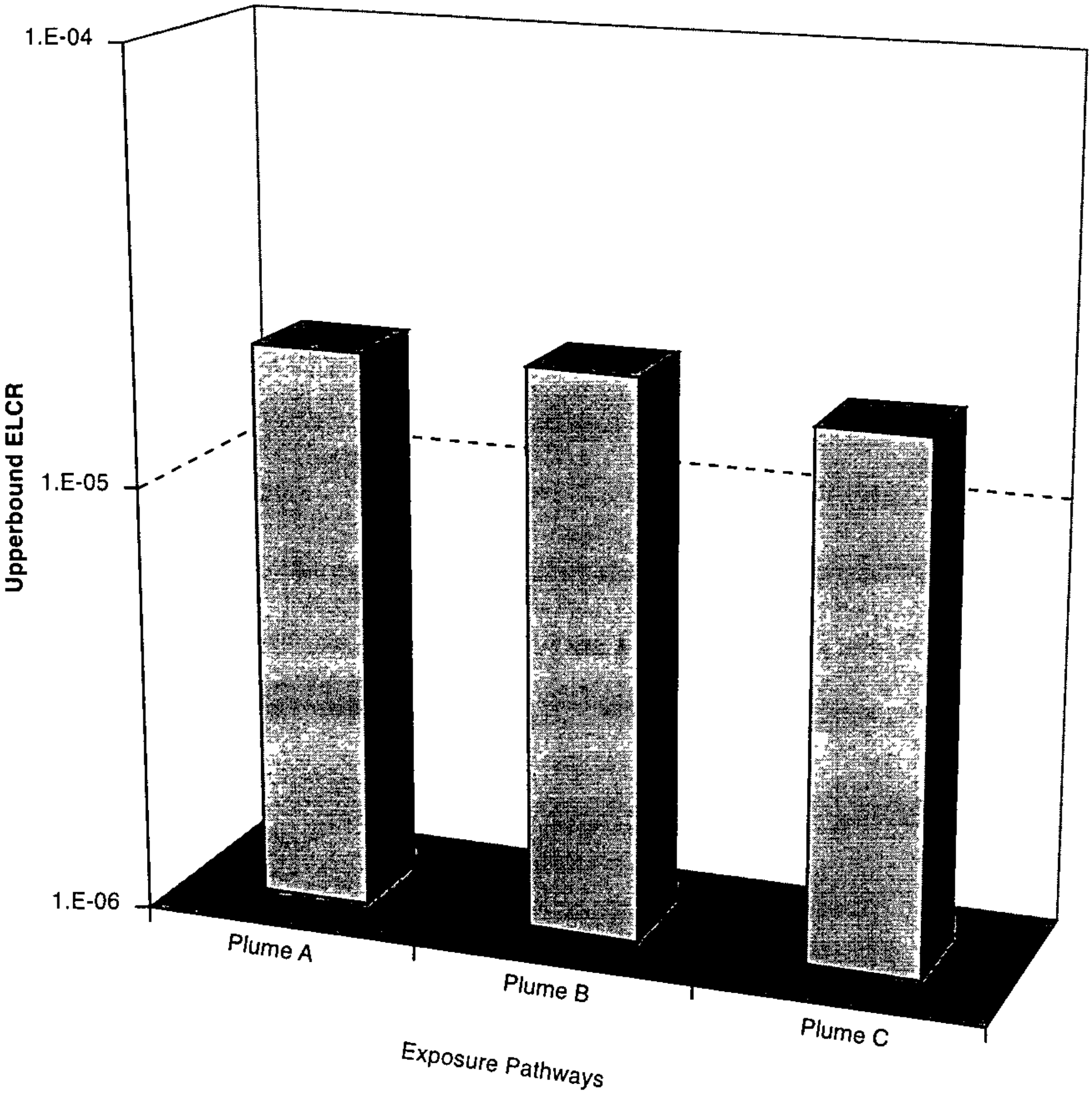

☐ Total ELCR (accepted range of 10-4 to 10-6)

Note
ELCR = Estimated Lifetime Cancer Risk
ELCR is dimensionless

FIGURE 34-1
TOTAL EXCESS LIFETIME CANCER RISKS FOR GROUNDWATER EXPOSURE (AVERAGES) FOR INDUSTRIAL WORKERS AT PLUMES A, B & C WITHIN FU7
MEMPHIS DEPOT MAIN INSTALLATION RI

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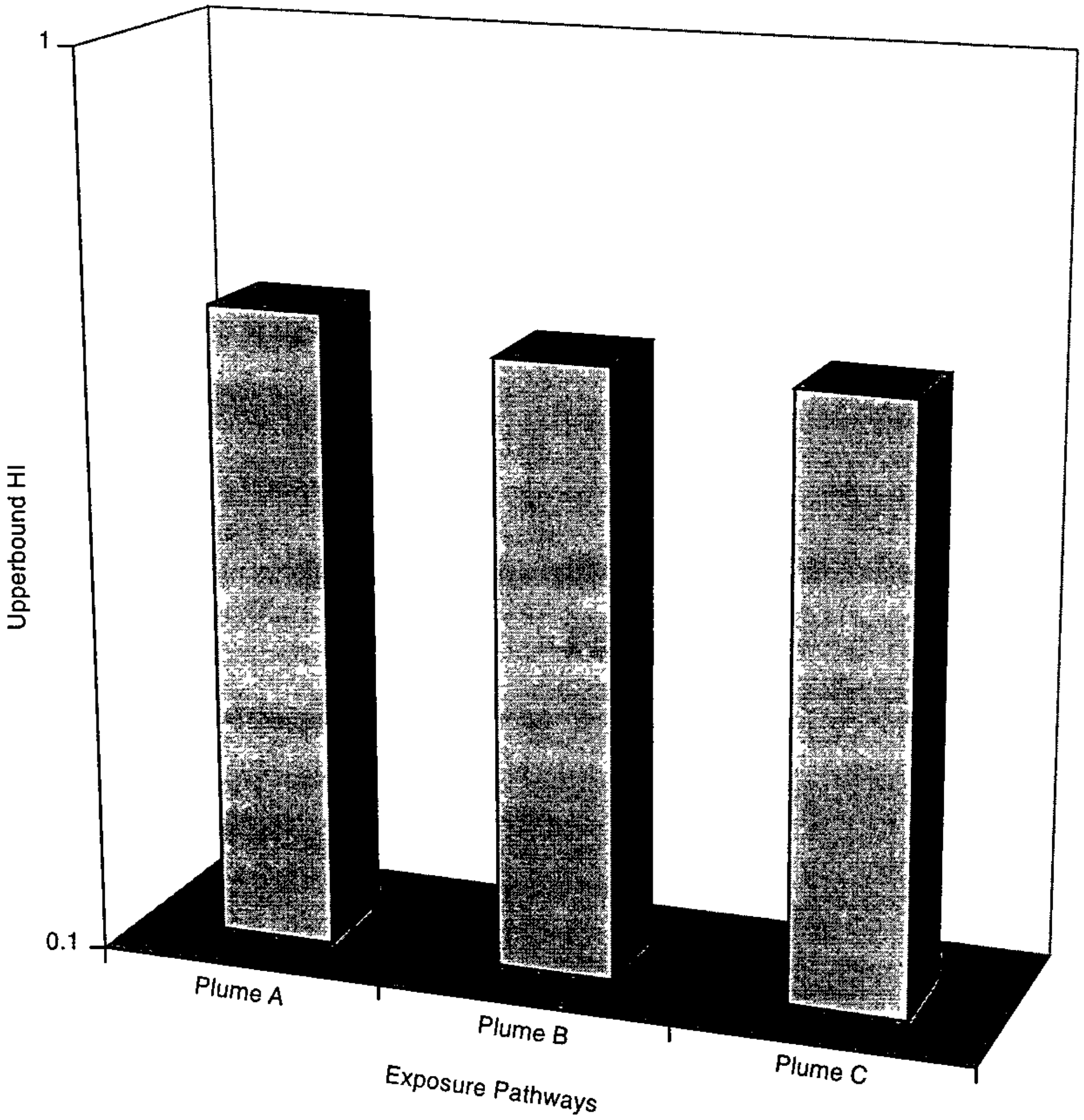

☐ Total HI (threshold of 1 0)

Note
HI = Hazard Index
HI is dimensionless

FIGURE 34-2
TOTAL HAZARD INDICES FOR GROUNDWATER EXPOSURE (AVERAGES) FOR INDUSTRIAL WORKERS AT PLUMES A, B, & C WITHIN FU7
MEMPHIS DEPOT MAIN INSTALLATION RI

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Section 35

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35. Summary and Conclusions for FU7

35.0 Summary and Conclusions for FU7

35.1 Summary

35.1.1 Nature and Extent of Contamination

To evaluate the nature and extent of contamination in the groundwater at FU7, samples were collected from 19 permanent groundwater monitoring wells and piezometers during five sampling events from January 1996 to November 1998. Groundwater samples were analyzed for herbicides, metals (total), pesticides/PCBs, SVOCs, and VOCs. Of these groups of chemicals, VOCs, SVOCs, and metals (total) were detected in groundwater samples. Because of their low mobilities from the surface to depth, herbicides and pesticides/PCBs were not detected in subsurface soils or groundwater samples.

Twenty VOCs were detected in groundwater. Of these, the VOCs PCE, TCE, 1,2-DCE, 1,1,1-TCA, chloroform, and carbon tetrachloride were evaluated for temporal and spatial distributions. PCE and its degradation products, which include TCE and 1,2-DCE, were the most frequently detected of the six compounds.

Spatial distributions of PCE and TCE, combined with an understanding of groundwater flow at the Main Installation, define two plumes: one that originates in the southwestern section of the Main Installation and a second plume that originates in the southeastern section. Groundwater from these areas flows toward the central section of the Main Installation and exits the Depot boundary via a low in the potentiometric surface in the northwestern area of the Depot. The highest concentration of any VOC detected was 0.120 mg/L of PCE. Some VOCs have been detected in groundwater samples downgradient, but in low concentrations–generally at estimated quantities (with a J-flag) below 0.010 mg/L. These low-end concentrations are near the sample quantitation limits. The extent of the plume in the southeast does not extend beyond the boundaries of the Main Installation. PCE and TCE have been detected in groundwater samples collected beyond the Main Installation boundaries in the southwestern section, implicating a source area to the farther southwest, possibly in the off-site area from which groundwater flows onto the Main Installation.

Twenty-two inorganic chemicals were detected in groundwater samples from monitoring wells on the Main Installation and surrounding vicinity. Most of the inorganic chemicals are naturally occurring. Although metals concentrations in groundwater samples from any individual well may have at one time or another exceeded background values, consistently elevated concentrations of metals exceeding background levels are not common; these are limited to only a few wells, and only a few of the metals are considered significant. These wells are located in the western third of the Main Installation and primarily in the southwestern section in the vicinity of the sandblasting area.

In contrast to the plumes of VOCs that cover larger areas of the Main Installation, the immediate vicinity of the sandblasting area is the only significant area where metals have been consistently detected, suggesting the presence of a metals "plume." The sandblasting area is also a location of significant surface and subsurface metals contamination, as discussed with regard to FU3. The most frequently detected metals that exceeded background were arsenic, vanadium, aluminum, iron, cadmium, and zinc. These metals are not present in areas away from the site and thus are limited in their distribution. Also, the latest monitoring data for the metals indicate lower concentrations; in particular, arsenic was detected in only a single well. There were no significant off-site detections of metals.

Metals detected in groundwater elsewhere, such as near Building 949, north of the sandblasting area, and in MW-55, in the northwestern section of the Main Installation, appear to be isolated occurrences unrelated to any specific activities that occurred at these locations.

The SVOCs detected in groundwater samples were attributed to sampling and analytical artifacts such as the introduction of plasticizers (e.g., BEHP) via the sampling and analysis process rather than to waste management practices at the Main Installation.

The nature and extent of contamination are defined by the occurrence of inorganic chemicals above background levels and organic chemicals based on their detection without a comparison to health-based criteria. However, the chemicals detected above background and health-based comparison criteria were selected as COPCs. The primary groundwater COPCs are as follows:

- VOCs, including PCE and its degradation products (TCE and 1,2-DCE), and carbon tetrachloride, 1,1,1-TCA, chlorobenzene, chloroethane, chloromethane, and 1,1,2,2-tetrachloroethane; and
- Ten metals: aluminum, arsenic, beryllium, cadmium, chromium, iron, lead, manganese, nickel, and vanadium.

35.1.2 Fate and Transport

The migration pathway that appears to be the most viable exposure route includes the potential for migration of groundwater to downgradient off-site locations and receptors. The potential groundwater receptors are the off-site public, who may drink water from off-site groundwater. There are no known receptors for the site groundwater within the site or in the immediate vicinity of the Depot. Among potential receptors considered are the off-site public who receive drinking water through the public water supply system, which withdraws from the Allen Well Field located 1.5 miles to the west of the Main Installation. No contamination currently is reaching the Allen Well Field from the Depot. The VOCs detected at the Allen Well Field are not related to the VOC contamination found in the groundwater at the Main Installation.

The suspected sources of metals contamination are primarily the Former Paint Spray Booth (RI Site 31) and the Sandblasting Waste Accumulation Process Area (RI Site 32). The most persistent and frequent detected concentrations of metals throughout the groundwater monitoring program were observed in MW-21 and MW-22. However, given the difficulty in achieving acceptable turbidity levels in groundwater samples at these locations, discretion should used before basing risk management decision on metals chemistry from low-yielding, small-diameter monitoring wells that exhibit large fluctuations in turbidity.

A recurring issue in the Main Installation is the ubiquitous presence of abundant, naturally occurring metals (primarily iron and aluminum) that are relatively nontoxic, which were identified in all media. A review of the patterns of these constituents suggests that they are not related to site activities.

The subsurface soils at the site are not a continuing source of groundwater chlorinated solvents. Organic contaminants either continue to migrate from undetermined on-site source terms, possibly related to past industrial process releases, or are transported advectively by groundwater from off-site sources onto the Main Installation from areas located southeast and southwest of the Main Installation property. Because the actual source of the chlorinated solvents has not been determined, it is not known if the solvents are directly site-related or if they are migrating onto the Main Installation from off-site areas.

Of the two distinct VOC plumes present at the Main Installation, the PCE plume is the larger and most concentrated and has two distinct centroids. The PCE within both the southwestern and southeastern plumes extends beyond the Main Installation property.

TCE comprises the other major contamination plume defined on the Main Installation. This plume is thought to be a result of the degradation of PCE and is located in the area formed by the outline of MW-64, MW-21, MW-39, and MW-62. The TCE plume is more centrally located within the Main Installation and is hydraulically downgradient from the PCE source areas. This interpretation is based on the biodegradation processes whereby PCE degrades to TCE, on the direction of groundwater gradients, and on the degradation ratios of PCE to TCE. An assessment of natural attenuation indicates that biodegradation is not a dominant physical process in the fluvial aquifer. The potential for biodegradation of chlorinated hydrocarbon compounds in the fluvial aquifer is low.

VOCs are the most widespread of the COPCs. The highest concentrations of VOCs were reported at the southwestern portion of the Main Installation at MW-21. The most mobile constituents are the CVOCs. On the basis of advection alone, it was estimated that contaminants from the site could migrate 149 ft each year.

The maximum extent of contamination confirmed in the fluvial aquifer is due to TCE. Considering that the site began operations approximately 55 years ago, the current horizontal migration potential of TCE because of advection, retardation, and dispersion is estimated to be 2,882 ft. This distance is consistent with plume maps developed for the nature and extent of contamination assessment that show TCE at MW-62, a distance of about 2,800 ft from MW-21. It would take an additional 8.5 years to reach MW-34, the last monitoring point within the uppermost aquifer on the Main Installation.

35.1.3 Risk Assessment Summary

Groundwater is not currently used within or in areas immediately surrounding the Depot. The nearest groundwater use in the downgradient location is at the Allen Well Field, located approximately 1.5 miles west of the Depot. These public water supply wells draw from a deeper (Memphis Sand) aquifer that is not contaminated either within the Depot or downgradient from it. In the interest of conservatism, a future exposure scenario was assumed whereby industrial and residential receptors are exposed to groundwater within the Depot through potable use.

Overall, risks to a current worker from groundwater are negligible because of the lack of exposure. A future industrial worker and a hypothetical resident, from exposure to average organic COPC concentration plumes, present risks that are within the 1 to 100 in a million risk range (10^{-6} to 10^{-4}). The HIs to the future industrial worker are within the acceptable level of 1.0, whereas the HIs for a future residential adult and a future residential child were at 1.0 and above 1, respectively. Risks from maximum organic COPC concentrations are within acceptable levels for Plume C, but above these levels in the upgradient areas (Plumes A and B). The HIs are above 1.0 for both the residential adult and child scenario. Concentrations of VOCs are decreasing over time because of dilution and natural attenuation. Although there is no intent to use groundwater under the Depot as potable water in the future, any plans for future use would have to be carefully evaluated.

35.2 Conclusions about Data Limitations and Recommendations for Future Work

35.2.1 Data Limitation and Recommendations for Future Work

The source of the VOC plume containing PCE in the southwestern section of the Main Installation that extends off the Main Installation boundaries has not been identified. Soil samples from borings (of which the deepest was collected at 38 ft) in the southwestern section of the Main Installation were devoid of PCE, but were found to contain other VOCs, supporting the inference of an off-site source. Therefore, it is recommended that one fluvial aquifer monitoring well be installed southwest (upgradient) of PZ04, which is the southwestern-most monitoring point. Samples from this well will be useful in defining the upgradient extent of the PCE plume, will provide an additional control point for delineating the potentiometric surface, and will provide geologic and stratigraphic information regarding the distribution of clay layers that could control the distribution of potentially perched organic compounds.

It also is recommended that groundwater monitoring be continued on a regular basis at strategic upgradient and downgradient locations to assess changes in the plume geometry and concentration levels.

35.2.2 Recommended Remedial Action Objectives

The recommended remedial action objectives include the evaluation of natural attenuation of the VOCs through continued regular groundwater monitoring and the prevention of future exposure to ground water. The concentrations detected to date do not suggest any significant source term such as a DNAPL present in the subsurface. Soil boring data also substantiate this conclusion.

Generally, in addition to the baseline RA results, the following factors must be considered in future site management decisions:

- Distance to the potential exposure point for the observed plume(s); and
- Time required for the plume(s) to attenuate below MCLs at the identified point of exposure.

There are no residents within the site. The downgradient location of the nearest potential receptor has not been identified. Contamination is present in the shallow aquifer, and the deeper aquifer is relatively clean. No off-site exposure points have been identified, because there are no water supply wells in the area and the observed plumes are either migrating onto the Depot or are not observed to extend beyond the Depot perimeter. Thus, although site groundwater has low-level CVOC contamination, the shallow aquifer is not suitable for residential or industrial potable use at the Depot or within the surrounding community. Therefore, risks are not considered significant because of the lack of exposure.

In summary, the shallow groundwater underneath the site presents risks mostly within the upper limit of the acceptable risk range of 10^{-6} to 10^{-4}. The noncarcinogenic hazards are at or below 1.0 for a future industrial worker, but above 1.0 for a residential receptor. Continued monitoring of groundwater migrating beyond the Depot boundary is recommended to protect potential off-site groundwater users. A specific groundwater monitoring schedule will be developed in conjunction with groundwater monitoring requirements at Dunn Field.

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36. References

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