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Resource Conservation and Recovery Act Facility Investigation Report

for

SWMU 01 - Mustard Gas Burial Ground

Naval Surface Warfare Center Crane Division

Crane, Indiana

Volume 1 of 2 - Text

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NAVAL SURFACE WARFARE CENTER
CRANE DIVISION
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY CONTRACT

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ACRONYM LIST

%R	Percent Recovery
µg/kg	Micrograms per Kilogram
µg/L	Micrograms per Liter
2,4-D	2,4 – Dichlorophenoxyacetic acid
2ADNT	2-Amino-4,6 – Dinitrotoluene
4ADNT	4-Amino-2,6 – Dinitrotoluene
ABG	Ammunition Burning Ground
ACH	Air Changes per Hour
amsl	Above Mean Sea Level
ANOVA	Analysis of Variance
APHA	American Public Health Association
ATSDR	Agency for Toxic Substances and Disease Registry
B&R	Brown & Root
BAFs	Bioaccumulation Factors
BCF	Bioconcentration Factor
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
BSAF	Biota Sediment Accumulation Factors
BTAG	Biological Technical Assistance Group
CAAA	Crane Army Ammunition Activity
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulation
CLEAN	Comprehensive Long-Term Environmental Act Navy
CMS	Corrective Measures Study
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CRAVE	Carcinogenic Risk Assessment Verification Endeavor
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CTE	Central Tendency Exposure

CTO	Contract Task Order
DA_{event}	Absorbed Dose per Event
DAF	Dilution and Attenuation Factor
DCA	Dichloroethane
DCAA	2,4-Dichlorophenylacetic Acid
DCB	Decachlorobiphenyl
DCE	Dichloroethene
DI	Deionized
DNAPL	Dense Non-Aqueous-Phase Liquid
DO	Dissolved Oxygen
DOD	Department of Defense
DPT	Direct-Push Technology
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DRMO	Defense Reutilization and Marketing Operations
EDQL	Ecological Data Quality Level
EEQ	Ecological Effects Quotient
Eh	Redox Potential
EMR	Environmental Monitoring Report
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
ER-M	Effects Range-Median
EU	Exposure Unit
FID	Flame Ionization Detector
F_{oc}	Fraction of Organic Carbon
FOL	Field Operations Leader
FSP	Field Sampling Plan
FTMR	Field Task Modification Request
g	Gram
GFAA	Graphite Furnace Atomic Absorption
gpm	Gallons per Minute
HASP	Health and Safety Plan
HD	Mustard Gas
HEAST	Health Effects Assessment Summary Tables
HH	Human Health

HHRA	Human Health Risk Assessment
HI	Hazard Index
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
HWY	Highway
i	Hydraulic Gradient
IA	Installation Assessment
IAS	Installation Assessment Study
ICP	Inductively Coupled Plasma
ICPMS	Inductively Coupled Plasma Mass Spectrometry
IDEM	Indiana Department of Environmental Management
IDW	Investigation-Derived Waste
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
K	Hydraulic Conductivity
K_d	Soil-Water Distribution Coefficient
K_{oc}	Organic Carbon-Water Partition Coefficient
K_{ow}	Octanol-Water Partition Coefficient
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOAELs	Lowest-Observed-Adverse-Effect Levels
LOEC	Lowest-Observed-Effects Concentration
MCL	Maximum Contaminant Level
MDL	Maximum detection Limit
meq	Milliequivalents
mg/kg	Milligrams per Kilogram
mg\L	Milligrams per Liter
MGBG	Mustard Gas Burial Ground
MHSPE	Ministry of Housing, Spatial Planning and Environment
MI	Mobility Index
mL	Milliliters
MNA	Monitored Natural Attenuation
MS	Matrix Spike
MSD	Matrix Spike Duplicates
N	Porosity
NAD	Naval Ammunition Depot

NAD27	1927 North American Datum
NAVD88	1988 North American Vertical Datum
NAVFAC	Naval Facilities
NAVSEASYSCOM	Naval Sea Systems Command
NCEA	National Center for Environmental Assessment
NEESA	Naval Energy and Environmental Support Activity
NOAA	National Oceanic and Atmospheric Administration
NOAELs	No-Observed-Adverse-Effects Levels
NOEC	No-Observed-Effects Concentration
NRC	Nuclear Regulatory Commission
NSWC	Naval Surface Warfare Center
NTU	Nephelometric Turbidity Unit
NWSC	Naval Weapons Support Center
OJT	Old Jeep Trail
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORNL	Oak Ridge National Laboratory
ORP	Oxidation-Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbon
PBA	Primary Burial Area
PCA	Tetrachloroethane
PCE	Tetrachloroethene
PCB	Polychlorinated Biphenyl
PE	Performance Evaluation
PID	Photoionization Detector
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RASO	Radiological Affairs Support Office
RBSL	Risk-Based Screening Level
RBTL	Risk-Based Target Limit
RCRA	Resource Conservation and Recovery Act

RFD	Reference Dose
RFI	RCRA Facility Investigation
RISC	Risk-Integrated System of Cleanup
RME	Reasonable Maximum Exposure
RPD	Relative Percent Difference
RQD	Rock Quality Designation
S	Solubility
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SERA	Screening-level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SOP	Standard Operating Procedure
SQG	Soil Quality Guideline
SOUTHDIV	Southern Division
SQL	Sample Quantitation Limit
SSLs	Soil Screening Levels
SSSLs	Surface Soil Screening Levels
SVOC	Semivolatile Organic Compounds
SWSL	Surface Water Screening Levels
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethene
TCX	Tetrachloro-meta-xylene
TNT	2,4,6-Trinitrotoluene
TOC	Total Organic Carbon
TOM	Task Order Manager
TOX	Total Organic Halogen
TRVs	Toxicity Reference Value
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
UET	Upper Effects Threshold
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Society

U.S. EPA	U.S. Environmental Protection Agency
UTL	Upper Tolerance Limit
UXO	Unexploded Ordnance
VDEQ	Virginia Department of Environmental Quality
VF	Volatilization Factor
VOC	Volatile Organic Compound
VP	Vapor Pressure
V_s	Seepage Velocity
WES	Waterways Experiment Station
WRS	Wilcoxon Rank Sum

EXECUTIVE SUMMARY

This report documents the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) 01, Mustard Gas Burial Ground (MGBG), located at the Naval Surface Warfare Center (NSWC), Crane, Indiana. The report summarizes RFI field activities conducted in year 2001 and 2002. It describes the nature and extent of contamination, and presents human health and ecological risk assessments.

SWMU 01 DESCRIPTION

The MGBG, located at NSWC Crane, Indiana was used between the end of World War II and the late 1960s as a burial ground for mustard gas bombs, radioactive thorium or thorium-containing chemicals and equipment, and small quantities of several laboratory chemicals. The only documented laboratory chemical disposal occurred in 1967.

Within the MGBG is the Primary Burial Area (PBA) which spans approximately 10% of the total MGBG area. Based on past records and site exhumations, this area is where most, if not all, burials and related activities took place.

In 1974 and 1980, radioactive thorium, mustard gas bombs and related materials were removed from the MGBG. During the 1974 exhumation, some mustard gas (an oily liquid) was released to the soil. The mustard gas was decomposed by chemical treatment soon after the release. After the 1980 exhumation, the MGBG was declared by the U.S. Navy Radiological Affairs Support Office (RASO) to have been cleared of radiological hazards.

A ground water sampling and analysis program was started in the early 1980s and continued into 1986. Radiological and chemical measurements were made on the sampled ground water in the 1980s. Those data were collected from 27 of 28 site wells. According to existing reports, those data have not been validated. Soil samples associated with the past exhumations were also analyzed for mustard gas (using field screening) and radionuclides (using gamma spectrometry).

In 1995 a geophysical survey identified the presence of two geophysical anomalies, each of which was believed to be trash buried at the site near the PBA (TtNUS, 2001a). A Phase II RFI plan was drafted but was not approved by the U.S. EPA Region 5 and was never implemented (see Section 1.3.3 for details).

PHASE III RFI PROGRAM

The most recent investigation, which is the subject of this report, was a Phase III RFI. The sample collection occurred in two rounds. Round 1 extended from July 2001 through September of 2001. Round 2 took place in May and June of 2002. The objectives of this investigation were to:

- Establish the nature and extent of contamination.
- Evaluate human health risks through a baseline risk assessment.
- Estimate risks to the environment through a screening level ecological risk assessment.
- Excavate and dispose of debris associated with two geophysical anomalies.

The Phase III RFI was designed to support any future RCRA Corrective Measures Study (CMS). That study, if required, would be conducted to identify and evaluate cleanup alternatives for the site.

FIELD AND ANALYTICAL PROGRAM FOR SWMU 01, MUSTARD GAS BURIAL GROUND

This Phase III RFI was conducted in two sampling rounds (Round 1 and 2). During Round 1, soil, sediment, and ground water samples were collected and analyzed for metals, volatile organic chemicals (VOCs), semivolatile organic chemicals (SVOCs), energetics, pesticides, herbicides, and polychlorinated biphenyls (PCBs), per 40 Code of Federal Regulations (CFR) Part 264 Appendix IX. Ground water was also analyzed for field parameters such as turbidity, pH, oxidation-reduction potential, specific conductance. Additional targeted chemicals in ground water and soil included mustard gas, mustard gas degradation products, and select radionuclides. Additionally, soil characteristic parameters [cation exchange capacity (CEC) and total organic carbon (TOC)] were collected to determine the likelihood of the potential fate and transport of contaminants at the site (and the potential for risks outside the site boundaries).

During Round 2, surface water, ground water and sediment environmental media were sampled. Very little surface water was found. Select ground water wells were sampled and samples were selected from those for analysis of metals, VOCs, gross alpha, gross beta, and natural attenuation parameters designed to provide information concerning the efficacy of natural attenuation processes on the ground water VOCs. Select sediment samples were analyzed for metals, VOCs, and thorium radioisotopes; surface water samples were analyzed for VOCs and field parameters.

NATURE AND EXTENT OF CONTAMINATION

Little contamination was found in MGBG environmental media. Ground water VOCs were the primary exception. PAHs were also detected in sediments near some debris piles just outside the southeast corner of the MGBG. The debris piles are not thought to have been related to site operations and could have come from roadwork or general NSWC Crane maintenance.

HUMAN HEALTH RISK ASSESSMENT

The human receptors evaluated for the MGBG were the construction worker, maintenance worker, occupational worker, adolescent trespasser, adult recreational user and future adult and child residents. Human exposure pathways for the MGBG that were evaluated were surface soil, subsurface soil, ground water, surface water, and sediment.

ECOLOGICAL RISK ASSESMENT

A screening ecological risk assessment was conducted at the MGBG. The ecological receptors that were evaluated in the screening assessment included:

- Those directly exposed to chemicals in the surface water, sediment, and surface soil (i.e., plants, invertebrates in soil and sediment, and aquatic organisms), and

- Those indirectly exposed to chemicals via the food chain (i.e., through the ingestion of plants and invertebrates).

As presented in Tables 4-15 and 4-16, several chemicals were eliminated as COPCs because they were not detected at concentrations greater than background concentrations. For soil, these chemicals included antimony, arsenic, barium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, strontium, thallium, and thorium. For sediment, these chemicals included aluminum, antimony, arsenic, barium, beryllium, chromium, copper, iron, lead, manganese, nickel, selenium, strontium, thallium, thorium, tin, and vanadium. Risks to these chemicals were not evaluated in the ERA, however, any risks would be within background risks and not related to site activities. Note that the use of background concentrations to select chemical as COPCs was done in accordance with the approved QAPP for SWMU 1. However, based on current U.S. EPA and Navy guidance, background will not be used to select chemicals as COPCs for future ERAs at NSWC Crane.

CONCLUSIONS

The project decision rules presented in Section 1.0 of the QAPP indicate the levels of risk at which the implementation of a Corrective Measures Study (CMS) would be warranted. For example, unless mitigating circumstances exist, an incremental lifetime cancer risk (ILCR) in excess of 1×10^{-4} would trigger a CMS. If the human health risks were less than that value, no further action would be required. Based on evaluation of the data obtained during this investigation, consideration of site operational history, data generated during past investigations, and the development of baseline human health risk assessment and screening-level ecological risk assessment for the MGBG, the following conclusions were reached:

- The soils, ground water, surface water, and sediment data collected during the RFI were adequate to support the development of baseline human health and screening-level ecological risk assessments for the MGBG.

- Mustard gas, mustard gas degradates, and radiological contamination were not detected, although background concentrations of radionuclides were observed.

- The MGBG reasonable maximum and central tendency exposure incremental lifetime cancer risks for the future adult and child residents were estimated to exceed the range of 10^{-6} to 10^{-4} established by the U.S. Environmental Protection Agency (U.S. EPA) as acceptable; therefore, the risk is unacceptable. The environmental medium contributing the only significant risk to these estimates is ground water and the chemicals that contribute the greatest risk in that medium are VOCs. Table ES-1 contains a summary of receptor-specific human risks and hazards, ecological risks, identifies critical pathways and chemicals of concern, for the MGBG.

- Non-carcinogenic reasonable maximum and central tendency exposure hazard estimates for the construction worker, the future child resident, and the future adult resident for the ground water exposure pathway were greater than unity for the MGBG; therefore, the risk is unacceptable (Table ES-1). The environmental medium contributing the only significant risk to these estimates is ground water and the chemicals that contribute the greatest risk in that medium are VOCs.

- Risks to terrestrial plants, invertebrates, birds, and mammals from organic and inorganic chemicals in the surface soil in the MGBG were estimated to be low to negligible.

- Risk to aquatic receptors from organic and inorganic chemicals in surface water and sediments were estimated to be low to negligible. No significant aquatic habitat exists in drainage channels associated with the MGBG.

- A CMS should be implemented to evaluate potential corrective actions.

TABLE ES-1

SUMMARY OF CONCLUSIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Concern[1]	Impact on Human Receptors	Comments
GROUND WATER		
1,1,1,2-Tetrachloroethane	Child Resident: ILCR = 7.3E-5 Adult Resident: ILCR = 8.0E-05 Total Lifelong Resident: ILCR = 1.5E-04	Risks for ground water are based on hypothetical exposure to ground water in future excavation projects or in future use of ground water as a domestic water supply. Ground water is not currently used at the site. Estimated risks for VOCs were based on exposure to concentrations in the most highly contaminated well (01GW02). There is considerable uncertainty in the exposure point concentrations. Concentrations in this well varied by several orders of magnitude between Rounds 1 and 2. Risks based on VOC concentrations in Well 01GW02 may be overestimated by more than 2 orders of magnitude compared to other contaminated wells at the site. However, total ILCRs for these other wells would be greater than 1.0E-03. The U.S. EPA has recently withdrawn the cancer slope factor (CSF) for 1,1-DCE. Therefore, carcinogenic risk estimates were not calculated for 1,1-DCE.
1,1,2,2-Tetrachloroethane	Construction Worker: ILCR = 1.8E-4 Child Resident: ILCR = 7.8E-2 HQ = 66 Adult Resident: ILCR = 8.6E-2 HQ = 19 Total Lifelong Resident: ILCR = 1.6E-1	
1,1-Dichloroethene (1,1-DCE)	Child Resident: HQ = 1.4	
1,2-Dichloroethane	Child Resident: ILCR = 2.5E-4 HQ = 6.4 Adult Resident: ILCR = 2.7E-4 HQ = 1.4 Total Lifelong Resident: ILCR = 5.2E-4	
Chloroform	Construction Worker: ILCR = 1.0E-6 HQ = 9.6 Child Resident: ILCR = 2.4E-4 HQ = 330 Adult Resident: ILCR = 2.2E-4 HQ = 72 Total Lifelong Resident: ILCR = 4.6E-4	
cis-1,2-Dichloroethene	Child Resident: HQ = 5.1 Adult Resident: HQ = 1.5	
Tetrachloroethene	Construction Worker: ILCR = 1.2E-6 Child Resident: ILCR = 2.3E-4 HQ = 5 Adult Resident: ILCR = 2.6E-4 HQ = 1.4 Total Lifelong Resident: ILCR = 4.9E-4	
Trichloroethene	Construction Worker: ILCR = 2.0E-4 HQ = 68 Child Resident: ILCR = 7.5E-2 HQ = 5700 Adult Resident: ILCR = 8.1E-2 HQ = 1600 Total Lifelong Resident: ILCR = 1.6E-1	

TABLE ES-1

SUMMARY OF CONCLUSIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Concern[1]	Impact on Human Receptors	Comments
GROUND WATER (Continued)		
Bis(2-ethylhexyl)phthalate (BEHP)	Total Lifelong Resident: ILCR = 1.2E-6	Risks for ground water are based on hypothetical future use as a domestic water supply. Ground water is not currently used at the site. BEHP is a common laboratory contaminant and the total residential ILCR for BEHP is well within the U.S. EPA's risk management range.
Hexachloroethane	Adult Resident: ILCR = 1.0E-6 Total Lifelong Resident: ILCR = 1.9E-6	Risks for ground water are based on hypothetical future use as a domestic water supply. Ground water is not currently used at the site. Hexachloroethane was only detected in one Round 1 sample and the total residential ILCR for hexachloroethane is within the U.S. EPA's risk management range.
Heptachlor	Child Resident: ILCR = 1.0E-6 Adult Resident: ILCR = 1.2E-6 Total Lifelong Resident: ILCR = 2.2E-6	Risks for ground water are based on hypothetical future use as a domestic water supply. Ground water is not currently used at the site. Heptachlor was detected in two samples at estimated concentrations (below the SQL) and the total residential ILCR for hexachloroethane is within the U.S. EPA's risk management range.
Arsenic	Child Resident: ILCR = 1.4E-5 Adult Resident: ILCR = 1.6E-5 Total Lifelong Resident: ILCR = 3.0E-5	Risks for ground water are based on hypothetical future use as a domestic water supply. Ground water is not currently used at the site. Total residential ILCR for arsenic is within the U.S. EPA's risk management range. Concentrations of arsenic in all wells at site are less than the proposed MCL (10 µg/L). Background was not used in the COPC selection of for ground water.
Manganese	Child Resident: HQ = 1.9	Risks for ground water are based on hypothetical future use as a domestic water supply. Ground water is not currently used at the site. Risks for manganese are based on the concentration in Well 01GW02 and may be underestimated by as much as an order of magnitude compared to concentrations in other wells. However, as shown in previous HHRAs performed for NSWC Crane, high concentrations of manganese are common in soil and ground water and may be naturally occurring at Crane. Background was not used in the COPC selection for ground water.

BEHP = Bis(2-ethylhexyl)phthalate
COPC = Chemical of Potential Concern
HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
MCL = Maximum Contaminant Level
1 - Any carcinogenic chemical with an ILCR greater than 1.0E-6 or a noncarcinogenic chemical contributing to target organ hazard indices (HI) greater than 1.0.

1.0 INTRODUCTION AND PROJECT OBJECTIVES

This Phase III RFI report describes the recent Phase III RFI investigation of the MGBG located at the NSWC Crane in Crane, Indiana. The MGBG is also known as Solid Waste Management Unit (SWMU) 01. This report was prepared by Tetra Tech NUS, Inc. (TtNUS) for the NSWC Crane facility for the U.S. Navy Southern Division Naval Facilities Engineering Command (NAVFAC). The RFI work described herein was conducted under Contract Task Order (CTO) 0131 and CTO 0158, for the Comprehensive Long-Term Environmental Act Navy (CLEAN) 3, Contract Number N62467-94-D-0888.

The Phase III investigation was conducted in accordance with applicable RCRA Corrective Action requirements, including the need for conducting RFIs at NSWC Crane. Investigation requirements are specified in the NSWC Crane RCRA Hazardous Waste Management Permit, originally issued by the U.S. EPA on December 29, 1989 and renewed on September 14, 1995 (U.S. EPA, 1995).

The planning for this investigation, which allowed for at least two rounds of sample collection, was conducted primarily under CTO 0131 in accordance with the U.S. EPA Data Quality Objectives (DQOs) Process (U.S. EPA, 2000b). The outputs of the DQO process (i.e., the DQOs) were translated into the CTO 0131 quality assurance project plan (QAPP) which was the document that governed the investigation from sample collection through sample analysis, data reduction, and interpretation. Prior to implementation of Phase III RFI activities, the CTO 0131 QAPP was revised under CTO 0158 to include the excavation of two previously identified geophysical anomalies (TtNUS, 2001b). The title of the final U.S. EPA Region 5-approved QAPP included both CTO identifiers (CTO 0131/0158) to ensure that project personnel used the correct document.

The following project objectives were established during planning:

- Determine the nature and extent of contamination in all affected environmental media
- Conduct a baseline human health risk assessment (HHRA)
- Conduct a screening-level ecological risk assessment (SERA)
- Excavate in the vicinity of two geophysical anomalies and remove the associated debris

The Phase III RFI field activities, implemented under CTO 0158, took place during two separate sampling events (rounds). Round 1 was implemented solely under the MGBG (CTO 0131/0158) QAPP. For Round 2, the level of effort was decreased so an abbreviated sampling and analysis plan (SAP) (the Round 2 SAP) was written, primarily to simplify the implementation of that field event (TtNUS 2002b). The Navy and U.S. EPA Region 5 approved the MGBG QAPP in advance of sample collection for Round

1. In accordance with the QAPP, the Round 2 SAP is considered to be a supplement to the approved QAPP. Formal approval of the Round 2 SAP by U.S. EPA Region 5 was not required, however the scope of the Round 2 field effort was agreed upon with the U.S. EPA Region 5 prior to the field effort.

1.1 REPORT PURPOSE AND FORMAT

1.1.1 Report Purpose

The purpose of this RFI Report is to describe the activities conducted and to present the results and interpretation thereof for the 2000 to 2002 Phase III RFI of the MGBG. Concentrations of select organic and inorganic chemicals and select radiological parameters were measured in surface soils, subsurface soils, sediment, surface water, and ground water at the MGBG. In addition, the current and potential future human health and ecological risks associated with the MGBG and related areas were evaluated by way of a baseline HHRA and SERA. The risk assessments were performed using the data collected during the most recent investigation; however, previous investigation results are presented, as appropriate, to provide perspective on current data. The historical data are of unknown quality and the quantitative uses of those data are for illustrative and gross comparative purposes only.

1.1.2 Report Format

Section 1.0 of this report begins with a review of the physical characteristics of the site such as the location, geology and hydrology. Much of the information in this section is gathered from historical records, but some was collected during this Phase III RFI. Section 2.0 describes the field sampling activities associated with the Phase III RFI and summarizes the procedures associated with data collection as described in the approved QAPP (TtNUS, 2001b) and the approved Round 2 SAP, (TtNUS, 2002b). Section 3.0 is a summary of the data quality evaluation procedures and of the data quality for this Phase III RFI. Also included in this section is a summary of data reduction methods and special reviews undertaken to resolve apparent anomalies. Section 4.0 describes the process for selecting chemicals of potential concern (COPCs) based on human health and ecological risk-based screening criteria. Section 5.0 presents an evaluation of the nature and extent of contamination detected at the MGBG. Section 6.0 is a description of the fate and transport of the COPCs and related chemicals. Sections 7.0 and 8.0 present the human health and ecological risk evaluations, respectively. Section 9.0 presents the overall RFI conclusions and recommendations.

1.2 NSWC CRANE FACILITY AND MUSTARD GAS BURIAL GROUND CHARACTERISTICS

Physical characteristics of NSWC Crane and, in particular, the MGBG are presented in this section. These physical characteristics are important when interpreting the data from this investigation and past investigations, especially as they relate to the fate and transport of contaminants and the potential for exposure to contaminated environmental media.

1.2.1 NSWC Crane and Mustard Gas Burial Ground Locations

NSWC Crane is located in a rural, sparsely populated region of south-central Indiana, approximately 75 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky, and immediately east of Burns City and Crane Village, Indiana (Figure 1-1). NSWC Crane encompasses approximately 62,463 acres or approximately 98 square miles of the northern portion of Martin County and smaller portions of Greene, Daviess, and Lawrence Counties.

The MGBG is located in the southeast quadrant of NSWC Crane (a remote portion of the facility) adjacent to Crane Highway (HWY)-251 (a gravel road), which is accessible from the asphalt-paved Crane HWY-161 (Figure 1-2). The MGBG is located in the southwest quarter (SW ¼) of Section 24, Township T4N, Range R4W (Latitude 38° 45' 55", Longitude 86° 48' 32") [U.S. Geological Service (USGS, 1978)]. It is an approximately 2-acre, almost rectangular area situated between two earth-covered, aboveground explosives magazines (numbered 1407 and 1409), each of which is located at least 50 feet from the former MGBG fence line.

A photograph of the site taken on January 18, 2000 is presented in Figure 1-3. This photograph shows explosives Magazine 1409, located west of the MGBG, in the background. HWY-251 runs along the left (south) edge of the photograph, into the distant trees beyond Magazine 1409. Figure 1-4 shows the MGBG from a different vantage point that is rotated counterclockwise approximately 120 degrees to the south from the vantage point of Figure 1-3. HWY-251 is visible as a faint, light-colored line to the right (i.e., the south) of the trees. Another explosives magazine, 1407, is out of view to the left (northeast) of the photographer's vantage point. Both of the figures show a well-vegetated MGBG in the winter season.

1.2.2 Land Use

The economic base of communities surrounding NSWC Crane is in transition from agriculture, mining, and quarrying to manufacturing and service industries. The patterns of settlement, population statistics, and median income are similar throughout the region (TtNUS, 2000a). Because most of the region is covered by vegetation, the area is classified as rural (TtNUS, 2000a).

There is no state or local land use planning within the vicinity of NSWC Crane. The only zoning and land use regulations are in the municipalities in the region and do not impact NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future. No known land use or community actions are being considered or proposed at this time at NSWC (TtNUS, 2000a).

1.2.3 Physiography and Topography

NSWC Crane is located in the unglaciated area of the Crawford Uplands Physiographic Province. This province is a rugged, highly vegetated, dissected plateau bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west (Murphy and Wade, 1995). The Mitchell Plain is a low, dissected, limestone plateau characterized by karst topographic features, including sinkholes. The boundary between the Crawford Upland and the Mitchell Plain is marked by the highly irregular, eastern-facing Chester Escarpment. Springs, caverns, caves, and other solution weathering features can be found along this escarpment, which runs along the eastern edge of the NSWC Crane facility. The boundary between the Crawford Upland and the Wabash Lowland, near the western boundary of NSWC Crane, is gradual (Murphy and Wade, 1995). The terrain at NSWC is predominantly rolling with moderately incised stream valleys throughout and occasional flat areas in the central and northern portions of the Facility. The elevations across NSWC Crane range from about 500 feet above mean sea level (amsl) to about 850 feet amsl. Topographic relief in the Crawford Upland generally ranges from 100 to 350 feet. Greater relief exists in the eastern part of NSWC Crane near the Chester Escarpment (Murphy and Wade, 1995).

The MGBG lies on a northwest/southeast-trending ridge crest with surface elevations ranging from approximately 660 to 680 feet amsl (Figure 1-5). The crest of the gently crowned MGBG is estimated to be 5 to 10 feet higher than HWY-251. A deeply incised drainage channel lies about 525 feet north of the MGBG. The elevation along this channel is approximately 530 to 580 feet amsl. Another deeply incised channel lies about 1200 feet south-southwest of the MGBG, and its elevation is about 510 to 560 feet amsl as it passes south of the MGBG. Total relief in the immediate vicinity of the MGBG is approximately 150 feet. The steepest slopes near the MGBG occur on the north side and are estimated to be about 30 percent.

The vegetative cover at the MGBG has changed over the past 50 years. Some changes have been imposed (e.g., clearing of vegetation during past investigations), and others have resulted from the natural succession of vegetation.

1.2.4 Climate and Meteorology

NSWC Crane is located in a warm, temperate climatic zone. In general, the summers are warm and humid, and winters are mild with occasional short cold periods. The temperature ranges from an average maximum July temperature of 89°F to an average minimum January temperature of 26°F. Precipitation is fairly evenly distributed throughout the calendar year, with the maximum precipitation occurring during the spring and early summer. The average annual precipitation at the Facility is 44 inches, consisting of 42 inches of rain and 15 inches of snow. The average humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter. Long-term climatological records for the area indicate that the monthly prevailing wind direction is from the southwest from April through December, and is from the northwest during January through March [National Oceanic and Atmospheric Administration (NOAA), 1988]. The annual prevailing wind direction for the region is from the southwest, and the annual average wind speed for the area is about 9.6 miles per hour. Figure 1-6 is a wind rose summarizing the wind direction and mean wind speed distribution for the Indianapolis International Airport, located approximately 60 miles northeast of NSWC, over a 5-year period (1985 to 1989).

Monthly rainfall amounts for the periods preceding the 2001 and 2002 sampling events are presented in Table 1-1.

1.2.5 Surface Hydrology

The surface drainage at NSWC Crane has formed a dense, dendritic pattern throughout the Installation. Most of the major streams flow in a general southward or southwestward direction. Seven primary creeks in five drainage basins carry surface water off the Installation and eventually drain into the East Fork of the White River and then to the Wabash River to the southwest. Figure 1-2 shows the drainage basins and surface drainage features of NSWC Crane. The MGBG is located in the Boggs Creek Basin, Drainage Basin IV. Runoff from the MGBG drains into two unnamed tributaries of Goldsberry Hollow, which drains west-southwest about 1.2 miles before it enters Boggs Creek (Figure 1-2). Boggs Creek then flows southward into a large reservoir located at the southern boundary of NSWC Crane. From the reservoir, Boggs Creek continues to flow south about 6 miles where it joins the East Fork of the White River. The Boggs Creek Basin (Basin No. IV, Figure 1-2) drains approximately 70 percent of NSWC Crane. There are east-west drainages to the immediate north and south of the MGBG that flow to Goldsberry Hollow. Smaller drainage channels flow north and south from the MGBG to connect to those drainages. These drainage channels are generally well scoured indicating that water flow is heavy during at least some rain events. A photograph of a portion of the main northern drainage located approximately 150 feet below the MGBG elevation and running east to west is presented in Figure 1-7. The view is toward the east

from the MGBG side of the channel. The scouring of this drainage is evident as is the lack of water in the drainage at the time the photograph was taken, January 2000.

A drainage ditch immediately north of and parallel to Highway 251 lies between the road and the southern border of the MGBG. At least one culvert transports site runoff via the drainage ditch, under the road, and into an intermittent drainage channel located about 400 feet south-southwest of the MGBG.

1.2.6 Geology and Stratigraphy

The unconsolidated overburden deposits over the entire Crane facility generally range from 0 feet thick on the ridge tops to 65 feet thick in the valley bottoms (Nohrstedt et al., 1998). These deposits generally consist of two types: Quaternary- and Pleistocene-age alluvial and colluvial deposits near the floodplains of streams and unconsolidated residual soil and loess on sides and tops of ridges. The U.S. Department of Agriculture (USDA) has classified soils of Martin County (McElrath, 1988). Thin residual soils on or near the tops of ridges are generally classified as Zanesville or Wellston silt loams. These residual soils are characterized as well-drained to moderately-drained. They have a brown organic silt loam at the surface (typically about 8 inches thick) underlain by 42 to 48 inches of mottled tan, gray, and yellow clay with varying percentages of sand and silt. The Wells-Berks-Gilpin soil complex is found on all of the hillsides near the MGBG (McElrath, 1988). This soil complex forms on very steep to moderately steep slopes and is well drained. In a typical profile, 1 to 2 inches of dark gray to brown silt loam is found at the surface. The subsurface soil is composed of light to dark yellowish-brown, silty loam to silty clay loam. All soils in the Wells-Berks-Gilpin complex contain about 15 percent to 35 percent clay.

Bedrock underlying NSWC Crane consists of sedimentary rocks from the Lower Pennsylvanian-age Mansfield Formation (Raccoon Creek Group) and the underlying Upper Mississippian-age Stephensport and West Baden Groups (Figure 1-8). The Mansfield Formation (uppermost bedrock) consists primarily of alternating beds of shales (e.g., black shale and carbonaceous shale), sandstone, and siltstone, but also includes thin discontinuous coal seams and limestone lenses. This formation is typically about 110 feet thick or more at NSWC Crane [U.S. Army Corps of Engineers Waterways Experiment Station (USACE WES), 1991] (See Figure 1-9). The Stephensport Group, generally 130 to 190 feet thick, includes a number of sandstone and limestone units including the Big Clifty Sandstone and the Beech Creek Limestone (Figure 1-8). An erosional unconformity separates the Pennsylvanian strata above from the Stephensport strata below. Depending on the location at NSWC Crane, pre-Pennsylvanian erosion has removed a significant portion of the Stephensport strata. At these locations the paleo valleys were filled with shales and sandstones of Pennsylvanian age (Figure 1-8).

The underlying West Baden Group also consists of limestone, shale, and sandstone units and is generally 60 to 140 feet thick.

The base of the Mansfield Formation is estimated to be at about 500 to 550 feet amsl at the MGBG. Based on structural mapping of the Beech Creek Limestone, the base of the Stephensport Group is estimated at 400 to 420 feet amsl near the MGBG [Naval Energy and Environmental Support Activity (NEESA), 1983]. The Upper Mississippian bedrock formations crop out near the bottom of the major stream channels in the MGBG area. The bedrock sideslopes and upland areas over most of NSWC Crane consist of Mansfield Formation, labeled as "Raccoon Creek Group and undifferentiated" in Figure 1-10. The bedrock formations in the NSWC Crane area dip west-southwest at about 25 feet per mile.

The shallow subsurface materials at the MGBG include fill (based on previous investigations and observations), natural unconsolidated materials, and bedrock. Figure 1-11 shows the locations of geologic cross-sections presented in Figures 1-12, 1-13, 1-14, and 1-15 for cross-sections A-A', B-B', C-C', and D-D', respectively. When reviewing Figure 1-15, the reader must consider that the elevation at the boring for well 01-12 is out of alignment with the other points in the D-D' cross-section and is topographically lower than the figure might suggest. A description of each of the subsurface materials is included in the remainder of this section.

Fill materials were not encountered at the MGBG during this phase III of RFI field activities (see Section 2.3.3 and associated boring logs in Appendix A). Natural unconsolidated material (residual soil formed on the Pennsylvanian bedrock) encountered in borings installed as part of the Phase III RFI consisted of sand, silt, and clay mixtures with a maximum thickness of approximately 30 feet (Boring 01T02), (See Figures 1-12 through 1-15). Most of the soils encountered were damp to moist and contained some roots. Depth to bedrock ranged from 5 to 30 feet bgs in borings installed as part of the Phase III RFI.

Chemical characteristics of soils at NSWC Crane were evaluated during the Final Basewide Background Soil Investigation Report conducted by TtNUS in 2001 on behalf of the Navy (TtNUS, 2001a). The objective of that investigation was to classify soils according to combinations of three physical factors: depositional environment, grain size, and depth. The soils would then be characterized according to native metal concentrations. A total of 16 soil types were identified and evaluated in the report based on combinations of the three physical factors. Four depositional environments were identified at NSWC Crane, based on the mapped geologic parent material (Pennsylvanian bedrock, Mississippian bedrock, alluvium, and loess). Three predominant grain sizes (clay, silt, and sand) and two depths (surface and subsurface) were also identified as factors contributing to soil chemical characteristics. The

representative background metals concentrations for each of the 16 soil types were shown to represent nine distinct soil groups.

Based on the classification scheme developed in the Final Basewide Background Soil Investigation Report (TtNUS, 2001a), the soils encountered at SWMU 01 fall into three different soil groups. The surface soils (0 to 2 feet bgs) all belong to Soil Group 3 (surface soils, undifferentiated). The subsurface soils (2 to 10 feet bgs) are divided into two different groups – Soil Group 8 (Pennsylvanian subsurface silt and clay) and Soil Group 9 (Pennsylvanian subsurface sand). These groupings are discussed further in Section 3.4.2.

1.2.7 Hydrogeology

USACE WES (1988) discussed regional ground water trends pertaining to the unglaciated southwestern portion of Indiana. In general, ground water is contained in joint openings of limestone and sandstone aquifers. Surficial unconsolidated aquifers are thin and have limited potential as water supplies.

Aquifers beneath NSWC Crane are considered to be vertically isolated from each other by interlayered shale beds that act as aquitards. Ground water recharge in the unconsolidated surficial materials occurs through rainfall infiltration at the ground surface. Ground water recharge in the underlying bedrock units can occur where aquifer units crop out or from vertical downward migration through joint openings from overlying units. After entering an aquifer outcrop, ground water flows by gravity down the dip of the aquifer unit. Given that the regional dip of rock units is to the southwest, regional ground water flow in all aquifers is expected to flow toward the southwest (USACE WES, 1988).

Local variations in bedding thickness and composition, dip, aquifer and aquitard thicknesses, the presence or absence of fractures, incision by surface drainage, and karstic conditions cause local ground water movement at NSWC Crane to differ from regional trends. Where erosion resulting from surface drainage has cut through aquifer units, groundwater discharge occurs as springs and seeps. Springs and seeps are prevalent at contacts between aquitards and overlying aquifers. Ground water flowing from springs and seeps into surface water can potentially re-enter the ground water system as recharge to a lower aquifer outcropping downstream below aquitards.

In the eastern portion of NSWC Crane, USACE WES (1988) hypothesized that karstic conditions are present primarily in major drainage valleys where erosion has cut into permeable sandstones overlying easily dissolved limestone units. Rapid infiltration in the Big Clifty Sandstone has caused dissolution and weathering of the underlying Beech Creek Limestone. The result of this occurrence has been the

creation of karst and collapse conditions along major drainageways within the eastern part of NSWC Crane.

The upper soil materials on the top and sides of the ridge at the MGBG are unsaturated. Bedrock is composed of Lower Pennsylvanian-age Mansfield Formation consisting of irregular beds and lenses of sandstone, siltstone, and shale from near the ground surface down to an elevation of about 525 feet amsl (Figure 1-14). Two thin coal seams (less than 1 feet thick) were encountered at elevations of approximately 610 and 565 feet amsl. Because of the irregularities in the extent and thickness of each lithologic unit and the variability in the permeability and yield of ground water for each well, it is not possible to divide the Pennsylvanian-age rock at this site into distinct aquifers or water bearing units. In general, ground water at the MGBG is likely moving along fractures, joints, and bedding planes and not through a porous matrix, as is commonly the case with unconsolidated deposits.

Limestone beds were encountered in wells 01-06, 01-10 and 01T03 (Figure 1-14) and 01-C01 (Figure 1-13) below an elevation of approximately 540 feet amsl. This limestone was also encountered in well 01T04 at an elevation of approximately 522 feet amsl (Figure 1-12). The limestone is thought to represent the uppermost Mississipian-age rock at this location and is probably part of the Glen Dean or Golconda Limstones of the Stephensport Group. Based on cores taken at wells 01T03 and 01T04, the limestone was fractured, and contained several horizontal and few high angle joints and was water stained at several of the joints. The uppermost Mississipian Limestone is considered to be a separate aquifer from the overlying Pennsylvanian rocks.

In August 2001, ground water levels measured in the shallow monitoring wells located on the ridge crest or upper flanks of the ridge were between 12 and 65 feet bgs. These wells are all screened in the upper or middle portions of the Pennsylvanian strata. A potentiometric surface map for the ground water elevations measured in shallow wells in August is presented on Figure 1-16. The shallow ground water elevation is highest in wells 01-01 and 01-03 located on the southeast and southwest sides of the MGBG, respectively. The high ground water elevations continue in the northwest direction along the ridge crest. On the northeast side of the ridge, the ground water elevations decline rapidly to the north and northeast in the direction of the intermittent stream channel. Between well 01-02 and well 01-09, ground water elevations drop approximately 55 feet. Based on Figure 1-16, shallow ground water flow is in a radial pattern with the steepest hydraulic gradients to the north and northeast. There is a much gentler gradient to the west, northwest and southeast. Hydraulic gradients have not been measured to the south, although topography indicates that the gradients should be steep in that direction. In general, direction of ground water flow mimics topography in this area. Hydraulic gradients range from approximately 0.3 foot/foot to the north to 0.05 foot/foot to the southeast.

The August 2001 ground water elevations were measured following a relatively dry summer period in which only 14.7 inches of rain fell in the previous three months (Table 1-1). The June 2002 water levels were measured after a relatively large amount of rain (23.14 inches) fell in the previous three months. The potentiometric surface for shallow wells based on June 2002 ground water measurements is presented in Figure 1-17. This surface is similar to the August 2001 potentiometric surface:

- the highest ground water elevations were measured in wells 01-01 and 01-03.
- the potentiometric contours form a ridge that generally follows the topographic ridge (in a northwest-southeast direction).
- the potentiometric surface slopes steeply to the north-northeast and to the southwest away from the ground water ridge.

The June 2002 ground water elevations averaged 3.2 feet higher than the August 2001 elevations. The water level increases between the two dates for individual wells ranged from 0.12 feet to 7.62 feet. The increases in the ground water elevations between the first and second measurement dates are shown on Figure 1-18. The largest increase occurred in wells 01-09 (7.62 feet) and 01-03 (7.56 feet). In general, the large increases in ground water elevations occurred in the shallow wells that lie immediately adjacent to the MGBG and on the north and northwestern sides (i.e., downgradient) of the MGBG. The increases in ground water elevations became progressively less with distance from the MGBG. This suggests that the disturbed soils and backfill materials in the MGBG (see Section 1.3.3) have a greater rate of infiltration compared to surrounding undisturbed soils. Ground water measurements were also recorded in September 1983 and were included in a Technical Memorandum dated March 2002 (TtNUS, 2002a).

Ground water levels measured in June 2002 in the four deep monitoring wells (Upper Mississipian) were between 66 and 137 feet bgs. These wells were screened in the upper portion of the Mississippian strata within the Glen Dean Limestone. A potentiometric surface map for the ground water elevations measured in deep wells in June 2002 is presented in Figure 1-19. The deep ground water elevation is highest in well 01-06 located northeast of the Primary Burial Area (PBA). The channel elevation near 01SD04 is about 550 feet amsl. The elevation of the top of the lowest Pennsylvanian sandstone unit (at well 01-06, see Figure 1-14) is about 560 feet amsl. Thus, erosion in the stream channel has cut down into the Pennsylvanian sandstone, which lies immediately above the Mississippian limestone. The lower sandstone was dry in well 01-06, and the ground water elevation in the limestone was at 529.21 feet amsl in June 2002. Therefore, when surface water is flowing in the ephemeral channel during storm events, it

is about 20 feet higher than the ground water elevation in the limestone. As a result, the limestone aquifer is probably being recharged by surface water from the channel during storm events. Ground water elevations in the Mississippian aquifer decline to the southwest toward well 01C01. Based on limited deep well information, it appears that ground water in the deep aquifer flows to the southwest, which is the general direction of the local dip of bedrock in this area. The hydraulic gradient of the deep aquifer is approximately 0.005 foot/foot.

As indicated on Figures 1-12 and 1-15 (cross-sections A-A' and D-D'), a vertical hydraulic head pressure exists between the shallow and deep wells. Water levels measured on June 17, 2002 indicate that a vertical head difference of 115 feet existed between wells 01T04 and 01-15, and 127 feet between wells 01-T03 and 01-02. This vertical head difference is interpreted to be caused by the fact that the two water-bearing zones are separated by the shale unit that lies at approximately 600 feet amsl. This shale unit acts as an aquitard, limiting the vertical movement of water from the shallow to the deep zone.

1.2.8 Ecology

NSWC Crane is a heavily forested facility situated within the Western Mesophytic Forest Region, Hill Section, and Beech-Maple Forest Region (Braun, 1950). Lindsey et al. (1970) further subdivided the area of the installation into the south-central Oak and Mixed Woods Division, including the Beech-Maple and the Beech-Oak-Maple-Hickory sub-elements. Deam (1940) classified the portion of Martin County in which the Facility is located as consisting of the Chestnut Oak Upland, based on the dominant floral components at that time. More recently, Kuchler (1964) mapped this portion of Indiana and classified it as belonging to two distinct vegetation classes, the Oak-Hickory and the Beech-Maple forest components of the Broadleaf Forest Classification. This latter classification most closely resembles the current floristic components observed at the Facility. The areas to the north of the MGBG (including the northeast corner of the site) and to the south of HWY-251 are heavily wooded with mature deciduous trees including oaks, maples, sycamore, and American beech. The forest understory north of the MGBG consists of sparse patches of ground vegetation (i.e., ferns, grasses, moss). The forest understory south of HWY-251 consists of vegetation including vines with thorns.

NSWC Crane contains old agricultural fields in various stages of biological succession. Openings on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Consisting of relatively dense brush and grasses, significant vegetation covers the MGBG (Figure 1-3). Areas that tend to be wetter have river birch, willow, sycamore, and cottonwood. Hillside communities have included hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech (NEESA, 1983). Cleared areas at the Facility have various

stages of grassland, oldfield, and scrub/shrub vegetational forms present. Dominant tree species include black oak, white oak, pignut hickory, and yellow poplar. These stands are relatively young with an average diameter ranges from 6 to 12 inches. No scrubs or shrubs are present in these areas, and leaf litter, limbs, and fallen saplings cover the understory.

Wildlife habitats and vegetation types present at NSWC Crane (including many stages of forest succession, streams, ponds, Greenwood Lake, and grassy open spaces) support a diverse terrestrial and aquatic fauna. The abundance of wildlife on the site is mainly because the mixture of landforms and vegetation types that occur over the Installation. In addition, the lack of agricultural pressures has enhanced the wildlife abundance and served to provide an Installation-wide "wildlife enclosure" condition. There is an adequate amount of forage materials, concealment opportunities, and shelter locations to support a highly diverse wildlife community at the site.

Terrestrial habitats (i.e., wooded areas and grasses) near the MGBG may provide shelter and food sources for various species of mammals such as white-tailed deer, coyote, red fox, rabbits, raccoons, and mice and for birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawks, and American robins.

The white-tailed deer is the most conspicuous large wild mammal at the Installation. Other mammals include opossum, raccoon, rabbits, mice, bats, chipmunks, squirrels, beaver, groundhogs, gray fox, coyotes, and long-tailed weasel. Fox, coyotes, and hawks are carnivores whose presence indicates a healthy ecosystem because smaller mammals are present to provide a food source (NEESA, 1983). The threatened and endangered Indiana Bat may be present in the vicinity of the MGBG.

The birds at NSWC Crane are diverse. Previous studies have identified over 100 species present at the Facility during breeding seasons (Hengeveld, 1987). Because the Facility is largely forested, the species found consist predominantly of those that frequent wooded habitat types. There are also species of waterfowl that use the Facility especially in the vicinity of Greenwood Lake (Figure 1-2). A large number of bird species frequent the non-forested grassland, oldfield, and scrub/shrub vegetation present over portions of NSWC Crane. The bird population includes a number of threatened, endangered, or species of special concern that use NSWC Crane as their home range. These species include the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and the worm-eating warbler [Brown & Root (B&R) Environmental, 1997].

Previous studies conducted at NSWC Crane (Nelson et al., 1987) identified 21 amphibian species and 22 reptile species (including skinks, lizards, snakes, and turtles).

A total of 46 distinct fish species were collected from the Installation during a 1987 inventory of the fish fauna at NSWC Crane. Other than Greenwood Lake, the 1987 study observed the greatest number of individual fish species were recorded from the largest stream (Boggs Creek) and the smallest number of species were recorded from Turkey Creek. Boggs Creek contained 29 species including eight species of fish characteristic of large river type systems. This included long-nose gar, paddlefish, bowfin, gizzard shad, ribbon shiner, big mouth buffalo, channel catfish and flathead catfish. By contrast, the Turkey Creek survey yielded 16 species of fish, none of which were unusual to the area (See Section 8.2.1.2 for specifics on fish species).

1.3 NSWC CRANE FACILITY AND MGBG HISTORY

The NSWC Crane facility and MGBG histories are provided in this section. Accounts of past MGBG investigations, including exhumations of buried material, geophysical surveys, and summaries of chemical and radiological analyses of samples collected from the MGBG are presented.

1.3.1 NSWC Crane Facility Ownership and Operations

NSWC Crane provides materiel, technical, and logistical support to the Navy for equipment, weapons systems, and expendable and non-expendable ordnance items. Early in 1940, Congress passed the first supplemental National Defense Appropriation Act. This act provided $5 million for new inland ammunition production facilities, $3 million of which were earmarked to build a Navy ammunition depot at Burns City on the site of the White River Project. Factors weighing in favor of the Burns City site were a remote location that was free of congested areas, hilly terrain ideal for magazine construction and camouflage, Greenwood Lake which could supply water for the facility, and the distance from the eastern seaboard, thus minimizing the danger of enemy attack.

The Facility was commissioned on 1 December 1941 as the Naval Ammunition Depot (NAD), Burns City. Its initial mission was to prepare, load, renovate, receive, store, and issue all types of ammunition including pyrotechnics and illuminating projectiles, and act as a principal supply source at a most critical time during the early days of World War II. In May 1943, the Depot was renamed the Naval Ammunition Depot, Crane, in honor of Commodore William Montgomery Crane, the Navy's first chief of the Bureau of Ordnance. The name changed again in 1975 to the Naval Weapons Support Center (NWSC) to reflect the facility's growing involvement in high-technology weapons systems. In 1977, the Secretary of Defense combined all conventional ammunition acquisition under the responsibility of a single service. The ammunition production and storage function was given to the Army, and the Crane Army Ammunition

Activity (CAAA) was established as a tenant of the Crane facility to accomplish this task for Naval ammunition. In 1992, based on changing missions and alignment, the facility name was changed to NSWC Crane.

The Army has assumed ordnance production, storage, and related responsibilities under the single-service management directive. All environmental activities on the Installation, including permitting activities, remain the responsibility of the Navy. Although ordnance production and storage still occurs on Base, activities at Crane also involve diverse and highly technical product lines, such as microwave devices, acoustic sensors, small arms, microelectronics technology, and more. The Army currently exists as a tenant activity on the Base, as do other major branches of the Department of Defense (DOD) including the Coast Guard and the Defense Reutilization and Marketing Operations (DRMO).

1.3.2 Operational History of the MGBG

The NSWC Crane MGBG is an inactive waste burial site approximately 2 acres in size (Figure 1-11). The approximately rectangular MGBG was fenced until 1995 at which time the USACE WES removed the fencing in preparation for a geophysical survey. When the fencing was removed a creosoted fence post was left at each of the four corners of the site to mark the site boundaries. Those corner posts were still present as of June 2002.

The MGBG was used between the end of World War II and 1956 for disposal of materials such as mustard munitions and other select items (USACE WES, 1991). Disposal was in the form of shallow burials (pits), typically within 6 feet of the surface. Three types of hazards or potential hazards were identified at the site:

- Aerial mustard bombs (without the explosives).
- Thorium nitrate powder (in pyrotechnic flares).
- Unspecified laboratory chemical wastes.

The thorium nitrate and illuminant material containing thorium or thorium compounds was buried as waste from a research and development effort related to pyrotechnic devices. The unspecified chemical wastes are documented to have comprised "some ninety (few ounces each) quantities of aged laboratory chemicals on May 18, 1967" (Fitch, 1974). No further information is available on the quantities or identities of the unspecified chemicals. The disposal was designed to encourage decomposition of the small amounts of chemical waste by effecting close contact with soil and moisture.

Located within the MGBG is the approximately rectangular PBA, which is approximately 0.2 acre in size (Figure 1-11). Although the PBA once shared its northern fence line with the MGBG proper, the PBA fence has been removed. An access gate was located near the middle of the southern former fence line of the PBA. Based on past investigations and exhumations, no hazardous materials are known to have been buried outside of the PBA (NSWC Crane, 1980). Several burial areas within the PBA were marked or remarked in 1955 and 1956 with signs detailing the contents, or in some cases, the authority under which burial was performed. The signs marking these burial sites had limited details as to the buried contents. These signs were removed during the exhumation activities described in Section 1.3.3 of this report.

On the eastern and southeastern sides of the MGBG, between the MGBG and HWY-251, a few debris piles comprising asphalt, concrete, and earth are visible among the trees. The piles are approximately 2 to 5 feet high and are not thought to be site-related. A photograph of the piles near the southeastern corner of the MGBG (see Figure 1-17) is shown in Figure 1-20. Explosives Magazine 1407 is visible in the background of the photograph.

1.3.3 MGBG Waste Exhumations and Investigative History

A chemical safety survey was conducted in March 1973 by the DOD Explosive Safety Board, which recommended that all hazards buried at the site be excavated so that the site could be certified safe (USACE WES, 1991). Two exhumations were undertaken to remove all buried hazards at the MGBG (U.S. Navy, 1980). Field testing for mustard gas and soil screening for gamma radiation using gamma spectrometry were performed during the exhumations. The exhumation locations estimated from historical information are depicted on Figure 1-21. Past records were at times vague concerning locations of buried and exhumed materials. Figure 1-21 represents the most complete summary available of past exhumation locations. The first of the exhumation efforts took place in May 1974. This effort uncovered 10 aerial bombs (three of which contained chemical agent) and seven 55-gallon-drums-worth of thorium nitrate-contaminated soil, illumination devices (i.e., flares), and other debris. Mustard Gas (HD) was released to the ground from one bomb because of leakage. The released chemical agent was decomposed by reacting it with solid hypochlorite and hypochlorite solution. Vent pipes were placed in the excavation to release hydrogen chloride gas formed during the reaction, then the excavation was backfilled with soil. The evacuation of hydrogen chloride through the vent pipes helped to ensure complete decomposition of the mustard gas. The bombs and radioactive materials were secured and placed into Magazine 1403 at the intersection of HWY 251 and HWY 161, approximately 0.5 miles southeast of the MGBG (U.S. Navy, 1974). No chemical or radiological releases are documented in relation to this transfer, and no such releases are suspected to have occurred. In 1975, all of the

exhumed radioactive material was sent to a Nuclear Regulatory Commission (NRC)-licensed burial ground in Barnwell, South Carolina.

In 1980, three additional locations within the MGBG were identified to be thorium nitrate burial areas (U.S. Navy, 1980). Exhumations were conducted at these three locations from 15 September to 24 September 1980 by the Naval Sea Systems Command (NAVSEASYSCOM). The goal of the exhumation effort was to properly remove the known material, rid the area of any chemical warfare weapons, and return the land to its original condition. During this effort, a magnetometer survey was completed and six additional bomb casings devoid of mustard gas, one mustard gas identification kit, an unspecified quantity of thorium nitrate, and illumination candle debris were found. The six newly exhumed bomb casings and original 10 aerial bombs exhumed in 1974 were dismantled, decontaminated using a steam cleaning and chemical soaking process, burned with thermite, and prepared for transport and disposal (U.S. Navy, 1980). Ultimate disposal was at the NSWC Crane landfill. The mustard gas identification kit is described as "...a chemical gas I.D. [identification] kit container which contained six ounces of mustard gas in a laboratory glass flask with a glass stopper. This material was apparently a laboratory sample and totally unlike standard I.D. sets" (U.S. Navy, 1980). This identification kit was also processed by steam cleaning and decomposing the mustard gas by soaking it in a hypochlorite solution followed by thermite burning and disposal (U.S. Navy, 1980).

As a result of these exhumation efforts, the MGBG was cleared for future investigations with the assurance that all ordnance items had been removed from the site and the risk of exposure to live mustard agent was extremely small (U.S. Navy, 1980). A copy of a memorandum from the NSWC Crane Explosives Safety Officer specifying these assurances is provided in Appendix A of the MGBG QAPP.

In 1981, a ground water monitoring program was undertaken involving the installation and sampling of five monitoring wells. Between 1982 and 1983, 12 additional wells were installed and sampled. In 1983, 10 more wells were installed and sampled. Another well was added prior to 1993, bringing the total number of monitoring wells at the MGBG to 28. Select wells were sampled between 1980 and 1986. No further groundwater sampling was conducted until 2001.

The locations of the original 28 wells (01-01 through 01-27 and 01C01) are shown on Figure 1-11 along with wells installed since that time. The original "WES" numbering scheme (not shown on Figure 1-11) for 27 of the wells identifies them as having been installed by the USACE WES. The numbering scheme was later changed to indicate the SWMU number (first two digits) followed by a hyphen and a two-digit sequential well number as shown in Figure 1-11. For wells installed since well 01-27, an installer code has been incorporated into the well number in place of the hyphen. For example, well 01C01 indicates

that it is at SWMU 01 (01) installed by the USACE WES ("C" as the third character) and is the first well (01) in the sequence. Installer code "T" represents wells installed by TtNUS.

A summary of ground water analytical results for samples collected from 1981 to 1986 is presented in Table 1-2 and complete laboratory data are presented in Appendix B of the MGBG QAPP (TtNUS, 2001b). Several halogenated solvents were detected in the wells, particularly trichloroethene (TCE) and 1,1,2,2-tetrachloroethane (PCA). Figure 1-22 shows historical ground water sampling locations at the MGBG and summarizes total organic halogen (TOX) analytical results. Because several chlorinated and brominated organic compounds were detected in the wells, TOX values are listed on Figure 1-21 rather than individual analyte concentrations, to indicate the general levels of contamination in each well. Based on the concentrations of individual compounds (Table 1-2 of this document) and the TOX data in Figure 1-21, the greatest levels of contamination were found in well 01-02, located about 40 feet north of the MGBG perimeter. The shallow solvent plume was estimated to extend at least 460 feet northwest from the MGBG, which was the expected ground water flow direction. The concentrations of volatile chemicals in well 01-02 appear to have decreased between 1982 and 1984.

Geophysical surveys conducted in conjunction with past exhumations (1974 and 1980) no longer reflect site conditions at the outset of this investigation because the conditions were changed by the exhumations. The associated exhumation reports were used to corroborate site boundaries but were not used to assess the nature and extent of contamination or human health or ecological risk.

A draft Phase II RFI Work Plan was developed in 1991, but was neither finalized nor implemented due to lack of funds (USACEWS, 1991). When funds became available, a Phase III Work Plan was developed to expedite the RFI process, i.e. to avoid two cycles of the QAPP, fieldwork, and reporting. The Navy and U.S. EPA agreed that enough investigative data had been collected to verify that a release had taken place at the SWMU and that a "release assessment" as described in the NSWC Crane RCRA Permit had already taken place based on investigative efforts conducted by the U.S. Army Corps of Engineers. Hence, Phase II had, in essence, already been completed.

A Phase III RFI is a "Release Characterization," which is what was accomplished by the work described in this report in accordance with Crane's RCRA Permit. The Phase II Work Plan was reviewed and was used primarily for historical information about the site. Appropriate information from this document was utilized in preparation of the U.S. EPA-approved Phase III RFI QAPP.

In 1995, a comprehensive surface geophysical survey was performed over the entire 2-acre MGBG (USACE WES, 1997). Results of the survey are summarized in the MBGB QAPP with figures showing

locations of anomalies. The geophysical investigation identified two strong anomalies and a linear array of small regular-spaced anomalies. The first strong anomaly was approximately 10 feet in diameter and 1 to 2 feet deep. It was believed to have been caused by ferrous material. The second strong anomaly was smaller, approximately 2 to 3 feet in diameter, caused by nonferrous metallic material, and interpreted to be approximately 1.5 feet deep. The series of small anomalies was detected along an old fence line, which led to the conclusion that the anomalies were caused by the remnants of metal fence posts, consistent with the regular spacing of the anomalies. These findings were used to guide the 2001 exhumation of the buried debris (the anomaly excavations).

1.4 PROBLEM STATEMENT AND DECISION RULES

The problem statement as described in the MGBG QAPP (TtNUS, 2001b) is summarized in this section along with the project objectives. Decision rules that govern project decision making are presented in the MGBG QAPP. Those rules are summarized here in text form whereas the MGBG QAPP presents them in flow chart form.

1.4.1 Problem Statement

Because of operationally related chemical releases that occurred at the MGBG and residual ground water contamination that was detected in the 1980s, the Navy was concerned that human or ecological receptors could be exposed to unacceptable human health or ecological risks from exposure to contaminated environmental media. The risks were expected to be confined primarily to aqueous and solid media because only minimal airborne release pathways (e.g., occasional minor resuspension of dust or release of volatile chemicals) was anticipated.

The degree of risk to a human or ecological receptor is estimated from the nature of contamination and the frequency, duration, and nature of exposure to contaminants. Consequently, it was important to estimate the nature and extent of contamination.

The chemicals of primary interest were those documented to have been buried at the MGBG (mustard gas and thorium or thorium compounds) and volatile organic contaminants that were detected during the 1980s ground water investigations. Consistent with U.S. EPA Region 5 investigative strategies, the range of chemicals to be investigated during the Phase III RFI was expanded to include the 40 CFR Part 264 Appendix IX chemical list specified by U.S. EPA Region 5, plus mustard gas, mustard gas primary degradation products, thorium, and select radionuclides. The targeted chemicals are listed in Table 2-2

(Section 2.0) of this document. Select appendices of this report, which list these same chemicals, are called out within this document where appropriate.

The human health and ecological receptor populations evaluated were:

- Trespassers.
- Maintenance workers.
- Construction workers.
- Occupational workers.
- Recreational users.
- Hypothetical future resident.
- Ecological species (representative species were selected for this evaluation).

Details concerning the human health and ecological risk exposure scenarios and risk evaluation methods are presented in Sections 7.0 and 8.0, respectively.

1.4.2 Decision Rules

The decision rules by which the attainment of project objectives would be assessed are presented in detail in the MGBG QAPP (TtNUS, 2001b) and are summarized in this section. Deviations from the decision rules are explained and justified in the appropriate sections of this report.

1.4.2.1 Selecting Background Concentrations

Comparisons of site data to background data were conducted using a Wilcoxon Rank Sum (WRS) test at the 5 percent significance level. For inorganic chemicals and select gamma-emitting radionuclides in soil, the background concentrations used for comparison were the soil background values determined in the NSWC Final Basewide Background Soil Investigation Report (TtNUS, 2001a) and the supplemental gamma spectrometric data (radionuclide concentrations) generated for this investigation. MGBG analytical data were compared to the soil background data set with physical characteristics (i.e., grain size, depositional environment and depth) most similar to the MGBG soil samples. Because three distinct soil groups were found at the MGBG, this resulted in three separate comparisons for each metal including the gamma spectrometry radionuclides.

Radioactive thorium was not assessed as part of the NSWC Crane Final Basewide Background Soil Investigation Report (TtNUS, 2001a); however, radioisotopic thorium-228 and thorium-232 concentrations

were computed from chemical thorium analyses using the natural relative abundances and specific activity of naturally occurring thorium (see Section 12.4 of MGBG QAPP). Isotopic thorium data was obtained from a single background location during this investigation for comparison to the thorium radioisotopic values computed from the background investigation data. If the values from this investigation did not match the background investigation values within established measurement uncertainty, professional judgment would be used to determine which values most represent background for this investigation.

For inorganics and radionuclides in ground water, surface water, and sediment, concentrations in water or sediment samples upstream or upgradient (or cross gradient) were considered to be anthropogenic background concentrations.

1.4.2.2 Selecting Chemicals of Potential Concern

A chemical (organic, inorganic, or radionuclide) detected in ground water (human health risk only) was selected as a chemical of potential concern (COPC) for ground water if the maximum detected concentration in any well exceeded a risk-based target limit (RBTL). The original decision rule incorporated a comparison to upgradient concentrations using a WRS test; however, because there are no upgradient wells at the MGBG, only a comparison to RBTLs was done.

A chemical detected in surface water (or sediment) was selected as a COPC for surface water (sediment) if the maximum detected concentration in any drainage channel exceeded the RBTL (human health risk) or ecological data quality level (EDQL) (ecological risk) for surface water (or sediment) (organics, inorganics and radionuclides) and the maximum upstream background concentration (inorganics and radionuclides only).

A chemical detected in soil was selected as a COPC for soil if any detected concentration exceeded the applicable RBTL (human health risk) or EDQL (ecological risk in surface soil only) for soils (organics, inorganics and radionuclides), and the WRS test at 5 percent significance indicated that the site concentration was statistically greater than the corresponding background concentrations (inorganics and radionuclides only). The background data set used for these comparisons was that which most closely matched the site data in terms of depositional environment, depth, and grain size.

If a chemical did not have an RBTL or EDQL, the chemical was evaluated qualitatively for inclusion as a COPC. Those evaluations were based on professional judgment that took into account the number of times the chemical was detected, the magnitudes of the observed concentrations, the spatial distributions

of the detected values, and the toxicities of similar chemicals. Individual chemicals could have been eliminated as COPCs if they were detected at a frequency less than 5 percent in any given medium, but only if there were no other indications that the chemical would pose an unacceptable risk to receptors. For example, chemicals that exhibited unusually high concentrations may have been retained as COPCs on that basis at the discretion of the human health or ecological risk assessor. If a chemical was not detected at the detection limit in all of the samples in a particular medium, and the detection limit exceeded the risk-based level, the chemical was qualitatively discussed in the uncertainty analysis section.

1.4.2.3 Estimating the Nature and Extent of Contamination

Soil and Ground Water

The spatial risk perimeter representing 1E-4 cumulative human health (HH) risk and the spatial hazard perimeter representing a Hazard Index (HI)=1.0 were planned to be generated and plotted separately. Once plotted, the best fit perimeter encompassing both the HH risk=1E-4 and HI=1.0 was to be generated to represent the union of HH risk and HI. Because of the sparse distribution of MGBG contaminants, this was not feasible for soils. For ground water, representative VOC concentrations were plotted and isoconcentration contours were plotted instead of HI or ILCR contours.

Sediment and Surface Water

If any COPC concentration in downgradient/downstream samples resulted in HH risk greater than 1E-4 or a HI greater than 1.0 (target organ-specific), a consultation with the regulators was to be initiated. Consultation with the regulators was initiated after Round 1, and additional sampling locations were selected for Round 2. Additional consultation was not initiated after Round 2 because the extent of surface water and sediment contaminants appeared to be well defined based on chemical concentrations alone.

Failure to Establish Nature and Extent of Contamination Within Two Sampling Rounds

If the COPC extent boundary was not identified within two rounds of sampling, the Navy was to seek consultation with the U.S. EPA to discuss the need for additional sampling. The following would be considered:

- The expected contribution to risk estimates of the as yet unbounded region of contamination
- The practicality of obtaining samples from the unbounded region

- The number of sampling locations exceeding screening criteria
- Other factors that are pertinent to the evaluation but could not be anticipated in advance

Because the extent of COPC contamination was sufficient to support the risk assessment and to establish the extent of the significant site contamination, this consultation was not necessary for soils, sediment and surface water. Additional consultation was sought for the ground water, which was the most contaminated of the environmental media and constituted the majority of human health risks.

1.4.2.4 Evaluating Human Health Risks

If the HH risk was demonstrated to be unacceptable by exceeding an HI=1.0 (target organ effect) or ILCR=1E-04 within the chosen exposure unit (EU), then the need to proceed to a CMS was evaluated. If risks were unacceptable and proceeding to a CMS was not warranted, but additional sampling was indicated, more samples were collected. If the risk was not unacceptable, no further action was required.

1.4.2.5 Evaluating Ecological Risks

Ecological risks were computed for the MGBG in accordance with the Navy Ecological Risk Assessment Decision Diagram through Step 3a. If risks were unacceptable, a refinement of the risk assessment was conducted. If risks were unacceptable after refinement, Tier 3 of Navy Ecorisk Tiered Approach was completed. If risks were found not to be unacceptable at any point in the risk assessment, no further action was required.

TABLE 1-1

CUMULATIVE RAINFALL PRIOR TO SAMPLING EVENTS, INCHES*
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Month	Year	
	2001	2002
March	NT	6.63
April	NT	6.07
May	3.51	10.44
June	4.7	5.3
July	6.49	NT
August	1.67	NT
September	3.69	NT
Total for Period	**20.06**	**28.44**

NT = Not tabulated.
Highlighted cells indicate sampling periods.

Source: U.S. Dept. of Commerce National Oceanic and Atmospheric Administration National Weather Service Record of River and Climatological Observations.
Station index No.: 12 1869 7
County: Martin
State: Indiana
*Obtained from the NSWC Crane Fire Dept. via facsimile transmission from Mr. Tom Brent to Tom Johnston, 22 Aug 2002.

TABLE 1-2

GROUND WATER DATA
SUMMARY FOR 1981 TO 1986
NSWC CRANE
CRANE, INDIANA

Parameter	Detection Frequency	Minimum Non-detected Conc'n	Maximum Non-detected Conc'n	Minimum Overall Conc'n	Maximum Overall Conc'n	Overall Concentration Range	Non-detects Concentration Range	Maximum Concentration Location[date]	Average of Detected Results	Average of All Results
VOLATILES (ug/L)										
1,1,1-Trichloroethane	11/22	1	1	1	29	1 - 29	1	01-14-[01/31/83]	9.09	4.80
1,1,2,2-Tetrachloroethane	29/39	0	1	7	589000	7 - 589000	0 - 1	01-02-[11/18/82]	24478.24	18201.87
1,1,2-Trichloroethane	12/21	1	5.2	2.2	341	2.2 - 341	1 - 5.2	01-12-[01/25/83]	44.34	25.65
1,1-Dichloroethene	4/24	1	1	1	65	1 - 65	1	01-02-[10/05/82]	18.50	3.50
1,2-Dichloroethane	11/30	1	1	3	4070	3 - 4070	1	01-02-[11/18/82]	573.45	210.58
1,3-Dichloropropene	1/7	1	1	1000	1000	1000	1	01-16-[02/15/83]	1000.00	143.29
Benzene	4/25	0	1	1	5	1 - 5	0 - 1	01-26-[01/28/86]	2.75	0.80
Bromoform	1/25	0	2	8600	8600	8600	0 - 2	01-02-[10/05/82]	8600.00	344.66
Carbon Tetrachloride	1/22	0	1	34	34	34	0 - 1	01-02-[10/05/82]	34.00	2.00
Chlorobenzene	1/22	1	1	6	6	6	1	01-02-[10/05/82]	6.00	0.75
Chlorodibromomethane	2/15	1	1	61	3040	61 - 3040	1	01-02-[11/18/82]	1550.50	207.17
Chloroform	21/39	0	5	2	2000	2 - 2000	0 - 5	01-02-[10/05/82]	109.36	59.26
Ethylbenzene	1/16	1	1	10.5	10.5	10.5	1	01-22-[01/08/85]	10.50	1.13
Methylene Chloride	16/31	1	10	1	47	1 - 47	1 - 10	01-02-[10/05/82]	9.50	5.29
Tetrachloroethane	1/1	0	0	7.1	7.1	7.1	0	01-19-[01/08/85]	7.10	7.10
Tetrachloroethene	11/24	0	3.8	0.1	4200	0.1 - 4200	0 - 3.8	01-02-[11/18/82]	652.93	299.57
Toluene	2/19	1	1	5	5.1	5 - 5.1	1	01-22-[01/08/85]	5.05	0.98
Trans-1,2-dichloroethene	16/28	0	1	3	2650	3 - 2650	0 - 1	01-02-[11/18/82]	320.44	183.29
Trichloroethene	37/45	0	644	1	133000	1 - 133000	0 - 644	01-02-[11/18/82]	5867.76	4831.82
Trichlorofluoromethane	4/20	0.1	1	2	19	2 - 19	0.1 - 1	01-14-[01/31/83]	7.25	1.83
Tetrahydrofuran	3/3	0	0	11	93	11 - 93	0	01-15-[01/28/86]	51.00	51.00
INORGANICS (ug/L)										
Arsenic	1/20	10	10	10	10	10	10	01-05-[10/05/82]	10.00	5.25
Iron	33/46	20	1000	30	7280	30 - 7280	20 - 1000	01-21-[01/08/85]	795.15	584.89
Iron, Total	17/23	10	20	10	18000	10 - 18000	10 - 20	01-15-[01/28/86]	2930.59	2168.26
Manganese	76/82	5	30	10	7000	10 - 7000	5 - 30	01-04-[03/23/82], 01-04-[07/18/82]	1889.47	1751.86
Mercury	4/20	0.2	0.7	0.2	1.1	0.2 - 1.1	0.2 - 0.7	01-05-[10/05/82]	0.60	0.21
Silver	1/20	10	10	10	10	10	10	01-03-[03/23/82]	10.00	5.25
Sodium	66/66	0	0	3800	210000	3800 - 210000	0	01-05-[03/23/82]	60869.70	60869.70
RADIONUCLIDES (pCi/L)										
Gross Alpha	1/20	2.89	10.8	4.59	4.59	4.59	2.89 - 10.8	01-02-[11/30/81]	4.59	2.99
Gross Beta	15/20	1.55	2.12	1.51	6.27	1.51 - 6.27	1.55 - 2.12	01-05-[11/30/81]	3.09	2.55
Radium-226	11/15	0.23	0.34	0.17	0.48	0.17 - 0.48	0.23 - 0.34	01-05-[03/23/82]	0.29	0.25

TABLE 1-2

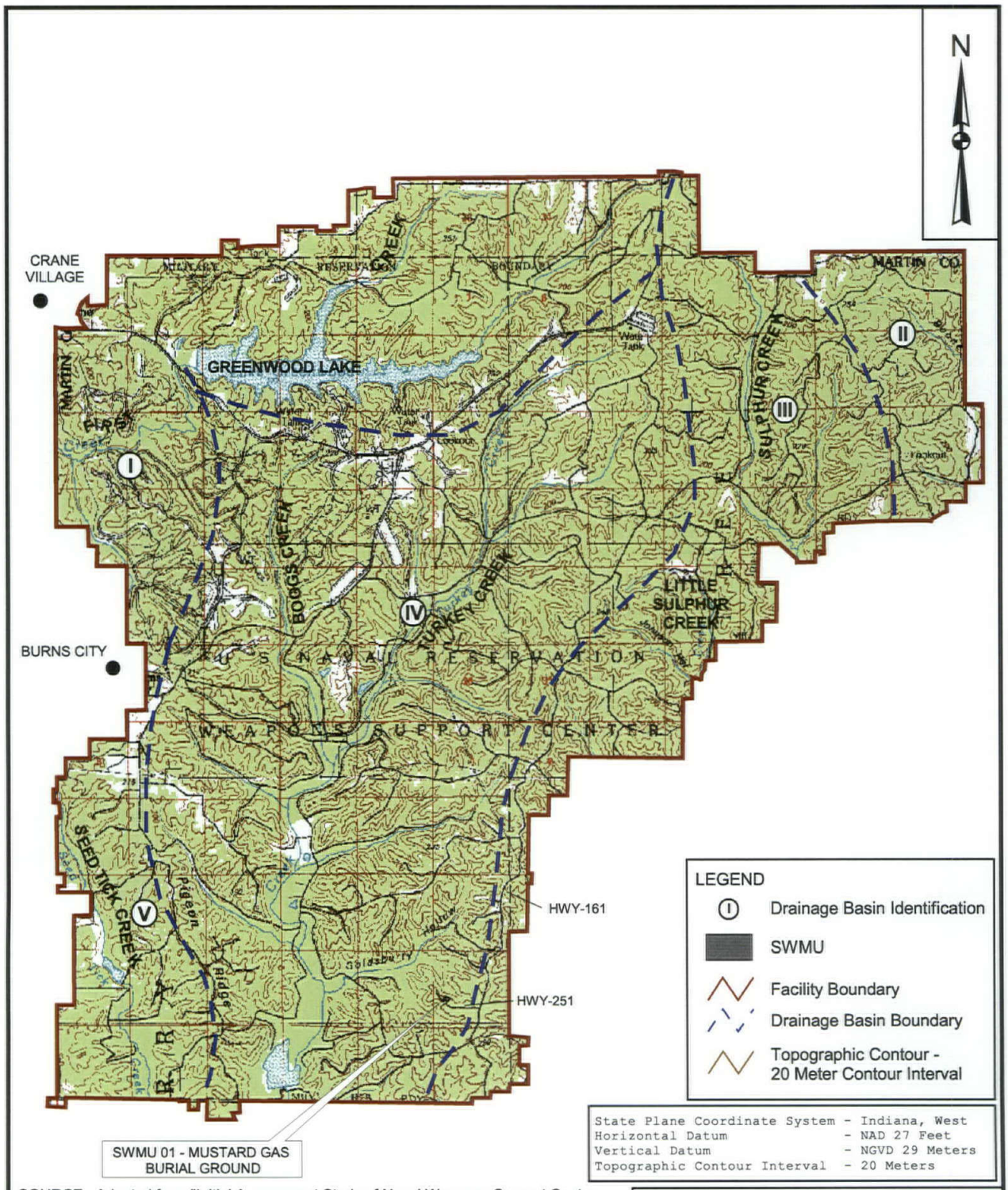
GROUND WATER DATA
SUMMARY FOR 1981 TO 1986
NSWC CRANE
CRANE, INDIANA

Parameter	Detection Frequency	Minimum Non-detected Conc'n	Maximum Non-detected Conc'n	Minimum Overall Conc'n	Maximum Overall Conc'n	Overall Concentration Range	Non-detects Concentration Range	Maximum Concentration Location[date]	Average of Detected Results	Average of All Results
MISCELLANEOUS PARAMETERS (mg/L)										
Chloride	54/66	1	1	1	110	1 - 110	1	01-02-[10/05/82]	33.99	27.9
Conductance, Field (uS/cm)	41/41	0	0	145	6400	145 - 6400	0	01-27-[06/10/85]	1129	1129
Fluoride	17/20	0.1	0.1	0.1	0.26	0.1 - 0.26	0.1	01-04-[07/20/82], 01-04-[10/05/82]	0.18	0.16
Nitrate/nitrite, As N	15/20	0.05	0.05	0.05	0.18	0.05 - 0.18	0.05	01-04-[10/05/82]	0.11	0.09
Organic Bromine	6/65	0.002	0.01	0.005	0.016	0.005 - 0.016	0.002 - 0.01	01-03-[01/31/84]	0.01	0.00
Organic Chlorine	52/68	0.01	0.01	0.01	48	0.01 - 48	0.01	01-02-[06/03/86]	2.41	1.85
Organic Iodine	33/68	0.002	0.5	0.002	0.15	0.002 - 0.15	0.002 - 0.5	01-02-[06/07/84]	0.02	0.02
pH, Laboratory (unitless)	41/41	0	0	6.1	7	6.1 - 7	0	01-03-[01/28/86], 01-09-[01/29/86], 01 10-[01/30/86], 01-10-[06/04/86]	6.59	6.59
pH, Field (unitless)	88/88	0	0	5.7	7.7	5.7 - 7.7	0	01-11-[01/07/85]	6.62	6.62
Phenols	22/66	0.004	0.05	0.01	0.17	0.01 - 0.17	0.004 - 0.05	01-02-[07/20/82]	0.03	0.02
Specific Conductivity uS/cm	81/81	0	0	-1300	2520	-1300 - 2520	0	01-05-[02/22/83]	1160	1160
Sulfate	82/82	0	0	15	990	15 - 990	0	01-23-[01/07/85]	358	358
Total Coliform (PHM)	6/8	1	1	2	9	2 - 9	1	01-04-[03/05/82], 01-04-[11/30/81]	5.33	4.13
Total Organic Carbon	99/123	0.5	2	0.8	72	0.8 - 72	0.5 - 2	01-05-[07/27/83], 01-05-[10/05/82]	12.97	10.55
Total Organic Halogens	64/71	0	0.01	0.0063	104	0.0063 - 104	0 - 0.01	01-02-[07/20/82]	2.90	2.61

ug/L = micrograms per liter
pCi/L = picoCuries per liter
mg/L = milligrams per liter

DRAWN BY J. LAMEY — DATE 3/9/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 9060	OWNER NO. CTO 279
CHECKED BY T. JOHNSTON — DATE 9/27/02	GENERAL LOCATION MAP NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY T. JOHNSTON — DATE 9/27/02	
COST/SCHEDULE-AREA		APPROVED BY — — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 1-1	REV 1

P:\GIS\NSWC_CRANE\0087.APR GENERAL LOCATION MAP 7/22/03 AJ



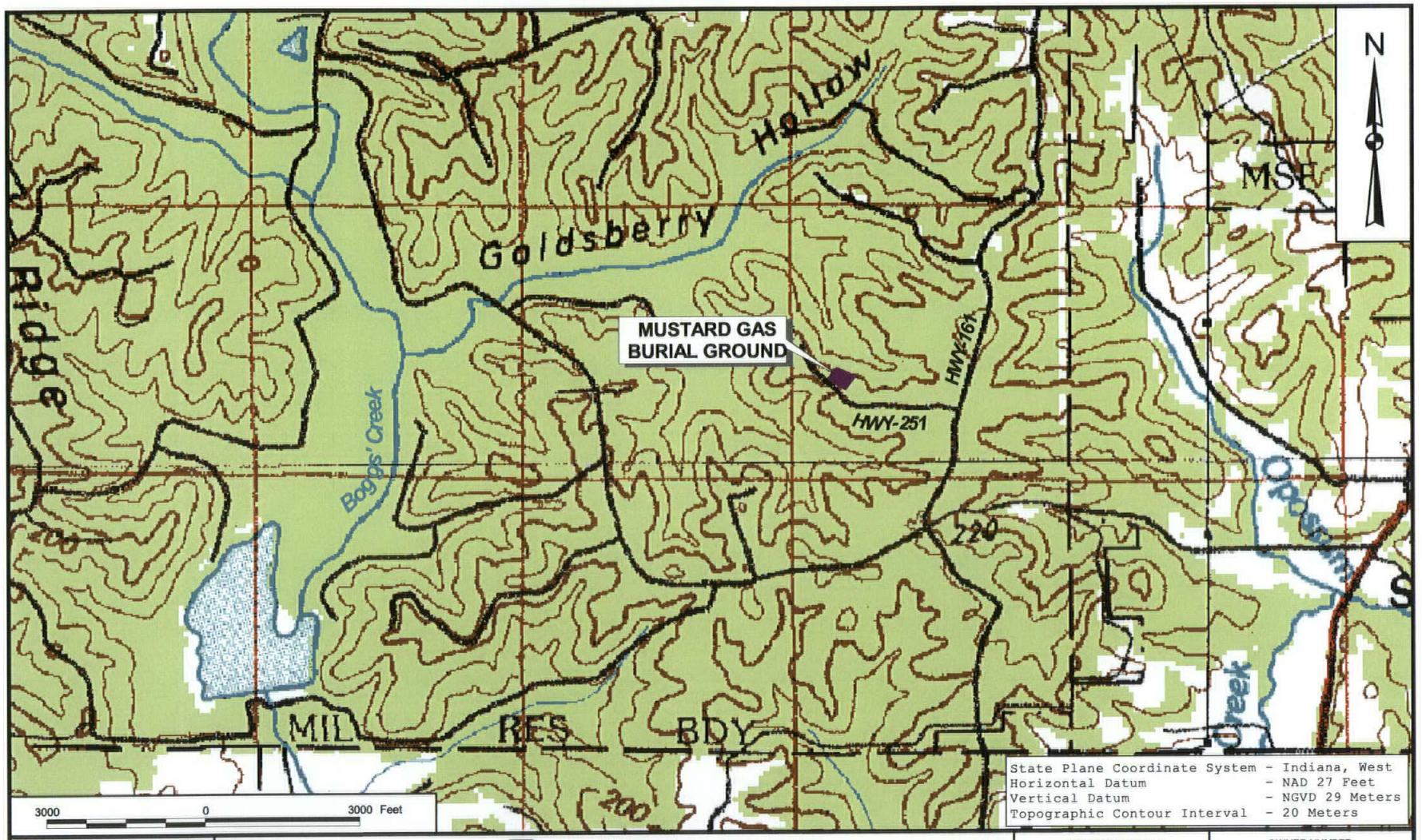
SOURCE: Adapted from "Initial Assessment Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY J. LAMEY — DATE 4/19/99	Tetra Tech NUS, Inc.	CONTRACT NUMBER N3959	OWNER NO. CTO 158
CHECKED BY T. JOHNSTON — DATE 9/27/02	LOCATION OF MGBG AND SURFACE DRAINAGE AT THE NAVAL SURFACE WARFARE CENTER CRANE CRANE ,INDIANA	APPROVED BY T. JOHNSTON	DATE 9/27/02
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 1-2	REV 0

P:\GIS\NSWC_CRANE\0087.APR SURFACE DRAINAGE - MGBG LAYOUT 9/27/02 AJ

FIGURE 1-3
VIEW TOWARD WESTERN END OF SITE FROM EASTERN END OF SITE
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

FIGURE 1-4
VIEW TOWARD SOUTHEAST CORNER OF MGBG FROM NEAR EASTERN CENTRAL PORTION OF SITE
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

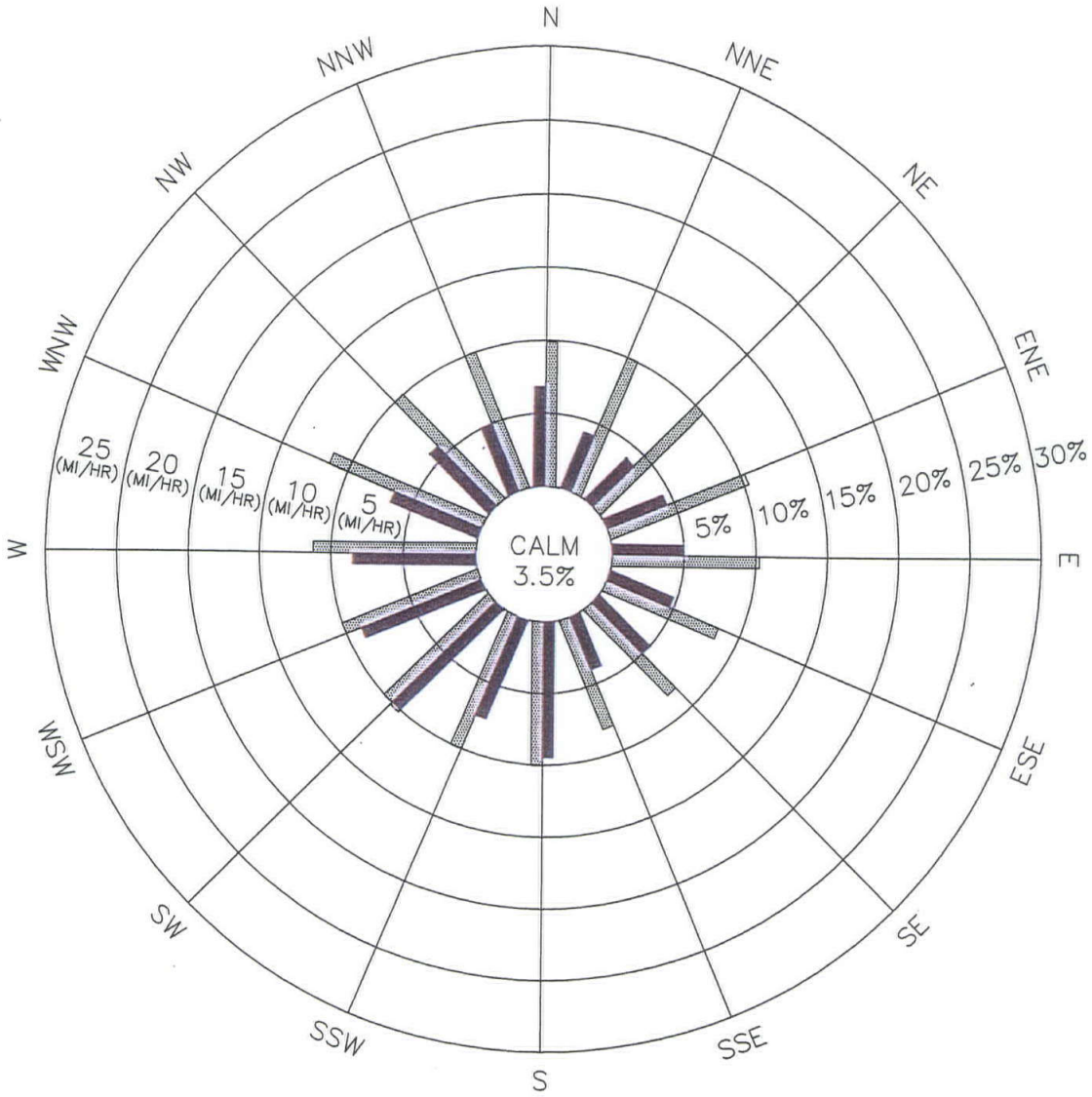


State Plane Coordinate System - Indiana, West
Horizontal Datum - NAD 27 Feet
Vertical Datum - NGVD 29 Meters
Topographic Contour Interval - 20 Meters

DRAWN BY J. LAMEY	DATE 2/9/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER N3959 / OWNER NUMBER CTO 158
CHECKED BY J. SCHUBERT	DATE 7/31/02	SURROUNDING TOPOGRAPHY SWMU 01 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY T. JOHNSTON / DATE 7/31/02
COST/SCHEDULE-AREA			APPROVED BY — / DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-5 / REV 0

P:\GIS\NSWC_CRANE\SWMU01.APR SITE MAP-QUAD 9/26/02 AJ

ACAD: 3959KM01.dwg 10/03/02 HJB PIT



LEGEND:

WIND DIRECTION FREQUENCY (PERCENT)
(DIRECTION FROM WHICH THE WIND IS BLOWING)

MEAN WIND SPEED (MI/HR)

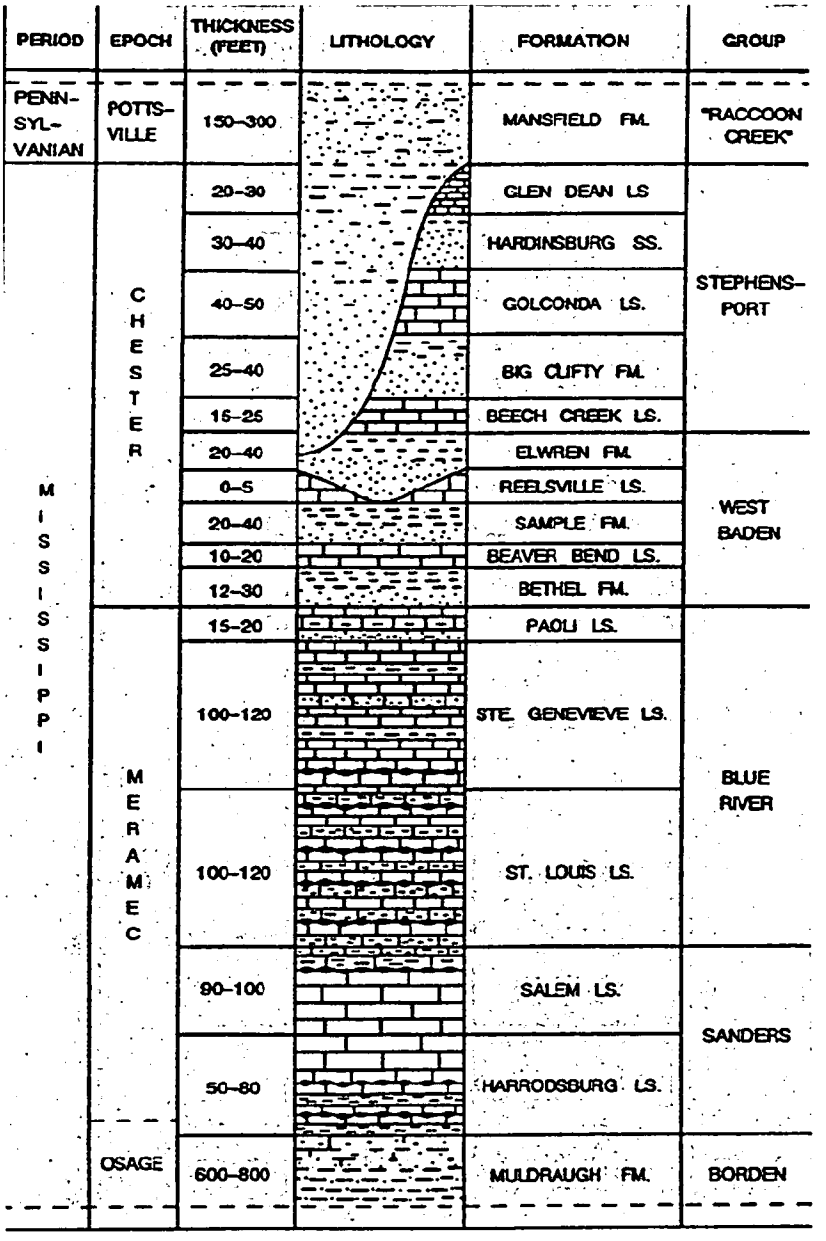
DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT

PERIOD OF RECORD: 1985–1989
43,824 OBSERVATIONS

DRAWN BY MF DATE 7/19/02	DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMMAND ★	FIVE-YEAR WIND ROSE SUMMARY FOR INDIANAPOLIS, INDIANA NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NO. 3959
CHECKED BY DATE			APPROVED BY DATE
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 1-6 / REV. 1

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

FIGURE 1-7
PRIMARY EAST-WEST DRAINAGE CHANNEL NORTH OF SITE
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

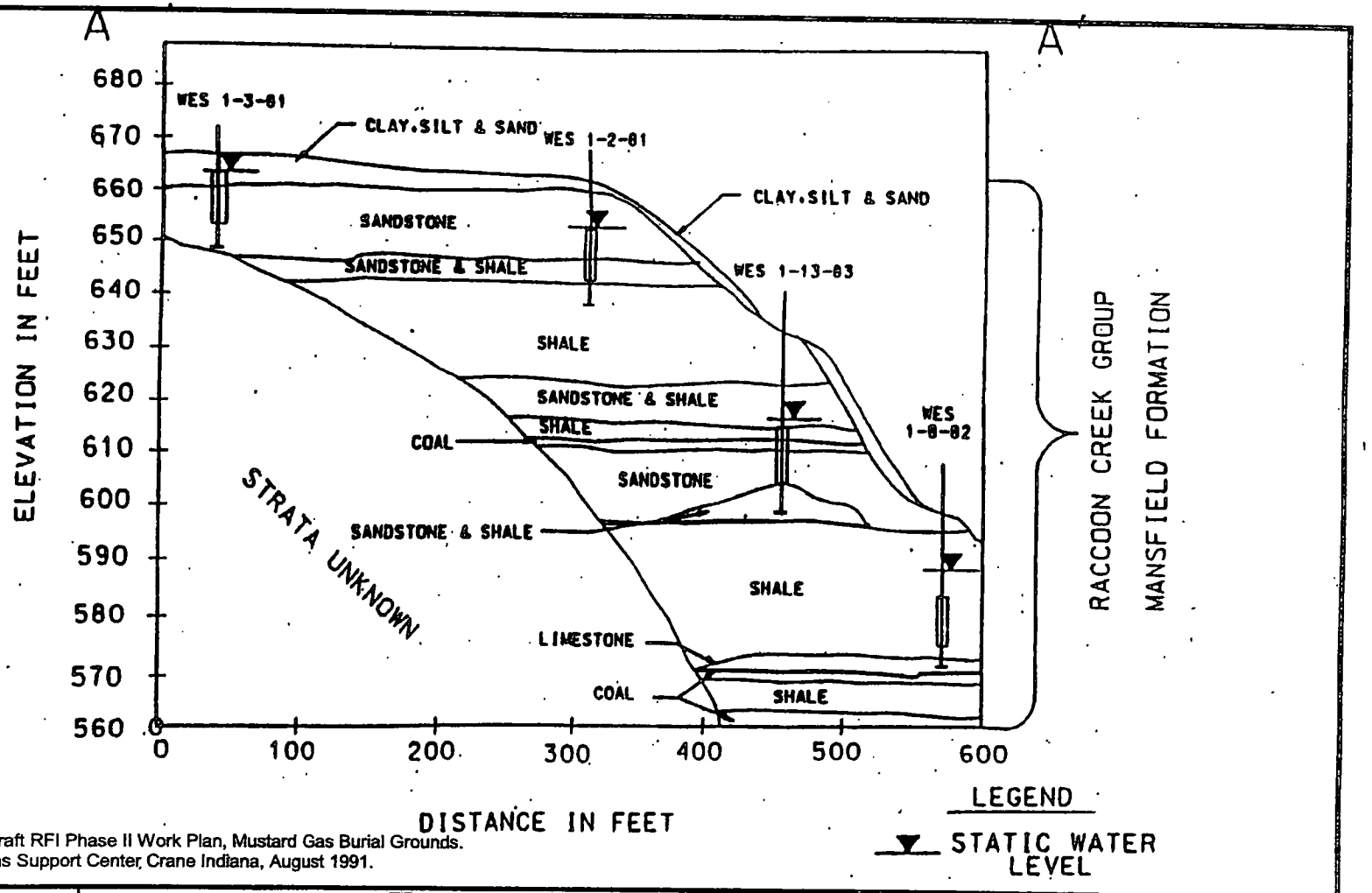


Source: Draft Report, RCRA Facility Investigation
Phase II Groundwater Release Assessment, SWMU 06/09
Demolition Area and Phase III Release
Characterization SWMU 07/09 Old Rifle Range
November 1995-Figure 11 by William L. Murphy and Roy Wade

Source: Palmer, 1969; Cited in Murphy and Wade, 1995

DRAWN BY J. LAMEY	DATE 4/26/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER N3959	OWNER NO. CTO 158
CHECKED BY J. SCHUBERT	DATE 7/31/02	STRATIGRAPHIC COLUMN NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY T. JOHNSTON	DATE 7/31/02
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-8	REV 1

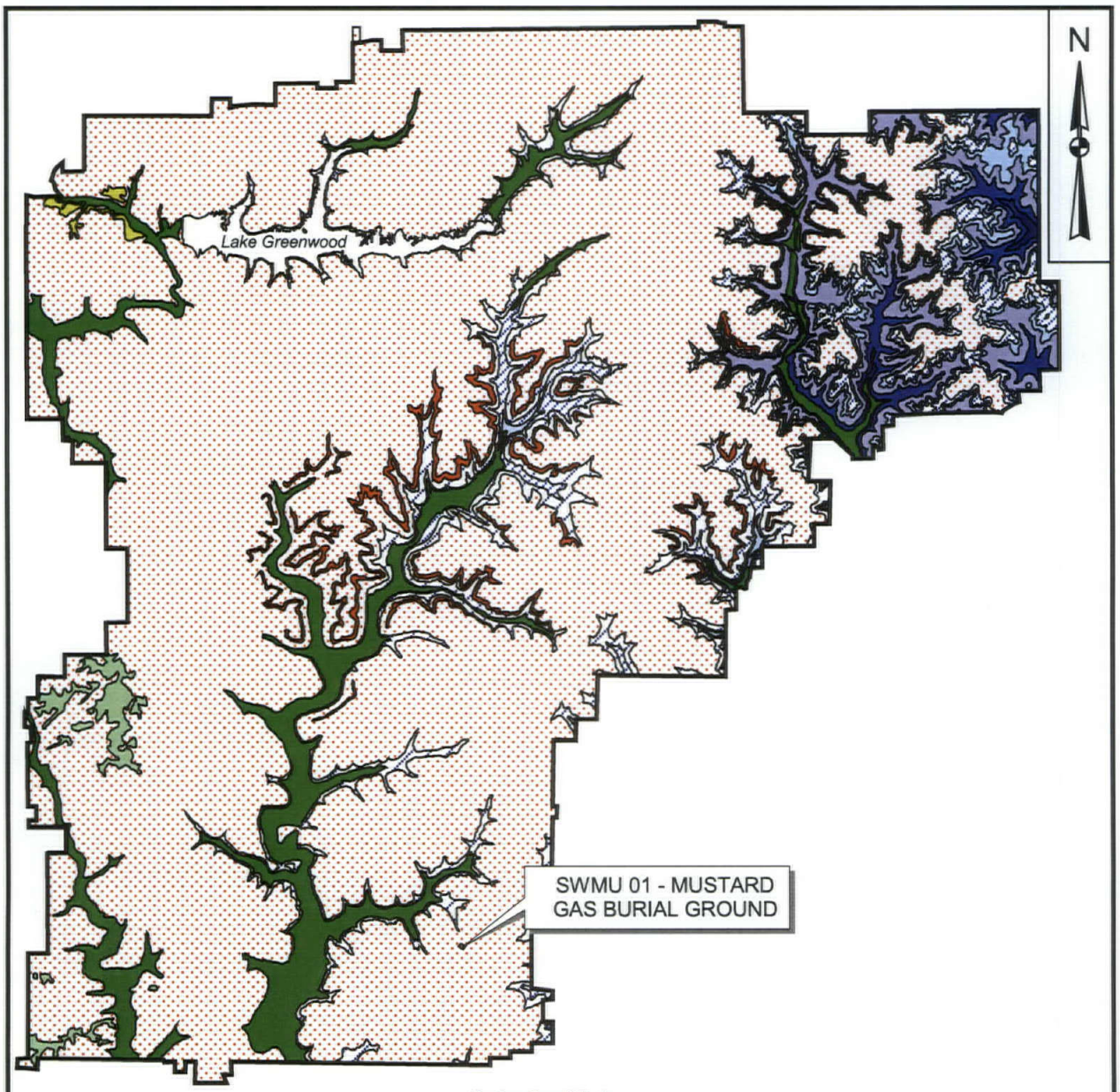
P:\GIS\NSWC_CRANE\SWMU01.APR STRATIGRAPHIC COLUMN 9/26/02 AJ



Taken from: Draft RFI Phase II Work Plan, Mustard Gas Burial Grounds.
Naval Weapons Support Center, Crane Indiana, August 1991.

DRAWN BY J. LAMEY — DATE 4/26/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 3959	OWNER NUMBER CTO 158
CHECKED BY T. JOHNSTON — DATE 12/13/02	LOCALIZED STRATIGRAPHY AND GROUND WATER ELEVATIONS SWMU 01 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY T. JOHNSTON	DATE 12/13/02
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 1-9	REV 0

P:\GIS\NSWC_CRANE\SWMU01.APR LOCALIZED GW ELEVATIONS 12/21/02 KMP



Explanation of Geology

- Qal — *Alluvium*
- Ql — *Loess*
- Qo — *Glacial Outwash*
- P — *Raccoon Creek Group and undifferentiated*
- Ps — *Sandstone-dominated horizon of Lower Pennsylvanian*
- Mg — *Glenn Dean Ls, Hardinsburg Fm, Haney Ls, Indian Springs Shale Mbr, and undifferentiated*
- M5 — *Sandstone member of the Big Clifty Fm*
- M4 — *Beech Creek Ls*
- M3 — *Elwren Fm, Reelsville Ls, upper Sample Fm, and undifferentiated*
- M2 — *Lower part of Sample Fm, Beaver Bend Ls, Bethel Fm, and undifferentiated*
- M1 — *Paoli Ls, Ste Genevieve Ls, and undifferentiated*

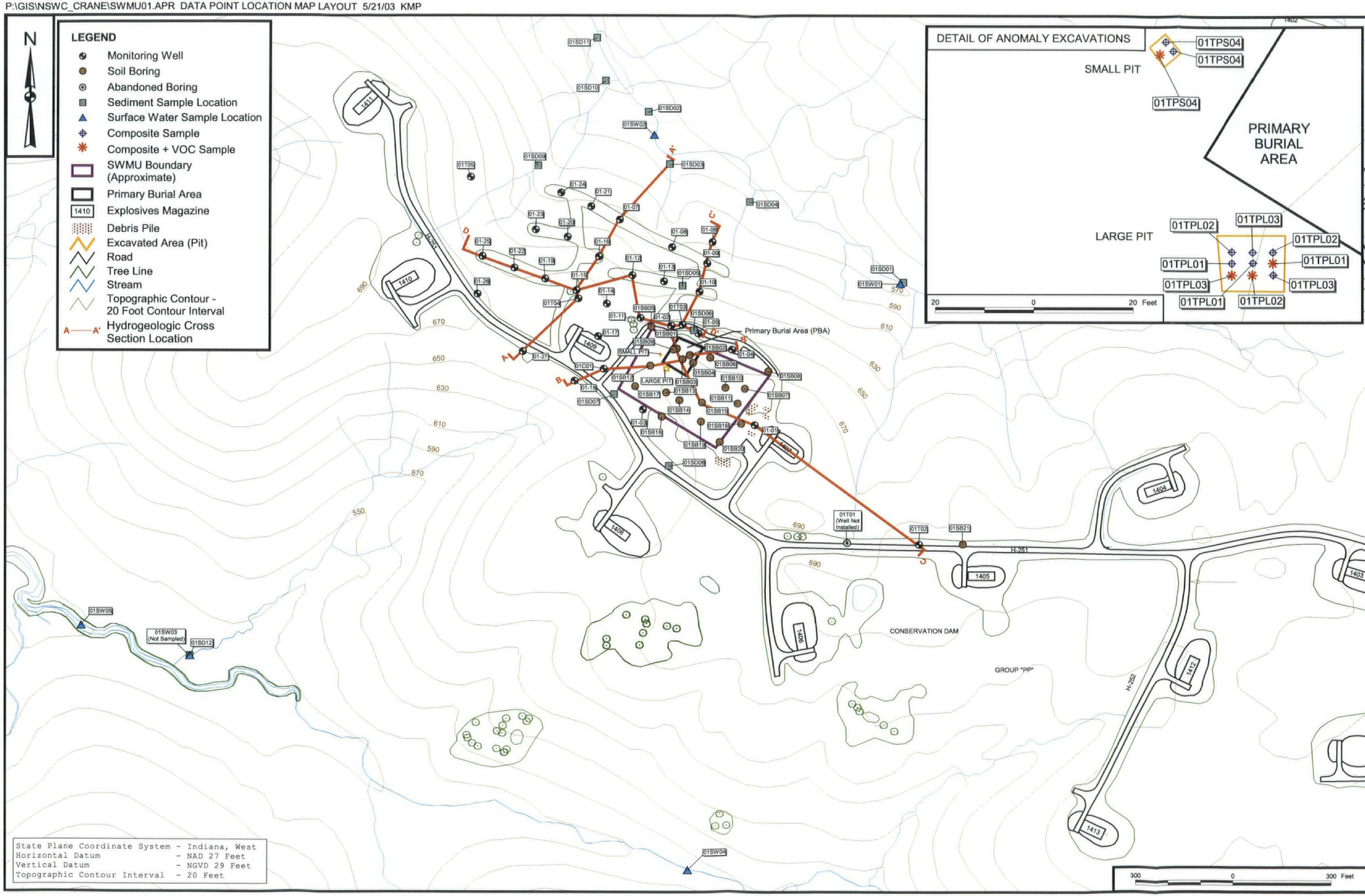
(Modified from Blunck, 1995)

2 0 2 Miles

DRAWN BY D. PERRY	DATE 3/15/99	Tetra Tech NUS, Inc.	CONTRACT NUMBER N3959	OWNER NO. CTO 158
CHECKED BY T. JOHNSTON	DATE 9/27/02	SURFICIAL GEOLOGY MAP NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	APPROVED BY T. JOHNSTON	DATE 9/27/02
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 1-10	REV 0

P:\GIS\NSWC_CRANE\0087.APR SURFICIAL GEOLOGY MGBG LAYOUT 9/27/02 AJ

P:\GIS\NSWC_CRANE\SWMU01.APR DATA POINT LOCATION MAP LAYOUT 5/21/03 KMP



State Plane Coordinate System - Indiana, West
Horizontal Datum - NAD 27 Feet
Vertical Datum - NGVD 29 Feet
Topographic Contour Interval - 20 Feet

CONTRACT NO. 3959

DATE 12/13/02

APPROVED BY T. JOHNSTON

DATE

APPROVED BY

DRAWING NO. FIGURE 1-11

REV 0

GEOLOGIC CROSS SECTIONS AND SAMPLING LOCATIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY * SOUTHERN DIV. FACILITIES ENGINEERING COMD

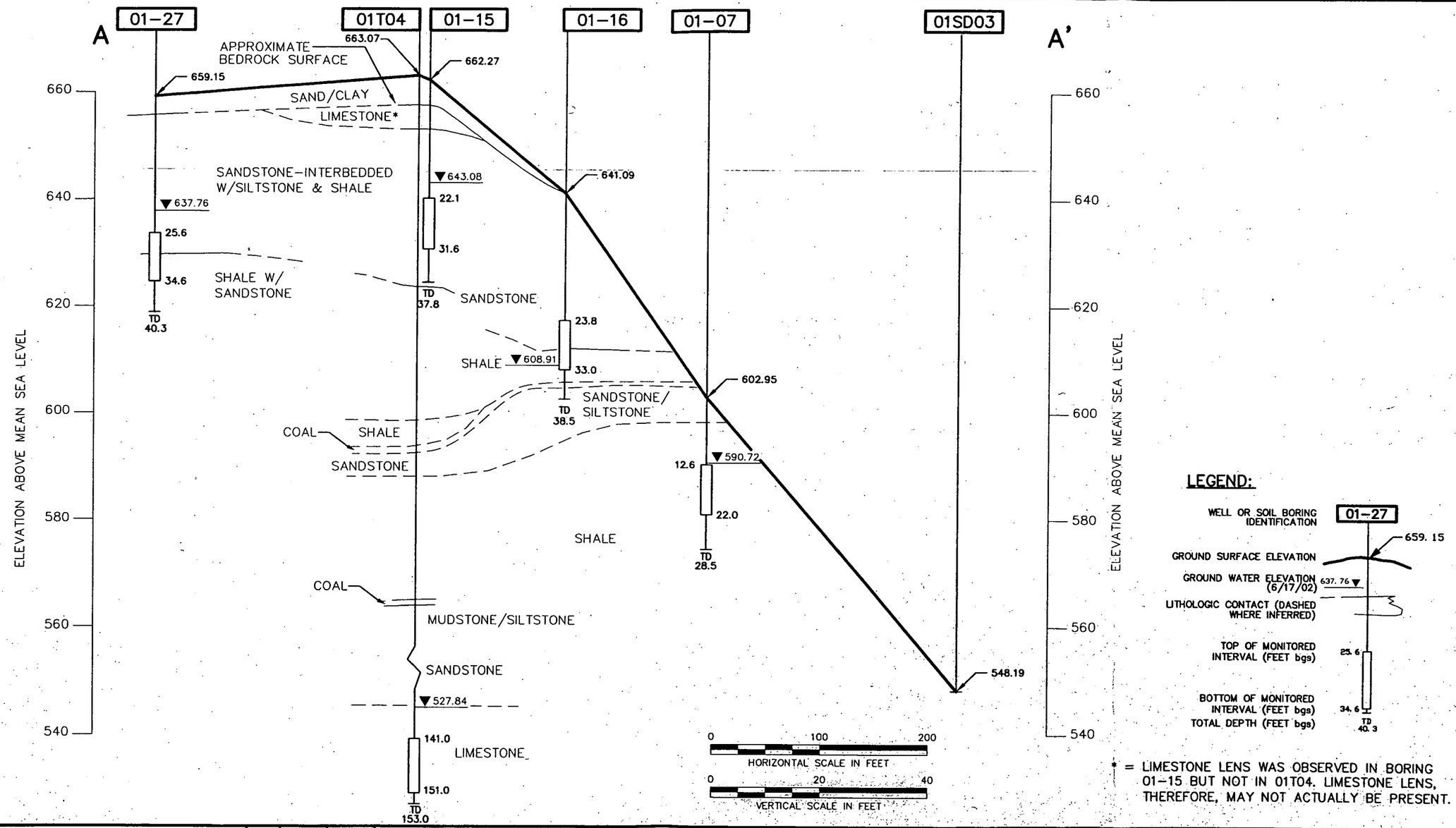
DRAWN BY A. JANOCHA — DATE 6/28/02

CHECKED BY K. SIMPSON — DATE 12/13/02

COST/SCHED-AREA

SCALE AS NOTED

ACAD: 3959GX06.DWG 12/05/02 HJB PIT



* = LIMESTONE LENS WAS OBSERVED IN BORING 01-15 BUT NOT IN 01T04. LIMESTONE LENS, THEREFORE, MAY NOT ACTUALLY BE PRESENT.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 9/25/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD

GENERALIZED HYDROGEOLOGIC CROSS SECTION A-A'
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. N3959
APPROVED BY TJ DATE 9/30/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-12
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

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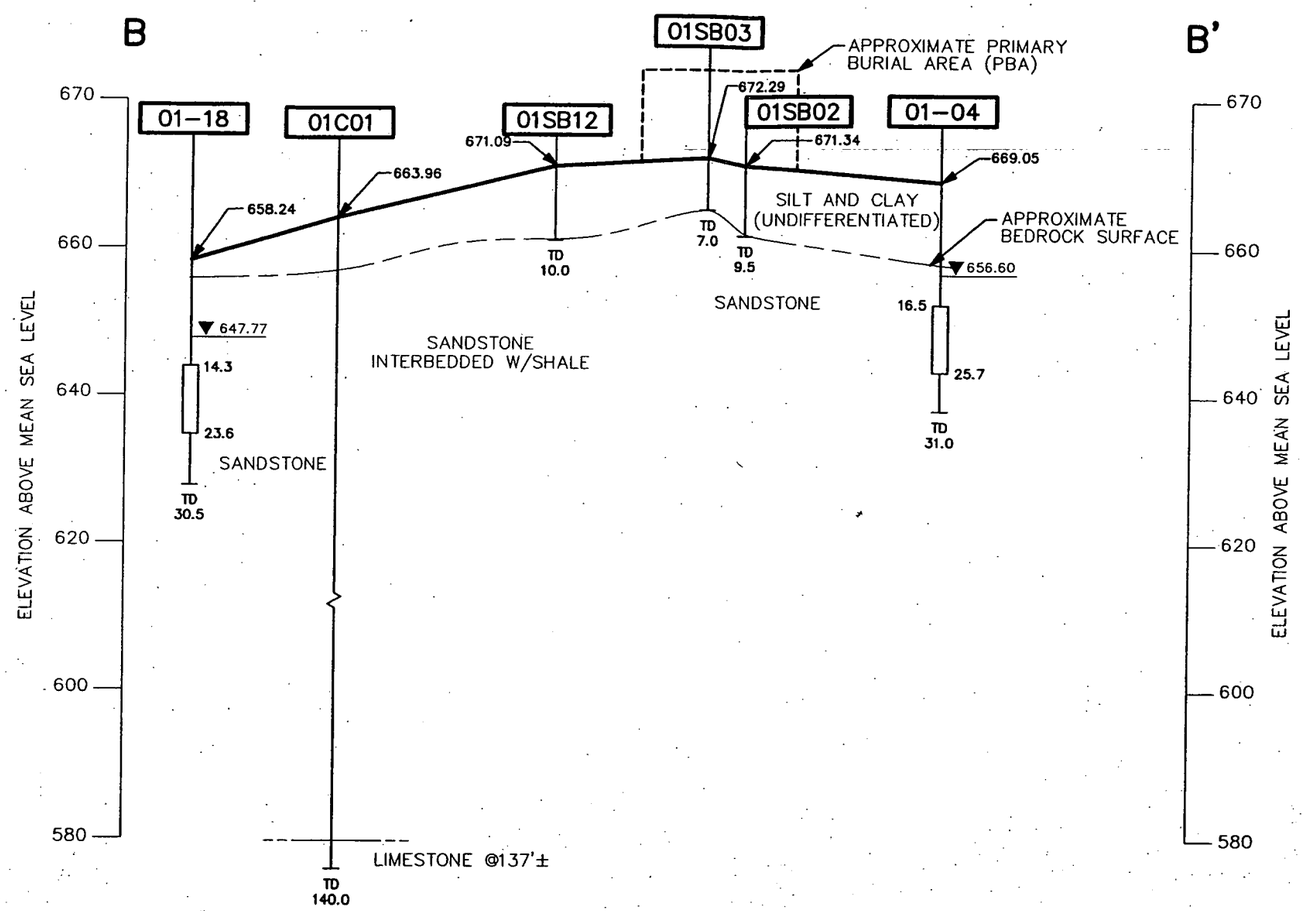

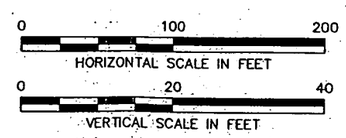

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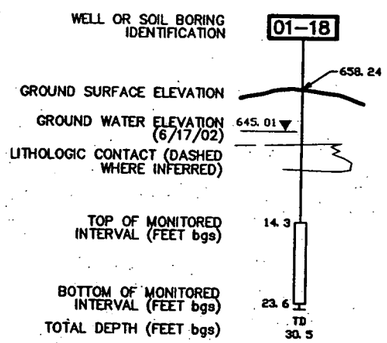


NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

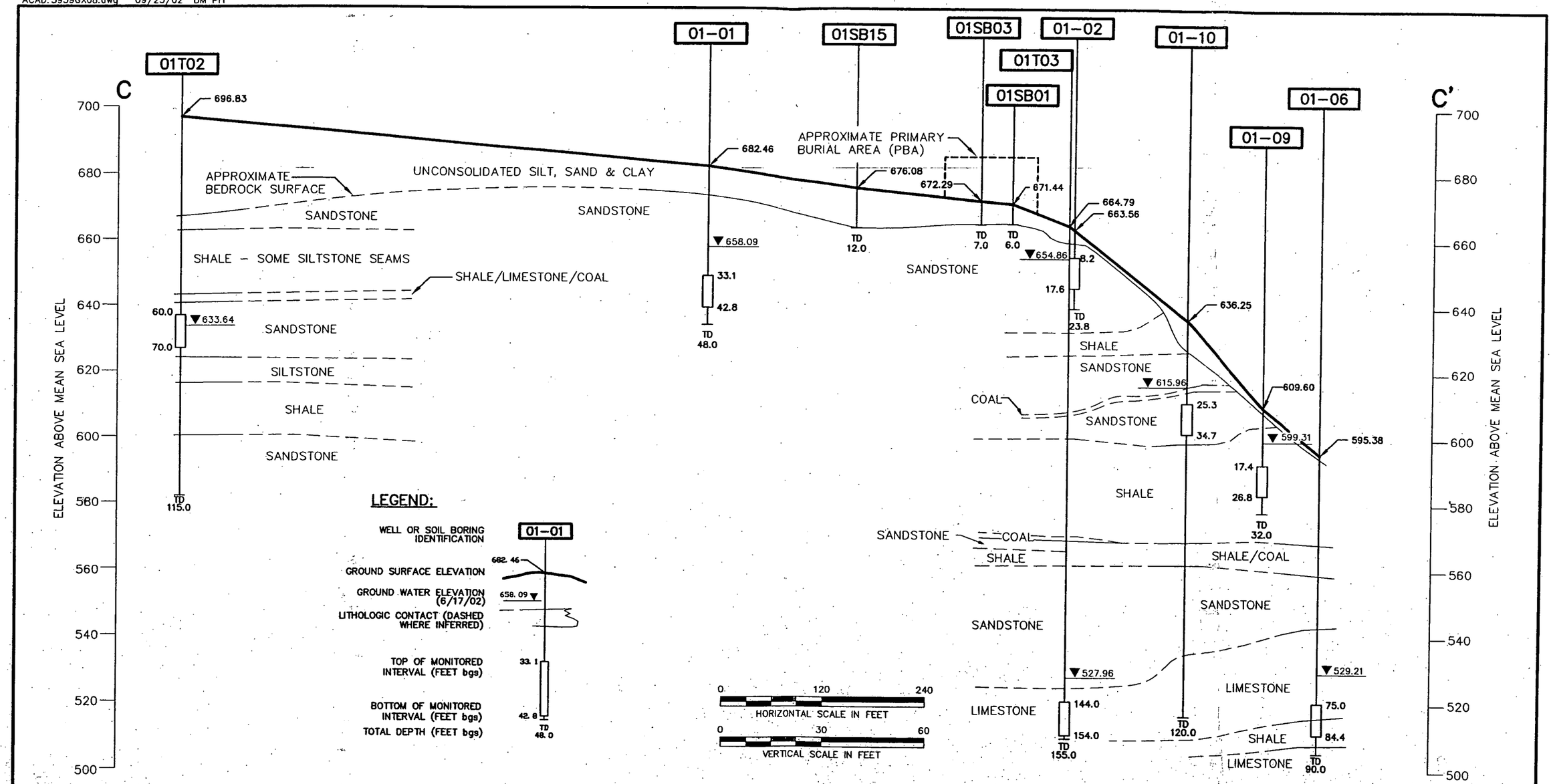
DRAWN BY DM DATE 9/25/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS-SECTION B-B'
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. N3959
APPROVED BY TJ DATE 9/30/02
APPROVED BY DATE
DRAWING NO. FIGURE 1-13 REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

ACAD: 3959GX08.dwg 09/25/02 DM PIT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

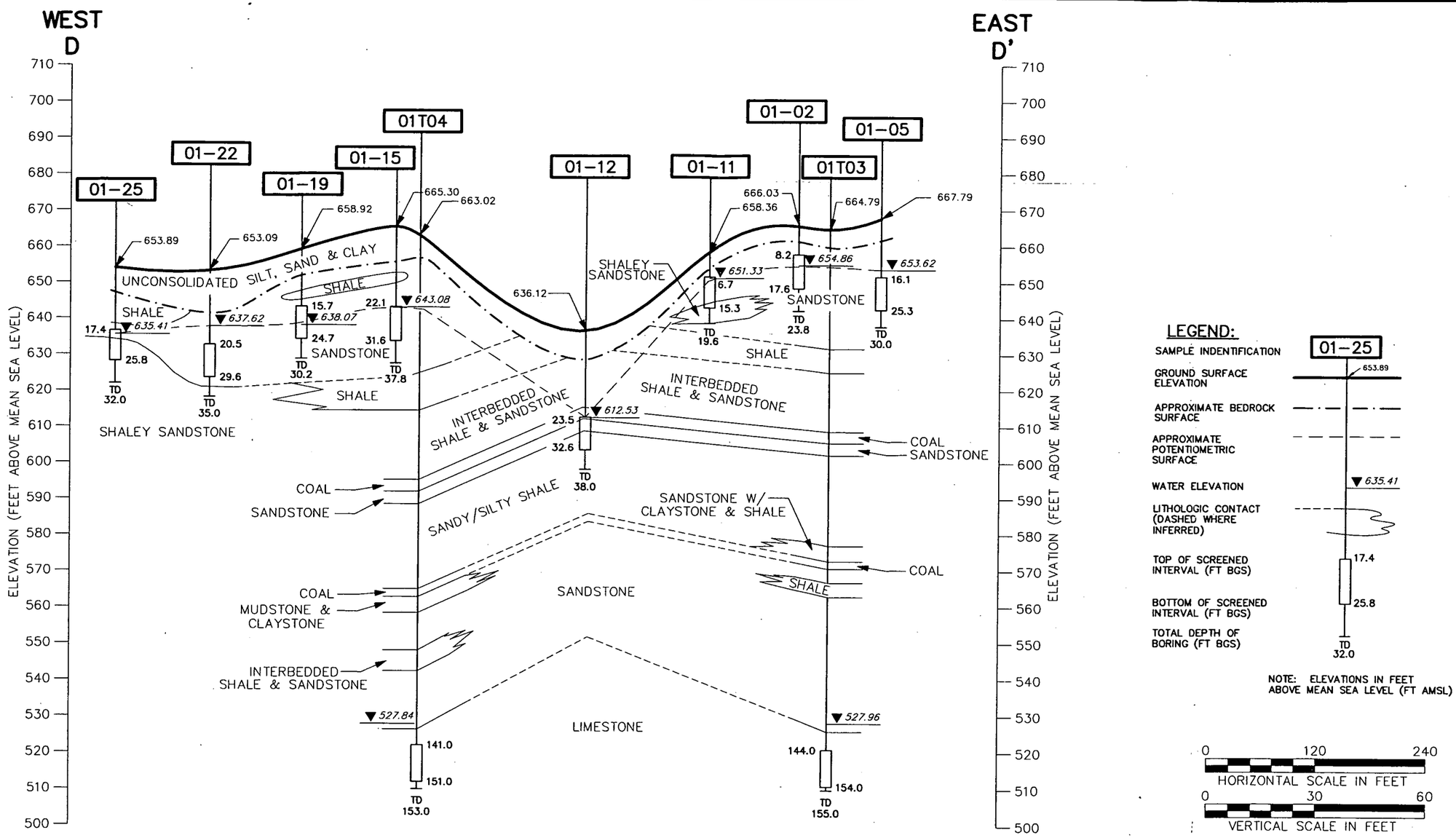
DRAWN BY DM DATE 9/25/02
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

GENERALIZED HYDROGEOLOGIC CROSS SECTION C–C'
SWMU 01 – MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. N3959
APPROVED BY TJ DATE 9/30/02
APPROVED BY DATE
DRAWING NO. FIGURE 1–14
REV. 0

FORM CADD NO. SDIV_BH.DWG – REV 0 – 1/20/98

ACAD: 3959GX10.dwg 05/22/03 MF PIT



LEGEND:

NOTE: ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL (FT AMSL)

0 120 240
HORIZONTAL SCALE IN FEET

0 30 60
VERTICAL SCALE IN FEET

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY DM DATE 5/14/03
CHECKED BY BMB DATE 5/22/03
COST/SCHED-AREA
SCALE: AS NOTED

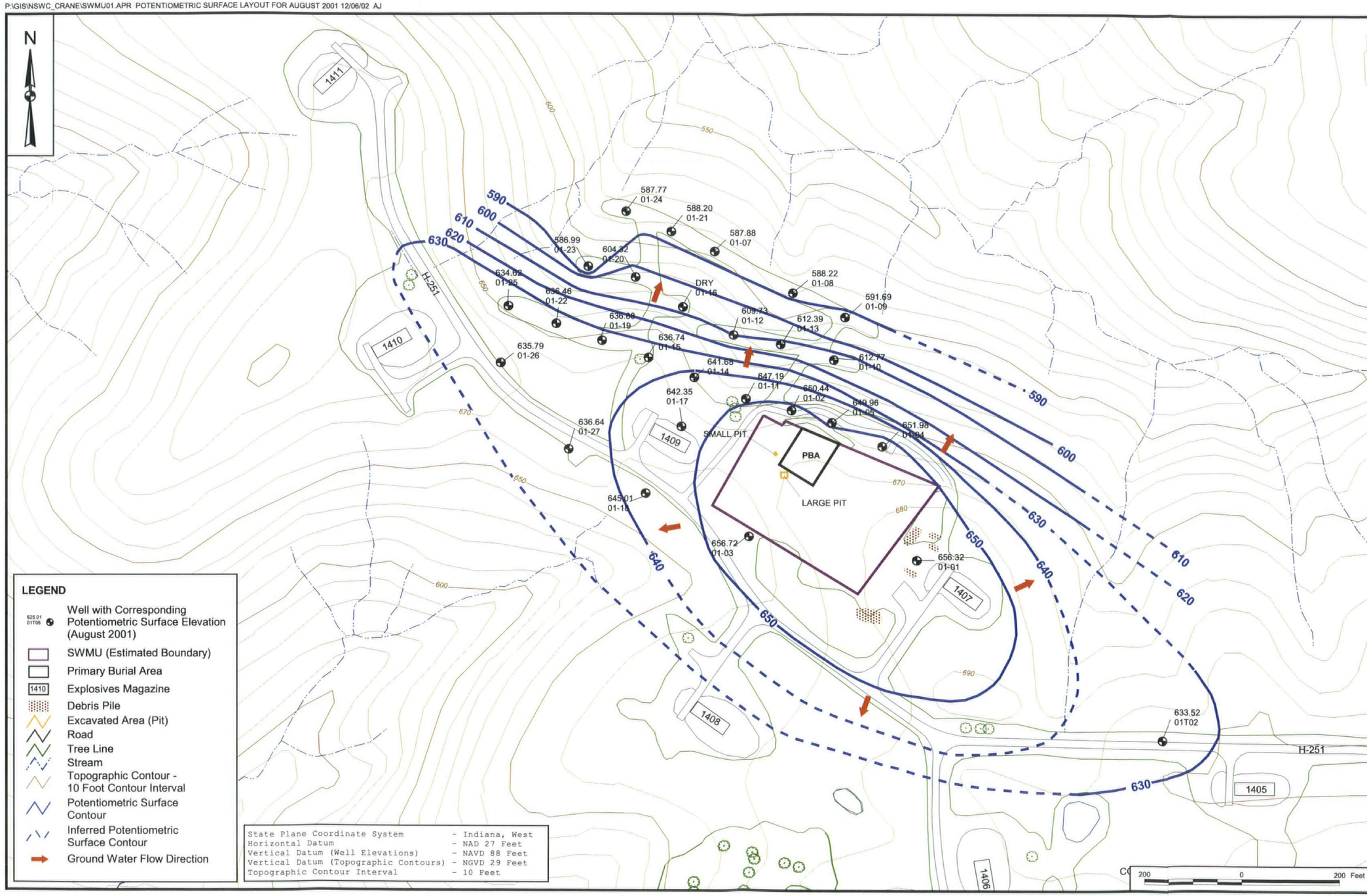
DEPARTMENT OF THE NAVY SOUTHERN DIV FACILITIES ENGINEERING COMD

GENERALIZED HYDROGEOLOGIC CROSS SECTION D-D'
SWMU 01-MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. 3959
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 1-15
REV. 0

FORM CADD NO. SDIV_BH.DWG - REV 0 - 1/20/98

P:\GIS\NSWC_CRANE\SWMU01.APR POTENTIOMETRIC SURFACE LAYOUT FOR AUGUST 2001 12/06/02 AJ



LEGEND

- Well with Corresponding Potentiometric Surface Elevation (August 2001)
- SWMU (Estimated Boundary)
- Primary Burial Area
- Explosives Magazine
- Debris Pile
- Excavated Area (Pit)
- Road
- Tree Line
- Stream
- Topographic Contour - 10 Foot Contour Interval
- Potentiometric Surface Contour
- Inferred Potentiometric Surface Contour
- Ground Water Flow Direction

State Plane Coordinate System	- Indiana, West
Horizontal Datum	- NAD 27 Feet
Vertical Datum (Well Elevations)	- NAVD 88 Feet
Vertical Datum (Topographic Contours)	- NGVD 29 Feet
Topographic Contour Interval	- 10 Feet

CONTRACT NO. 3959

APPROVED BY ____ DATE ____

APPROVED BY ____ DATE ____

DRAWING NO. FIGURE 1 - 16

REV 0

2001 POTENTIOMETRIC SURFACE MAP - SHALLOW WELLS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

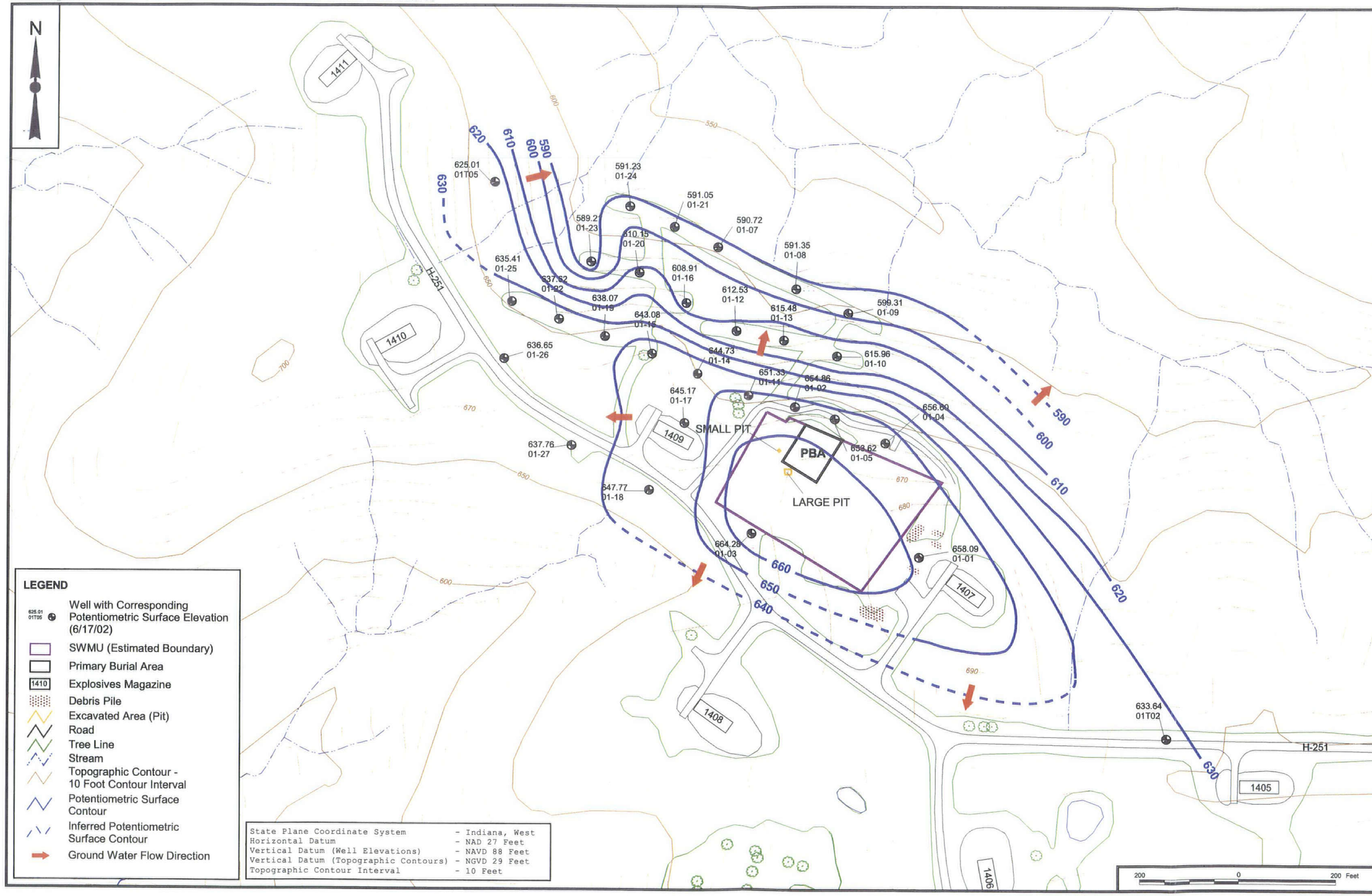
DRAWN BY A. JANOCHA DATE 12/06/02

CHECKED BY J. SCHUBERT DATE 12/06/02

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\SWMU01.APR DATA POINT POTENTIOMETRIC SURFACE LAYOUT - SHALLOW WELLS 10/21/04 AJ



LEGEND

- 625.01 01T05 — Well with Corresponding Potentiometric Surface Elevation (6/17/02)
- SWMU (Estimated Boundary)
- Primary Burial Area
- 1410 — Explosives Magazine
- Debris Pile
- Excavated Area (Pit)
- Road
- Tree Line
- Stream
- Topographic Contour - 10 Foot Contour Interval
- Potentiometric Surface Contour
- Inferred Potentiometric Surface Contour
- Ground Water Flow Direction

State Plane Coordinate System	- Indiana, West
Horizontal Datum	- NAD 27 Feet
Vertical Datum (Well Elevations)	- NAVD 88 Feet
Vertical Datum (Topographic Contours)	- NGVD 29 Feet
Topographic Contour Interval	- 10 Feet

CONTRACT NO. 3959

APPROVED BY T. JOHNSTON — DATE 10/21/04

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 1 - 17 — REV 1

2002 POTENTIOMETRIC SURFACE MAP - SHALLOW WELLS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

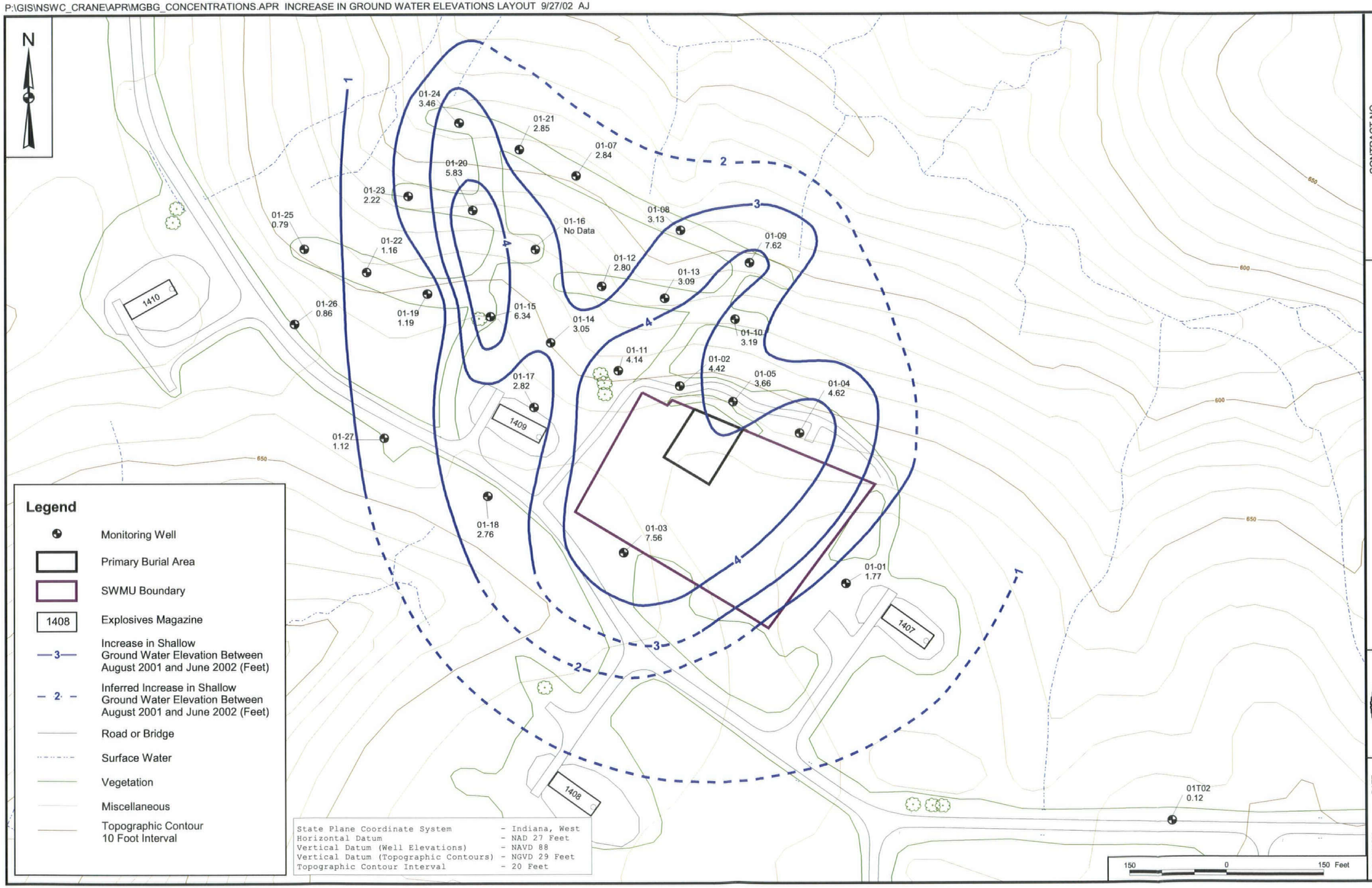
DRAWN BY A. JANOCHA — DATE 7/10/02

CHECKED BY T. JOHNSTON — DATE 10/21/04

COST/SCHED-AREA ___

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\MGBG_CONCENTRATIONS.APR INCREASE IN GROUND WATER ELEVATIONS LAYOUT 9/27/02 AJ



CONTRACT NO. N3959

APPROVED BY T. JOHNSTON — DATE 9/27/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 1 - 18 — REV 0

INCREASE IN SHALLOW GROUND WATER ELEVATIONS BETWEEN AUGUST 2001 AND JUNE 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

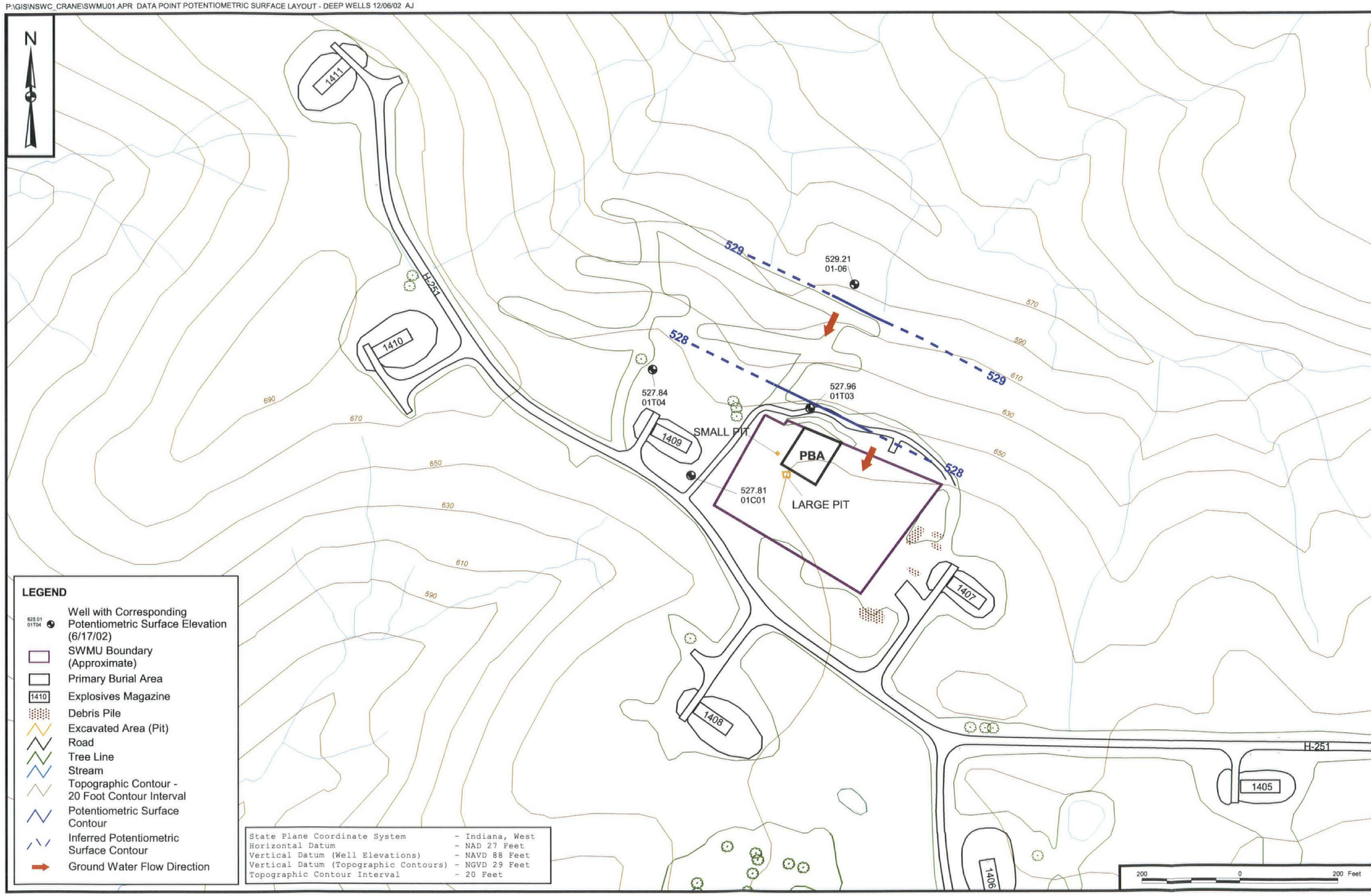
DRAWN BY A. JANOCHA — DATE 9/09/02

CHECKED BY J. SCHUBERT — DATE 9/11/02

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\SWMU01.APR DATA POINT POTENTIOMETRIC SURFACE LAYOUT - DEEP WELLS 12/06/02 AJ



CONTRACT NO.
N3959

APPROVED BY
T. JOHNSTON
DATE
7/31/02

APPROVED BY
DATE

DRAWING NO.
FIGURE 1-19

REV
0

2002 POTENTIOMETRIC SURFACE MAP - DEEP WELLS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD ★

DRAWN BY
A. JANOCHA
DATE
7/14/02

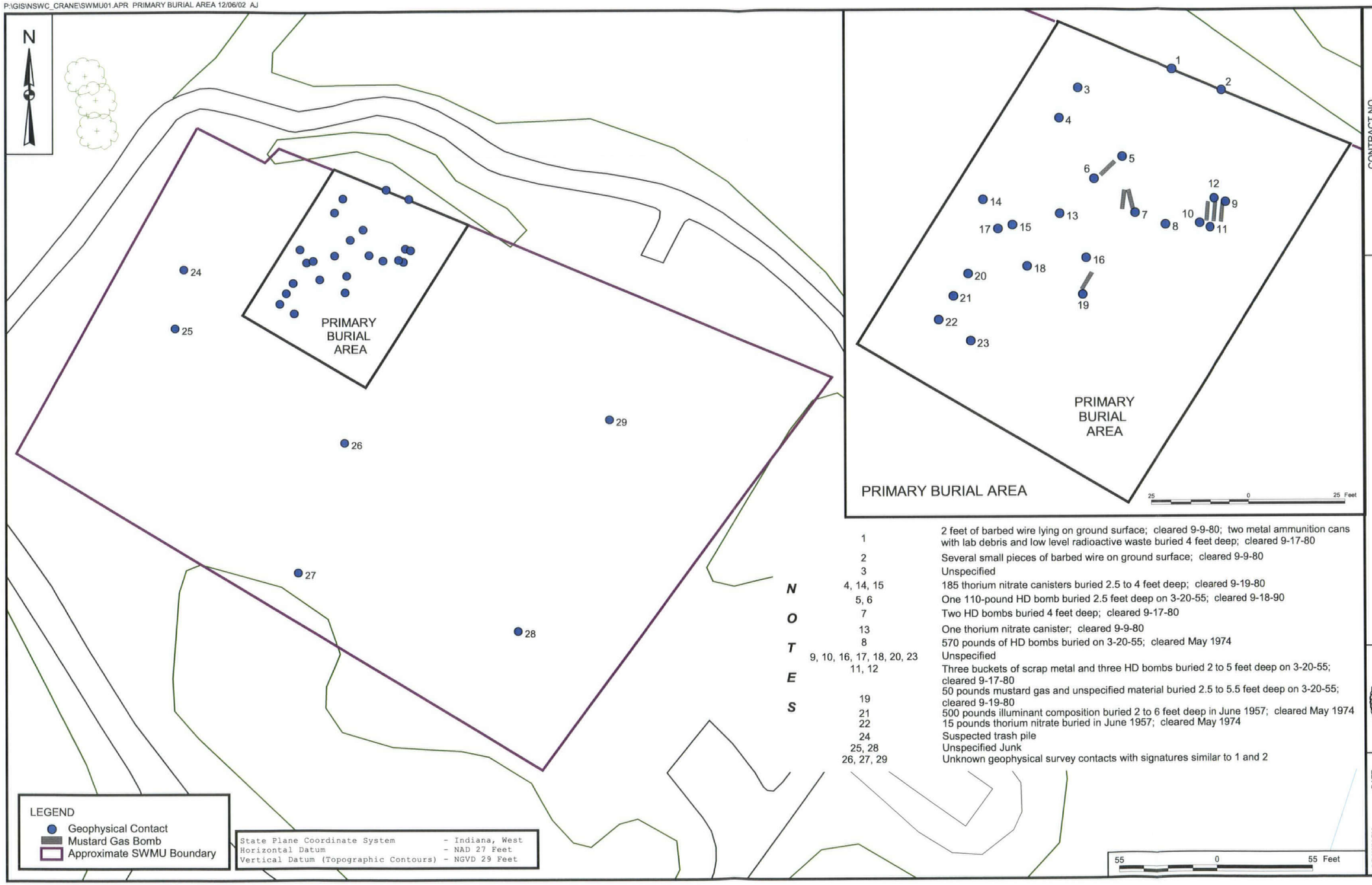
CHECKED BY
T. JOHNSTON
DATE
9/26/02

COST/SCHED-AREA

SCALE
AS NOTED

FIGURE 1-20
VIEW OVER DEBRIS PILES TOWARD MAGAZINE 1407
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

P:\GIS\NSWC_CRANE\SWMU01.APR PRIMARY BURIAL AREA 12/06/02 AJ



NOTES

1	2 feet of barbed wire lying on ground surface; cleared 9-9-80; two metal ammunition cans with lab debris and low level radioactive waste buried 4 feet deep; cleared 9-17-80
2	Several small pieces of barbed wire on ground surface; cleared 9-9-80
3	Unspecified
4, 14, 15	185 thorium nitrate canisters buried 2.5 to 4 feet deep; cleared 9-19-80
5, 6	One 110-pound HD bomb buried 2.5 feet deep on 3-20-55; cleared 9-18-90
7	Two HD bombs buried 4 feet deep; cleared 9-17-80
13	One thorium nitrate canister; cleared 9-9-80
8	570 pounds of HD bombs buried on 3-20-55; cleared May 1974
9, 10, 16, 17, 18, 20, 23	Unspecified
11, 12	Three buckets of scrap metal and three HD bombs buried 2 to 5 feet deep on 3-20-55; cleared 9-17-80
19	50 pounds mustard gas and unspecified material buried 2.5 to 5.5 feet deep on 3-20-55; cleared 9-19-80
21	500 pounds illuminant composition buried 2 to 6 feet deep in June 1957; cleared May 1974
22	15 pounds thorium nitrate buried in June 1957; cleared May 1974
24	Suspected trash pile
25, 28	Unspecified Junk
26, 27, 29	Unknown geophysical survey contacts with signatures similar to 1 and 2

CONTRACT NO. N3959

APPROVED BY T. JOHNSTON — DATE 8/31/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 1-21 — REV 0

PREVIOUSLY EXHUMED GEOPHYSICAL CONTACTS (ESTIMATED LOCATIONS)
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

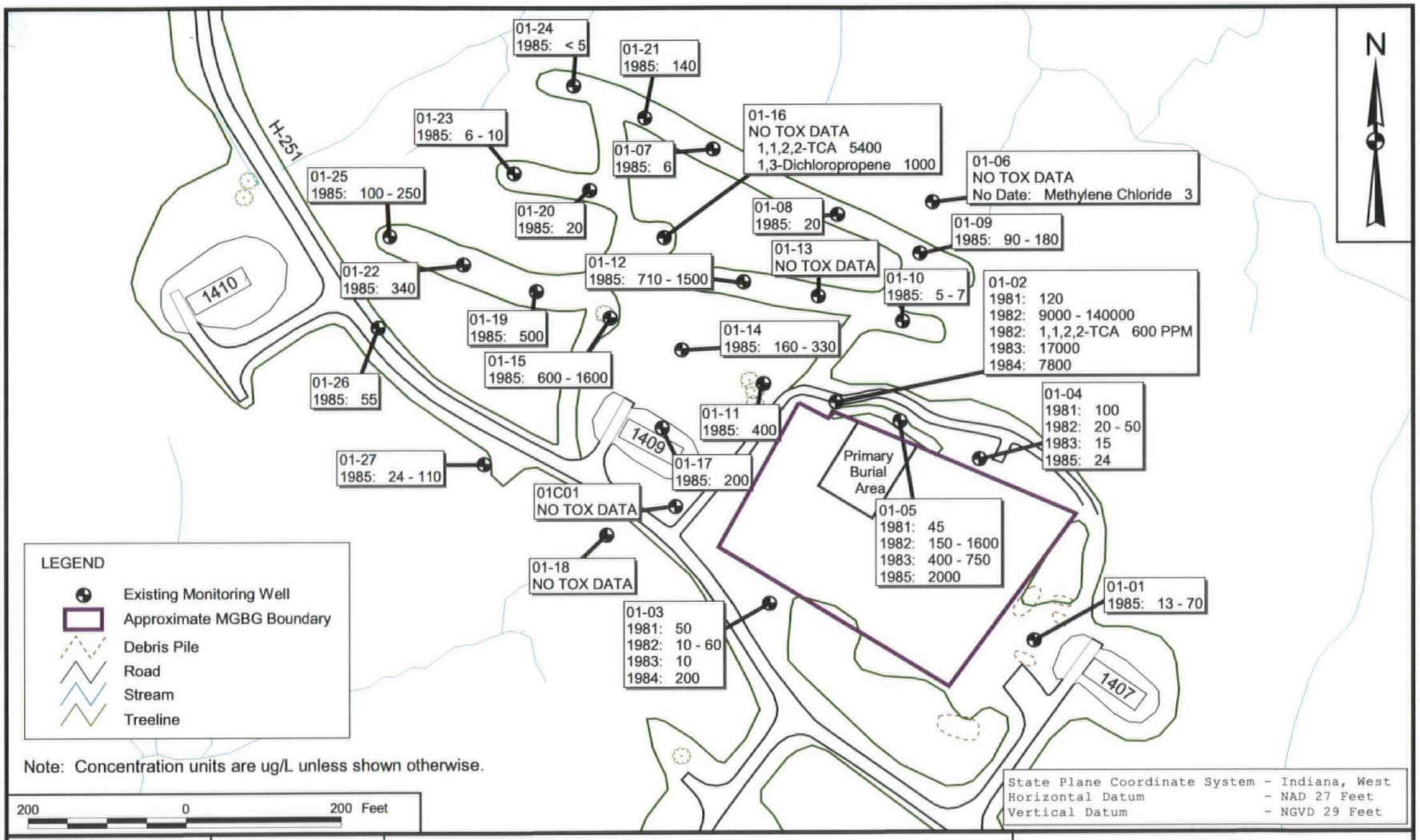
DEPARTMENT OF THE NAVY * SOUTHERN DIV. NAVAL FACILITIES ENGINEERING COMD *

DRAWN BY J. LAMEY — DATE 8/29/02

CHECKED BY T. JOHNSTON — DATE 9/26/02

COST/SCHED-AREA

SCALE AS NOTED



DRAWN BY	DATE
J. LAMEY	8/31/02
CHECKED BY	DATE
T. JOHNSTON	9/27/02
COST/SCHEDULE-AREA	
SCALE	
AS NOTED	

TOTAL ORGANIC HALOGEN (TOX) DATA (APPROXIMATE)

1981 - 1986

SWMU 01 - MUSTARD GAS BURIAL GROUND

NAVAL SURFACE WARFARE CENTER CRANE

CRANE, INDIANA

CONTRACT NUMBER	
N3959	
APPROVED BY	DATE
T. JOHNSTON	9/27/02
APPROVED BY	DATE
—	—
DRAWING NO.	REV
FIGURE 1-22	0

P:\GIS\NSWC_CRANE\SWMU01.APR TOTAL ORGANIC HALOGEN DATA 12/06/02 AJ

2.0 FIELD INVESTIGATION

This section presents sampling activities, procedures, and documentation utilized during field operations performed in 2001 and 2002 for the MGBG SWMU 01 at NSWC Crane.

2.1 OVERVIEW

Phase III RFI field activities were conducted July through September 2001 (Round 1) and May through June 2002 (Round 2). All work was performed in accordance with the procedures and methodologies described in the U.S. EPA approved MGBG QAPP (TtNUS, 2001b) for Rounds 1 and 2, including the approved SAP (TtNUS, 2002b) for Round 2. Appropriate referenced standard operating procedures (SOPs) included in Appendix H of the MGBG QAPP and Appendix A of the Round 2 SAP were followed during both Round 1 and Round 2 field activities conducted at the MGBG. Copies of all field notes/records and field logbooks are provided in Appendices A through D of this document (Volume 2 of 2), as follows:

- A Boring Logs and Monitoring Well Construction Sheets
- B Sample Log Sheets and Other Field Forms
  - B-1 Monitoring Well Inspection Sheets
  - B-2 Monitoring Well Development Records
  - B-3 Anomaly Excavation with Test Pit Logs and Soil Sample Log Sheets
  - B-4 Ground Water Sample Log Sheets with Low Flow Purge Data Sheets and Natural Attenuation Parameter Sheets
  - B-5 Water Level Measurement Sheets, and Hydraulic Conductivity and Seepage Velocity Calculations
  - B-6 Soil Sample Log Sheets
  - B-7 Surface Water Sample Log Sheets
  - B-8 Sediment Sample Log Sheets
  - B-9 Chain of Custody Records
  - B-10 Field Task Modification Request Forms
  - B-11 Equipment Calibration Logs
- C Site Log Book and Field Log Books
- D Land Survey Data

2.2 MOBILIZATION / DEMOBILIZATION

Following approval of the appropriate documents cited in Section 2.1, TtNUS began mobilization activities. All field team members reviewed the appropriate documentation for each round prior to the start of project activities.

Prior to the initiation of both rounds of fieldwork, the field operations leader (FOL) arrived at the site and began on-site mobilization activities. These activities included coordination with Base personnel and utility clearance of all drilling and excavation locations. Utility clearances (dig permits) were issued through NSWC Crane Public Works. NSWC Crane also provided building space for use as the TtNUS field office. The equipment required for the field activities was shipped to the site from the TtNUS Pittsburgh warehouse and equipment vendors.

A subcontractor was procured to clear brush from a portion of the MGBG site during Round 1. Brush clearing improved layout conditions for soil borings and provided access to the ground surface for unexploded ordnance (UXO) avoidance.

Additional rented facilities including two field trailers (for field screening and decontamination equipment), two 1500-gallon water storage tanks (potable and gray water), a diesel generator, and a portable toilet were set up in the vicinity of the MGBG to meet the requirements of the Health and Safety Plan (HASP) and to facilitate the Round 1 fieldwork. The field screening trailer housed instrumentation and laboratory apparatus (i.e., bake ovens, vented hood, etc.) needed for the screening of chemical warfare agents, chemical hazards, and radiological hazards. The decontamination trailer was used for personnel decontamination and housed three showering units and storage space for clean personal protective equipment (PPE). A fenced temporary investigation-derived waste (IDW) satellite storage area and a barricaded compressed gas cylinder storage area were set up near the field trailers. NSWC Crane Navy personnel approved the locations of all the above site facilities to ensure adequate distance outside the buffer zone of the closest explosives magazine. NSWC Crane personnel (including Navy explosion safety, Army safety, Army storage and security) were contacted prior to work start up, and a NSWC Crane fire inspector inspected the site and issued a "hot work permit" prior to the start up of the generator. Photographs showing the MGBG site and select operations are included as Figure 2-1. Keys showing the viewing directions of the photographs are provided in Figures 2-2 and 2-3.

After each round of field activities, the FOL was responsible for the decontamination and demobilization of all equipment and cleaning of the field facilities.

At the completion of the Round 1 sampling event (September 2001), gray water from the shower trailer was transported to Building 3245 and discharged into the NSWC Crane permitted waste treatment plant, in accordance with NSWC Crane-approved practice.

During Round 2, the drilling subcontractor used a bulldozer to clear vegetation to provide access for one of the three drilling locations, monitoring well 01T05. This access road is shown in Figures 2-1e and 2-1f.

2.2.1 Restoration and Revegetation

TtNUS and its subcontractors performed site restoration on any areas impacted by drilling and/or heavy equipment (backhoe and bulldozer) activities at SWMU 01. Approximately 30 pounds of seed were broadcast and 45 bails of straw were spread over the seeded areas. In an effort to facilitate erosion control, special attention was given to the cleared area at 01T05 that was in close proximity to an intermittent stream and on a slope. Photographs of the restored areas are presented in Figures 2-1g through 2-1k.

2.3 SUBSURFACE INVESTIGATION METHODOLOGIES AND PROCEDURES

2.3.1 Direct-Push Technology Drilling

The direct-push technology drilling (DPT) method was used to complete a total of 21 soil borings during Round 1 (20 MGBG site borings and 1 offsite background location). No DPT activities were conducted during Round 2. Figure 1-11 shows the locations of all 21 soil borings completed as part of Phase III RFI activities. The DPT method involves pushing sampling tools hydraulically and/or mechanically downward into the ground to the desired depth. Soil samples were collected from borings for chemical analyses and for lithologic logging. Each boring was advanced to a total depth of 10 feet or refusal. Soil sample collection information is provided in Section 2.7.2. Refusal was encountered in 19 of the 21 soil borings at depths shallower than 10 feet. Borings 01SB08 and 01SB15 were advanced to 10 feet bgs. All soil borings were installed as described in the MGBG QAPP for Round 1.

2.3.2 Air Rotary Coring

A total of five borings were drilled using air rotary coring methods, two in Round 1 and three in Round 2. Four of the borings were converted into monitoring wells and 1 boring was abandoned. Boring 01T01 was abandoned as a dry hole, and boring 01T02 was converted into a monitoring well during Round 1. Round 2 drilling actives included the installation of three borings (01T03, 01T04 and 01T05), and all were converted into monitoring wells (Figure 1-11). The five borings and the four converted monitoring wells

were installed as described in the MGBG QAPP (Rounds 1 and 2) and SAP (Round 2). Rock cores collected from the five borings to investigate the degree of bedrock fracturing were placed into labeled core boxes and turned over to the NSWC Crane Environmental Protection Department for storage.

2.3.3 Borehole and Sample Logging

The TtNUS geologist maintained a log for each boring in accordance with the Drilling and Geologic Logging of Boreholes in Rock SOP found as an Appendix in the MGBG QAPP and the Round 2 SAP. At a minimum, the boring logs contained the following information:

- Well identification (where applicable)
- Boring identification
- Name of geologist logging the boring
- Name of drilling contractor
- Sample numbers and types
- Sample depths
- Sample recovery and sample interval
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material description
- Rock type and description, recovery, and rock quality designation (RQD)
- Location of boring
- Drilling and/or well construction problems or deviations from the project-specific QAPP
- Date(s) of drilling
- Screening instrument readings

In addition, depths of changes in lithology, sample moisture observations, depth to water, presence of organic vapor using a photoionization detector (PID) or flame ionization detector (FID), drilling methods, and total depth of each borehole were included on each log, as well as any other pertinent observations. All borings were drilled and logged in accordance with the appropriate SOPs. Logs for the 26 borings drilled as part of the Phase III RFI and all the historical boring logs are included in Appendix A of this document.

2.3.4 Borehole Abandonment

Proposed background monitoring well location 01T01 was dry at 120 feet bgs and was backfilled with a cement-bentonite slurry using a tremie pipe from the bottom up to the ground surface. The 21 DPT soil borings were backfilled with bentonite chips and hydrated in accordance with the manufacturer's specifications. The ground surface at all boring locations was restored to its original condition.

2.4 AVOIDANCE OF UNEXPLODED ORDNANCE AND MUSTARD GAS AND RADIOLOGICAL SCREENING

Avoidance of UXO and mustard gas and radiological screening were performed as precautionary measures at borings drilled within the SWMU boundary.

Waste burial was believed to be no deeper than 6 feet bgs at the MGBG; however, as an added safety precaution screening to 10 feet was performed. Prior to, and during drilling, each boring was screened for the presence of UXO. Avoidance of UXO consisted of the following steps:

(1) Scanned the ground surface in the vicinity of the proposed drilling location with a magnetic locator.
(2) Drilled vertically and sampled 2 feet of soil.
(3) Removed the drilling and soil sampling equipment from the hole.
(4) Moved all drilling and soil sampling equipment at least 20 feet away from the hole to avoid any interference with the magnetic locator.
(5) Scanned (down hole) for magnetic anomalies in the newly drilled section of the hole.
(6) Repeated steps 2, 3, 4 and 5 until a depth of 10 feet was reached.

Details regarding UXO avoidance procedures are found in SOP CTO131-1, located in Appendix H of the MGBG QAPP. The types of geophysical equipment that were used to perform the UXO avoidance are listed in Table 4-1 of the QAPP.

In addition to UXO, there was a potential for field personnel performing sampling activities at the MGBG site to be exposed to mustard gas and radioactivity. Therefore, prior to, and during drilling and anomaly excavation activities, all locations within the SWMU were scanned and screened for mustard gas and radioactivity. After soils were brought to the surface, they were scanned for gross beta and gamma activity (see SOP CTO131-2 in MGBG QAPP Appendix H). Samples were collected every 2 feet and screened for mustard gas using the headspace screening method (see SOP CTO131-3 in MGBG QAPP Appendix H). No metallic objects or discolored soil materials were encountered and no positive detections

of mustard gas or above-background measurements of VOCs or radioactivity were noted during the field investigation.

2.5 MONITORING WELL INSTALLATION AND DEVELOPMENT

2.5.1 Well Installation

Four monitoring wells were installed during Phase III RFI field operations at the MGBG in accordance with SOP CTO131-14 (See Figure 1-11). One new monitoring well (01T02) was installed during Round 1 and three monitoring wells (01T03, 01T04 and 01T05) were installed during Round 2. Two of the Round 2 monitoring wells, 01T03 and 01T04 were installed as deep wells adjacent to existing shallow wells 01-02 and 01-15, respectively. One shallow well, (01T05) was installed approximately 230 feet north-northwest of existing well 01-25. The borings for the four monitoring wells were drilled using air rotary coring methods as described in Section 2.3.2. The deep well borings (01T02, 01T03 and 01T04) were drilled through the overburden and into the bedrock, and a 6-inch diameter steel casing was installed and pressure grouted in place to isolate shallow ground water from deep ground water. The casing was installed in the shale confining unit and allowed to cure for a minimum of 24 hours prior to resuming drilling into the deep ground water unit. After the boring was drilled to the desired depth, a 2-inch-diameter polyvinyl chloride (PVC) Schedule 40 well screen was set, and the riser pipe was lowered into the boring through the steel isolation casing. All well screens were 10 feet in length.

After the screen and the riser pipe were in place, the annulus of the boring was backfilled with clean silica sand from the bottom of the boring to 1 foot above the top of the well screen. A 2 foot-thick bentonite pellet seal was then installed and allowed to hydrate in accordance with the manufacturer's recommendations. The remainder of the annulus of the borehole (from the bentonite seal to the ground surface) was grouted by pumping a cement/bentonite slurry through a tremie pipe until the grout reached the level where the concrete apron was placed. The depth of the backfill materials was continuously monitored during the installation of the monitoring wells using a weighted steel tape measure to ensure that the sand pack or bentonite did not bridge during the installation process. Indiana State well installation requirements in 310 IAC 16 were followed for all well installation activities. Well construction logs were completed for each well and are presented in Appendix A. Monitoring well construction information and water level measurements for the site are recorded in Table 2-1. Figures 2-1h through 2-1k, show a typical installed well and revegetated areas.

2.5.2 Monitoring Well Protection

After each monitoring well was installed and the annulus grouted to the land surface, a 4-inch square steel protective casing with a locking cap was cemented in place over the riser pipe. This stick-up-type protective casing extended approximately 2.5 feet above and 2.5 feet below the ground surface. A drain hole was drilled into the protective casing approximately 6 inches above the ground surface. Pea gravel was used to fill the space between the outer protective casing and the riser pipe. A 3-foot-square and 6-inch-thick concrete apron was cemented in place around the protective casing, and four safety yellow barrier posts (nominal 4-inch-diameter, 7-foot-long steel pipes buried 4 feet deep and filled with concrete) were cemented just outside the four corners of the concrete apron.

To maintain well security, a lock was placed on the locking cap of each well.

2.5.3 Monitoring Well Repair and Development

All existing wells sampled as part of this investigation were inspected, repaired as needed, and redeveloped during Round 1. Inspection reports are included as Appendix B of this document. The repairs made included:

- Replacing broken PVC risers at monitoring wells 01-06, 01-07 and 01-15.
- Replacing the cement pad at monitoring well 01-07.
- Backfilling a hole near well 01-23 with powdered bentonite and limestone gravel to the surface. The hole was approximately 6 to 8 inches in diameter, estimated at 3 to 4 feet deep, and was thought to have been created by animals or possibly by erosion.
- Marking the top of all PVC riser pipes for use as a reference point for water level measurements and surveying.

All newly installed monitoring wells were developed by surging and pumping methods no sooner than 24 hours after installation to remove fine material from around the well screen and the sand filter pack that surrounds the well screen. If the well was pumped dry, TtNUS personnel typically waited 20 to 30 minutes, noted the rate of recharge, and then pumped the well dry at least a second time in an effort to maximize the amount of fine material removed.

During Round 1, 28 existing monitoring wells and one newly installed monitoring well were developed. Wells less than 60 feet in depth were developed by inserting a 2-inch surge block into the well and surging over the length of the saturated screen for a minimum of 5 minutes. Immediately after surging, a submersible Whale® pump was lowered into the well and was pumped in accordance with SOP CTO131-15 (see Appendix H of the MGBG QAPP). Wells greater than 60 feet in depth (01-06, 01C01 and 01T02) were surged and purged using the Watteria® method. The Watteria® method involved attaching a decontaminated foot valve to new ¾-inch polyethylene tubing, extending the tubing to the bottom of the well, and both surging and purging by moving the tubing in an up and down motion. On the downward stroke, the ball in the foot valve lifts and the tubing fills with water and on the upward stroke, the ball is set and surged ground water is forced out of the tubing and into a purge bucket. All three of the wells developed using the Watteria® method were purged until dry and allowed to recharge several times. Section 2.14 describes the disposal of all IDW including development fluids.

During Round 2, the three newly installed monitoring wells (01T03, 01T04 and 01T05) were developed using a submersible Grundfos® pump in accordance with SOP 4 contained in Appendix A of the Round 2 SAP. None of the existing wells at the MGBG were redeveloped during Round 2.

Water-quality parameters (pH, specific conductivity, temperature, and turbidity), pumping rates, volume of ground water removed, recharge rates, and water levels were recorded on monitoring well development records during both rounds. Monitoring well development records for each well can be found in Appendix B-2 of this document.

2.6 GEOPHYSICAL ANOMALY EXCAVATIONS

During the 1995 USACE WES geophysical survey at the MGBG, two anomalies were detected and mapped (USACE WES, 1997). The approximate locations of the anomalies, both reported to be within 2 feet of the ground surface, are depicted in the MGBG QAPP, Figure 4-1. The larger anomaly, located south of the PBA, had been dubbed the "horse trough" anomaly because it was believed that a horse trough used in a previous investigation had been discarded in that location and covered with earth. No particular designation was given to the other smaller anomaly located west of the PBA.

Although the anomalies are identified in historical records as containing non-ordnance related debris, they remained a concern because of their unknown identities and the history of bomb burials at the site. Given the locations of the anomalies near a bomb burial area, it was thought that the anomalies could be mustard gas bombs or ordnance-related debris. There was no expectation that the anomalies were

associated with chemical or radiological contamination, although the potential for such association did exist.

The anomaly investigation was performed with the intention of finding and removing the materials causing the two geophysical anomalies previously mapped near of the PBA. Details of the anomaly investigation are included in Appendix B-3 of this document. In summary, a broken metal fence post was found at the small anomaly location, and two large perforated steel plates were found at the "horse trough" anomaly location. No horse trough was found. The debris in both cases was found at the expected locations. Figures 2-1l through 2-1p show some of the anomaly excavation activities.

2.7 SAMPLING OPERATIONS

This section discusses the sampling methodology for all ground water, surface water, soil, and sediment sampling activities performed at the MGBG site at NSWC Crane, Indiana. All sample locations are depicted on Figure 1-11, and a summary of Round 1 and Round 2 analyses is included in Table 2-2.

2.7.1 Ground Water Purging and Sampling

Twenty-nine ground water samples were collected during Round 1, and 20 ground water samples were collected during Round 2 of the Phase III RFI. During Round 1 (July through September 2001), ground water samples were collected from one new and 28 existing monitoring wells. Newly installed monitoring well 01T02 was sampled twice, and all 28 of the existing monitoring wells with the exception of 01-16, which was dry, were sampled once during Round 1. During Round 2 (May through June 2002), three new and 17 existing wells were sampled. Purging was accomplished in accordance with SOP CTO 131-17 (see Appendix H of the QAPP), and sampling was accomplished using the low-flow technique in accordance with SOP CTO 131-19 (see Appendix H of the QAPP).

Wells were purged prior to sampling using a peristaltic pump or bladder pump, depending on the static water level and well depth. In general, bladder pumps were used to sample wells with a water level greater than 20 feet bgs, and peristaltic pumps were used to sample wells having a water level less than 20 feet bgs. Disposable tubing was used with both pump types, and new tubing was used for each well.

After the well cap was opened, a PID reading at the riser pipe was taken prior to purging or sampling. No elevated PID readings were noted throughout the monitoring well sampling activities.

Ground water quality parameters including pH, specific conductance, temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP) were measured during purging at 5- to 10-minute intervals using a YSI Model 650MDS multi-parameter water-quality meter and flow-through cell. Turbidity readings were measured using a LaMotte 2020 turbidity meter. Water levels and pumping rates were also measured during purging at 5- to 10-minute intervals. Purging continued until a minimum of one well volume was removed and the above parameters stabilized, in accordance with Section 4.6.9 of the MGBG QAPP (TtNUS, 2001b). Copies of the monitoring well low-flow purge data sheets, and ground water sample log sheets are provided in Appendix B-4 of this document.

When appropriate, the pumping rates were adjusted to prevent drawdown from exceeding 0.3 foot during purging. Slowly recovering wells were identified and purged at the beginning of the workday. If possible, samples were collected from these wells within the same 24-hour period. Well purging continued until all parameters stabilized and the minimum purge volume (stabilized well volume plus the extraction tubing volume) was removed. If the water quality parameters did not stabilize within 4 hours of purging or after three well volumes were purged, this information was recorded on the well purge log sheet and sampling was initiated.

Monitoring wells were sampled using the same pump (peristaltic or bladder) and tubing used during well purging. Immediately following the purging process and before sampling, the temperature, pH, specific conductance, DO, ORP, and turbidity of the water sample were measured and recorded on the ground water sample log sheet (included in Appendix B-4).

Sample containers were filled by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence. Samples for VOC analysis were collected by the pipette method when using the peristaltic pump and were filled directly when using the bladder pump. These samples were immediately sealed in 40-mL vials so that no headspace existed. Samples for SVOCs, Polycyclic Aromatic Hydrocarbons (PAHs), pesticides/PCBs, herbicides, explosives, mustard gas, total thorium radioisotopes, gross alpha, gross beta, TOC, total target analyte list (TAL) metals, strontium, tin, and dissolved TAL metals, dissolved thorium radio isotopes analyses were collected next and in the order given (when applicable). Samples with turbidity values greater than 5 nephelometric turbidity units (NTUs) were field filtered for dissolved analyses using a 0.45 µm in line filter. Eight ground water samples were analyzed for monitored natural attenuation (MNA) field parameters during Round 2. MNA sample log sheets are included in Appendix B-4 of this document.

2.7.1.1 Ground Water-Level Measurements

Water level measurements were obtained from each monitoring well prior to development and purging. In addition, two complete synoptic rounds of water levels were taken in all the wells at the site during Round 1 (September 17, 2001) and Round 2 (June 17, 2002). Monitoring wells 01T03, 01T04 and 01T05 were installed during Round 2; therefore, were not included in Round 1. Each round of synoptic water level measurements was obtained within a 24-hour time period. Measurements were taken with an electrical water level indicator (M-scope), using the top of the riser pipe as the reference point for determining water depth. All measurements were taken in accordance with SOP CTO 131-16. A mark was placed at the top of the riser pipe to ensure that measurements were taken from a consistent reference point. Water level measurements were recorded to the nearest 0.01-foot on a ground-water-level measurement form, provided in Appendix B-5 of this document.

2.7.2 Soil Sampling

A total of 58 soil samples were collected during Round 1 from the 21 soil borings. Three composite soil samples were collected from the bottom of the large anomaly excavation and one composite soil sample was collected from the bottom of the small anomaly excavation. No soil samples were collected during Round 2 of the field investigation. Soil boring locations are shown on Figure 1-11. All soil samples were collected in accordance with the QAPP and SOP CTO131-8 contained in Appendix H of the QAPP. Soil sample log sheets are included in Appendix B-6 of this document.

2.7.2.1 Surface Soil Sampling

A total of 21 surface soil samples, one from each of the 21 boring locations, were collected from the ground surface to a depth of 2 feet bgs using DPT methods. Boring numbers 01SB01 through 01SB04 and 01SB09 were located within the PBA. Boring numbers 01SB05 through 01SB20 (except 01SB09) were located within the remaining area encompassed by the SWMU perimeter and extending approximately 20 feet beyond the former MGBG fence line. Boring 01SB09 was intended to be collected just to the west of the PBA, but uncertainty in citing the desired sampling location caused this boring to be installed just inside the western boundary of the PBA. This is within the uncertainty associated with the location of the MGBG and PBA boundaries and with the siting of unsurveyed sample locations. Therefore, this deviation had no adverse impact on the intended representativeness or spatial coverage of the soil sampling. Boring 01SB21 is a background sample location situated southeast of the SWMU boundary. The four composite surface soil samples collected from the bottoms of the anomaly excavations were collected in accordance with Section 15 of the MGBG QAPP. Upon sample retrieval, all samples were monitored for the presence of VOCs using a PID or FID. The results of this screening were recorded prior

to filling the appropriate sample containers. Samples for VOCs analyses were collected first from the 0.5- to 2.0-foot bgs interval that had the highest PID/FID reading. Samples to be analyzed for VOCs were collected using 5-gram EnCore™ samplers. Sample aliquots for the other analyses were collected from the remaining soil core material within the 0- to 2-foot depth interval following homogenization.

2.7.2.2 Subsurface Soil Sampling

A total of 37 subsurface soil samples were collected from the 21 soil boring locations. The subsurface soil samples were collected using DPT methods at pre-defined depths of 2 to 6 and 6 to 10 feet bgs, or until DPT refusal was encountered. Attempts were made to advance the even-numbered borings (e.g., SB02, SB04, SB06, etc.) to a depth greater than 10 feet bgs or until bedrock was encountered with the intent of collecting water at the bedrock-overburden interface. However, only two of the 21 borings reached a depth of 12 feet (01SB08 and 01SB15) because bedrock was encountered at 10 feet or less bgs in all other borings. Saturated soils were not encountered at any of the 21 boring locations; therefore, no ground water samples were collected from any of the 21 DPT locations. Subsurface soil samples were collected from soil borings using direct-push 4-foot long, 2-inch diameter macro-core samplers with disposable clear plastic sleeves. All DPT subsurface soil sampling was conducted in accordance with SOP CTO 131-5. Samples for VOCs analyses were collected first from the interval that had the greatest PID/FID reading using 5-gram EnCore™ samplers. The remaining soil core material was then homogenized, and soil to be analyzed for other parameters was placed into the required containers.

2.7.3 Surface Water Sampling

Five surface water and two discretionary seep locations were proposed for sampling at the MGBG. During Round 1, all surface water locations were dry and no samples were collected. The five locations were also checked during a rain event on July 28, 2001, and no flow was observed at that time.

The surface water locations (see Figure 1-11) were checked during Round 2 and flow was noted at four of the five locations. Surface water locations 01SW01, 01SW02, 01SW04 and 01SW05 were sampled on June 17 and 18, 2002, and location 01SW03 (collocated with 01SD12) was found to be dry. At the completion of sampling, all locations were marked with a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree to facilitate relocation of the sample location for surveying purposes. All surface water samples were collected in accordance with the MGBG QAPP and SOP 7 contained in Appendix A of the Round 2 SAP. All pertinent field data, including water quality parameters, sampling method, and location were recorded on a surface water sample log sheet (see Appendix B-7).

Photographs taken of selected sample locations and of dry streambed location 01SW03 can be found in Figures 2-1q, through 2-1s. A reconnaissance of the area around the MGBG was performed for evidence of seeps, and none were found. A damp area was noted on a slope approximately 12 feet south of wells 01-07 and 01-08, but there was insufficient water for sampling.

2.7.4 Sediment Sampling

A total of 16 sediment samples were collected from 14 locations (see Figure1-11) in streams, drainage ways, and surface runoff locations at the MGBG during Rounds 1 and 2. Eight sediment locations, 01SD01 through 01SD08, were sampled during Round 1. Six sediment samples were collected during Round 2, including 01SD01, 01SD03, and 01SD09 through 01SD12. Sediment locations 01SD01 and 01SD03 were sampled during Round 1 and Round 2. Sediment samples were collected according to SOP CTO 131-22 contained in Appendix H of the MGBG QAPP. Sediment samples were collected in a depositional area that had predominantly fine (clay and silt) particles present in the streambed or drainage ways. Sediment samples were collected to a depth of 0 to 6 inches. Decontaminated stainless steel or disposable plastic trowels were used to collect sediment samples. Samples for VOC analysis were taken first using 5-gram EnCore™ samplers. At the completion of sampling, all locations were marked with a labeled, wooden survey stake. Fluorescent flagging was tied to the stake and to a nearby tree to facilitate relocation of the sample location for surveying purposes. All pertinent field data, including sample method, depth, description, and location were recorded on sediment sample log sheets (see in Appendix B-8).

2.8 FIELD SAMPLE DOCUMENTATION

Sample documentation consisted of the completion of boring logs, matrix-specific sample log sheets, sample bottle tags, chain-of-custody records, FTMR forms (if necessary), equipment calibration log sheets, field logbooks, and health and safety documentation. Field documentation was discussed in the MGBG QAPP, SAP, and SOP CTO 131-25 contained in Appendix H of the MGBG QAPP. Boring logs are discussed in Section 2.3 and can be found in Appendix A of this document. The sample log sheets contain information such as sample location and sample ID, container requirements and analyses to be performed, sample type, time, date, and method of sample collection. Also, any problems or unusual circumstances encountered during sample collection were noted on the form. Sample log sheets can be found in Appendix B. The chain-of-custody records (see Appendix B-9) track each sample from collection to receipt and analysis at the laboratory. Field task modification request forms (see Appendix B-10) are used to document deviations from the QAPP and SAP. Equipment calibration log sheets are

discussed in Section 2.11 and can be found in Appendix B-11 of this document. Copies of all the field logbooks are contained in Appendix D. Copies of the Health and Safety logs are maintained in the CTO 158 file at the TtNUS Pittsburgh, Pennsylvania office. Upon completion of sample analyses, sample bottle tags were forwarded to the NSWC Crane Environmental Protection Department for storage.

2.9 SAMPLE HANDLING, PACKAGING, AND SHIPMENT

Sample handling activities included the field-related considerations concerning the selection of sample containers, preservatives, allowable holding times, sample custody, and maintaining samples at the appropriate storage temperature. Sampling containers were sealed in Ziploc® plastic bags, and glass containers were wrapped in plastic bubble wrap to minimize the possibility of breakage during transport. The sample containers were then placed in a cooler lined with a large plastic garbage bag. The cooler was packed with a cushioning material (bubble wrap) to prevent container breakage. Samples were cooled immediately after collection with ice placed around the sample containers. A temperature blank was placed in each cooler prior to shipment. The plastic garbage bag was sealed with a knot, and the chain-of-custody form was sealed in a Ziploc® bag and taped to the inside of the cooler lid. The cooler was sealed at both ends using strapping tape. A signed and dated custody seal was applied to the each end of the cooler, beneath the last wrap of strapping tape, to provide a tamper-evident seal. A Federal Express® airbill was applied to the shipping cooler. TtNUS maintained custody of the samples until they were relinquished to the carrier (Federal Express®). The Federal Express® tracking number (airbill number) was recorded on the chain-of-custody form, and the sender's copy of the airbill was maintained for shipment tracking, if needed. All samples were shipped to the laboratories for overnight delivery and received within sample holding times, with the exception of samples from three monitoring wells 01GW17, 01GW22 and 01GW24 that were sampled on September 11, 2001, and shipped via Federal Express on September 12, 2001. Because of the September 11 terrorist attacks on the United States, the shipment did not arrive at the laboratory until 6 days later, and the samples were subsequently discarded. The three wells were resampled and successfully shipped during the week of September 17, 2001. The procedures for sample preservation, packing, and shipment can be found in the MGBG QAPP and SOP CTO131-24. The procedures used to maintain sample custody requirements are described in the MGBG QAPP and SOP CTO131-25. Sample bottle tags were removed from each sample bottle and forwarded to the NSWC Environmental Protection Department.

2.9.1 Radioactivity Screening for Sample Shipment

All soil and sediment samples were screened for radioactivity during Round 1 of the field effort. Monitoring results did not indicate the presence of radioactive materials above background in the areas

surveyed. This conclusion was later supported through laboratory analyses and passive monitoring thermoluminesence detector Badges and ring dosimeters results. The screening procedure used can be found in SOP CTO 131-2 of the MGBG QAPP..

2.10 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Quality assurance/quality control (QA/QC) samples were collected and generated during sampling activities to monitor both field and laboratory procedures. These procedures are detailed in the MGBG QAPP and SAP. QA/QC samples included field duplicates, equipment rinsate blanks, trip blanks, source water blanks, and temperature blanks. A summary of QA/QC samples (excluding field duplicates) submitted for analysis is included in Table 2-2. Field duplicates are tabulated in Appendix E. These types of QA/QC samples are briefly described below:

- Field Duplicates - Field duplicates consisted of two samples collected either independently at a sampling location at approximately the same time in the case of ground water and surface water or as a single sample split into two portions in the case of soil and sediment. Field duplicates were collected at the rate of 1 in 10 per medium, and were used to assess the overall precision of the sampling and analysis program.

- Equipment Rinsate Blanks - Equipment rinsate blanks were obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through or over sample collection equipment after decontamination and before use. One equipment rinsate blank per 10 samples per aqueous matrix and 20 samples per solid matrix was collected for each type of sampling equipment used (i.e., bailer, macro-core sampling shoe, etc.) on a daily basis. However, when pre-cleaned, dedicated, or disposable sampling equipment was used and no decontamination was required, one equipment rinsate blank was collected as a batch blank. Additionally, bladder pump equipment rinsate blanks were collected at a rate of one equipment rinsate blank for every five samples (See the FTMR form in Appendix B-10). Equipment rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples.

- Trip blanks - Trip blanks were used to determine whether contamination of the bottleware or VOC samples had occurred during transit or storage. Trip blanks consisted of analyte-free water taken from the laboratory to the site and returned to the laboratory. One trip blank was submitted to the laboratory in each cooler that contained samples for VOC analyses and analyzed for VOCs only.

- Source water blanks - Source water blanks were obtained by sampling the analyte-free water and potable water source(s) used for decontamination of sampling equipment. Source water blanks were used to determine whether the analyte-free water and the potable water (used for steam cleaning, etc.) contributed to sample contamination.

- Temperature blanks - Temperature blanks were used to determine if samples were adequately cooled during shipment. Temperature blanks consisted of analyte-free water poured in a clean sample container at the site. One temperature blank was submitted to the laboratory in each cooler, and the temperature was checked upon receipt at the laboratory.

2.11 FIELD INSTRUMENT MEASUREMENTS

Field measurements taken and recorded during field sampling operations included radiological, ambient air real time measurements, water temperature, pH, specific conductance, ORP, DO, turbidity and ground water level measurements. Ambient air measurements included monitoring of organic vapors in the breathing zone during intrusive field investigation activities and monitoring of organic vapors emanating from site sources such as soil samples and well casings. Several instruments were used during field activities to achieve these measurements included the following:

- Ludlum radiological meters
- PID and FID
- YSI Model 6 series, Multi-Parameter Water Quality Meter
- LaMotte 2020 Turbidity Meter
- M-scope water level meter
- Magnetic locator
- Mustard gas screening instruments

2.11.1 Equipment Calibration

Instruments used in the field were calibrated daily prior to use according to manufacturers' requirements and in accordance with applicable SOPs. Equipment calibration logs can be found in Appendix B-11.

2.12 LAND SURVEYING

All new and existing monitoring wells, soil borings, surface water locations, and sediment sample locations, and excavated areas associated with both Rounds 1 and/or 2 were surveyed. The top of the

riser pipe (where the uncapped well riser is marked), the top of the protective casing, and the ground surface elevation at each monitoring well location were surveyed to within 0.01 foot vertical accuracy. For all other locations, the ground surface elevation was surveyed to the nearest 0.10 foot. Vertical elevations were referenced to the 1988 North American Vertical Datum (NAVD88). Existing survey monuments at NSWC Crane were used as reference points. Horizontal locations of samples, borings, and wells were surveyed to Indiana State Plane coordinates to the nearest 0.10 foot and referenced to the 1927 North American Datum (NAD27). All surveying was subcontracted to Bledsoe Tapp & Riggert, Inc., of Bloomington, Indiana who are professionally licensed surveyors in the state of Indiana. Copies of the land survey data can be found in Appendix D.

2.13 DECONTAMINATION

The nondedicated, nondisposable equipment involved in field sampling activities was decontaminated before beginning work, during drilling and sampling activities, and at the completion of Rounds 1 and 2. This equipment included drilling rigs, the backhoe, down-hole tools, augers, and soil and water sampling equipment.

2.13.1 Major Equipment

All down-hole equipment, including downhole drilling tools, were steam cleaned with high-pressure hot water prior to beginning work, between borings, and at the conclusion of each round of drilling.

Well riser pipe and screens were supplied at the site in certified clean packaging. All decontamination activities took place at a predetermined area within NSWC Crane. Additional requirements for drilling equipment decontamination are found in SOP CTO 131-26 contained in Appendix H of the MGBG QAPP.

2.13.2 Sampling Equipment

All nondedicated (reusable) sampling equipment used for collecting samples was decontaminated both before field sampling, between sample collections, and at the end of each sampling event. This equipment included stainless steel trowels, the macro-core sampler shoe, stainless steel mixing bowls, bladder pumps, etc. The following decontamination steps were taken:

- Potable water, phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse

- Air dry (if possible)
- Wrap in aluminum foil (if not to be used immediately)

An isopropanol rinse was not necessary because no oily residue was evident on the sampling equipment.

Field analytical equipment such as pH, conductivity, and temperature probes were rinsed first with analyte-free water, then with the sample prior to making measurements. Water level measurement devices were rinsed with DI water.

2.14 INVESTIGATION-DERIVED WASTE HANDLING

The field investigations generated several types of potentially contaminated wastes, including PPE, decontamination fluids from the drill rig, backhoe, and bulldozer, sampling equipment decontamination fluids, DPT plastic sleeves, development and purge water, and soil cuttings. Based on the activities and types of contaminants present, none of the residues represented a significant risk to human health or the environment when properly managed. Management of each residue was performed as follows.

PPE, Pump Tubing and DPT Plastic Sleeves – All PPE, tubing, and plastic sleeves were decontaminated, double bagged, and placed in NSWC Crane trash receptacles (i.e., dumpsters).

Purge Water, Development Water, Drill Rigs, Heavy Equipment, Sampling Equipment Decontamination Fluids and Gray Water – During Round 1, all well development and purge waters and equipment decontamination waters were collected and stored in containers in the temporary IDW satellite storage area on site. After analytical results were reviewed and the results confirmed the IDW to have acceptable levels of radioactivity, the NSWC Crane Public Works Department, using a vacuum truck, transported and discharged the water to the NSWC Crane permitted wastewater treatment system.

Gray water produced from the Round 1 decontamination showers at the MGBG was stored in a 1500-gallon holding tank. During demobilization after completion of Round 1 field actives, the gray water was pumped into a vacuum truck transported to Building 3245 and discharged to the NSWC Crane permitted wastewater treatment system via the floor drain located in the back of the building. Approval to discharge the water to the treatment system was obtained from the U.S. Naval Sea Systems Command Detachment Radiological Affairs Support Office via electronic mail (RASO, 2001).

All Round 2 well development waters (from newly installed wells), purge waters, and equipment decontamination waters were collected, transported, and discharged to the NSWC Crane permitted wastewater treatment system via the floor drain located outside the rear of Building 3245.

Waste Cuttings and Rock Cores from Drilling Activities – For each boring, the cuttings that were produced during drilling were scanned for VOCs. VOC readings were at background levels for all borings; therefore, all cuttings were used as backfill if the boring was above the water table. Any remaining cuttings were spread on the ground in the immediate vicinity of the boring. Rock cores were collected and placed into labeled core boxes and turned over to NSWC Crane Environmental Protection Division for storage.

Excavated Soil from Anomaly Excavations – During excavation, soil was placed onto plastic sheeting. After sample collection, the excavated soil was placed back into the pits and graded to the original ground contour.

Additional requirements for IDW handling can be found in SOP CTO 131-27 contained in Appendix H of the MGBG QAPP.

2.15 FIELD CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or "out of quality control" performance that can affect data quality.

Corrective action in the field resulted when substantive changes were made to the sampling network (i.e., more/fewer samples collected, sampling locations other than those specified, etc.) and sampling procedures or field analytical procedures required modification. For example, well number 01T01 was not installed as planned because the hole did not produce water. Project personnel reported all suspected technical or QA nonconformance or suspected deficiencies of any activity or issued document by reporting the situation to the FOL or designee. The Task Order Manager (TOM) was responsible for assessing the suspected problems in consultation with the project QA/QC manager and for making a decision based on the potential for the situation to affect the quality of the data. If it was determined that the situation warranted a reportable nonconformance requiring corrective action, then a nonconformance report was initiated by the TOM. No nonconformances or suspected deficiencies occurred during this field investigation; however, six deviations from the MGBG QAPP occurred during Round 1. These deviations were addressed using FTMR forms, copies of which are included in Appendix B-10.

TABLE 2-1

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Ground Elevation (ft amsl)	Top of Riser Elevation (ft amsl)	Total Depth (ft bgs)[1]	Screened Interval				Aquifer	August 17, 2001		June 17, 2002	
					Top (ft bgs)	Bottom (ft bgs)	Top (ft amsl)	Bottom (ft amsl)		Depth to Water (ft btor)	Ground Water Elevation (ft amsl)	Depth to Water (ft btor)	Ground Water Elevation (ft amsl)
01-01	1981	682.46	685.22	48	33.14	42.77	649.32	639.69	Upper Pennyslvanian	28.9	656.32	27.13	658.09
01-02	1981	663.56	666.03	23.8	8.24	17.6	655.32	645.96	Upper Pennyslvanian	15.59	650.44	11.17	654.86
01-03	1981	666.85	669.55	18.6	3.99	13.41	662.86	653.44	Upper Pennyslvanian	12.83	656.72	5.27	664.28
01-04	1981	669.05	671.99	31	16.47	25.68	652.58	643.37	Upper Pennyslvanian	20.01	651.98	15.39	656.60
01-05	1981	665.07	667.79	30	16.18	25.3	648.89	639.77	Upper Pennyslvanian	17.83	649.96	14.17	653.62
01-06	11/10/1982	595.38	597.98	90	75.02	84.4	520.36	510.98	Lower Pennyslvanian	71.12	526.86	68.77	529.21
01-07	11/14/1982	602.95	605.43	28.5	12.61	21.99	590.34	580.96	Upper Pennyslvanian	17.55	587.88	14.71	590.72
01-08	11/15/1982	601.25	604.09	31	13.63	22.95	587.62	578.30	Upper Pennyslvanian	15.87	588.22	12.74	591.35
01-09	11/16/1982	609.6	612.23	32	17.4	26.78	592.20	582.82	Upper Pennyslvanian	20.54	591.69	12.92	599.31
01-10	11/30/1982	636.25	638.92	120	25.25	34.65	611.00	601.60	Upper Pennyslvanian	26.15	612.77	22.96	615.96
01-11	1/8/1983	655.49	658.36	19.6	6.72	15.35	648.77	640.14	Upper Pennyslvanian	11.17	647.19	7.03	651.33
01-12	1/19/1983	633.31	636.12	38	23.26	32.67	610.05	600.64	Upper Pennyslvanian	26.39	609.73	23.59	612.53
01-13	1/19/1983	634.17	637.06	35	19.97	29.42	614.20	604.75	Upper Pennyslvanian	24.67	612.39	21.58	615.48
01-14	1/25/1983	655.45	658.09	36	21.12	30.65	634.33	624.80	Upper Pennyslvanian	16.41	641.68	13.36	644.73
01-15	2/10/1983	662.27	665.3	37.8	22.1	31.6	640.17	630.67	Upper Pennyslvanian	28.56	636.74	22.22	643.08
01-16	2/11/1983	641.09	644.05	38.5	23.75	33	617.34	608.09	Upper Pennyslvanian	DRY	DRY	35.14	608.91
01-17	2/12/1983	662.12	664.61	39	23.25	32.55	638.87	629.57	Upper Pennyslvanian	22.26	642.35	19.44	645.17
01-18	6/17/1983	658.24	660.55	30.5	14.3	23.59	643.94	634.65	Upper Pennyslvanian	15.54	645.01	12.78	647.77
01-19	6/17/1983	656.44	658.92	30.2	15.7	24.7	640.74	631.74	Upper Pennyslvanian	22.04	636.88	20.85	638.07
01-20	6/20/1983	630.55	633.45	36.1	21.35	30.69	609.20	599.86	Upper Pennyslvanian	29.13	604.32	23.30	610.15

TABLE 2-1

MONITORING WELL CONSTRUCTION INFORMATION AND WATER LEVEL MEASUREMENTS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Well Number	Installation Date	Ground Elevation (ft amsl)	Top of Riser Elevation (ft amsl)	Total Depth (ft bgs)[1]	Screened Interval				Aquifer	August 17, 2001		June 17, 2002	
					Top (ft bgs)	Bottom (ft bgs)	Top (ft amsl)	Bottom (ft amsl)		Depth to Water (ft btor)	Ground Water Elevation (ft amsl)	Depth to Water (ft btor)	Ground Water Elevation (ft amsl)
01-21	6/20/83	603.47	606.01	40.50	23.74	32.75	579.73	570.72	Upper Pennyslvanian	17.81	588.20	14.96	591.05
01-22	7/8/83	653.09	655.85	35.00	20.50	29.65	632.59	623.44	Upper Pennyslvanian	19.39	636.46	18.23	637.62
01-23	7/9/83	625.41	627.88	45.00	30.51	39.58	594.90	585.83	Upper Pennyslvanian	40.89	586.99	38.67	589.21
01-24	7/9/83	599.82	602.66	30.40	15.62	25.03	584.20	574.79	Upper Pennyslvanian	14.89	587.77	11.43	591.23
01-25	8/6/83	653.89	656.33	32.00	17.42	25.79	636.47	628.10	Upper Pennyslvanian	21.71	634.62	20.92	635.41
01-26	8/6/83	669.76	672.33	55.00	40.45	49.57	629.31	620.19	Upper Pennyslvanian	36.54	635.79	35.68	636.65
01-27	8/6/83	659.15	661.86	40.30	25.55	34.55	633.60	624.60	Upper Pennyslvanian	25.22	636.64	24.10	637.76
01C01	NA	663.96	666.23	NA	NA	NA	NA	NA	Lower Pennyslvanian	139.53	526.70	138.42	527.81
01T02	9/8/01	696.83	698.89	115.00	60.00	70.00	636.83	626.83	Upper Pennyslvanian	65.37	633.52	65.25	633.64
01T03	6/3/02	664.79	667.12	155.00	144.00	154.00	520.79	510.79	Lower Pennyslvanian	NI	NI	139.16	527.96
01T04	6/4/02	663.02	665.81	153.00	141.00	151.00	522.02	512.02	Lower Pennyslvanian	NI	NI	137.97	527.84
01T05	6/5/02	639.59	641.85	32.00	21.00	31.00	618.59	608.59	Upper Pennyslvanian	NI	NI	16.84	625.01

Notes:
1 = Total depth of boring, total depth of well may be less.
bgs = below ground surface.
btor = below top of riser.
amsl = above mean sea level (NAVD88).
NA = Well construction data not available.
NI = Not installed at time of water level measurements
* Well 01T01 was not installed because the hole did not produce enough water to yield representative ground water samples.

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
Ground Water Samples, Round 1																		
01GW0101		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0201		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0301		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0301-F					X	X								X				
01GW0401		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0501		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0601		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GW0701		X			X	X			X				X				X	
01GW0801		X			X	X			X				X				X	
01GW0901		X			X	X			X				X				X	
01GW1001		X			X	X			X				X				X	
01GW1001-F					X	X												
01GW1101		X	X	X	X	X	X	X	X	X	X	X	X	X			X	
01GW1101-F					X	X								X				
01GW1201		X			X	X			X				X				X	
01GW1301		X			X	X			X				X					
01GW1301-F					X	X												
01GW1401		X			X	X			X				X				X	
01GW1501		X			X	X			X				X				X	
01GW1701		X	X	X	X	X	X	X	X	X	X	X	X	X			X	
01GW1801		X	X	X	X	X	X	X	X	X	X	X	X	X			X	
01GW1801-F					X	X								X				
01GW1901		X			X	X			X				X				X	
01GW2001		X			X	X			X				X				X	
01GW2001-F					X	X												
01GW2101		X			X	X			X				X	X			X	
01GW2201		X			X	X			X				X	X			X	
01GW2301		X			X	X			X				X	X			X	

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
01GW2301-F					X	X												
01GW2401		X			X	X			X				X				X	
01GW2501		X	X	X	X	X	X	X	X	X	X	X	X	X			X	
01GW2601		X			X	X			X				X				X	
01GW2601-F					X	X												
01GW2701		X			X	X			X				X				X	
01GW2701-F					X	X												
01GWC0101		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GWT0201		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
01GWT0202		X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	
Ground Water Samples, Round 2																		
01GW0102									X									
01GW0202		X				X			X				X		X	X		
01GW0302									X									
01GW0402									X									
01GW0502									X									
01GW0602									X									
01GW0802									X									
01GW0902									X									
01GW1002									X									
01GW1102		X				X			X				X		X	X		
01GW1402									X									
01GW1502		X				X			X				X		X	X		
01GW2302									X								X	
01GW2502		X				X			X				X		X	X		
01GW2602									X									
01GWC0102									X									
01GWT0203		X				X			X				X		X	X	X	
01GWT0302		X				X			X				X		X	X	X	

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
01GWT0402		X				X			X				X		X	X	X	
01GWT0502		X				X			X				X		X	X	X	
Surface Water Samples, Round 2 Only																		
01SW01		X							X									
01SW02		X							X									
01SW04		X							X									
01SW05		X							X									
Subsurface Soil Samples, Round 1 Only																		
01SB010206	X		X	X	X	X	X	X	X	X	X	X	X	X				X
01SB020206			X	X	X	X	X	X	X	X	X	X		X				X
01SB020610			X		X	X	X	X	X	X				X				
01SB030206	X		X	X	X	X	X	X	X	X	X	X	X	X				X
01SB040206			X	X	X	X	X	X	X	X	X	X		X				
01SB040610			X		X	X	X	X	X	X				X				X
01SB050206	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SB050610	X		X		X	X	X	X	X	X			X	X				
01SB060206			X	X	X	X	X	X	X	X	X	X		X				
01SB060610			X		X	X	X	X	X	X				X				
01SB070206	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SB080206			X	X	X	X	X	X	X	X	X	X		X				
01SB080610			X		X	X	X	X	X	X				X				
01SB090206			X	X	X	X	X	X	X	X	X	X		X				
01SB100206			X	X	X	X	X	X	X	X	X	X		X				
01SB110206			X	X	X	X	X	X	X	X	X	X		X				
01SB110610			X		X	X	X	X	X	X				X				
01SB120206			X	X	X	X	X	X	X	X	X	X		X				
01SB120610			X		X	X	X	X	X	X				X				
01SB130206	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SB130610	X		X		X	X	X	X	X	X			X	X				

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
01SB140206			X	X	X	X	X	X	X	X	X	X		X				
01SB140610			X		X	X	X	X	X	X				X				
01SB150206			X	X	X	X	X	X	X	X	X	X		X				
01SB150610			X		X	X	X	X	X	X				X				
01SB160206			X	X	X	X	X	X	X	X	X	X		X				
01SB160610			X		X	X	X	X	X	X				X				
01SB170206			X	X	X	X	X	X	X	X	X	X		X				
01SB170610			X		X	X	X	X	X					X				
01SB180206			X	X	X	X	X	X	X	X	X	X		X				
01SB180610			X		X	X	X	X	X	X				X				
01SB190206			X	X	X	X	X	X	X	X	X	X		X				
01SB190610			X		X	X	X	X	X	X				X				
01SB200206	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SB200610	X		X		X	X	X	X	X	X			X	X				
01SB210206														X	X			
01SB210610														X	X			
Sediment Samples, Round 1																		
01SD0101	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0201	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0301	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0401	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0501	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0601	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0701	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
01SD0801	X		X	X	X	X	X	X	X	X	X	X	X	X	X			
Sediment Samples, Round 2																		
01SD0102					X	X			X				X					
01SD2302									X									
01SD0902									X									

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
01SD1002									X									
01SD1102									X									
01SD1202									X									
Surface Soil Samples, Round 1 Only																		
01SS010002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS020002			X	X	X	X	X	X	X	X	X	X		X				
01SS030002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS040002			X	X	X	X	X	X	X	X	X	X		X				
01SS050002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS060002			X	X	X	X	X	X	X	X	X	X		X				
01SS070002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS080002			X	X	X	X	X	X	X	X	X	X		X				
01SS090002			X	X	X	X	X	X	X	X	X	X		X				
01SS100002			X	X	X	X	X	X	X	X	X	X		X				
01SS110002			X	X	X	X	X	X	X	X	X	X		X				
01SS120002			X	X	X	X	X	X	X	X	X	X		X				
01SS130002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS140002			X	X	X	X	X	X	X	X	X	X		X				
01SS150002			X	X	X	X	X	X	X	X	X	X		X				
01SS160002			X	X	X	X	X	X	X	X	X	X		X				
01SS170002			X	X	X	X	X	X	X	X	X	X		X				
01SS180002			X	X	X	X	X	X	X	X	X	X		X				
01SS190002			X	X	X	X	X	X	X	X	X	X		X				
01SS200002	X		X	X	X	X	X	X	X	X	X	X	X	X				
01SS210002														X	X			
Anomaly Excavation Samples, Round 1 Only																		
01TPL01					X	X	X	X	X	X			X	X				
01TPL02					X	X	X	X	X	X			O	X				U

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
01TPL03					X	X	X	X	X	X			O	X				
01TPS04					X	X	X	X	X	X			O	X				
Rinsate Blank Samples, Round 1																		
RB08140101			X	X	X	X	X	X	X	X	X	X		X				
RB08210101			X	X	X	X	X	X	X	X	X	X		X				
RB08220101			X	X	X	X	X	X	X	X	X	X		X				
RB08240101			X	X	X	X	X	X	X	X	X	X		X				
RB08260101			X	X	X	X	X	X	X	X	X	X		X				
RB08270101			X	X	X	X	X	X	X	X	X	X		X				
RB08280101			X	X	X	X	X	X	X	X	X	X		X	X			
RB08280101-F					X	X								X				
RB09040101			X	X	X	X	X	X	X	X	X	X		X	X			
RB09080101					X	X			X					X				
RB09080101-F					X	X												
Rinsate Blank Samples, Round 2																		
RB06020201					X	X												
RB06020202									X									
RB061402					X	X			X									
RB061602						X			X									
RB061602-F					X	X												
RB06180201						X												
Source Blank Samples, Round 1																		
SB08220101			X	X	X	X	X	X	X	X	X	X		X	X			
SB08230101			X	X	X	X	X	X	X	X	X	X		X	X			
Source Blank Samples, Round 2																		
SB06030201					X	X			X									
SB06030202					X	X			X									

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC
Trip Blank Samples, Round 1																		
TB08140101									X									
TB08210101									X									
TB08220101									X									
TB08240101									X									
TB08240102									X									
TB08250101									X									
TB08280101									X									
TB09040101									X									
TB09060101									X									
TB09070101									X									
TB09180101									X									
TB09200101									X									
Trip Blank Samples, Round 2																		
TB060102									X									
TB060402									X									
TB061102									X									
TB061402									X									
TB06170201									X									
Waste Disposal Samples, Round 1 Only																		
01IDW01														U				X
01IDW02																		X

CEC - Cation Exchange Capacity.
EXP - Explosives.
FP - Field parameters (dissolved oxygen by probe, oxidation-reduction potential, specific conductance, temperature, and turbidity).
GA/B - Gross alpha and beta.
GSPEC - Gamma spectrometric analysis.
HERB - Herbicides.

TABLE 2-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Analytical Fraction																	
	CEC	FP	EXP	HERB	HG	Metals	HD	SVOC	VOC	PAH	PCB	PEST	PH	TH	TOC	MNA	GA/B	GSPEC

HG - Mercury.
HD - Distilled Mustard Gas.
MNA - Natural Attenuation Parameters (alkalinity, carbon dioxide, chloride, dissolved oxygen by test kit, ethane, ethene, hydrogen sulfide, iron (+2), manganese(+2), methane, nitrate, nitrite, sulfate, total sulfide).
SVOC - Semivolatile organic compounds.
VOC - Volatile organic compounds.
PCB - Polychlorinated biphenyls.
PEST - Pesticide.
PAH - Polycyclic aromatic hydrocarbon.
TH - Thorium-228, -230, -232 radioisotopes (total).
TOC - Total organic carbon.
Ground water samples with a -F designation were filtered in the field.
O - Scheduled analysis that was omitted.
U - Unscheduled analysis.

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1a - View east of MGBG from atop magazine 1409 with magazine 1407 in background. Prior to brush hog clearing of site (Round 1).

Figure 2-1b - View east of MGBG from atop magazine 1409 with magazine 1407 in background. After brush hog clearing of site (Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1c - View south of the MGBG field operations facility layout (Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1d - View southeast of the MGBG field operations facility layout (Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1e - Drill rig backing down bulldozed access road to monitoring well 01T05 installation area (view northeast- down slope, Round 2).

Figure 2-1f - Drill rig in position to start monitoring well 01T05 installation (view north, Round 2).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1g - Revegetation of the access road to monitoring well 01T05 (view southwest- up slope, Round 2).

Figure 2-1h - Revegetation of disturbed area around newly constructed monitoring well 01T05 (view southwest- up slope, Round 2) and safety barriers.

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1i - Close-up of newly constructed monitoring well 01T05 (Round 2).

Figure 2-1j - Revegetation at newly constructed monitoring well 01T04 (view southwest-Round 2).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1k - Close-up of newly constructed monitoring well 01T04 (Round 2).

Figure 2-1l - Initial site operations set up prior to test pit anomaly excavation activities (view south-southwest – Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1m - Start of anomaly excavation at large test pit (01TPL) (view northeast – Round 1).

Figure 2-1n - View of geophysical anomaly excavation, large pit (01TPL) showing the two sections of perforated steel plating removed (view northwest – Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1o - View of geophysical anomaly excavation, small pit (01TPS) showing the section of steel fence post removed (Round 1).

Figure 2-1p - Steel scrap removed from anomaly excavations. Located at east side of site pending Navy disposal at the Crane DRMO (view west – Round 1).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1q - View of predetermined surface water sampling location 01SW03 facing upstream (northeast) of a dry Boggs Creek tributary. This sampling location also lies southwest of the MGBG and was found to be dry during both sampling rounds. Note that this sampling location was collocated with sediment sampling location 01SD12 (Round 2).

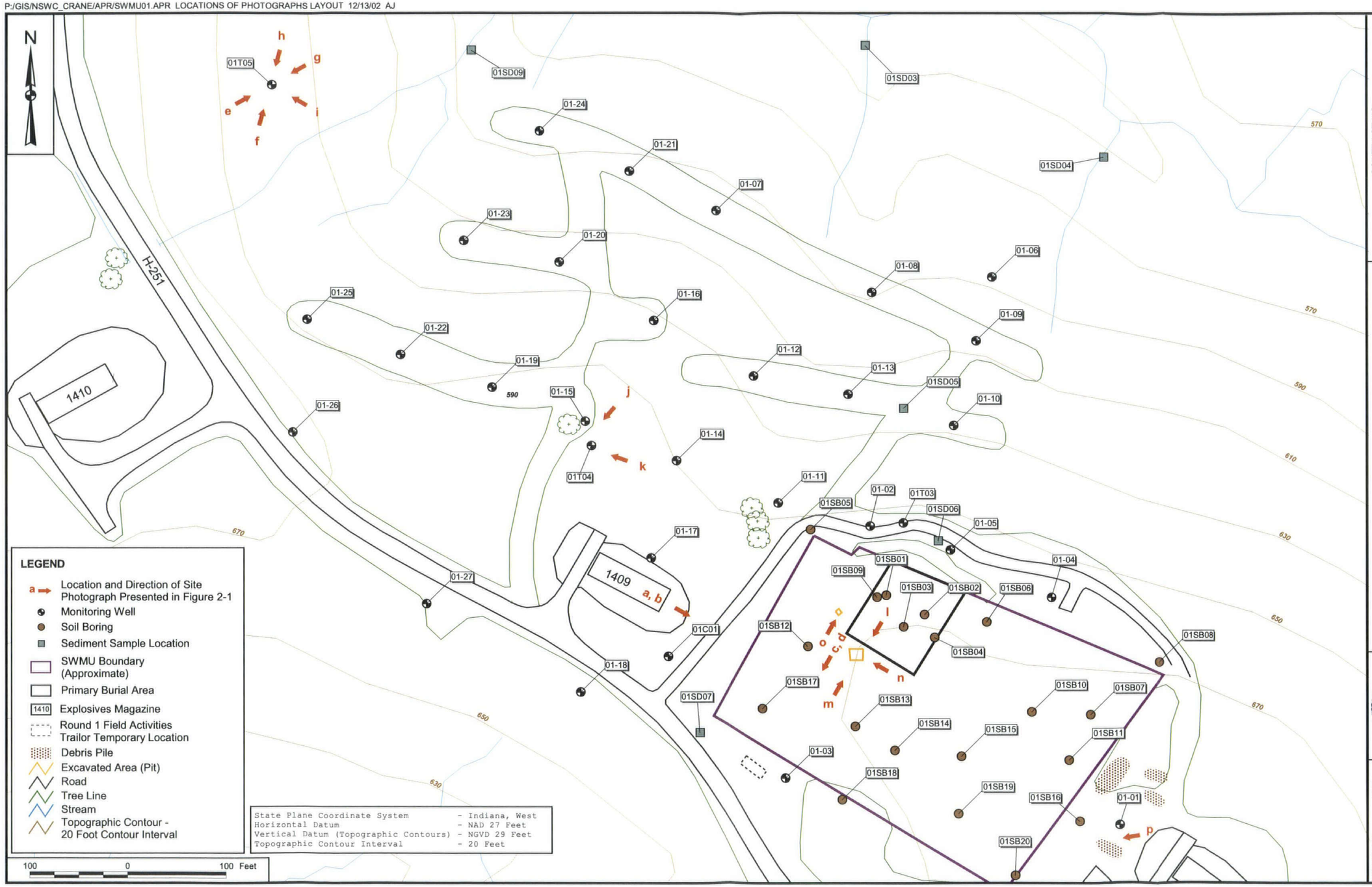
Figure 2-1r - View of sampling location 01SW04, facing upstream (east) of a slow flowing Boggs Creek tributary (Round 2).

FIGURE 2-1

SITE PHOTOGRAPHS
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Figure 2-1s - View east of surface water sampling location 01SW05. Sample was collected from the pooled area on the right side (south side) of the photograph (Round 2).

P:/GIS/NSWC_CRANE/APR/SWMU01.APR LOCATIONS OF PHOTOGRAPHS LAYOUT 12/13/02 AJ



CONTRACT NO. 3959

APPROVED BY T. JOHNSTON — DATE 12/13/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 2-2

REV 0

LOCATIONS OF PHOTOGRAPHS TAKEN AT SWMU 01 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA

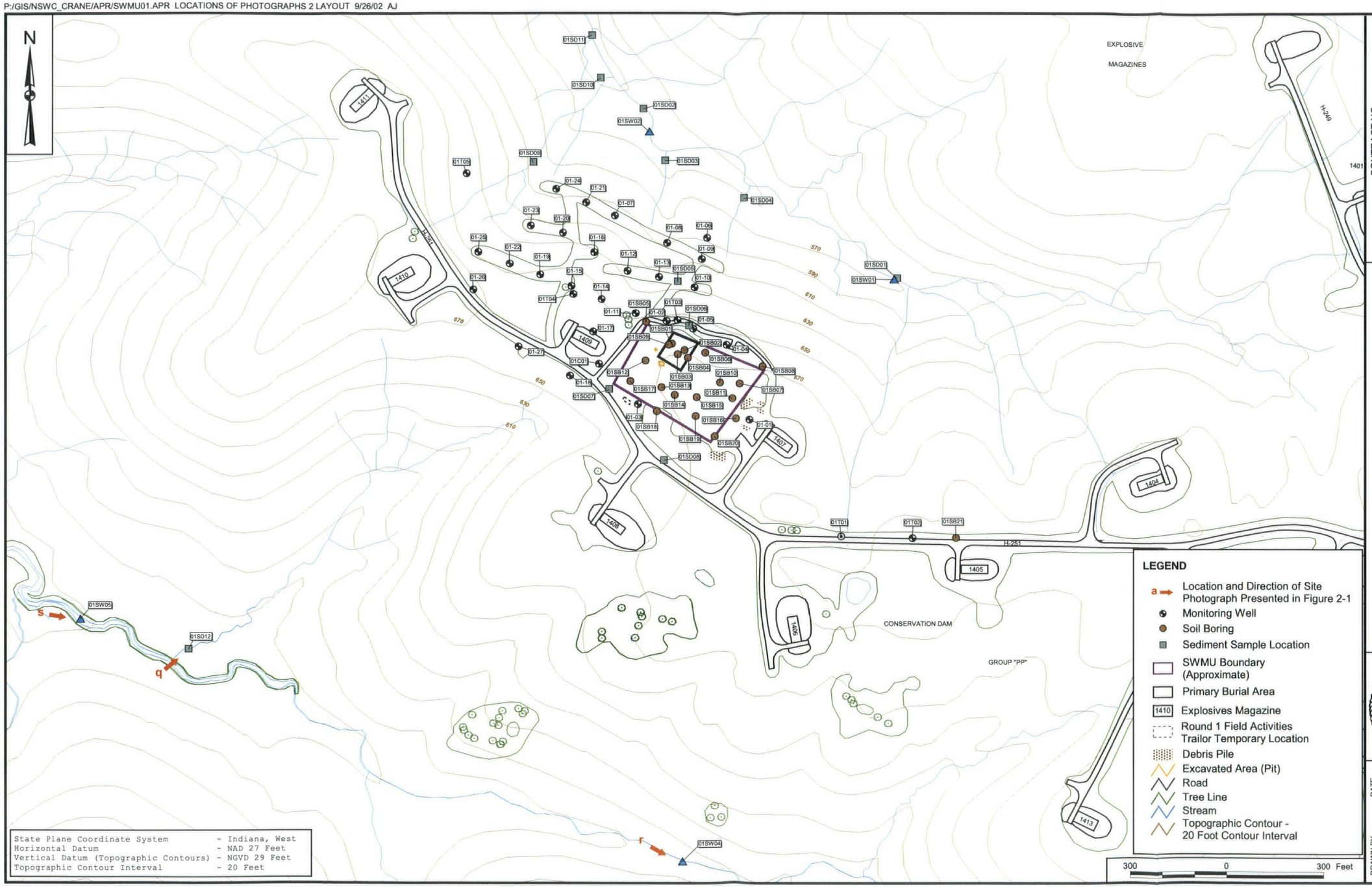
DRAWN BY A. JANOCHA — DATE 7/28/02

CHECKED BY K. SIMPSON — DATE 12/13/02

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/SWMU01.APR LOCATIONS OF PHOTOGRAPHS 2 LAYOUT 9/26/02 AJ



CONTRACT NO. N3959

APPROVED BY T. JOHNSTON — DATE 9/11/02

APPROVED BY ____ — DATE ____

DRAWING NO. FIGURE 2-3

REV 0

LOCATIONS OF PHOTOGRAPHS TAKEN AT SWMU 01 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA

DRAWN BY A. JANOCHA — DATE 7/28/02

CHECKED BY K. SIMPSON — DATE 7/29/02

COST/SCHED-AREA

SCALE AS NOTED

3.0 DATA QUALITY REVIEW AND DATA REDUCTION METHODS

This section contains a description of the data review processes used to determine whether analytical laboratory data were of acceptable technical quality for use in decision making. The review began with data validation, which is a comparison of data quality indicators (DQIs) against prescribed acceptance criteria. The DQIs used are measures to assess the bias and precision of the analytical calibrations and sample analyses. The output of this review was a set of alphabetic flags such as "U," "J," "R," or combinations thereof, that may have been assigned to individual results based on the validation effort. These flags were used to infer the general quality of the data. The data validation was followed by a summary of quantitative data quality measures to provide the user with a more quantitative estimate of any bias or imprecision associated with the data. Also evaluated were the measures of data completeness, sensitivity, comparability and representativeness.

Sections 3.1 and 3.2 provide an overview of the data validation process, Section 3.3 presents an evaluation of the data quality beyond data validation, and Section 3.4 describes various data reduction methods and special reviews that were undertaken to evaluate the MGBG data. Appendix E contains all the qualified data and the associated reasons for the data qualifications.

3.1 DATA VALIDATION PROCESS

Field analytical data and sampling location coordinates were reviewed both in the field and after completion of the field event to assure data users that the results were accurate. Calibration logs and QC check sample results were reviewed for accuracy. In addition, field data were reviewed for comparability among sampling locations and consistency with theoretical expectations. For example, low pH values would not be expected if alkalinity values were high. These evaluations were based, in part, on professional judgment. Well stabilization parameters were required to represent stable sampling conditions (manifested as reproducible measurements) prior to sample collection but were not required to compare well to field test kit results.

All of the results from analytical laboratory samples were validated according to several specifications. Assignment of data qualification flags for non-radiological data conformed to U.S. EPA Region 5 Standard Operating Procedures for Validation of Contract Laboratory Program Organic Data (U.S. EPA, 1993c) and Region 5 Standard Operating Procedures for Validation of Contract Laboratory Program Inorganic Data (U.S. EPA, 1993d); and the U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (U.S. EPA, 1994a) and U.S. EPA Contract Laboratory Program National

Functional Guidelines for Inorganic Data Review (U.S. EPA, 1994b) to the greatest extent practicable for non-contract laboratory program data. Radiological data validation specifications do not exist so the data were validated according to the following parameters:

- Data completeness
- Holding times
- Instrument calibrations
- Laboratory blank analyses
- Laboratory control sample results
- Laboratory duplicate results
- Chemical yield recoveries
- Sample quantitation

Data validation specifications require that various data qualifiers be assigned when a deficiency is detected or when a result is less than its detection limit. If no qualifier is assigned to a result that has been validated, the data user is assured that no technical deficiencies were identified during validation. The qualification flags used are defined below:

U – Indicates that the chemical was not detected at the numerical detection limit (sample-specific detection limit) noted. Non-detected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.

UJ – Indicates that the chemical was not detected; however, the detection limit (sample-specific detection limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.

J – Indicates that the chemical was detected; however, the associated numerical result is not a precise representation of the concentration that is actually present in the sample. The laboratory reported concentration is considered to be an estimate of the true concentration.

UR – Indicates that the chemical may or may not be present. The non-detected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration non-compliances, and extremely low analyte recoveries).

R – Indicates that the chemical may or may not be present. The positive analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies.

BU - Indicates that an organic chemical was detected in this sample as well as the associated laboratory method blank, but has been qualified non-detected resultant of laboratory blank contamination (i.e., concentration was less than the blank action level).

BJ - Indicates that an organic chemical was detected in this sample as well as the associated method blank, and is considered estimated because the concentration is in excess of the blank action level.

The use of "B" qualifiers is a U.S. EPA Region 5-specific requirement.

The preceding data qualifiers may be categorized as indicative of major or minor problems. Major problems are defined as issues that result in the rejection of data and qualification with UR or R data validation qualifiers. These data are considered invalid and are not used for decision- making purposes unless they are used in a qualitative way and the use is justified and documented. Minor problems are defined as issues resulting in the estimation of data, and qualification with U, J, B, BJ, BU, and UJ data validation qualifiers. Estimated analytical results are considered to be suitable for decision-making purposes unless the data use requirements are very stringent and the qualifier indicates a deficiency that is incompatible with the intended data use. It is noteworthy that a U qualifier does not necessarily indicate that a data deficiency exists because all non-detect values are flagged with the U qualifier regardless of whether a quality deficiency has been detected.

During data validation the laboratory control sample (LCS) and the laboratory control sample duplicate (LCSD) accuracy acceptance limits for PAHs as shown in Table 3-9 of the MGBG QAPP (TtNUS, 2001b) were determined to be incorrect. The correct values are provided in Table 3-1 of this document.

3.2 DATA VALIDATION OUTPUTS

After data were validated, a list was developed of non-conformities requiring data qualifier flags that were used to alert the data user to inaccurate or imprecise data. For situations in which several QC criteria were out of specification, the data validator made professional judgements and /or comments on the validity of the overall data package. The reviewer then prepared a technical memorandum presenting qualification of the data, if necessary, and the rationale for making such qualifications. The net result was

a data package that had been carefully reviewed for its adherence to prescribed technical requirements. Validators incorporated data qualifiers into the electronic database and submitted the information to the data management group. A complete printout of the data with validation flags is presented in Appendix E. Pertinent quality estimates are summarized in a more quantitative format in the following section.

3.3 GENERAL DATA QUALITY REVIEW

DQIs are parameters that are monitored to help establish the quality of data generated during an investigation. Some of the DQIs are generated from analysis of field samples (e.g., field duplicates) and some are generated from the analysis of laboratory samples (e.g., laboratory duplicates). Individually, field and laboratory DQIs provide measures of the performance of the respective investigative operations (field or laboratory). During data validation, individual QC results were evaluated. If individual QC results were acceptable, no validation flag was assigned to an analytical result, otherwise a flag indicating the type of QC deficiency was assigned to the result. The data quality review provided in this section, which was implemented after the data validation process was completed, is not designed to identify data that are acceptable or unacceptable according to data QC criteria. Instead, it is designed to provide an overall quantitative measure of analytical performance not provided by data validation. Taken together, the DQIs provide a measure of overall analytical performance.

The data for the MGBG was of generally acceptable quality with the following significant exceptions:

SVOCs – The compounds pronamide, methapyrilene, and 4-nitroquinoline-1-oxide constitute the majority of the results rejected for the semivolatile analyses. The rejections were because these compounds yielded poor analytical responses. This is a systematic problem that occurs for one or more of these compounds in the majority of the samples analyzed from the MGBG.

VOCs – The compounds 1,4-dioxane, 2-butanone, acetone, acrolein, acrylonitrile, isobutanol, methacrylonitrile, and propionitrile constitute the majority of results rejected for the volatile analyses. The rejections were because these compounds yielded poor analytical responses. This is a systematic problem that occurs for one or more of these compounds in the majority of the samples analyzed from the MGBG.

The various DQIs are discussed in detail below. In addition to the DQIs discussed below, temperature blanks that accompanied each cooler containing samples were used to assess whether the samples had been stored at the appropriate temperature during shipping. All temperature blanks fell within the acceptance range of 4°C ± 2°C, indicating no deficiencies with regard to shipping temperature.

Each section below addresses data quality for a particular DQI for samples of a given matrix (solid or aqueous) and analytical fraction (e.g., metals or VOCs).

3.3.1 Completeness

Completeness is a measure of the number of valid samples or measurements that are available relative to the number of samples or measurements that were intended to be generated. For this project, completeness was measured on three different bases: samples collected, field measurements, and laboratory measurements.

- Sample completeness was a measure of the usable samples collected as compared to those intended to be collected.
- Field measurement completeness was a measure of the usable field measurements made relative to those intended to be made.
- Laboratory measurement completeness was a measure of the amount of usable, valid laboratory measurements per matrix obtained for each target analyte.

Usable, valid samples (or results) were those judged, after data assessment, to represent the sampling populations and to have not been disqualified for use through data validation or additional data review. The total number of samples (or results) planned to be collected or generated are those listed in the MGBG QAPP (TtNUS, 2001b) for sampling round 1 (Round 1), and the MGBG SAP (TtNUS, 2002b) for sampling round 2 (Round 2). Completeness was determined using the following equation:

$$\%C = \frac{V}{T} \times 100$$

where %C = percent completeness
V = number of samples (or results) determined to be valid
T = total number of planned samples (or results)

Discretionary samples and provisional wells were not included in the estimates of total planned samples.

3.3.1.1 Sample Completeness

Round 1

Table 3-2 compares the samples collected to the samples proposed. For the ground water percent completeness, the number of wells sampled was compared to the number of wells intended to be sampled (excluding four proposed provisional wells). The ground water sample percent completeness was 93 (28 of 30 wells were sampled). Well 01-16 could not be sampled because it was dry during Round 1. There is no adverse effect from not sampling this well because it is located in the interior of the well field and the missing data can be inferred from the data from surrounding wells. The second well that could not be sampled was the planned deep ground water well, 01T01. This well could not be installed at the background location. Two different holes were drilled to the desired depth, but neither hole produced enough water to yield representative samples. Therefore, no deep ground water is available for comparison with site ground water samples in the deep water-bearing zone. The effect of this was to preclude the comparison of deep ground water chemical and radiological concentrations measured in the study area against deep upgradient ground water concentrations. However, the shallow well, 01T02, which was planned as an upgradient well proved to be sidegradient or downgradient of the MGBG and could not be used as an upgradient well for background comparisons. As shown in Figures 1-15 and 1-16, well 01T02 lies near the crest of the ground water ridge, but the ground water elevation measured in O1T02 is still lower than the elevations measured in wells 01-01 and 01-03. This would have limited the utility of well 01T01 had it been installed. In summary, the inability to install a producing well 01T01 and the fact that well 01T02 was sidegradient or downgradient of the MGBG were a reflection of site conditions and did not reflect a project deficiency. Comparisons to upgradient concentrations were not made, as discussed further in Section 3.4.2.3.

The Round 1 percent completeness for sediment samples, including the upstream location (01SD01), was 100, and the percent completeness for soil samples was 92.2. All planned soil samples were collected except where bedrock was encountered at depths shallower than the intended sampling depth. There was no negative impact from not having collected the planned samples because the entire soil column was represented adequately by the samples that were collected in the affected locations. The calculated percent completeness for surface water samples, including seeps, was 0 in Round 1 because no surface water was available during the sampling event. The lack of water was evidence of limited potential for exposure to surface water and did not have an adverse impact on the attainment of project objectives.

Round 2

The sample completeness for Round 2 is 100 for all planned media except surface water (50 percent). Three planned ground water wells (two deep and one shallow were installed, 20 out of 20 planned wells (including the three new wells) were sampled, six of six planned sediment samples were collected, and four of eight planned surface water samples were collected. The four surface water locations that were not sampled were dry although rain events ranged from light to very heavy during Round 2 sampling. Discretionary seep samples could not be collected because no seeps could be found.

3.3.1.2 Field Measurement Completeness

Round 1

Field measurement completeness is a measure of the amount of valid field measurements obtained from all the field measurements taken in the project. Field measurements for Round 1 comprised only well stabilization parameters and land surveying coordinates. The percent completeness for field measurements was approximately 99.6. A single sampling location, 01SD07, was not surveyed. This location was surveyed during Round 2.

Round 2

The percent completeness for field measurements, including natural attenuation parameter measurements, well stabilization measurements, and land surveying, was slightly greater than 100 because of the inclusion of survey data from 01SD07, which was missed in Round 1. As of the completion of Round 2, all planned field data had been collected.

3.3.1.3 Laboratory Measurement Completeness

Under ideal conditions, the laboratory completeness objective would be 100 percent. However, samples can be rendered unusable during shipping and preparation (e.g., bottles broken or extracts accidentally destroyed) or analysis (e.g., loss of instrument sensitivity, strong matrix effects). Laboratory completeness objectives were 90 percent for each critical target analyte per sample matrix. It is possible for individual analytes to exhibit very low completeness values while achieving the overall completeness goals on the basis of analytical fraction. This occurred in a few cases and is discussed in more detail below for the affected analytes and fractions.

Round 1

Table 3-3 presents the percent completeness among analytical fractions for solid samples and aqueous samples. Percent completeness for laboratory analytical data collected during the Round 1 field investigation was greater than the 90 percent completeness required by the MGBG QAPP (TtNUS, 2001b), with the exception of VOCs in ground water samples. The calculated percent completeness for laboratory analytical data is 86.5 for VOCs in ground water samples. The VOC rejections were mostly because of poor calibration sensitivities of 1,4-dioxane, 2-butanone, acetone, acrolein, acrylonitrile, isobutanol, methacrylonitrile, and propionitrile. One IDW sample (IDW01) and one composite sample (O1TPL02) from the large anomaly excavation were accidentally analyzed for thorium isotopes and gamma spectrometry radionuclides, respectively, in addition to the scheduled analyses. The IDW samples (01IDW01 and 01IDW02) are not included in the completeness tallies because they were used only to characterize waste. All scheduled IDW samples were collected and all scheduled IDW sample analyses, plus unscheduled isotopic thorium analysis on sample O1IDW01, were completed satisfactorily. Although not noted in the MGBG QAPP, analysis for thiodiglycol was proposed only if mustard gas or one of its other degradation products was detected. None of those chemicals was detected in any sample; therefore, no samples required analysis for thiodiglycol.

Round 2

Table 3-3 presents the percent completeness among analytical fractions for solid and aqueous samples. As for Round 1, the VOCs represented the only fraction not satisfying the completeness criteria primarily because of poor analytical responses for 1,4-dioxane, 2-butanone, acetone, acrolein, acetonitrile, acrylonitrile, isobutanol, methacrylonitrile, and propionitrile.

The impact of not having attained completeness goals because of the VOCs listed above is discussed in Sections 7.6.1 and 8.6.5 of the human health and ecological risk assessments, respectively. Table 3-4 lists all the rejected data and the reasons for the rejections.

3.3.2 Sensitivity

Tables 3-5, 3-6, 3-7, and 3-8 compare the observed minimum and maximum non-detect values during laboratory analyses to the target laboratory reporting limits contained in Table 1-5 of the MGBG QAPP (TtNUS, 2001b) for soils, sediments, ground water, and surface water, respectively. Observed exceedances of the target laboratory reporting limits occurred in several instances. At the outset of the project, it was known that the concentrations of several chemicals could not be measured at the RBTLs; however, the analytical methods selected are standard methods used throughout the industry.

Development of methods with greater sensitivity was not feasible nor was it required for the chemicals of primary interest (e.g., mustard gas, thorium, and chlorinated VOCs). The impact of these exceedances is discussed in Sections 7.6.1 and 8.6.5 of the human health and ecological risk assessments, respectively.

In some cases, elevated detection limits were incurred because select samples had to be diluted to obtain measurable concentrations of VOCs. This was especially true in Round 1 for a few ground water samples that had high concentrations of TCE and 1,1,2,2-PCA. The high concentrations of these VOCs resulted in a need to dilute the samples to prevent contamination of laboratory purge equipment. For Round 2, the laboratory was asked to obtain, if possible, lower detection limits for VOCs in the samples with high TCE/1,1,2,2-PCA concentrations. The laboratory achieved this where possible.

To understand the impact of not having achieved RBTLs, it is important to understand the convention used for reporting non-detect values. Concentrations of organic analytes that were less than their MDLs were reported as the reporting limit (not the MDL) followed by a "U" qualifier. The reporting limits were generally less than typical reporting laboratory limits, but were typically greater than MDLs. This convention was used in response to the need to try to achieve the RBTLs. If a measured organic analyte concentration exceeded the MDL but was less than the reporting limit, the reported concentration was the measured concentration followed by a "J" qualifier. The "J" qualifier signified that the reported concentration had a high degree of uncertainty even though there was a high level of confidence that the analyte had been detected in the sample. Concentrations less than the MDLs for inorganics or MDAs for radiologicals were reported as the MDL (or MDA) with a "U" qualifier. Concentrations of organics, inorganics, or radiologicals that exceeded reporting limits were not qualified unless a data quality deficiency was identified. These reporting conventions are summarized below:

Analyte Non-Detect Reporting

Measured Concentration	Reported Concentration	Qualifier*
<MDL (MDA)	MDL (inorganics) MDA (radiologicals) RL (organics)	U
>MDL and <RL	Measured concentration (organics)	J
>MDL (MDA) and <RL	Measured concentration (inorganics and radiologicals)	No qualifier
>RL	Measured concentration	No qualifier

Tables 3-5 through 3-8 show the nominal MDLs and the minimum and maximum non-detect values for each analyte. The nominal MDLs represent MDLs as measured by the laboratory without any

adjustments for sample-specific conditions such as moisture content or sample dilutions. Especially in cases where a dilution caused the maximum observed non-detect value to exceed the RBTL, the nominal MDL can be seen to be less than the RBTL. For example, 2-hexanone had a nominal MDL of 1.4 µg/L, but the maximum observed MDL was 5,000 µg/L. The significant elevation of the MDL was due to the dilution of at least one ground water sample that had a high concentration of at least one other target analyte.

3.3.3 Laboratory Precision

Precision is a measure of the degree to which two or more measurements are in agreement and describes the reproducibility of measurements of the same parameter for samples analyzed under similar conditions.

Precision for chemical parameters is expressed as a Relative Percent Difference (RPD), which is defined as the ratio of the difference to the mean for the two values being evaluated. RPDs, typically expressed as percentages, are used to evaluate both field and laboratory duplicate precision and are calculated as follows:

$$RPD = \frac{|V1 - V2|}{(V1 + V2)/2} \times 100$$

where RPD = relative percent difference
V1, V2 = two results obtained by analyzing duplicate samples

Precision for alpha spectroscopy and gamma spectrometry laboratory duplicates is represented as the mean difference, computed as follows:

$$\text{Mean Difference} = \frac{|\text{activity}_1 - \text{activity}_2|}{\sqrt{\text{error}_1^2 + \text{error}_2^2}}$$

where *activity*$_1$ is the activity measured for the original sample, *activity*$_2$ is the activity measured for the duplicate sample, *error*$_1$ is the counting uncertainty for the original sample, and *error*$_2$ is the counting uncertainty for the duplicate sample.

The precision estimates obtained from duplicate field samples encompass the combined uncertainty associated with sample collection, homogenization, splitting, handling, laboratory and field storage (as applicable), preparation for analysis, and analysis. In contrast, precision estimates obtained from analyzing duplicate laboratory samples incorporate only homogenization, subsampling, preparation for analysis, laboratory storage (if applicable), and analysis uncertainties.

Field duplicates for MGBG soils and sediments were collected as a single sample that was sampled in duplicate for VOCs, homogenized, split into two portions, and placed into separate sample bottles for the non-VOC analyses. Each sample bottle was assigned a unique nomenclature so as to be "blind" to the laboratory. Field duplicates were collected during a single act of sampling and were analyzed for chemical and radiological constituents to measure the precision of the sampling and analysis program, as well as the natural sample heterogeneity.

Field duplicates were collected at a rate of one duplicate per 10 environmental samples. Seven field duplicates were collected for 60 surface/subsurface soil samples and eight sediment samples in Round 1. Four field duplicates were collected for 30 ground water samples in Round 1. In Round 2, one surface water, one sediment, and two ground water duplicates were collected. Therefore, the 10 percent frequency criterion for field duplicates specified in the MGBG QAPP (TtNUS, 2001b) was achieved.

Laboratory precision QC samples [i.e., laboratory duplicates for inorganic chemicals and LCS/LCSD and matrix spike (MS) / matrix spike duplicate (MSD) samples for organic chemicals] were scheduled to be analyzed at a rate of one QC sample per 20 environmental samples. This 5 percent rate as specified in the MGBG QAPP (TtNUS, 2001b) was achieved for aqueous, soil, and sediment samples. During Round 1 three aqueous laboratory duplicates were analyzed per 30 aqueous samples and four soil laboratory duplicates were analyzed per 68 soil and sediment samples. In Round 2, one aqueous and one solid duplicate sample were analyzed for inorganic and organic parameters. Laboratory precision was assessed by comparing calculated RPD values to precision control limits specified in the MGBG QAPP (TtNUS, 2001b).

An RPD value greater than 50 percent for solid matrices and 30 percent for aqueous matrices is not common, although they are occasionally observed. In addition, such values are often overshadowed by the variability observed across site samples that are combined when evaluating uncertainty in site concentrations. Unless otherwise specified, RPD values cited in the discussions below refer to individual RPDs of a single pair of original and duplicate samples. A value of zero for individual RPD values indicates perfect repeatability.

Nitroaromatics and Nitramines (Explosives) in Soil and Sediment, Round 1

RPDs for the surrogate and target compounds ranged from 0 percent to 2 percent across all target analytes in LCS/LCSD pairs. For MS/MSD pairs, the RPDs also ranged from 0 percent to 2 percent. These RPDs indicated no unexpected uncertainty associated with the analysis of soils and sediments.

Nitroaromatics and Nitramines (Explosives) in Ground Water, Round 1

RPDs for the surrogate and target compounds ranged from 0 percent to 4 percent across all target analytes in LCS/LCSD pairs. For MS/MSD pairs, the RPDs also ranged from 0 percent to 2 percent. These RPDs indicated no unexpected uncertainty associated with the analysis of ground water samples.

Herbicides in Soil and Sediment, Round 1

RPDs for the surrogate and target compounds ranged from 0 percent to 5 percent across all target analytes in LCS/LCSD pairs. For MS/MSD pairs, the RPDs ranged from 0.2 percent to 7 percent. These RPDs indicated no unexpected uncertainty associated with the analysis of soils and sediments.

Herbicides in Ground Water, Round 1

RPDs for the surrogate and target compounds ranged from 0 percent to 18 percent across all target analytes in LCS/LCSD pairs. For MS/MSD pairs, the RPDs ranged from 0.9 percent to 50 percent. Dinoseb and pentachlorophenol, exhibited the 50 percent RPD values; all other RPD values were less than 10 percent for the target analytes. These RPDs indicated that no unexpected uncertainty was associated with ground water sample analytical parameters, with the exception of Dinoseb and pentachlorophenol.

Polycyclic Aromatic Hydrocarbons in Soil and Sediment, Round 1

RPDs for surrogate and target compounds ranged from 0 percent to 24 percent across all target analytes in LCS/LCSD pairs. Naphthalene was the compound yielding 24 percent RPD; all other target analytes yielded RPD values less than or equal to 15 percent. For MS/MSD pairs, the RPDs ranged from 0 percent to 50 percent. Naphthalene exhibited 50 percent RPD, and acenaphthene exhibited 40 percent RPD; all other RPD values were less than or equal to 22 percent. These RPDs indicated that no unexpected uncertainty was associated with the analysis of soils and sediments, although, for acenaphthene and naphthalene, RPDs approached the upper bound of expectation.

Polycyclic Aromatic Hydrocarbons in Ground Water, Round 1

RPDs for surrogate and target compounds ranged from 0 percent to 20 percent across all target analytes in LCS/LCSD pairs. For MS/MSD pairs, the RPDs ranged from 0.7 percent to 18 percent. These RPDs indicated that no unexpected uncertainty was associated with the analysis of ground water samples.

Polychlorinated Biphenyls in Soil and Sediment, Round 1

RPDs for surrogate and target compounds in MS/MSD and LCS/LCSD pairs ranged from 0 percent to 3 percent across all target analytes in LCS/LCSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of soils and sediments.

Polychlorinated Biphenyls in Ground Water, Round 1

RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 6 percent. The RPD values ranged from 0 percent to 2 percent in MS/MSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of ground water samples.

Pesticides in Soil and Sediment, Round 1

RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 7 percent. The RPD values ranged from 0 percent to 24 percent in MS/MSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of soils and sediments.

Pesticides in Ground Water, Round 1

RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 7 percent. The RPD values ranged from 0 percent to 3 percent in MS/MSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of ground water samples.

Metals in Soil and Sediment, Rounds 1 and 2

Ninety-two RPD values were computed across all solid samples and all detected metals in Round 1. The mean RPD value was 4 percent, and the standard deviation was 5 percent. The maximum RPD value out of the 92 RPD values for metals in soil and sediment samples was 29 percent (for cadmium). The next greatest RPD value was 21 percent (for calcium). In general, this is better performance (smaller RPD values) than expected.

The Round 2 RPD values for two laboratory duplicate samples ranged from 0 percent to 5.4 percent indicating acceptable analytical precision for Round 2 across all analytes. LCS/LCSD RPD values fall within the same range.

The RPD values for soil and sediment field duplicates were within the expected range for all detected metals. The RPD values ranged from 9.0 percent to 46.7 percent, with all but two values (magnesium at 46.7 percent and potassium at 36.2 percent) being less than 35 percent. In summary, no unexpected uncertainty was observed for metals in soil or sediment.

Metals in Ground Water and Surface Water, Rounds 1 and 2

Forty-four RPD values were computed across all aqueous samples and all detected metals in Round 1. The mean RPD value was 3 percent, and the standard deviation was 5 percent. The maximum RPD was 27 percent (for zinc), and the next greatest RPD value was 10 percent (for cadmium). This kind of performance is typical for water samples, which are relatively homogeneous by nature.

Of the metals detected in the aqueous field and laboratory duplicates during Round 2, manganese was the only metal with a duplicate RPD value (26.5 percent) that exceeded 8.7 percent. This occurred for field duplicate sample pair 01T0401 and 01T0401-D, but is consistent with typical expectations. In summary, no unexpected uncertainty was observed for metals in aqueous samples.

Semivolatile Organic Compounds in Soil and Sediment, Round 1

The RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 1 percent to 13 percent. The RPD values ranged from 0 percent to 18 percent in MS/MSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of soils and sediments.

Semivolatile Organic Compounds in Ground Water, Round 1

The RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 9 percent. The RPD values ranged from 0 percent to 6 percent in MS/MSD pairs. These RPDs indicated that no unexpected uncertainty was associated with the analysis of soils and sediments.

Volatile Organic Compounds in Soil, Round 1 and Sediment, Rounds 1 and 2

Sediment samples were collected in Rounds 1 and 2 whereas soil samples were collected only in Round 1. The RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to

16 percent. The RPD values ranged from 0 percent to 50 percent in MS/MSD pairs. The LCS RPDs indicate no unexpected uncertainty, but MS/MSD RPD values near 50 percent suggest some potentially unusual analytical performance in the soil and sediment matrix at the MGBG. The following analytes yielded RPD values exceeding 30 percent for individual MS/MSD pairs:

Item	Analyte	Mean (Count) of RPD %	Standard Deviation of RPD %	Min/Max of RPD %
1	Acetonitrile	12.8 (4)	25	0.0 / 50
2	Acrolein	12.3 (4)	13	2.7 / 30
3	Ethyl Methacrylate	21.3 (4)	15	8.1 / 42
4	Isobutyl Alcohol	13.6 (4)	24	0.0 / 50
5	Proprionitrile	13.8 (4)	24	0 / 50
6	Vinyl Acetate	8.3 (4)	17	0 / 33

In each of these six cases, only one RPD value out of four was greater than 10 percent. This is an indication that VOC analyses generally showed little to no unusual uncertainty, yet the possibility for high uncertainty should be considered for the six analytes in the table above.

Round 2 RPDs ranged from 0 percent to 164 percent with most values being less than 35 percent. The exceptions are: isobutyl alcohol (94 percent for one LCS/LCSD); methylene chloride (72 percent in one LCS/LCSD); and 1,4-dioxane (42 percent and 45 percent in two LCS/LCSDs; 164 percent in the MS/MSD).

In summary, VOC analytical precision was acceptable with a potential for significant data scatter for the six compounds tabulated above plus 1,4-dioxane. In addition, data for a select number of other Round 1 and Round 2 VOCs were rejected on the basis of poor calibration response (Table 3-4), even for compounds not determined to exhibit unusually high RPDs. The rejections were typically associated with a poor analytical sensitivity, which could also be the cause of the observed imprecision because a very small change in analytical response corresponds to a large change in concentration.

Volatile Organic Compounds in Ground Water and Surface Water, Rounds 1 and 2

The Round 1 RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 43 percent. The 43 percent recovery (%R) is associated with chloroform in one LCS sample, otherwise RPD values were less than 30 percent with most values being less than 15 percent. The RPD values ranged from 0 percent to 50 percent in MS/MSD pairs. Acrylonitrile yielded an RPD of 39 percent in sample 01GW0101, and 2-hexanone yielded an RPD of 37 percent in sample 01GW0801. Despite these

relatively high RPD values, the VOC LCS/LCSD and MS/MSD RPD results were generally less than 30 percent with most values less than 10 percent. This is an indication that the VOC analyses generally showed little to no unusual uncertainty, yet the possibility for high uncertainty should be considered for acrylonitrile and 2-hexanone.

Round 2 ground water RPDs for surrogate and target compounds in LCS/LCSD pairs ranged from 0 percent to 26 percent. Only two RPD values exceeded 20 percent. The surface water precision was comparable with one exception. The 1,1,2,2-PCA MS/MSD RPD for surface water was 178 percent. The MS recovery was 2 percent and the MSD recovery was 37 percent. Otherwise, the LCS and LCSD RPDs were acceptable at 4 percent and 18 percent for those two pairs of QC samples.

Overall, the RPD values for VOCs in ground water and surface water, including the dissolved gases, were acceptable with a notable exception - 1,1,2,2-PCA in surface water during Round 2. This imprecision was of little consequence because VOCs were not detected in surface water. Data for a select number of other Round 1 and Round 2 VOCs were rejected on the basis of poor calibration response (Table 3-4), even for compounds not determined to exhibit unusually high RPDs.. Rejected data should not be used in a quantitative manner.

Radiological Parameters in Soil and Sediment, Rounds 1 and 2

QC data were not available in electronic file format for Round 1 or Round 2. However, mean difference values were tabulated for Round 1 and Round 2 thorium-228, thorium-230, and thorium-232 results to estimate the analytical precision of the alpha spectroscopy. The alpha spectroscopy mean difference values ranged from 0 percent to 1.27 for Round 1, with only 4 of 27 values greater than 1.0. Any value less than 1.5 represents agreement within a 95 percent confidence level for the two replicate samples. The observed mean difference value range was less than 1.5 and was an indication of acceptable analytical precision.

The Round 2 mean difference values for laboratory duplicates ranged from 0.32 to 0.81 for the three thorium isotopes in sediment sample 01SD0102. The field duplicate RPDs for all three isotopes ranged from 2.82 percent to 16.0 percent. These results were indications of acceptable analytical precision with no expectation of unusual uncertainty.

Overall, the analytical precision for soil and sediment samples appeared to be within normal limits with no exceptions.

Radiological Parameters in Ground Water, Rounds 1 and 2

The alpha spectroscopy mean difference values for thorium-228, thorium-230, and thorium-232 ranged from 0 to 0.94. The observed mean difference value range was less than 1.5 and indicated acceptable analytical precision.

The Round 1 LCS recovery precision measured across all LCSs was approximately 3 percent (1 standard deviation). The recoveries of gamma spectrometry calibration standards ranged from 96.40 percent to 102.2 percent. These results indicated satisfactory precision.

The Round 2 RPD value for gross alpha MS and MSD samples was 27 percent for field sample 01GW2302. For field samples FD06160201, 01GWT0401, 01GWT0301, and 01GWT0501, the MS/MSD RPD was 1 percent, and for sample 01GWT0203, it was 18 percent. These results represent overall acceptable analytical precision. The turbidity of sample 01GW2302 was 30 NTU (turbidity of most other samples was less than 10 NTU), which could explain the relatively high degree of imprecision in the gross alpha results. The gross alpha results were less than the detection limit for the field duplicate pair, so an RPD could not be computed for that sample.

The MS and MSD recoveries for Round 2 gross beta analyses across all sample delivery groups (SDGs) ranged from 69 percent to 91 percent with RPDs ranging from 1 percent to 15 percent. The field duplicate results for 01GWT0401 yielded an RPD of 25.8 percent for gross beta, which is consistent with expectations for water samples. This indicated acceptable analytical precision with no unexpected uncertainty for gross beta.

Overall, the analytical precision for ground water and surface water samples was within normal limits with no particular exceptions.

Mustard Gas and Degradates in Soil and Sediment, Round 1

Mustard gas QC data were not available electronically, so a detailed analysis of the data was not conducted. Nevertheless, no mustard gas results were qualified during data validation, and a manual review of the QC precision indicators revealed that all but one of the mean RPD values ranged from 4 percent to 8 percent with a standard deviation ranging from 3 percent to 8 percent. The lone exception was sample 01SS060002. The surrogate recovery for this sample was 63 percent for the original analysis and 127 percent for the duplicate analysis. These data suggested some unexpected uncertainty in the analysis of that sample. It is possible that a similar effect would have been observed for other samples,

although the other precision indicators did not identify any other problems. Because no mustard gas [bis-(2-chloroethyl) sulfide], 1,4-dithiane, or 1,4-thioxane was detected in any site samples and that sample 01SS060002, which first exhibited low recovery and was reanalyzed, yielded a slightly high bias, there is no cause for concern. Overall, there were no significant uncertainties associated with mustard gas analyses.

Mustard Gas and Degradates in Ground Water, Round 1

No mustard gas results were qualified during data validation, and a manual review of the QC precision indicators revealed no significant imprecision concerns. The mean MS/MSD and original/duplicate RPD values ranged from 3 percent to 11 percent over all of the ground water samples with standard deviations ranging from 3 percent to 18 percent. This was indicative of acceptable analytical performance with no unusual uncertainties.

Miscellaneous Parameters in Soil and Sediment, Round 1

CEC - Six representative surface soil samples, nine representative subsurface soil samples, and all eight sediment samples from Round 1 were analyzed to determine their CEC values. The surface and subsurface samples and all but two of the sediment samples had CEC values that spanned the range of 11 to 25 milliequivalents (meq) per 100 grams (g) of sample. This CEC range is typical of soils that have a moderate to high clay content (Dragun, 1988). Results are displayed in the table below.

Soil Type	Minimum CEC, meq/100 g	Maximum CEC, meq/100 g
Surface	11.2	24.4
Subsurface	11	20.1
Sediment	11.1	48.6

Two samples, 01SD05 and 01SD08, had CECs of 45.5 and 58.6 meq/100 grams of sample, respectively. Sample 01SD05 was collected farthest downstream in the ravine south of the MGBG, and sample 01SD06 was collected from the shallow drainage just outside the southern boundary of the MGBG. These values fall within the CEC range for clay soils of 5 to 60 meq/100 grams of sample (Dragun, 1988). Furthermore, sediments commonly represent fine-grained material with a high surface area-to-volume ratio and a correspondingly high CEC, so these values do not appear to be out of agreement with expectations.

The RPD values for CEC (two results) ranged from 0.5 percent to 10 percent, indicating good precision and no expectation of unusual uncertainty associated with CEC analyses.

TOC - RPD values for TOC (two results) ranged from 0.2 percent to 1.2 percent, indicating good precision and no expectation of unusual uncertainty associated with TOC analyses.

pH - Typical precision indicators are not analyzed for this parameter because the pH measurement scale is logarithmic.

Miscellaneous Parameters in Ground Water, Rounds 1 and 2

Natural Attenuation Parameters (Round 2 only) - RPD values for the parameters measured in duplicate in the field ranged from 0 percent to 15.3 percent. This is indicative of acceptable field measurement precision. Inorganic chloride RPD values ranged from 0.39 percent to 2.1 percent. This is well within expectations, indicating no unexpected uncertainty with chloride analyses. Dissolved gases, ethane, ethene and methane, were not present at detectable concentrations in the single field sample that was duplicated, so RPD values could not be computed. The LCS/LCSD RPD values ranged from 5 percent to 7 percent, indicating acceptable analytical precision. No MS/MSDs were analyzed for these parameters.

TOC - RPD values for TOC (three results) ranged from 0.0 percent to 0.1 percent for Rounds 1 and 2, indicating good precision and no expectation of unusual uncertainty.

pH - Typical precision indicators are not analyzed for this parameter because the pH measurement scale is logarithmic.

3.3.4 Laboratory Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy measurements are designed to detect biases resulting from sample handling and analysis. This parameter is assessed by measuring spiked samples (e.g., MSs) or well-characterized samples of certified analyte concentrations (e.g., LCSs) and by measuring blanks.

Accuracy requirements for field measurements are typically ensured through control over the sample collection and handling and through routine instrument calibration. Field accuracies were monitored through the use of blanks to detect cross-contamination and by monitoring adherence to procedures that prevent sample contamination or degradation. Source blanks were collected from analyte-free water and

potable water sources to assess the water sources used for decontaminating sampling equipment. Equipment rinsate blanks were collected for this investigation to assess cross-contamination via sample collection equipment. These blanks were obtained under representative field conditions by collecting the rinse water generated by running analyte-free water through sample collection equipment after decontamination and before use. Rinsate blanks were obtained for each type of sampling equipment for each day that the sampling equipment was decontaminated. Where pre-cleaned, dedicated sampling equipment was used, one rinsate blank was collected as a "batch blank". Rinsate blanks were analyzed for the same chemical constituents as the associated environmental samples. Accuracy was also assured qualitatively through adherence to all sample handling, preservation, and holding time requirements for all analytical parameters except pH, for which holding time criteria were exceeded in several soil and sediment samples. The pH holding time exceedances were less than two times the holding time criteria, and the effect on data quality was minimal. The pH data thus affected were qualified as estimated (J qualifier).

Accuracy in the laboratory is measured through the comparison of a spiked sample or LCS result to a known or calculated value and is expressed as a percent recovery (%R). It was also assessed by monitoring the analytical recovery of select surrogate compounds added to samples that are analyzed by organic chromatographic methods. LCSs were used to assess the accuracy of laboratory operations with minimal sample matrix effects. MS and surrogate compound analyses measure the combined accuracy effects of the sample matrix, sample preparation, and sample measurement. Spiking concentrations equaled or approximated the default concentrations detailed in the applicable sample preparation or analysis SOPs. LCS and MS analyses were performed at a frequency of one per 20 associated samples of like matrix as required by the MGBG QAPP (TtNUS, 2001b). Laboratory accuracy was assessed by comparing calculated %R values to accuracy control limits specified in the MGBG QAPP (TtNUS, 2001b).

Percent recovery is calculated using the following equation:

$$\%R = \frac{Ss - So}{S} \times 100$$

where %R = percent recovery
Ss = result of spiked sample
So = result of non-spiked sample
S = concentration of spiked amount.

Absence of bias is represented as a recovery of 100 percent. Mean recovery values less than 100 percent indicate a low bias, and recovery values greater than 100 percent indicate a high bias. Because measurement uncertainty exists in all bias estimates, a bias is not considered to be significant unless it falls outside the range of 100 percent ± 25 percent. The more extreme the bias value, the more significant the bias.

Unless otherwise specified, each percent R value cited in the discussions below refers to an individual percent R value. When appropriate, mean or average percent R values are also discussed. Data qualifiers assigned during data validation because of non-compliant bias indicators are presented in Appendix E.

Nitroaromatics and Nitramines (Explosives) in Soil and Sediment, Round 1

The LCS, LCSD, MS, and MSD target compound recoveries ranged from 88 percent to 111 percent, which was well within the expected range. Thus, the chemical analyses performed well and the recoveries were acceptable for these analytes in soil and sediment.

The mean recovery of the surrogate compound, 3,4-dinitrotoluene, was slightly high at 115 percent across all soil and sediment and related solid QC samples (98 results), including those samples in which this compound was not detected.

These data indicated a slightly high, but insignificant, bias for nitroaromatics and nitramines in soil and sediment.

Nitroaromatics and Nitramines (Explosives) in Ground Water, Round 1

The LCS, LCSD, MS, and MSD target compound recoveries ranged from 87 percent to 104 percent, well within the expected range. Thus, the chemical analyses performed well and the recoveries were acceptable for these analytes in aqueous samples.

The mean recovery of the surrogate compound, 3,4-dinitrotoluene, was slightly high at 108 percent across all aqueous environmental and QC samples (52 samples total), including those in which no target compounds were detected. There is no significant bias associated with this analysis for aqueous samples.

Herbicides in Soil and Sediment, Round 1

Mean herbicide target compound recoveries in soil and sediment LCS, LCSD, MS, and MSD samples were generally good with the exception of Dinoseb and pentachlorophenol. The mean Dinoseb recovery was approximately 53 percent in LCS and LCSD samples and approximately 63 percent in MS and MSD samples. These recoveries indicated a likely low bias for Dinoseb in soil and sediment samples. The degree of bias may vary with the concentrations of this compound in individual samples. Pentachlorophenol recoveries were excellent in LCS and LCSD samples and most MS and MSD samples, but the pentachlorophenol recovery in SDG 47433 was approximately 470 percent. This extremely high value was inconsistent with all other pentachlorophenol recoveries and may indicate a laboratory error, such as a spike that was five times greater in concentration than intended. Because the bias is high and indicates a potential overestimation of pentachlorophenol concentrations, and because no samples in SDG 47433 exhibited detectable concentrations of this compound, the potential for laboratory errors was not investigated. In general, no significant bias is expected for pentachlorophenol results.

The mean recovery of surrogate compound 2,4-dichlorophenylacetic acid (DCAA) was slightly low at 86 percent across all 57 soil and sediment and related QC samples, including those in which no target compounds were detected. Recoveries ranged from 52 to 134 percent. Sixteen samples had recoveries of less than 75 percent, and 14 samples had recovery values greater than 100 percent.

Overall, no significant bias was anticipated for herbicide analysis in soil and sediment samples. A possible exception is a moderately low bias for Dinoseb as described above.

Herbicides in Ground Water, Round 1

Mean herbicide target compound recoveries in ground water LCS, LCSD, MS, and MSD samples were generally good with the exception of Dinoseb and pentachlorophenol. Pentachlorophenol exhibited extremely high %R values in the LCSs and LCSDs of SDGs 47442 (approximately 5,200 %R) and 47521(approximately 5,200 %R). Dinoseb exhibited an extremely high %R value (approximately 2,400 %R) in the LCS and LCSD of SDG 47624.

The mean recovery of surrogate compound DCAA was slightly low at 86 percent across all 57 ground water and related QC samples, including those in which no target compounds were detected. Recoveries ranged from 52 to 104 percent. Four samples had DCAA recoveries of less than 75 percent, and one sample had a recovery greater than 100 percent (104 percent).

Because the bias was high and indicated a potential overestimation of pentachlorophenol concentrations, the potential for laboratory errors was not investigated. On average, the recoveries of all herbicides were within 40 percent of the 100 percent target value, with most being closer to the target value, especially for herbicides other than Dinoseb and pentachlorophenol.

Polycyclic Aromatic Hydrocarbons in Soil and Sediment, Round 1

The mean %Rs of all target PAHs across all soil and sediment LCS, LCSD, MS, and MSD samples ranged from 73 percent to 124 percent with the exception of acenaphthene, acenaphthalene, dibenzo(a,h)anthracene, and naphthalene. Naphthalene had the lowest mean recovery, approximately 25 percent in all LCS, LCSD, MS, and MSD samples. The lowest naphthalene recovery was 2 percent in a single MS sample, and two different LCS samples yielded recoveries of only 7 percent. These data indicated an expected low bias for the latter four compounds, with naphthalene exhibiting a severe low bias. The lowest %Rs for acenaphthene and acenaphthalene were 9 percent and 16 percent, respectively, in MS samples. Otherwise, the PAH data were generally acceptable with no expected bias. The following mean recovery values represent the degree of bias expected for the latter four compounds (including the extreme low values) at the spiking concentration of 32 µg/kg:

Mean Percent Recoveries of Poor Performing PAHs, Including Extreme Low Values

Parameter	LCS	LCSD	MS	MSD
Acenaphthene	57	49	49	52
Acenaphthalene	61	57	54	61
Dibenzo(a,h,)anthracene	47	47	40	39
Naphthalene	29	19	26	29

The actual degree of bias may vary with the concentrations of these compounds in individual samples.

The mean recovery of surrogate compound *p*-terphenyl varied widely from sample to sample. Two samples, 01SB130206 and 01SB170610, yielded *p*-terphenyl recoveries of 5 percent and 10 percent, respectively. Reanalysis of those samples yielded similar *p*-terphenyl recoveries of 6 percent and 12 percent, respectively. This indicated a problem potentially associated with only those two samples, especially when recognizing that all other recoveries ranged from 43 to 237 percent. The 237 %R is also an extreme value. Not considering these five extreme values, 101 recovery values ranged from 43 to 109 percent with five recoveries exceeding 100 percent. This indicated a general slight to moderate low bias for the surrogate compound. This is consistent with the observations for the target compounds.

Overall, the data user should expect no bias to a moderate low bias for most PAH compounds. For the compounds tabulated above, the expected recoveries are as presented in the table.

Polycyclic Aromatic Hydrocarbons in Ground Water, Round 1

The mean target analyte %Rs of all PAHs across all ground water LCS, LCSD, MS, and MSD samples ranged from 72 percent to 134 percent with the exception of benzo(b)fluoranthene and dibenzo(a,h,)anthracene. A single MS sample yielded a 51 %R for benzo(b)fluoranthene, otherwise the recovery values for that compound ranged from 89 percent to 106 percent, which is viewed to be good performance. Dibenzo(a,h)anthracene exhibited poorer performance, with mean recoveries across aqueous LCS, LCSD, MS, and MSD samples ranging from 40 percent to 45 percent.

The target compound recoveries were reflected in the recoveries of surrogate compound, *p*-terphenyl. The mean *p*-terphenyl recovery across all aqueous samples, including those in which no target compounds were detected, was 84 percent, with a range of 58 to 106 percent.

These results indicated that, on average, PAH results in water should be expected to exhibit no significant biases with the exception of dibenzo(a,h)anthracene. Dibenzo(a,h)anthracene results were likely to be biased slightly low (about -60 percent), and the degree of bias may vary with the concentrations of this compound in individual samples.

Polychlorinated Biphenyls in Soil and Sediment, Round 1

The %R values for target PCBs in soil and sediment across all LCS, LCSD, MS, and MSD samples ranged from an average of 88 to 106 percent, indicating no significant biases.

There were two surrogate compounds used in PCB analyses of soil and sediments - decachlorobiphenyl (DCB) and tetrachloro-meta-xylene (TCX). DCB recoveries ranged from 85 to 121 percent across all soil and sediment and related QC samples, with a mean recovery of 102 percent; TCX recoveries ranged from 68 percent to 106 percent with a mean recovery of 87 percent. These data indicated that there were generally no significant biases associated with PCB results in soil and sediment.

Polychlorinated Biphenyls in Ground Water, Round 1

The %R values for target PCBs in ground water across all LCS, LCSD, MS, and MSD samples ranged from an average of 65 to 84 percent, indicating a slight low bias in aqueous samples. The degree of bias may vary with the concentrations of these compounds in individual samples.

As for solid samples, DCB and TCX were used as surrogate compounds in the PCB analyses of aqueous samples. DCB recoveries ranged from 40 to 145 percent across all ground water and related QC samples, with a mean recovery of 75 percent; TCX recoveries ranged from 44 to 136 percent with a mean recovery of 73 percent in these aqueous samples.

One sample, 01GWT0202, which exhibited 44 and 61 %Rs for DCB and TCX, respectively, was re-extracted and re-analyzed. The second set of results yielded 92 percent and 115 percent for DCB and TCX, respectively. This was a significant improvement in performance. The statistics above include both sets of results.

Together, these target analyte and surrogate compound recovery data indicated that there was a slight low bias (perhaps as great as -30 percent) associated with PCB analyses, on average, in aqueous samples.

Pesticides in Soil and Sediment, Round 1

The %R values for organochlorine pesticide target compounds across all soil and sediment LCS, LCSD, MS, and MSD samples ranged from 73 to 153 percent except as noted here.

Endrin and 4,4'-DDE each exhibited generally acceptable recoveries within the range of 100 percent +/-25 percent, yet two values exceeded 125 percent. One MS Endrin recovery was 313 percent (Sample 01SS100002), and one MS 4,4'-DDE recovery was 323 percent, indicating a possible quantitation interference for those compounds in soil samples. In general, only a positive bias, if any, should be expected for Endrin and 4,4'-DDE. Because neither of these analytes was detected in any site samples and the extreme biases are on the high side, the possibility of laboratory error or quantitation interferences was not investigated.

The range of %R values was 33 to 100 percent with most values being less than 75 percent.

Endosulfan I and Endosulfan II exhibited mean %Rs across all LCS, LCSD, MS, and MSD samples of approximately 50 percent and 60 percent, respectively. Thus, the concentrations of these compounds were expected to exhibit a low bias. The magnitude of bias may vary with the concentrations of these compounds in individual samples.

Endrin aldehyde %R values ranged from 41 to 109 percent with a mean %R at 103% across LCS, LCSD, MS, and MSD samples.

DCB and TCX were the surrogate compounds used in pesticide analyses of soil and sediment samples. DCB recoveries ranged from 66 to 140 percent across all soil and sediment and related QC samples, with a mean recovery of 94 percent; TCX recoveries ranged from 65 to 100 percent with a mean recovery of 85 percent. In general, these data indicated there were no significant biases associated with pesticide analyses except for Endosulfan I and Endosulfan II, which exhibit a moderate low bias.

Pesticides in Ground Water, Round 1

Except for Endosulfan I and Endosulfan II, the mean %R values for pesticides in ground water across all LCS, LCSD, MS, and MSD samples ranged from 60 to 119 percent, indicating a potentially slight, but probably insignificant, low bias in aqueous samples. Endosulfan I exhibited recoveries ranging from 33 to 57 percent, indicating a moderately low bias, the degree of which may depend on Endosulfan I concentrations in individual samples. Endosulfan II also exhibited a moderate low bias with %R values ranging from 40 to 75 percent.

As for solid samples, DCB and TCX were used as surrogate compounds in the pesticide analyses of aqueous samples. DCB recoveries ranged from 28 to 118 percent across all ground water and related QC samples, with a mean recovery of 80 percent. Only one sample (rinsate blank RB08240101) had a recovery less than 40 percent. TCX recoveries ranged from 48 to 119 percent with a mean recovery of 86 percent in these aqueous samples. Only one sample (rinsate blank RB08260101) had a recovery less than 69 percent.

Together, these target analyte and surrogate compound recovery data generally indicated that there were no significant biases associated with pesticide analyses except for a moderate low bias for Endosulfan I and Endosulfan II.

Metals in Soil and Sediment, Rounds 1 and 2

The mean LCS and LCSD %R across all Round 1 soil and sediment SDGs for metals analyses ranged from 97 to 117 percent except for mercury. The mean mercury LCS and LCSD percent recoveries were 77 to 80 percent, respectively. This indicated that, with the exception of mercury, all metals LCS and LCSD recoveries were acceptable for soil samples, and solid metals concentrations exhibited no bias to a slight positive bias. Mercury results exhibited a slight negative, but insignificant, bias.

The situation was slightly different in the actual Round 1 soil or sediment sample matrix, as reflected in MS recoveries. Metal recoveries were generally acceptable with no significant bias, except for antimony. A potentially poor antimony recovery was anticipated, based on past experience with antimony analyses in soil at the site. To mitigate the anticipated poor recoveries, the hydrochloric acid option of SW-846 Method 3050B was specified in the sample preparation method (MGBG QAPP, Table 7-1). This option generally facilitates antimony recovery from soils. Despite the attempt to mitigate poor antimony recoveries, the antimony mean %R for MS samples was 57 percent with a standard deviation of 23 percent. This indicated a negative bias for antimony in the site soil samples. The degree of bias may fluctuate with native antimony concentrations in the samples.

The solid LCS/LCSD recoveries for Round 2 ranged from 79 to 113 percent. Thallium was analyzed in Round 2 by graphite furnace atomic absorption (GFAA) rather than by inductively coupled plasma spectroscopy for reasons explained in Section 3.4.5. The thallium LCS/LCSD recoveries were 84.7 percent and 89.3 percent.

MS recoveries for Round 2 sediment ranged from -13,761 to 927.3 percent. Except in one case, the extreme values were manifestations of a low spike amount relative to the native sample concentration which invalidates the spike as a QC measure and does not reflect poor analytical. Antimony had a 30.7 %R, which does indicate a low bias. The post digestion spike recovery for antimony was 92.5 percent, which indicated that the low recovery was probably associated with matrix effects that affected the sample preparation.

The essential nutrients, aluminum, calcium, iron, magnesium, potassium, and sodium, are not required to be spiked in soil or sediment samples because of their large native concentrations, and these metals were not evaluated for MS recovery.

Metals in Ground Water, Round 1

All metal %Rs in Round 1 ground water LCSs, LCSDs and MSs were within the acceptable ranges except for calcium, which had a mean %R of 70 percent. This recovery is not far outside expected recovery limits of approximately 100 percent +/-25 percent, and calcium is a macronutrient. Therefore, no adverse impact to data usability is expected. Use of these calcium data for any objective not specified for this project should take this bias into account.

All Round 2 %Rs except thallium in one MS (68.7) were within the 75 percent to 125 percent range. Except for this single thallium recovery, which is just outside the 75 percent to 125 percent range, all MS recovery values were within the 83 percent to 110 %R recovery range with nearly all values falling within the 90 percent to 105 percent range. In summary, there were no biases expected for metal recoveries.

Semivolatile Organic Compounds in Soil and Sediment, Round 1

Although PAHs are generally classified as SVOCs, they are excluded from this discussion because they were analyzed separately from the majority of SVOCs and are discussed separately.

The mean %Rs of all target SVOCs across all soil and sediment LCS, LCSD, MS, and MSD samples and related QC samples ranged from 24 percent to 138 percent, which is typical of SVOC analyses. MS and MSD recoveries were approximately 10 percent less than in LCSs and LCSDs, on average. This indicates a slight difference between the actual environmental sample matrices and the LCSs used to determine whether the analytical system is working properly prior to analysis of environmental samples.

As a group, the SVOCs exhibit a slight low bias with recoveries ranging from 65 to 90 percent in MS except as noted here. 2,6-Dichlorophenol recovery values were less than 10 percent. Aniline (17 to 46 %R), 4-chloroaniline (19 to 65 %R), diphenylamine (29 to 34 %R), hexachlorocylopentadiene (12 to 36 %R), and pyridine (12 to 40 %R) showed low biases across MSs. Di-n-butylphthalate (44 to 88 %R) and 4-nitroaniline (51 to 90%R) showed a moderately low bias across MSs. For the affected analytes, these recoveries reflect difficulty in extracting the analyte from the sample matrix and indicate that site concentrations are probably greater than the reported concentrations.

Bis(2-ethylhexylphthalate, butylbenzylphthalate, and di-n-octylphthpalate exhibited high biases with recoveries in the range of 95 to 142 %R. The concentrations reported for these compounds are probably slightly to moderately exaggerated relative to the actual site concentrations.

Six surrogate compounds were used in SVOC analyses of soil and sediment: 2,4,6-tribromophenol, 2 fluorobiphenyl, 2-fluorophenol, nitrobenzene-d5, phenol-d5, and terphenyl-d14. The mean recovery of surrogate compounds ranged from 74 percent to 108 percent, with most of the mean surrogate recoveries greater than 85 percent. This indicated typical analytical performance overall and is consistent with the observations for the target compounds. The potential for moderately low biases should be considered when using the data.

Semivolatile Organic Compounds in Ground Water, Round 1

Except as noted below, non-PAH recoveries fell in the range of 40 to 155 percent across LCS/LCSDs and MS/MSDs which is typical of SVOCs. PAH recoveries are discussed separately.

The mean %R of all target SVOCs across all aqueous LCS, LCSD, MS, and MSD samples and related QC samples ranged from 7 percent to 158 percent. MS and MSD recoveries were approximately 10 percent less than in LCSs and LCSDs, on average. This indicates a slight difference between the actual environmental sample matrices and the LCSs used to determine whether the analytical system is working properly prior to analysis of environmental samples.

Six surrogate compounds were used in SVOC analyses of ground water: 2,4,6-tribromophenol, 2-fluorobiphenyl, 2-fluorophenol, nitrobenzene-d5, phenol-d5, and terphenyl-d14. The mean recovery of surrogate compounds ranged from 48 percent to 97 percent, with most of the mean surrogate recoveries greater than 70 percent. This indicates typical analytical performance overall and is consistent with the observations for the target compounds. The potential for moderately low biases should be considered when using the data.

A potential for severe low bias should be expected for the following compounds. Hexachlorocylclopentadiene recoveries averaged 15 percent across LCSs and LCSDs with a minimum of 7 percent and a maximum of 28 percent. Diphenylamine recoveries in LCS/LCSD pairs were tightly grouped from 28 to 33 percent. The 2,6-Dichlorophenol recovery was 17% in the MS/MSD pair and ranged from 16 to 21 %R across five LCS/LCSD pairs. The 2,6-dichlorophenol recoveries ranged from 16 to 21%R in the LCSD. These recoveries are low and indicate that reported concentrations are probably less than actual site concentrations.

Volatile Organic Compounds in Soil and Sediment, Rounds 1 and 2

Most of the mean recoveries of VOC target analytes across all soil and sediment LCS, LCSD, MS, and MSD samples ranged from 75 percent to 125 percent. The 19 exceptions out of 56 target VOCs are presented in Table 3-9 with their mean recoveries in each of the four bias QC indicator samples.

Of the exceptions, items 1, 2, 3, 7, 8, 10, 12, 14, 16, 17, and 18 in Table 3-9 exhibit recoveries that are within, or close to being within, the 100 percent ±25 %R range for all four QC indicators. For these compounds, one or more of the individual QC sample recoveries (not shown) exhibited an unusually high bias. Given that these compounds were detected infrequently, if at all, the consequence of the unusual high bias was considered to be insignificant. Furthermore, the existence of a high bias suggested that analyte concentrations were overestimated and thus limited the possibility of not detecting the analyte if it is present.

Analytes that exhibited extremely high mean recoveries (greater than 200 percent) in at least one QC sample type are those for which the analytical response is poor. Problems with the quantitation of these compounds is common and does not reflect any deficiency with the implementation of the analytical method. It does, however, reflect the relatively common occurrence of spurious results for these and other analytes that exhibit low analytical responses.

For parameters that exhibited an extreme high bias in the MSD, the recoveries were not investigated in detail because the other QC indicators appeared to be normal and the high bias was considered insignificant for reasons previously described. Seven other VOCs - items 4, 6, 9, 11, 13, 15, and 19 in Table 3-9 - exhibited significant low biases as represented by the LCS/LCSD and MS/MSD recoveries. Those items are highlighted in the table. The only extreme case is item 13 (ethyl methacrylate), which exhibited a mean recovery of about 20 percent in the MS and MSD. Otherwise, the exceptions generally exhibited moderately low recoveries in the 40 percent to 70 percent range.

Four surrogate compounds were used in VOC analyses of soil and sediment: 1,2-dichloroethane-d4, 4-bromofluorobenzene, dibromofluoromethane, and toluene-d8. The mean recovery of surrogate compounds across all soil and sediment samples ranged from 92 percent to 103 percent. These recoveries represented excellent analytical performance with no significant bias.

In summary, Round 1 VOC analyses in soil and sediment should generally not be expected to exhibit a bias, with the exceptions as indicated above. Biases can vary with analyte concentration.

The Round 2 surrogate recoveries across all samples ranged from 78 percent to 114 percent, indicating good recovery of the surrogates and probably of chemically similar compounds.

Round 2 LCS and LCSD recoveries were generally within the 75 to 125 percent range or greater. For example, carbon disulfide yielded LCS recoveries of 160 percent and 170 percent in two LCSs. However, this is an extreme case, and most LCS/LCSD recoveries greater than 100 percent were less than 125 percent. The few exceptions where at least one LCS or LCSD recovery was less than 75 percent are: isobutyl alcohol (47 percent in one LCSD); methylene chloride (52 percent in one LCSD); bromomethane (65 percent in one LCS); chloroethane (73 percent in one LCSD); acetone (73 percent in one LCSD); 1,1-dichloroethene (73 percent in one LCS); carbon disulfide (70 percent in one LCSD) 1,4-dioxane (9 percent in one LCSD); and 2-butanone (70 percent in one LCS).

The Round 2 MS/MSD recoveries were also generally biased high, if at all, with the exception of 1,4-dioxane (9 %R in the MS); and bromomethane (74 %R in the MS).

Overall, the VOC results appeared to be without significant bias, except for the Round 1 exceptions highlighted in the table above. Nevertheless, several Round 1 and Round 2 1,4-dioxane and other VOC results have been rejected on the basis of poor calibration response (Table 3-4) and should not be used in a quantitative manner.

Volatile Organic Compounds in Ground Water, Rounds 1 and 2

Most of the mean recoveries of VOC target analytes across all ground water LCS, LCSD, MS, and MSD samples ranged from 75 percent to 125 percent in Round 1. The 32 exceptions out of 56 target VOCs are presented in Table 3-10 with their mean recoveries in each of the four bias QC indicator samples.

Of the exceptions, items 3, 6, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 26, 27, 29, 30, and 32 in Table 3-10 exhibited recoveries close to the 100 percent ±25 %R range, and/or one or more individual QC sample recoveries exhibited an unusually high bias. Given that these compounds were detected infrequently, if at all, the consequence of any unusual high bias was insignificant for reasons similar to those for soils and sediments. Item 9 in Table 3-10 (2-hexanone), exhibited an unusually high bias in the MSD, but the cause of the reported high this was not investigated because the other QC indicators appeared to be normal. This leaves 11 VOCs - items 1, 2, 4, 5, 7, 8, 16, 24, 25, 28, and 31 - that exhibited significant low biases as reflected in the LCS/LCSD and MS/MSD recoveries. Those compounds are highlighted in Table 3-10. In general, the 11 exceptions exhibited moderately low mean recoveries in the 55 to 103 percent range, with only three out of 44 recoveries exceeding 100 percent

across all four QC sample types. The only extreme cases are items 2 (1,1,2,2-PCA), 16 (carbon disulfide), and 25 (methyl methacrylate). These compounds exhibited mean recoveries within the range of 30 percent to 40 percent for the LCS and/or LCSD. Individual LCS and LCDS recoveries for 1,1,2,2-PCA ranged from 5 percent to 120 percent, whereas the individual recoveries in site ground water samples were more consistent, ranging from 64 percent to 90 percent. A similar effect was observed for carbon disulfide. The methyl methacrylate recoveries were virtually identical regardless of whether the matrix was site ground water or the LCS.

Four surrogate compounds were used in VOC analyses of ground water: 1,2-dichloroethane-d4, 4-bromofluorobenzene, dibromofluoromethane, and toluene-d8. The mean recovery of surrogate compounds across all groundwater samples ranged from 94 percent to 113 percent. These recoveries represented excellent analytical performance with no significant bias.

Round 2 LCS/LCSD recoveries ranged from 75 to 125 percent across nine LCS/LCSD pairs with exceptions described below. The exceptions are bromomethane (69 percent to 74 %R across eight LCSs; 70 to 72 percent across six LCSDs), methylene chloride (70 percent, 2x130 percent, and 160 %R across four LCSs; 72 percent, and 2x130 percent across three LCSDs), acetone, 2x53 percent, and 69 %R across three LCSs; 2x65 percent and 69 percent across three LCSDs), chloroform (2x140 percent across two LCSs; 2x150 %R across two LCSDs), 1,4-dioxane (2X0 percent, and 65 percent across three LCSs; 2X0 percent across two LCSDs), isobutyl alcohol (70 percent in one LCS). These recoveries were generally just outside the 75 percent to 125 percent range except for acetone and 1,4-dioxane, which exhibited consistently low recoveries. In general, the acetone is moderately affected by a low bias, 1,4-dioxane is greatly affected by severe low bias.

The same compounds that exhibited LCS/LCSD recoveries outside the 75 percent to 125 percent range generally exhibited MS/MSDs recoveries results outside that range. Otherwise, the MS/MSD recoveries fell within this range across the three MS/MSD pairs that were analyzed. In one SDG, bromomethane yielded MS and MSD recoveries of 31 percent, and 35 percent, respectively, acetone yielded MS and MSD recoveries of 44 percent and 41 percent, respectively, and methylene chloride yielded MS and MSD recoveries of 73 percent and 86 percent, respectively. In another SDG, chloroform yielded 60 %R in the MS and 50 %R in the MSD; isobutyl alcohol yielded 140 %R in the MS and 145 %R in the MSD; and 1,4-dioxane yielded 0 %R in both the MS and MSD. In the surface water SDG, acetone yielded a 50 percent MS recovery and 40 percent MSD recovery; bromomethane yielded a 65 percent MS recovery and 69 percent MSD recovery; TCE yielded a 140 percent MS recovery; 1,4-dioxane yielded a 135 percent MS recovery and 145 percent MSD recovery; tetrachloroethene yielded 150 percent MS and MSD recoveries and 1,1,2,2-PCA yielded 2 percent MS and 37 percent MSD recoveries.

Round 2 surrogate recoveries ranged from 50 to 119 percent. The 50 %R represented a single result. All other surrogate recoveries were greater than or equal to 85 percent, indicating acceptable analytical performance with regard to surrogate recoveries.

All Round 2 dissolved gas (ethane, ethene and methane) results were within the acceptance ranges. The LCS recoveries for all three gases was 99 percent to 106 percent, and for the LCSDs it was 92 percent to 100 percent.

In summary, approximately half of the VOC target analytes, but none of the surrogate compounds exhibited a slight to moderate low bias in the analysis of water samples. The VOCs that were most likely to exhibit such a bias are presented in Table 3-10. The Round 1 exceptional compounds highlighted in that table, plus isobutyl alcohol, should be expected to yield low recoveries in most ground water samples, and 1,4-dioxane should be expected not to be recoverable from aqueous samples in many cases. Some of these poor recoveries are manifestations of a poor (i.e., low) analytical response. Several Round 1 and Round 2 results for 1,4-dioxane and other VOCs have been rejected on the basis of poor calibration response (Table 3-4) and should not be used in a quantitative manner. The surface water LCS/LCSD and MS/MSD samples did not show a poor 1,4-dioxane recovery; however, dioxane results should still be considered uncertain because of the poor analytical response. Finally, the surface water MS and MSD recoveries for 1,1,2,2-PCA are biased low (approximately 30 %R on average). When compared to ground water QC indicators, which should behave similarly to surface water QC indicators, it appears that the single matrix spike performance for this compound was a fluke. However, this is not demonstrable with the available data and 1,1,2,2-PCA results should be considered potentially biased low in surface water. Biases can vary with analyte concentration.

Radiological Parameters in Soil and Sediment, Rounds 1 and 2

QC data were not available in electronic file format; however, LSC recoveries were tabulated manually for gamma spectrometry and alpha spectroscopy to yield estimates of accuracy. Minimum and maximum tracer yields were tabulated manually for alpha spectroscopy and an estimate was made of the average yield, based on visual inspection of the data, again to support estimates of accuracy. Minimum and maximum calibration standard recoveries were tabulated manually for gamma spectrometry and an estimate was made of the average recovery, based on inspection of the data, to support estimates of accuracy.

The average LCS recovery across all Round 1 soil and sediment samples was 116 percent for alpha spectroscopy. The range of yields was 22.7 percent to 91.7 percent for the thorium-234 tracer, with an estimated average yield of approximately 60 percent. Any individual yield greater than 20 percent is considered to be acceptable. These values indicate acceptable analytical yields for thorium isotopic analyses by alpha spectroscopy.

The average LCS recovery across all Round 1 soil and sediment samples was 100 percent for gamma spectrometry. The LCS recovery precision was approximately 3 percent (1 standard deviation). The recoveries of gamma spectrometry calibration standards ranged from 96.4 to 102.6 percent. These results are indications of satisfactory precision and accuracy.

The LCS recovery for Round 2 thorium analyses was 112 percent, indicating acceptable laboratory accuracy with no expectation of bias. The tracer percent yields ranged from 59 percent to 66 percent, also indicating acceptable laboratory performance.

Overall, no significant analytical biases were detected for radiological parameters in soil or sediment.

Radiological Parameters in Ground Water and Surface Water, Rounds 1 and 2

LSC recoveries were tabulated manually for gamma spectrometry and alpha spectroscopy to yield estimates of accuracy. Minimum and maximum tracer yields were tabulated manually for alpha spectroscopy and an estimate was made of the average yield, based on visual inspection of the data, to support estimates of accuracy. Minimum and maximum calibration standard recoveries were tabulated manually for gamma spectrometry and an estimate was made of the average recovery, based on inspection of the data, to support estimates of accuracy.

The average LCS recovery across all Round 1 soil and sediment samples was 119 percent for alpha spectroscopy. The range of yields was 26 percent to 80 percent for the thorium-234 tracer, with an estimated average yield of approximately 50 percent. Any individual yield greater than 20 percent is considered to be acceptable. These values indicate acceptable analytical yields for thorium radioisotopic analyses by alpha spectroscopy.

The average Round 1 gamma spectrometry LCS recovery across all aqueous samples was 100 percent with a precision of approximately 3 percent (1 standard deviation). The recoveries of gamma spectrometry calibration standards ranged from 96.4 to 102 percent. These results are indications of satisfactory accuracy.

The Round 2 gross alpha LCS recovery was 114 percent for samples FD06160201, 01GWT0401, and 01GWT0301, and 01GWT0501, indicating acceptable performance. The gross alpha MS recoveries for Round 2 exceeded 125 percent for some samples (FD06160201, 01GWT0401, and 01GWT0301, and 01GWT0501). The MS and MSD recoveries were 172 percent and 169 percent, indicating a high bias. However, the gross alpha concentrations were less than the minimum detectable activity for the associated samples so there is no adverse impact to data quality for those samples. The gross alpha LCS recovery was 100 percent for sample 01GW2302, indicating acceptable performance. However, the gross alpha MS and MSD recoveries were 45 percent and 34 percent, respectively for sample 01GW2302, indicating a moderate low bias. The gross alpha LCS recovery for sample 01GWT0203 was 94 percent and the MS and MSD recoveries were 118 percent and 98 percent, all indicating acceptable analytical performance.

The gross beta LCS and MS/MSD recoveries ranged from 69 percent to 91 percent across all SDGs with only one of the nine values being less than 75 percent. This indicates acceptable analytical performance with a potential for a slight low bias.

Overall, the radiochemical analytical performance was acceptable; however, gross alpha results for Round 2 sample 01GW2302 could be biased low, as explained above.

Mustard Gas and Degradates in Soil and Sediment, Round 1

Mustard gas QC data were not available electronically, so a detailed statistical analysis of the data was not conducted. Nevertheless, no mustard gas results were qualified during data validation, and a manual review of the QC bias indicators revealed that most surrogate recoveries were within the range of 90 percent to 110 percent. This indicates very good analytical performance overall, but there was one exception. The surrogate %R in sample 01SS060002 was 63 percent for the original analysis and 127 percent for the duplicate analysis. On average, there was no significant bias for this sample, but the data suggested some unexpected uncertainty in the analysis. Overall, there were no significant biases associated with mustard gas analyses in soil and sediment.

Mustard Gas and Degradates in Ground Water, Round 1

No mustard gas results were qualified during data validation, and a manual review of the bias indicators revealed that there were no significant bias concerns for ground water mustard gas analyses.

Miscellaneous Parameters in Soil and Sediment, Round 1

TOC - No TOC results were qualified, and all bias indicators fell within the acceptable range. The mean LCS/LCSD recovery was 82 percent with a standard deviation of 3 percent (4 values), indicating no significant bias in TOC analyses.

CEC - Six of 25 CEC results were qualified as estimated (J qualifier) because of high LCS/LCSD recoveries. The mean LCS/LCDS recovery was 247 percent with a standard deviation of 88 percent (8 values), indicating a high bias. No MSs are analyzed for CEC analyses. Despite the high LCS and LCSD recoveries, the CEC results appeared to be consistent with the soil types encountered at the MGBG. It was not possible to estimate whether the data were biased or by what magnitude given the available QC data.

The observed high LCS bias cannot be explained by imprecision because the RPD values presented in the previous section for CEC are less than or equal to 10 percent. The RPD values are much less than the standard deviation of the LCS and LCSD recoveries. This could indicate a problem with the LCS, but not enough data are available to assess the nature of any potential problems.

In summary, the LCS results could be biased high, but it is not possible to know this with confidence. This uncertainty does not affect the ability to achieve project objectives; however, the potential bias should be considered if more accurate CEC data are required.

pH - A bias indicator was not analyzed.

Miscellaneous Parameters in Ground Water, Rounds 1 and 2

Natural Attenuation Parameters (Round 2 only) – All field QC checks were within acceptance ranges prior to measuring natural attenuation parameters in the field. The same was true for fixed laboratory measurements. For example, inorganic chloride LCS/LCSD and MS recoveries ranged from 99.6 percent to 102.5 percent, well within expectations. No bias was expected for MNA analyses.

TOC - No TOC results were qualified, and all bias indicators were within the acceptable range. The mean LCS/LCSD recovery for Round 1 was 104 percent with a standard deviation of 2 percent (12 values), indicating no significant bias in TOC analyses. For Round 2, the LCS and LCSD recoveries ranged from 97.4 percent to 98.1 percent (four values), well within expectations. No bias was expected for TOC analyses.

pH - A bias indicator was not analyzed.

3.3.5 Comparability

Comparability is defined as the confidence with which one data set can be compared with another (e.g., among sampling points and among sampling events). Comparability was achieved by using standardized sampling and analysis methods, as well as standardized data reporting formats. Comparability of field data was ensured by following the MGBG QAPP, the Round 2 SAP and the associated SOPs (TtNUS, 2001b; TtNUS, 2002b). Comparability of laboratory measurements was achieved primarily through the use and documentation of standard sampling and analytical methods. Results were reported in units that ensured comparability with previous data and with current state and federal standards and guidelines. Comparability of laboratory measurements was assessed primarily through the use of QC samples and through adherence to the QA plan. No comparability problems were detected.

The laboratory analyzed various QC samples along with the environmental samples to allow data users to assess the quality of the data. Tables 3-9 and 3-10 show the rates of data qualification that resulted from application of the data validation process for aqueous and solid samples, respectively. Quantitative summaries of precision and accuracy are provided in Sections 3.3.3 and 3.3.4.

The issue of comparability can be very important when comparing data sets that were generated at different times or at different laboratories. For this project, both conditions exist. Background soil data were generated in 2000 by Laucks Testing Laboratory, Inc., located in Seattle, Washington. The MGBG data for this investigation were generated in 2001 and 2002 by Southwest Laboratory of Oklahoma. The historical data set spans a seven-year period from 1980 to 1986, and the laboratory data quality are unknown for that time period. Despite these various time frames for data generation, no differences have been detected that would indicate the inability to compare data, at least qualitatively. Potentially different laboratory biases and analytical limitations and improvements over the past 20 years were considered when interpreting the data quantitatively for this project.

3.3.6 Representativeness

Representativeness is an expression of the degree to which data accurately and precisely depict the actual characteristics of a population or environmental condition existing at an individual sampling point and is contingent on a good design for the sampling program. For each environmental medium investigated, there were two general populations - site and background. The site population(s) is the

portion of a medium potentially contaminated as a result of site operations. Sampling of the site population was designed to directly support the project objectives of determining the nature and extent of contamination and evaluating human and ecological risks. The background population is that portion of a medium that is similar to the site population but expected or known not to be contaminated through site operations. A background population is a point of reference for understanding whether or not site chemical concentrations represent site-related contamination. For mobile media (sediment, surface water and ground water) the term upgradient, rather than background, is generally used to refer to locations unaffected by site operations.

For ground water, an adequate number of representative upgradient samples could not be collected because, as described in Section 1.0, the ground water flows in all directions from the MGBG. For soils, an adequate number of subsurface background samples from Soil Group 9 is unavailable for all NSWC Crane investigations. This is explained in more detail in the next section. Otherwise, an adequate number of background (or upgradient) samples was collected to establish a point of reference for determining whether inorganic chemicals detected at the MGBG were site-related.

Data were collected from the locations specified in the MGBG QAPP and Round 2 SAP with only minor modifications that reflect uncertainty in marking the locations in the field. The project planning documents (MGBG QAPP, Round 2 SAP) and the use of standardized sampling, handling, analytical, and reporting procedures were designed so that the final data would be accurate representations of actual site conditions. Few deviations were noted from the prescribed procedures and governing documents. These deviations, described in Section 2.0, have been evaluated for their impact on the ability to achieve project objectives. It is believed that all reported data are adequately representative of site conditions.

3.4 CALCULATED CONCENTRATIONS AND ADDITIONAL DATA EVALUATIONS

After the technical data quality was assessed, several additional calculations and data evaluations were implemented before the MGBG were evaluated for extent of contamination, contaminant transport, and human health and ecological risks. The additional evaluations are described in this section.

3.4.1 Calculated Values

Physical characteristics of the shallow and deep water-bearing zones were calculated. In addition, the concentrations of ground water hardness and natural thorium in soil and sediment were computed from other chemical or radiochemical data, respectively. With the exception of values calculated according to

Section 3.4.1.1, the calculated concentrations are stored in the TtNUS CTO 158 database. The methods of computing those values are described in the next three subsections.

3.4.1.1 Hydraulic Conductivities

Water level drawdown data were acquired during sampling of shallow and deep ground water monitoring wells. The drawdown rates were converted to hydraulic conductivities for the shallow and deep wells using the approach documented in Appendix B-5. The results are summarized here.

Seepage velocity, V_s, was calculated for each water-bearing zone using the following equation:

$$V_s = K \times i/n.$$

The horizontal hydraulic conductivity (K) for the shallow water-bearing zone was estimated to be 0.023 feet/day. The porosity (n) was estimated to be 21 percent from the Indiana Geological Survey Open-File Report 93-8. The hydraulic gradients (i) were estimated to range from 0.05 to 0.3. The calculated seepage velocity ranged from 0.0054 to 0.033 feet/day.

The horizontal hydraulic conductivity (K) for the deep water bearing zone was estimated to be 0.27 feet/day. The porosity (n) was estimated from the Beech Creek Limestone analysis to be 1.67 percent from the Indiana Geological Survey, and the hydraulic gradient (i) was estimated to be 0.005. The seepage velocity was calculated to be 0.080 feet/day for the deep water-bearing zone.

3.4.1.2 Hardness

Instead of measuring hardness directly in the field or at a fixed laboratory, hardness values were computed using the method described in Standard Methods for the Examination of Water and Wastewater [American Public Health Association (APHA), 1998]. This calculation method, reported to be applicable to all waters and to be more accurate than the direct measurement method, uses the following equation:

$$\text{Hardness} = 2.497 * [\text{Ca}] + 4.118 * [\text{Mg}]$$

where: hardness is expressed in units of mg/L of calcium carbonate ($CaCO_3$)
[Ca] is the calcium concentration in units of mg/L
[Mg] is the magnesium concentration in units of mg/L

Total calcium and magnesium concentrations (rather than dissolved concentrations) were used for these calculations. Dissolved and total calcium and magnesium results from site ground water samples generally agreed within a few percent on a sample-by-sample basis, indicating that these metals were essentially completely dissolved. The TtNUS CTO 158 lists these calculated hardness results as parameter name "HARDNESS-CALC", with associated measurement units of mg/L.

3.4.1.3 Conversion of Thorium Radioactivity Concentrations to Chemical Concentrations

Alpha spectroscopy is a radioanalytical technique that provides radioisotope-specific concentrations. This technique was selected as the preferred technique for quantifying thorium concentrations in MGBG samples because it would provide radioisotopic data. The radioisotopic thorium concentrations could be used to infer whether thorium detected at the site was naturally occurring thorium by comparing the radioacitivities of thorium-228 and thorium-232. These radioisotopes are in secular equilibrium in naturally occurring thorium. Thus, with allowance for measurement uncertainty, these radioisotopes each have the same radioactivity levels in a given sample of naturally occurring thorium. Furthermore, alpha spectroscopy exhibits a detection limit for thorium that is less than the detection limits of commonly used chemical analytical techniques such as ICP. The low detection limit of alpha spectroscopy was well suited to the analysis of water samples that were expected to have very low to non-detectable concentrations of thorium (thorium binds very tightly to soil and bedrock). The measurement units for alpha spectroscopy results are pCi/g (soil and sediment) or pCi/L (water).

The available background soil data for thorium was generated through the use of inductively coupled plasma mass spectrometry (ICPMS) (TtNUS, 2001a). These ICPMS measurements are classified as chemical measurements. They do not provide information on the concentrations of individual radioisotopes, and the measurement units are mg/kg (soil and sediment) or µg/L (water). However, rather than analyze MGBG soil samples by both ICPMS and alpha spectroscopy, a simple conversion between radioisotopic and chemical concentrations was conducted. The concentration ratio of thorium-228 to thorium-232 in each sample was first computed and reviewed to provide assurance that the ratios were approximately equal to unity (Figure 3-1). Of 79 soil, sediment, and ground water ratios from Round 1, including duplicate samples, 76 fell within 50 percent of unity. The three exceptions were ratios of 0.47, 1.63, and 1.78. The 0.47 and the 1.63 ratios are associated with the same soil boring located several hundred feet from where any thorium burials are documented to have occurred. These exceptional results appear to reflect random data scatter. In addition, the radioactivity levels measured at the MGBG for thorium-232 and thorium-228 are comparable to what would be expected from naturally occurring thorium - up to 0.6 pCi/g of thorium-228 and thorium-232, or up to 12 mg/kg of natural thorium.

These results indicate that the measured thorium-228 and thorium-232 concentrations represent naturally occurring thorium. Only one ground water sample had detectable concentrations of both thorium-228 and thorium-232, so a figure similar to Figure 3-1 could not be generated for ground water results. Nevertheless, that single thorium-228/thorium-232 ratio was 0.9, which is consistent with a ratio expected for naturally occurring thorium.

The conversions used to translate radioisotopic thorium-228 and thorium-232 concentrations into chemical thorium concentrations are:

Solid Samples

$$^{Nat}Th, mg/kg = \frac{\left(^{228}Th + ^{232}Th\right)}{0.22}$$

Aqueous Samples

$$^{Nat}Th, ug/L = \frac{\left(^{228}Th + ^{232}Th\right)}{0.22}$$

where: ^{Nat}Th represents naturally occurring thorium (as would be measured in a chemical analysis) in mass concentration units of mg/kg (soil and sediment) or ug/L (water);

^{228}Th and ^{232}Th are the radioactivity concentrations of thorium-228 and thorium-232, respectively, in units of pCi/g or pCi/L;

0.22 is the conversion factor as described in Section 12.0 of the MGBG QAPP.

The 0.22 conversion factor is the same for aqueous and solid samples when the measurement units are as described. Although the QAPP states that chemical thorium concentrations would be converted to radioisotopic concentrations, the inverse conversion (radiochemical to chemical units) proved to be more efficient and was used for this project.

The computed natural thorium values were used in background comparisons to determine whether natural thorium at the site exceeded background concentrations (Section 3.4.2).

Because thorium concentrations can be measured using both radiochemical and chemical techniques, it was necessary to indicate in the TtNUS database which results were generated by the different techniques. The TtNUS CTO 158 database for MGBG lists thorium-232 results from alpha spectroscopic analyses with a parameter name of "THORIUM." Thorium-228 results are listed with parameter name "THORIUM-228." The measurement units for these results are pCi/g (soil and sediment) or pCi/L (water).

The computed natural thorium concentrations are represented in the database as parameter name "THORIUM-CALC" and the associated measurement units are mg/kg (soil and sediment) or ug/L (water).

3.4.2 Background Comparisons

For this project, background concentrations of all targeted organic chemicals were assumed to be zero in all environmental media. Thus, any detection of an organic chemical indicated that the concentration was greater than its background concentration unless the chemical appeared to be associated with non-site-related contamination (e.g., laboratory contamination). Metals and radionuclides on the other hand, occur naturally in environmental media at measurable concentrations. Therefore, detection of a metal or metallic radionuclide in an environmental medium does not automatically indicate that the metal is a site contaminant. To make the latter determination, a comparison must be made between site and background data.

The term background comparison is used to represent the comparison of site sample data to data from samples that reflect site conditions in the absence of operationally related contaminants. In the case of MGBG soils, it refers to comparisons of MGBG soil data to background soil data collected under the NSWC Crane Base-wide Background Soil Investigation (TtNUS 2001a). For sediment and surface water, it represents the comparison of MGBG site samples to samples upgradient of the MGBG. Because the MGBG is on a ridge top, and ground water flow is radial, upgradient ground water data were not available.

Some background comparisons were conducted using simple one-to-one comparisons between site concentrations and background sample concentrations. Where enough data were available, statistical comparisons were made to account for the natural uncertainty that exists in the data. An analysis of variance (ANOVA) technique, described in detail in Appendix F, was used for all statistical comparisons.

The chemical analysis results needed no special treatment before conducting the background comparisons. Radioisotopic thorium data were compared to background thorium concentrations using both chemical and radiochemical concentrations, depending on the thorium isotope. Conversion of thorium-228 and thorium-232 radiochemical concentrations to mass concentrations are described in Section 3.4.1.3. Thorium-230 comparisons were made directly in the radiochemical units. Gamma spectrometric analytical data for select radionuclides were compared to background data generated from gamma spectrometric analysis of background soils associated with the MGBG. Descriptions of these comparisons are provided in the following subsections. Radiochemical analytical data were corrected for

background radiation levels in the radioanalytical laboratory but were not corrected for MGBG background radiation levels.

3.4.2.1 Soil

A comprehensive background soil investigation was conducted at NSWC Crane in 2000 (TtNUS, 2001a). One hundred and fifty-six surface and subsurface soil samples representing soils across NSWC Crane were collected, and 67 were selected randomly for chemical analysis. The targeted analytes were the U.S. EPA TAL of 23 metals plus lithium, strontium, thorium, and tin. The concentrations of these metals and related statistics are compiled in the Final Base-wide Background Soil Investigation Report for NSWC Crane (TtNUS, 2001a). Those concentrations represent the concentrations of metals in native soils that are unaffected by past and present operations at NSWC Crane.

Each background soil sample was classified according to the three physical characteristics of (1) soil parent material (depositional environment), (2) depth (surface or subsurface), and (3) dominant grain size (sand, silt, or clay). Consideration of these physical characteristics and a careful statistical evaluation of metal concentrations in the background samples led to the classification of the background soils into nine mutually exclusive soil groups.

Each of the MGBG soil samples falls into one of the following groups identified in the base-wide background soil investigation:

- Group 3 – All surface soil except surface soil from the loess/glacial depositional environment
- Group 8 – Pennsylvanian clay and silt subsurface soil
- Group 9 – Pennsylvanian subsurface sand

Summary statistics for these soil groups are provided in Appendix F.

MGBG background comparisons were accomplished by compiling all MGBG samples of a particular soil group into a single data set and comparing that data set to the corresponding background soil data set. Non-radioactive chemical data were compared directly to background data in chemical concentration units using the statistical method described in Appendix F. The concentrations of thorium-228 and thorium-232, in units of pCi/g, were converted to natural thorium concentrations in units of mg/kg as described in Section 3.4.1.3. The calculated thorium results (thorium-calc) in units of mg/kg were then compared to the thorium data from the NSWC Crane Base-wide Background Soil Investigation using the statistical method described in Appendix F.

Gamma spectrometric data were treated similarly except that gamma spectrometry data were not generated as part of the background investigation. Therefore, the background soil samples from the base-wide background investigation that corresponded to the soil groups found at the MGBG were analyzed in 2001 using gamma spectrometry. The radionuclides to be quantified were selected in advance of the analysis. The background data set for gamma spectrometric radionuclides is summarized in Table 3-13.

Thorium-230 required a different background comparison approach than the other metals and radionuclides. This radionuclide is not in radioactive equilibrium (secular equilibrium) with thorium-228 and thorium-232, so a simple conversion to chemical measurement units is not sufficient to enable comparisons to background chemical concentrations. Instead, background comparisons were made directly in radiochemical units of pCi/g without conversion to normal chemical units of mg/kg. Radioactivity levels of thorium-230 were compared directly to thorium-230 radioactivity levels observed in soil samples collected from the site-specific soil background location, 01SB21. Only one background value for thorium-230 was available for each of the three soil groups obtained from this location; therefore, no rigorous statistical comparisons could be performed. Instead, soil concentrations of thorium-230 at each MGBG sampling location were compared directly to the corresponding background concentrations.

Thorium-230 is a radioactive decay daughter of Uranium-234. When secular equilibrium is established between Uranium-234 and Thorium-230, the activity concentrations of each of these radionuclides per unit mass of sample is identical. If the specific activity of either radionuclide is known, the mass concentration may be calculated by recognizing that the radioactivity concentration divided by the specific activity yields the mass concentration:

$$\frac{g\ radionuclide}{g\ soil\ sample} = \frac{\dfrac{pCi}{g\ soil\ sample}}{\dfrac{pCi}{g\ radionuclide}}$$

The reverse calculation may also be performed to obtain a radioactivity concentration from a mass concentration. From the above relationship, the expected radioactivity of Thorium-230 in soil (assuming the condition of secular equilibrium) can be computed from the typical mass concentration of naturally occurring uranium in soil (i.e., approximately 3 mg/kg, of which 0.0055 percent is Uranium-234 by mass).

$$\frac{3\ mg\,U-Nat}{kg\,soil} * \frac{0.000055\ mg\,U-234}{mg\,U-Nat} = \frac{0.000165\ mg\,U-234}{kg\,soil}$$

Multiplying the mass concentration of Uranium-234 by its specific activity yields the activity concentration of Uranium-234:

$$\frac{0.000165\ mg\,U-234}{kg\,soil} * \frac{6.25E6\ pCi}{mg\,U-234} * \frac{kg}{1000\ mg} = \frac{1.03\ pCi}{g\,soil}$$

The Uranium-234 and Thorium-230 are assumed to be in secular equilibrium, so:

$$Thorium\ Activity = \frac{1.03\ pCi}{g\,soil}$$

This value is consistent with the observed Thorium-230 radioactivities at the MGBG and the background samples collected from soil boring 01SB21, thus demonstrating that the observed radioactivities are representative of naturally occurring background radioactivities. Some of the thorium-230 activity levels appear to be low as compared to the activities of other radionuclides in the same radionuclide decay chain, but the observed differences appear to be due, at least in part, to the different sample preparation used for the thorium isotopic analyses. Because the thorium-230 and other radionuclide activities were within background levels further investigation of the differences was not undertaken.

In addition to the non-statistical background comparisons, the relationship of thorium-230 to other radionuclides measured at the MGBG was exploited. This was done by comparing the thorium-230 results obtained from alpha spectroscopy to the results obtained using gamma spectrometry for other radionuclides that are in the same natural decay chain (i.e., thorium-234, uranium-234, protactinium-234, radium-226, lead-214, lead-210, and bismuth-214). If radionuclides in a given decay chain represent background radiation levels and are in secular equilibrium, the activities of the individual radionuclides should be similar.

Thorium-230 (Th-230) is a radioactive decay daughter of Uranium-234 (U-234). When secular equilibrium is established between U-234 and Th-230, the activity concentrations of each of these radionuclides per unit mass of sample is identical. For actual radioactivity measurements the activities will not necessarily be identical because of sampling and measurement uncertainties. Nevertheless, if the specific activity of

either radionuclide is known, the mass concentration may be calculated by recognizing that the radioactivity concentration divided by the specific activity yields the mass concentration:

$$\frac{g\ radionuclide}{g\ soil\ sample} = \frac{\dfrac{pCi}{g\ soil\ sample}}{\dfrac{pCi}{g\ radionuclide}} \quad (1)$$

The reverse calculation may also be performed to obtain a radioactivity concentration from a mass concentration. From the above relationship, the expected radioactivity of Th-230 in soil (assuming the condition of secular equilibrium) can be computed from the typical mass concentration of naturally occurring uranium in soil (i.e., approximately 3 mg/kg, of which 0.0055 percent is U-234 by mass).

$$\frac{3\ mg\ U\text{-}Nat}{kg\ soil} * \frac{0.000055\ mg\ U\text{-}234}{mg\ U\text{-}Nat} = \frac{0.000165\ mg\ U\text{-}234}{kg\ soil} \quad (2)$$

Multiplying the mass concentration of U-234 by its specific activity yields the activity concentration of U 234:

$$\frac{0.000165\ mg\ U\text{-}234}{kg\ soil} * \frac{6.25E6\ pCi}{mg\ U\text{-}234} * \frac{kg}{1000\ mg} = \frac{1.03\ pCi}{g\ soil} \quad (3)$$

The U-234 and Th-230 are assumed to be in secular equilibrium, so:

$$Thorium\ Activity = \frac{1.03\ pCi}{g\ soil}$$

This value is consistent with the observed thorium-230 radioactivities at the MGBG and the background samples collected from soil boring 01SB21, thus demonstrating that the observed radioactivities are representative of naturally occurring background radioactivities. Allowing for sampling and measurement uncertainties, the same approximate radioactivity levels would be expected of the other radionuclides in this decay chain, and similar activities were observed. In some cases, the thorium-230 results were lower than expected but this is attributed, at least in part, to the different sample preparations used for gamma spectrometry versus alpha spectroscopy. The gamma spectrometry samples were ground, homogenized, sealed in a container for 30 days, and then counted. The results for the gamma spectrometry radionuclides represent the entire sample matrix plus any contamination that is present. The alpha

spectroscopy samples were digested using the same acid leach procedure used for the other non-gamma spectrometry metals. The results from the acid leach represent surface contamination on the soil matrix plus a small amount of soil matrix. As observed, this would be expected to yield concentrations that are less than or equal to the gamma spectrometry data.

Some of the radium-226 results appear to be slightly elevated relative to an expected 1 pCi/g typical background concentration, but this has been attributed to the radium detection energy range being slightly wider than was perhaps necessary. Overlap between the 186 keV radium-226 energy and the 183 keV uranium-235 energy would also explain the existence of slightly elevated radium values. Because of this and because the radium-226 concentrations were well below soil cleanup levels (e.g., 15 pCi/g in subsurface soil), this was not investigated further.

3.4.2.2 Sediment

Sediment samples were collected during Rounds 1 and 2 from 01SD01 to represent upgradient sediment concentrations for all of the MGBG inorganic chemicals. The upgradient sediment sample numbers for Round 1 and Round 2 were 01SD0101 and 01SD0102, respectively. The Round 2 sample was analyzed only for metals, radioisotopic thorium, and VOCs in accordance with the March 13, 2002 technical memorandum concerning additional MGBG sampling. Round 1 and Round 2 data for the metals and radioisotopic thorium were pooled to support statistical background comparisons according to the method described in Appendix F.

Round 2 sediment analyses incorporated the use of GFAA rather than trace ICP for reasons explained in Section 3.4.5. The Round 2 sediment upgradient thallium result is consistent with the Round 1 thallium GFAA analyses in sediment and soil.

3.4.2.3 Ground Water

Wells 01T01 and 01T02 were intended to represent background conditions at the MGBG, although it was known at the outset of the 2001 field effort that these wells could be downgradient of the MGBG because of potential radial flow outward from the MGBG. Well 01T01, the deeper of the two wells, was not installed after two attempts at installation in two different locations because the holes did not produce enough water to be useful. This left one shallow well for comparison to site well data to determine whether site wells were contaminated. Two samples (01T0201 and 01T0202) were collected from well 01T02 in 2001, and one sample (01T0203) was collected in 2002 to support statistical comparisons planned using data from that well. The potentiometric surface map of Figure 1-15 shows that well 01T02

is downgradient of the MGBG. Because of its water elevation, well 01T02, which was originally intended to represent ground water that is uncontaminated by MGBG operations, is considered to be equivalent to a site well and was not used as an upgradient point of reference for comparisons to site contaminants in ground water.

Because background comparisons are precluded by the hydraulic conditions at the MGBG, selection of COPCs, described in Section 4.0, was based solely on comparisons of MGBG well data to COPC screening levels.

3.4.2.4 Surface Water

No surface water samples were collected in Round 1 because all MGBG drainage channels were dry. Four surface water samples were collected in Round 2 and were analyzed for VOCs and field parameters only. No VOCs were detected so no background comparison was necessary.

3.4.3 Additional Evaluation of Soil Methylene Chloride Concentrations

Methylene chloride was detected in several surface and subsurface soil samples at concentrations (2 µg/kg to 86 µg/kg) that could reflect laboratory contamination. However, while the laboratory blanks that were analyzed with the soil samples did exhibit some methylene chloride contamination, the concentrations (generally less than 10 mg/kg) were consistently less than those observed for the soil samples. Thus, the presence of methylene chloride in soil samples could not be attributed solely to laboratory contamination, although methylene chloride was not expected to be a site contaminant even though other chlorinated organic compounds had been detected in samples from the MGBG. Methylene chloride is not a common biotic or abiotic degradation product of any of the major VOCs detected at the site. This conflict was investigated further as described below.

Methylene chloride concentrations of samples shipped together in the same coolers showed considerable variation. A review of the associated field data and field QC sample analyses did not identify the coolers or field materials such as rinse water as a source of the contamination.

The spatial relationship of the methylene chloride concentrations was investigated. The greatest methylene chloride concentrations were measured at locations 01SB06, 01SB07, 01SB10, and 01SB14. Locations 01SB07 and 01SB10 are in close proximity, but locations 01SB06 and 01SB14 are at least 150 feet apart from each other and are well separated from locations 01SB07 and 01SB10. An example of the random spatial distribution of methylene chloride is seen in the concentrations at three different

depths at location 01SB14. The surface sample contained methylene chloride at 47 µg/kg, the 2-to-6 foot sample contained methylene chloride at 5 µg/kg, and the 6-to-10 foot sample contained methylene chloride at 47 µg/kg. This distribution does not support a model of methylene chloride emanating from one or a few localized contaminant sources in MGBG soils. Several non-detect values were also in the 30 to 50 µg/kg range.

This chemical appears to be randomly distributed across the MGBG and randomly distributed across the three different sampling depths. The source of the apparent contamination has not been determined nor can it be concluded with certainty that the reported concentrations reflect actual site concentrations.

3.4.4 Additional Evaluation of Soil Arsenic Concentrations

Arsenic was detected in all 24 surface soil samples from Round 1 at concentrations ranging from 6 mg/kg to 10.9 mg/kg. Concentrations of arsenic were in excess of the Base-wide background concentrations; however, the arsenic concentrations were distributed relatively uniformly across the MGBG. This kind of spatial distribution is inconsistent with most forms of liquid or solid waste releases, which would typically exhibit an area of high concentration surrounded by increasingly lower concentrations as the distance from the point(s) of release increases.

Figure 3-2 shows a comparison of NSWC Crane background surface soil arsenic concentrations to MGBG surface soil arsenic concentrations. Each box and whisker plot represents a distribution of site or background data from Soil Group 3 (surface soil). In each of the two plots, the median concentration is represented with a small square near the center of the larger rectangle. The top and bottom of each rectangle represent the top 75th percentile and the bottom 25th percentile of the data distribution, respectively. The T-shaped whiskers protruding vertically upward and downward from each box show the minimum and maximum observed concentrations for each data set.

The MGBG arsenic surface soil concentrations are compressed into a distribution that is approximately half the range of concentrations observed across all of NSWC Crane, but the upper end of the MGBG distribution is comparable to the upper end of the NSWC Crane background concentrations. This suggests that the MGBG arsenic surface soil concentrations are a subset of NSWC Crane background surface soil concentrations and are probably not an indication of site-related contamination. The background soils were collected from several widely scattered areas throughout the nearly 100-square-mile NSWC Crane facility. The 2-Acre MGBG is a small fraction of the total background investigation area; therefore, it is quite plausible that the MGBG could represent a subset of the overall base-wide background concentrations.

A comparison of the relative ranges of the MGBG and base-wide background data sets are even more significant when considering that there are more sample results in the MGBG surface soil data set (20) than in the NSWC Crane background surface soil data set (15 samples). Such a situation favors observing a concentration in the MGBG data set that is greater than the maximum value observed across all of NSWC Crane.

The reported arsenic concentrations are near the analytical detection limit. Widespread detection of an analyte at concentrations that are tightly grouped and approximately equal to the detection limit can be an indication of an analytical interference that artificially elevates the concentrations, thus yielding false positive results.

A comparison of site data to background concentrations presumes that site contamination, if present, was added to background concentrations. To obtain the observed arsenic concentration distribution for MGBG samples, virtually all contamination would have to have been selectively deposited at areas having the least arsenic concentrations, thus raising only those concentrations to the observed concentrations, and yielding a "compressed" but very slightly elevated concentration distribution. Such a contamination scenario is extremely implausible.

In summary, although MGBG surface soil arsenic concentrations were determined to be statistically greater than NSWC Crane background concentrations, the MGBG is not considered to be contaminated with arsenic. Instead, the very slightly elevated surface soil arsenic concentrations at the MGBG are considered to be a subset of the NSWC Crane background.

Arsenic was detected in 26 of 35 subsurface soil samples at concentrations ranging from 0.48 mg/kg to 20.2 mg/kg. There are two distinct soil groups (SG8 and SG9) in the subsurface. All concentrations in Soil Group 8 were within background concentrations. Only four soil samples belonging to Soil Group 9 were collected at the MGBG. All but one of those values was less than the background subsurface soil 95/95 Upper Tolerance Limit (UTL) of 8.2 mg/kg (TtNUS, 2001a). Similar to the situation for arsenic in surface soils, it is not believed that the observed arsenic concentrations in subsurface soils represent site contamination despite the single high value of 20.2 mg/kg.

Figure 3-3 displays four box and whisker plots of the arsenic concentrations for site and background samples for the two subsurface soil groups at the MGBG. The Soil Group 8 plots show that the arsenic concentrations at the site appear to be shifted to values that are less than site background concentrations. This is a theoretical impossibility if the background concentrations are truly

representative. The interpretation is that the Soil Group 8 site subsurface data are a subset of the overall base-wide background data. This is a situation similar to the surface soil arsenic, except that the site concentrations in this case appear to be generally less than the background concentrations.

The Soil Group 9 data are more difficult to interpret because the background data set has only one value and the site data set has only four values. Nevertheless, two of the site concentrations, 0.48 mg/kg and 1.7 mg/kg, were significantly less than the background value of 2.9 mg/kg. The remaining two site values were 7.8 and 20.2 mg/kg, much greater than the Soil Group 9 background value. However, these isolated cases of elevated arsenic concentrations are not considered to be site-related contamination. It is believed that, had more Soil Group 9 samples been collected in the base-wide background investigation, they would have reflected a distribution comparable to the observed site data, and the site data would be shown statistically not to exceed background concentrations. Only the Soil Group 9 value of 20.2 mg/kg exceeded the maximum background values for either the Soil Group 3 or Soil Group 8 data distributions. Furthermore, this exceedance is within a factor of approximately two times the maximum values. This is not considered to be significant, especially when relatively few samples at NSWC Crane belong to Soil Group 9 (TtNUS, 2001a). Additionally, arsenic concentrations throughout the United States have been determined to fall within a range of 1 mg/kg to 97 mg/kg and the 20.2 mg/kg site value is well within that range (Shacklette and Hansford, 1984.). The geometric and arithmetic mean concentrations for arsenic in the conterminous United States are reported by Shacklette and others to be 5.2 mg/kg and 7.2 mg/kg, respectively. Another consideration is that most metal concentrations for Soil Group 9 appear to be elevated relative to the single Soil Group 9 sample from soil boring 01SB21. This is an unlikely situation, especially at a site that exhibits little soil contamination, and suggests that the background soil concentration most likely represents the lower end of the concentration distribution for Soil Group 9.

3.4.5 Additional Evaluation of Thallium Concentrations in All Media

The analysis of arsenic and thallium by trace ICP is known to yield false positive results (U.S. EPA 2001a). Similar to arsenic, thallium was widely detected across the MGBG at concentrations near the trace ICP detection limit for the sampled environmental media. To investigate whether the thallium results were analytical artifacts, a re-analysis of select Round 1 samples was conducted. Samples of soil, sediment, and ground water representing the greatest reported thallium concentrations in each medium were submitted for re-analysis by GFAA. That analytical technique provided significantly lower detection limits for thallium than the trace ICP technique used for the original analyses. Results of the re-analyses are shown in Table 3-14. In every case, detectable thallium concentrations from the re-analyses were much less than the original results. In two cases, the samples undergoing re-analysis had to be diluted by a factor of five and the re-analyses results were reported as non-detect. Even in those two cases,

however, the re-analyses yielded non-detect values for thallium that were less than the originally reported results. These re-analyses results are convincing evidence that thallium is not present at the concentrations reported for Round 1 sampling. Based on these re-analyses, it is believed that all original thallium results are artificially elevated and that thallium concentrations were within background concentrations.

3.4.6 Gross Beta Re-Evaluation for Well 01-23

The gross beta ground water concentration from Round 1 in well 01-23 (50.2 pCi/L) was more than twice the next greatest value from all other MGBG wells. Upon re-analysis, the gross beta value dropped significantly to 8.35 pCi/L, which was well within the range of the other gross beta results in ground water (from less than 1.58 to 20.8 pCi/L). To investigate this large discrepancy between the original analysis and the re-analysis, well 01-23 was re-sampled and analyzed for gross beta radiation in Round 2. The Round 2 result was 12.3 pCi/L, which confirms the 8.35 pCi/L re-analysis result from Round 1, even after consideration of any analytical biases identified in Section 3.3.4 for radiological parameters in ground water.

3.4.7 Additional Thorium-230 Evaluation for Soil

Thorium-230 is a special radionuclide for the MGBG because it is not in secular equilibrium with either thorium-228 or thorium-232, so its concentration is not necessarily correlated to that of either of these two other thorium isotopes. Thus, its concentration cannot be computed from knowledge of either of the other thorium isotope concentrations. In addition, while the historical record does not suggest that releases of thorium-230 occurred at the MGBG, there is no historical radiochemical evidence that such releases did not occur. Finally, there was only one background sample for each of the three soil types occurring at the MGBG for thorium-230 because this radionuclide was not included in the background studies for either NSWC Crane or the gamma spectrometric background soil analyses for the MGBG. When the MGBG soil thorium-230 concentrations were compared to the single background sample, one or more soil data sets from the MGBG samples were greater than the single background result (from O1SB21).

The statistics greatly favor this outcome because the MGBG data set was so much greater than unity. Yet, the spatial distribution of thorium-230 in soils appeared to be relatively uniform across the MGBG. Such a distribution, especially for naturally occurring materials such as thorium (but not necessarily for thorium-230), is often an indication that the material in question is not related to site activities. The mounting body of evidence suggested that the PBA was not an area of contamination for metals

(radioactive or otherwise) despite the fact that comparisons indicated that concentrations of thorium-230 exceeded the background concentration.

To test whether thorium-230 should be considered as a site contaminant, the thorium-230 results from PBA samples were compared to the rest of the MGBG samples. Given that the PBA is where the documented burials and exhumations of thorium and other items were conducted, one would expect site contaminant concentrations to be greater in the PBA if the exhumations were incomplete. A WRS test was conducted with the null hypothesis that the PBA population is statistically similar to the rest of the MGBG. The test was run at a 5 percent significance level with the result that the PBA and remaining MGBG samples data sets were indistinguishable with respect to thorium-230 concentration. A description of how this test was conducted for thorium-230 and other analytes can be found in Section 3.4.9. The supporting documentation can be found in Appendix F.

Further evidence that thorium-230 is not a site contaminant is derived from comparisons of upgradient and downgradient sediment samples. Two upgradient sediment samples were used in a WRS statistical comparison to eight downgradient sediment samples. The upgradient and downgradient samples were collected from the same depths throughout the drainage channels to the north and south of the MGBG and were analyzed for thorium-230. The group of six downgradient samples was statistically indistinguishable from the two upgradient samples with respect to throium-230 concentrations. Downgradient concentrations ranged from 0.791 to 1.26 pCi/g, and upgradient concentrations were 0.908 pCi/g and 1.2 pCi/g. The maximum observed thorium-230 concentration in surface and subsurface soils (0.637 pCi/g) was approximately one-half of the maximum observed upgradient or downgradient sediment concentration. Another indication that thorium-230 is not a site contaminant is evident in the duplicate sample for sample 01SB210610. This sample, which had a thorium-230 concentration of 0.254 pCi/g, belongs to Soil Group 9. Its duplicate, technically used only for QC purposes, had a thorium-230 concentration of 0.413 pCi/g, greater than any site sample belonging to Soil Group 9. If the duplicate sample been considered the original sample, thorium-230 would not have been classified as exceeding background concentrations in Soil Group 9 samples. Finally, background concentrations for the two soil groups represented by more than five samples at MGBG (3 and 8), are within the middle to top third of the data set. This is an indication that any exceedance of background, if ignored, is slight and has little adverse impact or implication.

In summary, the site history (i.e., no record of disposal or use of thorium-230 at the MGBG) coupled with the measured thorium-230 concentrations and spatial distributions overwhelmingly indicate that thorium-230 is not a site contaminant.

3.4.8 Evaluation of Dramatic Concentration Change for Chlorinated Volatile Compounds

Concentrations of select VOCs at well 01-02 decreased from tens of thousands of µg/L in 2001 to tens of µg/L in 2002. This was cause for concern because this magnitude of concentration change was not expected during a one-year period. Past VOC concentration data had also exhibited wide fluctuations, but those data were of unknown quality and it was not clear that the observed temporal fluctuations were real.

The 2002 raw laboratory data were reviewed, and the laboratory was asked to re-analyze the 2002 sample from well 01-02 even though the holding time had been exceeded. The laboratory re-analyzed each of the remaining three VOC sample vials for sample 01GW0202 collected from well 01-02. This re-analyses confirmed the original 2002 results of approximately 30 µg/L for TCE and approximately 20 µg/L for 1,1,2,2-PCA (facsimile transmission from Sandy Grovenstein of SWLO to E. Sedlmyer of TtNUS on 7-25-02, on file). These values differ significantly from the year 2001 results, but the year 2001 results are consistent with most previous results. Based on the data reviews, the observed historical fluctuations have been confirmed for ground water VOCs. There is no reason to expect that a sampling error occurred; therefore, the measured concentrations in years 2001 and 2002 are believed to accurately represent ground water concentrations from well 01-02 at the time of sampling. Graphs showing some of the observed temporal variations are presented in Section 6.0.

3.4.9 Validation of Exposure Unit Size

The historical record indicates that past burials and exhumations were associated primarily with the PBA. PBA soil sample concentrations were compared to soil concentrations from across the remainder of the site to evaluate whether the PBA samples represented a population different from the rest of the MGBG. This comparison was effected in the following manner. Sample data for the five soil sampling locations in the PBA were segregated from data for the 15 other locations of the MGBG. These 15 sampling locations represent the complement to the PBA samples. Descriptive statistics (frequency of detection, minimum, maximum, mean) were calculated for surface soil and subsurface soil samples from both of these areas. Evaluation of these values established that the organic chemical and radionuclide concentrations were similar in the PBA and the PBA complement. Differences between surface and subsurface concentrations were discovered for organic chemicals, but these differences were consistent across both the PBA and the PBA Complement. Descriptive statistics are presented in Appendix F.

WRS non-parametric ANOVA comparisons at 5 percent significance were made for each of the 26 inorganic and radiological constituents in samples from the PBA and PBA Complement. Surface soil

results from the PBA were compared to surface soil results from the PBA Complement, and subsurface soil results from the PBA were compared to subsurface soil results from the PBA Complement. Results of these comparisons showed only sodium to have statistically different concentrations in the surface soil (higher in the PBA Complement) and mercury and beryllium to have statistically different concentrations in the subsurface soil (mercury higher in the PBA Complement and beryllium higher in the PBA). Results are provided in Appendix F.

Based on statistics for comparing two sets of samples from a single population, one of the 26 chemicals would be expected to be greater in either the PBA or PBA Complement more than 72 percent of the time. Two of the 26 chemicals would be expected to be greater in one of the areas more than 35 percent of the time. Based on these findings, there is no statistical evidence to indicate that chemical concentrations from the PBA or the PBA Complement are from different populations. This indicated that PBA and PBA Complement samples could be used as one population for statistical and risk calculations.

3.4.10 Thorium Performance Evaluation Sample

Prior to accepting a laboratory for analytical work, the Navy ensures that the laboratory meets Navy and EPA qualification requirements. In addition to the usual qualification requirements, Southwest Laboratory of Oklahoma was required to analyze a performance evaluation (PE) sample for thorium radioisotopes. The PE sample was provided by an independent organization, Analytics, Inc. of Atlanta, Georgia. The PE sample was certified to contain 26.65 ± 1.28 pCi/g of thorium-234. The laboratory reported a value of 25.6 ± 5.21 (2-sigma). The reported value was within the acceptance range, demonstrating competency in radioisotopic thorium analysis, and was accepted by U.S. EPA Region 5.

3.4.11 Map Warping

After the year 2001 surveyed coordinates for wells and other sampling locations were plotted on the MGBG base map, a few discrepancies were identified. Well 01-17 was plotted in the northern edge of the earthen berm covering Magazine 1409, yet it was known not to be located in the berm. In addition, well locations 01T01 (not installed) and 01T02 (installed) and soil boring location 01SB21 were plotted along a straight line down the center of Highway 251, yet their correct locations were known to be at the northern edge of Highway 251. All other coordinates appeared to be close to the planned locations. In particular, the well coordinates for wells 01-01 through 01-16, wells 01-18 through 01-27, and well 01C01 were less than one foot from previously surveyed locations. The apparently erroneous coordinates did not represent a constant shift, constant rotation, or combined shift and rotation from the known correct locations. The surveyor rechecked the coordinates first by inspecting the survey documentation, then by

resurveying a closed loop at the MGBG. The loop was closed to within 0.2 feet, indicating that the 2001 plotted coordinates were correct.

Based on this information, the MGBG base map was warped slightly to align the base features (explosives magazines and roads) with the known correct locations of wells and soil borings. All MGBG sampling location figures, potentiometric surface maps, etc. that relied on surveyed sampling locations were affected. The outcome of this base map warping is that site features may appear to be shifted by as much as 20 feet any direction. An effort was made to minimize the amount of warping in any one direction to facilitate alignment of site features with known relative map positions.

3.4.12 Change in Sediment Sample Nomenclature

A sampling round number was not included as part of the Round 1 sediment sample ID numbers. To enable data users to distinguish between samples collected in Rounds 1 and 2, especially at sediment locations 01SD01 and 01SD03 that were sampled in both rounds, it was necessary to update the sample numbers. Round 1 sediment sample numbers were changed by adding "01" to the end of the number. All Round 2 sediment and surface water samples have "02" at the end of the number indicating that they were collected in Round 2. Field duplicates and filtered samples have "-D" and "-F", respectively, at the end of the sample number. The affected sediment samples are 01SD0101 through 01SD0801 (updated nomenclature used here). No surface water samples were collected in Round 1; therefore, there are no surface water samples ending in "01". Noting this change in nomenclature may be important when comparing other documents such as the MGBG QAPP with this report.

3.4.13 Additional Europium-155 Evaluation

Europium-155 is normally identified and quantified using two energy peaks in the gamma spectrometry analysis. To be conservative, europium-155 was reported as detected even when only one of the peaks was present. This resulted in the "detection" of europium-155 in two samples, even though the relatively short half-life of this radionuclide suggests that it should not be detected except if fission products had been disposed at the site. The detected values were less than many europium-155 non-detect values for similar samples and were equal to detection limits for the samples. Furthermore, no fission products were known or suspected to have been discarded at the MGBG and the two europium detections (0.08 pCi/g each) were far less than the conservative soil screening level for this project (3.8 pCi/g). Therefore, europium-155 detections are considered to be false detections and were also within measured background values, so they were not investigated further.

TABLE 3-1

QUALITY CONTROL LIMITS[1]
LABORATORY CONTROL SAMPLES
POLYCYCLIC AROMATIC HYDROCARBONS ANALYSES
NSWC CRANE
CRANE, INDIANA

Chemical	Solid Matrix Accuracy (%R)	Aqueous Matrix Accuracy (%R)
Acenaphthylene	50-112	32-136
Acenaphthene	47-122	34-138
Anthracene	24-149	16-126
Benzo(a)anthracene	60-130	44-145
Benzo(a)pyrene	32-132	24-123
Benzo(b)fluoranthene	47-137	34-165
Benzo(k)fluoranthene	59-130	45-123
Benzo(g,h,i)perylene	42-127	40-125
Chrysene	61-134	55-147
Dibenzo(a,h)anthracene	58-128	26-160
Fluoranthene	54-138	58-128
Fluorene	43-128	27-141
Indeno(1,2,3-c,d)pyrene	60-126	59-130
Naphthalene	50-118	10-139
Phenanthrene	57-122	40-132
Pyrene	30-136	50-136

1 In-house QC limits provided by SWLO meet or exceed these limits.
%R = Percent recovery

TABLE 3-2

SAMPLES COLLECTED VERSUS SAMPLES PROPOSED IN THE QAPP, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Analytical Fraction	SOIL[1,2] (collected/ proposed)	SD[1,6] (collected/ proposed)	GW[5] (collected/ proposed)	SW[4] (collected/ proposed)	SP[7] (collected/ proposed)
Round 1					
Explosives	55/60	8/8	28/30	0/7	NA
Volatiles	59/64	8/8	28/30	0/7	NA
Semivolatiles	59/64	8/8	28/30	0/7	NA
Pesticides/PCBs	40/40	8/8	28/30	0/7	NA
Herbicides	40/40	8/8	28/30	0/7	NA
Mustard Gas	59/64	8/8	28/30	0/7	NA
Metals	59/64	8/8	28/30	0/7	NA
Metals, filtered[3]	NA	NA	10/10	0/7	NA
Thorium	62/67	8/8	28/30	0/7	NA
Total Organic Carbon	3/3	8/8	NA	NA	NA
Cation Exchange Capacity	15/18	8/8	NA	NA	NA
Gamma Spectrometry	5/4	NA	NA	NA	NA
Gross Alpha	NA	NA	28/30	0/7	NA
Gross Beta	NA	NA	28/30	0/7	NA
Total Suspended Solids	NA	NA	NA	0/7	NA
pH	16/19	8/8	NA	NA	NA
Round 2					
Volatiles	NA	6/6	20/20	4/5[7]	NA
Metals	NA	6/6	8/8	NA	NA
Metals, filtered[3]	NA	NA	1/1	NA	NA
Isotopic Thorium	NA	1/1	NA	NA	NA
Total Organic Carbon	NA	NA	8/8	NA	NA
Gross Alpha	NA	NA	1/1	NA	NA
Gross Beta	NA	NA	1/1	NA	NA
Natural Attenuation Parameters	NA	NA	8/8	NA	NA
pH	NA	NA	20/20	8/8	NA

SD - Sediment samples. SW - Surface water samples NA - Not Applicable
GW - Ground water samples SP - Seep

1 - All soil and sediment samples analyzed for 40 CFR Part 264 Appendix IX organics and U.S. EPA Target Analyte List + tin for metals.
2 - Samples 01SB010610, 01SB0306010, 01SB070610, 01SB090610, and 01SB100610 were not collected due to encountering bedrock at less than 6 to 10 feet.
3 - Samples required filtered metals analyses due to high turbidity.
4 - All Round 1 and one Round 2 surface water locations were dry at the time of sampling.
5 - Well 01GW1601 was dry and well 01GWT0101 was not installed.
6 - Samples 01SD09 and 01SD10 were to be collected at the FOL's discretion.
7 - Discretionary seep sampling locations were dry at the time of Round 1 and Round 2 sampling.

Well 01T01was not installed.
Wells 01T03, 01T04, and 01T05 were installed in Round 2.
Well 01T06 was never installed.

TABLE 3-3

PERCENT COMPLETENESS FOR ANALYTICAL FRACTIONS, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Analytical Fraction ROUND 1	Soil and Sediment			Ground Water and Surface Water		
	Total Data Points	Rejected Data Points	% Completeness	Total Data Points	Rejected Data Points	% Completeness
CEC	25	0	100.0	NA	NA	NA
EXP	980	0	100.0	350	9	97.4
HD	222	0	100.0	75	0	100.0
HERB	265	6	97.7	125	1	99.2
HG	115	0	100.0	55	0	100.0
M	2917	0	100.0	1350	0	100.0
SVOC	6660	158	97.6	2250	64	97.2
VOC	4144	297	92.8	3080	415	86.5
PAH	1184	35	97.0	400	0	100.0
PCB	371	0	100.0	175	0	100.0
PEST	1060	6	99.4	500	7	98.6
pH	26	0	100.0	29	0	100.0
RAD	506	0	100.0	228	0	100.0
TOC	13	0	100.0	NA	NA	NA

Analytical Fraction ROUND 2	Soil and Sediment			Ground Water and Surface Water		
	Total Data Points	Rejected Data Points	% Completeness	Total Data Points	Rejected Data Points	% Completeness
HG	1	0	100.0	8	0	100.0
M	24	0	100.0	192	0	100.0
VOC	336	34	89.9	1344	210	84.4
RAD	3	0	100.0	10	0	100.0
TOC	NA	NA	NA	8	0	100.0
CHLORIDE	NA	NA	NA	8	0	100.0

CEC - Cation Exchange Capacity
EXP - Explosives
HERB - Herbicides
HG - Mercury
HD - Distilled Mustard Gas
M - Metals
SVOC - Semivolatiles
VOC - Volatiles
PCB - Polychlorinated biphenyls
RAD - Thorium-228, -230, -232 isotopes (total)
PEST - Pesticides
PAH - Polynuclear aromatic hydrocarbons
TOC - Total organic carbon

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
ROUND 1		
01GW0101	1,4-DIOXANE	Calibration and Matrix Spike Noncompliance
	2-BUTANONE	Calibration and Matrix Spike Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance and %D between columns >100%
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	DINOSEB	Calibration and Matrix Spike Noncompliance
	HEXACHLOROCYCLOPENTADIENE	Matrix Spike Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration and Matrix Spike Noncompliance
01GW0201	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ENDOSULFAN II	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
	RDX	%D between columns >100%
01GW0301	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
	RDX	%D between columns >100%
01GW0401	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	METHACRYLONITRILE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0501	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0601	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	HMX	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0701	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0801	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0901	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
01GW1001	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1101	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1201	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1301	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1401	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1501	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1701	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1801	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1901	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2001	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2101	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2201	1,4-DIOXANE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2301	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2401	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2501	1,4-DIOXANE	Calibration and Matrix Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2601	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2701	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWC0101	1,4-DIOXANE	Calibration and Laboratory Control Spike Noncompliance
	2-BUTANONE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	BENZENE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0201	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0202	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	HEXACHLOROPHENE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB010206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB020206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	PROPIONITRILE	Calibration Noncompliance
01SB020610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB030206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB040206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB040610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB050206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB050610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB060206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
01SB060610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB070206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB080206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB080610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB090206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB100206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB110206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB110610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB120206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB120610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB130206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB130610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB140206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB140610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB150206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	PROPIONITRILE	Calibration Noncompliance
01SB150610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB160206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB160610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB170206	1,4-DIOXANE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB170610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACENAPHTHENE	Surrogate Recovery Noncompliance
	ACENAPHTHYLENE	Surrogate Recovery Noncompliance
	ACROLEIN	Calibration Noncompliance
	ANTHRACENE	Surrogate Recovery Noncompliance
	BENZO(A)ANTHRACENE	Surrogate Recovery Noncompliance
	BENZO(A)PYRENE	Surrogate Recovery Noncompliance
	BENZO(B)FLUORANTHENE	Surrogate Recovery Noncompliance
	BENZO(G,H,I)PERYLENE	Surrogate Recovery Noncompliance
	BENZO(K)FLUORANTHENE	Surrogate Recovery Noncompliance
	CHRYSENE	Surrogate Recovery Noncompliance
	DIBENZO(A,H)ANTHRACENE	Surrogate Recovery Noncompliance
	FLUORANTHENE	Surrogate Recovery Noncompliance
	FLUORENE	Surrogate Recovery Noncompliance
	INDENO(1,2,3-CD)PYRENE	Surrogate Recovery Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Surrogate Recovery Noncompliance
	PHENANTHRENE	Surrogate Recovery Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	PYRENE	Surrogate Recovery Noncompliance
01SB180206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB180610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB190206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB190610	1,4-DIOXANE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB200206	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SB200610	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD01	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD02	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
01SD03	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD04	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD05	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD06	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD07	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ENDRIN ALDEHYDE	Matrix Spike Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD08	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS010002	1,4-DIOXANE	Calibration Noncompliance
	2,4-D	%D between columns >100%
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	GAMMA-CHLORDANE	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	PROPIONITRILE	Calibration Noncompliance
01SS020002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS030002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS040002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACENAPHTHYLENE	Matrix Spike Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Matrix Spike Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS050002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS060002	1,4-DIOXANE	Calibration Noncompliance
	2,4-D	%D between columns >100%
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	HEPTACHLOR	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS070002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS080002	1,4-DIOXANE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS090002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS100002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	GAMMA-CHLORDANE	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS110002	1,4-DIOXANE	Calibration Noncompliance
	2,4,5-T	%D between columns >100%
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS120002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS130002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	DINOSEB	Calibration Noncompliance and %D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS140002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS150002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	GAMMA-CHLORDANE	%D between columns >100%
	ISOBUTANOL	Calibration Noncompliance
	NAPHTHALENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS160002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS170002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS180002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS190002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SS200002	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PHENANTHRENE	Laboratory Control Spike Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01TPL01	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01TPL02	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01TPL03	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01TPS04	1,4-DIOXANE	Calibration Noncompliance
	4-NITROQUINOLINE-1-OXIDE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHAPYRILENE	Calibration Noncompliance
	PRONAMIDE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
ROUND 2		
01GW0102	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0202	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0302	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0402	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0502	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0602	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0802	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW0902	1,4-DIOXANE	Calibration and LCS/LCSD Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1002	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1102	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1402	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW1502	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2302	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
01GW2502	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GW2602	1,4-DIOXANE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWC0102	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0203	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0301	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0401	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0401-	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01GWT0501	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD0102	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD0302	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD0902	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD1002	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
01SD1102	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SD1202	1,4-DIOXANE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SW0102	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SW0202	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SW0402	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance
01SW0502	1,4-DIOXANE	Calibration Noncompliance
	2-BUTANONE	Calibration Noncompliance
	ACETONE	Calibration Noncompliance
	ACETONITRILE	Calibration Noncompliance
	ACROLEIN	Calibration Noncompliance
	ACRYLONITRILE	Calibration Noncompliance
	ISOBUTANOL	Calibration Noncompliance

TABLE 3-4

REJECTED DATA, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample	Parameter	Reason for Rejection
	METHACRYLONITRILE	Calibration Noncompliance
	PROPIONITRILE	Calibration Noncompliance

TABLE 3-5

SOIL MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Maximum Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA SSL for Migration to Ground water	U.S. EPA Region 5 EDQLs
Explosives (ug/kg)								
1,3,5-TRINITROBENZENE	ND		27.4	454	500	1800000	NA	376.15
1,3-DINITROBENZENE	ND		26.8	454	500	6100	NA	654.7
2,4,6-TRINITROTOLUENE	ND		87.6	454	500	16000	NA	NA
2,4-DINITROTOLUENE	ND		13.1	454	500	120000	0.04	1280
2,6-DINITROTOLUENE	ND		26.2	454	500	61000	0.03	32.83
2-AMINO-4,6-DINITROTOLUENE	ND		52.9	454	500	NA	NA	NA
2-NITROTOLUENE	ND		28.3	454	500	370000	NA	NA
3-NITROTOLUENE	ND		40.7	454	500	370000	NA	NA
4-AMINO-2,6-DINITROTOLUENE	ND		115	454	500	NA	NA	NA
4-NITROTOLUENE	ND		28.9	454	500	370000	NA	NA
HMX	70.6	J	30.5	454	500	3100000	NA	NA
NITROBENZENE	ND		25.5	454	500	20000	0.7	1310
RDX	ND		28.2	454	500	4400	NA	NA
TETRYL	ND		82.7	454	500	610000	NA	NA
Herbicides (ug/kg)								
2,4,5-T	ND		3.3	11	16	610000	NA	NA
2,4,5-TP (SILVEX)	5.9	J	1.8	11	16	490000	NA	108.8
2,4-D	35	J	10	75	100	690000	NA	27.3
DINOSEB	ND		11	21	32	61000	NA	21.8
PENTACHLOROPHENOL	ND		2.2	11	16	3000	1	119.27
Metals (mg/kg)								
ANTIMONY	1.7	J	0.17 - 0.56	0.18	1.6	31	0.3	0.01423
ARSENIC	0.48	J	0.16 - 0.37	0.36	2.3	0.39	1	5.7
BERYLLIUM	0.21		0.03 - 0.09	0.22	0.59	150	3	1.06
CADMIUM	0.04	J	0.01 - 0.05	0.01	0.05	3	0.4	0.00222
COBALT	1.3	J	0.1 - 0.21	0.6	0.6	4700	NA	0.14
MERCURY	0.02	J	0.02	0.02	0.1	NA	0.1	0.073
SELENIUM	0.12	J	0.08 - 0.42	0.18	1.5	390	0.3	0.0277
SILVER	ND		0.02 - 0.46	0.02	0.46	390	2	4.04
THALLIUM	0.69		0.44 - 0.77	0.53	0.63	6.3	0.04	0.057
TIN	2.3		1.95 - 29.2	2.3	29.2	47000	NA	7.62
Miscellanous								
1,4-DITHIANE (ug/kg)	ND		0	216	323	610000	NA	NA
1,4-OXATHIANE (ug/kg)	ND		0	216	323	NA	NA	NA
BIS(2-CHLOROETHYL)SULFIDE (ug/kg)	ND		0	216	323	NA	NA	NA
TOTAL ORGANIC CARBON (mg/kg)	ND		500	619	619	NA	NA	NA
SVOCs (ug/kg)								
1,2,4,5-TETRACHLOROBENZENE	ND		92	360	2000	18000	NA	2020
1,2,4-TRICHLOROBENZENE	ND		47	360	2000	6000	300	11100
1,2-DICHLOROBENZENE	ND		35	180	1000	370000	900	2960
1,3-DICHLOROBENZENE	ND		35	180	1000	13000	NA	37700
1,4-DICHLOROBENZENE	ND		40	180	1000	3000	100	545.6
1,4-NAPHTHOQUINONE	ND		59	360	2000	NA	NA	1670
1,4-PHENYLENEDIAMINE	ND		308	890	5000	12000000	NA	6160
1-NAPHTHYLAMINE	ND		169	360	2000	NA	NA	9340
2,2'-OXYBIS(1-CHLOROPROPANE)	ND		58	180	1000	2500	NA	NA
2,3,4,6-TETRACHLOROPHENOL	ND		96	360	2000	1800000	NA	199
2,4,5-TRICHLOROPHENOL	ND		109	890	5000	6100000	14000	14100
2,4,6-TRICHLOROPHENOL	ND		65	360	2000	44000	8	9940
2,4-DICHLOROPHENOL	ND		114	360	2000	1000	50	87500
2,4-DIMETHYLPHENOL	ND		182	360	2000	1000	400	10.8
2,4-DINITROPHENOL	ND		384	890	5000	120000	10	60.86
2,6-DICHLOROPHENOL	ND		104	360	2000	NA	NA	1170
2-ACETYLAMINOFLUORENE	ND		73	180	1000	NA	NA	596
2-CHLORONAPHTHALENE	ND		56	180	1000	4900000	NA	12.2
2-CHLOROPHENOL	ND		69	180	1000	6000	200	242.7
2-METHYLNAPHTHALENE	ND		3.2	180	1000	NA	NA	3240
2-METHYLPHENOL	ND		126	180	1000	3100000	800	NA
2-NAPHTHYLAMINE	ND		190	190	1000	NA	NA	3030
2-NITROANILINE	ND		128	450	2500	3500	NA	74100
2-NITROPHENOL	ND		68	360	2000	490000	NA	1600
2-PICOLINE	ND		250	260	1600	NA	NA	9900
3,3'-DICHLOROBENZIDINE	ND		234	360	2000	1100	0.3	646.4
3,3'-DIMETHYLBENZIDINE	ND		144	360	2000	53	NA	1042
3-METHYLCHOLANTHRENE	ND		284 - 380	400	2300	NA	NA	77.9
3-METHYLPHENOL	ND		79	180	1000	3100000	NA	NA
3-NITROANILINE	ND		217	890	5000	NA	NA	3160
4,6-DINITRO-2-METHYLPHENOL	ND		144	890	5000	NA	NA	NA
4-AMINOBIPHENYL	ND		135	180	1000	NA	NA	3.05

TABLE 3-5

SOIL MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Maximum Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA SSL for Migration to Ground water	U.S. EPA Region 5 EDQLs
4-BROMOPHENYL PHENYL ETHER	ND		44	360	2000	NA	NA	NA
4-CHLORO-3-METHYLPHENOL	ND		231	360	2000	NA	NA	NA
4-CHLOROANILINE	ND		186	360	2000	240000	30	1100
4-CHLOROPHENYL PHENYL ETHER	ND		116	180	1000	NA	NA	NA
4-METHYLPHENOL	ND		130	180	1000	310000	NA	NA
4-NITROANILINE	ND		348	890	5000	NA	NA	21900
4-NITROPHENOL	ND		374	890	5000	490000	NA	5120
4-NITROQUINOLINE-1-OXIDE	ND		783	890	970	NA	NA	122
5-NITRO-O-TOLUIDINE	ND		128	360	2000	15000	NA	NA
7,12-DIMETHYLBENZ(A)ANTHRACENE	260	J	249	270	1500	NA	NA	16300
A,A-DIMETHYLPHENETHYLAMINE	ND		153	890	5000	61000	NA	300.16
ACENAPHTHENE	4.34	J	3.9	10.7	15.8	3700000	29000	682000
ACENAPHTHYLENE	ND		8	10.7	15.8	3700000	NA	682000
ACETOPHENONE	ND		52	180	1000	490	NA	300000
ANILINE	ND		140	180	1000	85000	NA	56.8
ANTHRACENE	41.5		3.3	10.7	15.8	22000000	590000	1480000
ARAMITE	ND		43	890	5000	19000	NA	166000
BENZO(A)ANTHRACENE	153	J	3.9	10.7	15.8	620	80	5210
BENZO(A)PYRENE	5.85	J	4.2	10.7	15.8	62	400	1520
BENZO(B)FLUORANTHENE	318	J	5.7	10.7	15.8	620	200	59800
BENZO(G,H,I)PERYLENE	9.3	J	4.8	10.7	15.8	56000	NA	119000
BENZO(K)FLUORANTHENE	14.1	J	5	10.7	15.8	6200	2000	148000
BENZYL ALCOHOL	ND		270	270	1400	18000000	NA	65800
BIS(2-CHLOROETHOXY)METHANE	ND		64	360	2000	NA	NA	NA
BIS(2-CHLOROETHYL)ETHER	ND		49	180	1000	210	0.02	NA
BIS(2-ETHYLHEXYL)PHTHALATE	83	J	71	180	1000	35000	180000	925.94
BUTYL BENZYL PHTHALATE	ND		63	180	1000	12000000	810000	239
CHLOROBENZILATE	ND		51	360	2000	1800	NA	5050
CHRYSENE	108	J	4.8	10.7	15.8	62000	8000	4730
DIALLATE	ND		46	360	2000	8000	NA	452
DIBENZO(A,H)ANTHRACENE	5.76	J	3.7	10.7	15.8	62	80	18400
DIBENZOFURAN	ND		71	180	1000	290000	NA	NA
DIETHYL PHTHALATE	ND		142	180	1000	49000000	23000	24800
DIMETHYL PHTHALATE	ND		115	180	1000	100000000	NA	734000
DI-N-BUTYL PHTHALATE	ND		113	180	1000	6100000	270000	150
DI-N-OCTYL PHTHALATE	ND		190	190	1000	1200000	10000000	NA
DIPHENYLAMINE	ND		111	180	1000	1500000	NA	1010
ETHYL METHANE SULFONATE	ND		59	180	1000	NA	NA	NA
FLUORANTHENE	3.98	J	3.8	10.7	15.8	2300000	210000	122000
FLUORENE	22.3		3.7	10.7	15.8	2600000	28000	122000
HEXACHLOROBENZENE	ND		47	360	2000	3000	100	199
HEXACHLOROBUTADIENE	ND		47	360	2000	6000	100	39.8
HEXACHLOROCYCLOPENTADIENE	ND		86	360	2000	420000	20000	755
HEXACHLOROETHANE	ND		40	180	1000	35000	20	596
HEXACHLOROPHENE	ND		4760	14000	80000	18000	NA	199
HEXACHLOROPROPENE	ND		126	360	2000	NA	NA	NA
INDENO(1,2,3-CD)PYRENE	4.52	J	3.2	10.7	15.8	620	700	109000
ISODRIN	ND		57	360	2000	NA	NA	3.32
ISOPHORONE	ND		68	180	1000	510000	30	139000
ISOSAFROLE	150	J	58	360	2000	611000	NA	9940
KEPONE	ND		72	890	5000	27	NA	3217
METHAPYRILENE	ND		215	890	1200	NA	NA	2780
METHYL METHANE SULFONATE	ND		172	450	2500	NA	NA	315.49
NAPHTHALENE	8.52	J	7.9	10.7	15.8	56000	4000	99.39
N-NITROSODIETHYLAMINE	ND		70	180	1000	3.2	NA	69.3
N-NITROSODIMETHYLAMINE	ND		121	180	1000	9.5	NA	0.0321
N-NITROSO-DI-N-BUTYLAMINE	ND		45	360	2000	24	NA	NA
N-NITROSO-DI-N-PROPYLAMINE	ND		90	180	1000	69	0.002	NA
N-NITROSOMETHYLETHYLAMINE	ND		125	180	1000	22	NA	1.66
N-NITROSOMORPHOLINE	ND		63	180	1000	NA	NA	70.6
N-NITROSOPIPERIDINE	ND		73	360	2000	NA	NA	6.65
N-NITROSOPYRROLIDINE	ND		73	180	1000	230	NA	12.6
O,O,O-TRIETHYL PHOSPHOROTHIOATE	ND		87	360	2000	NA	NA	817.57
O-TOLUIDINE	ND		86	180	1000	2000	NA	2970
P-(DIMETHYLAMINO)AZOBENZENE	ND		24	360	2000	NA	NA	NA
PENTACHLOROBENZENE	ND		38	360	2000	49000	NA	497
PENTACHLORONITROBENZENE	ND		59	890	5000	1900	NA	7090
PHENACETIN	ND		51	360	2000	NA	NA	11700
PHENANTHRENE	278	J	4	10.7	15.8	56000	NA	45700
PHENOL	ND		99	180	1000	37000000	5000	120000

TABLE 3-5

SOIL MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Maximum Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA SSL for Migration to Ground water	U.S. EPA Region 5 EDQLs
PRONAMIDE	ND		47	360	540	4600000	NA	13.6
PYRENE	4.1	J	4.1	10.7	15.8	2300000	210000	78500
PYRIDINE	ND		220	220	1100	61000	NA	1030
SAFROLE	ND		78	360	2000	NA	NA	404
VOCs (ug/kg)								
1,1,1,2-TETRACHLOROETHANE	ND		0.6	2	5	3000	NA	127.22
1,1,1-TRICHLOROETHANE	ND		0.8	2	5	770000	100	29800
1,1,2,2-TETRACHLOROETHANE	2	J	0.6	2	5	380	0.2	127
1,1,2-TRICHLOROETHANE	ND		0.7	4	10	840	0.9	28600
1,1-DICHLOROETHANE	ND		0.9	2	5	590000	1000	20100
1,1-DICHLOROETHENE	ND		1.1	4	10	54	3	8280
1,2,3-TRICHLOROPROPANE	ND		1.8	2	5	1.4	NA	3360
1,2-DIBROMO-3-CHLOROPROPANE	ND		1.9	4	10	450	NA	35.18
1,2-DIBROMOETHANE	ND		0.6	2	5	6.9	NA	1230
1,2-DICHLOROETHANE	ND		0.9	2	5	350	1	21200
1,2-DICHLOROPROPANE	ND		0.7	4	10	350	0.1	32700
2-BUTANONE	38		4 - 4.5	4	10	7300000	NA	NA
2-HEXANONE	ND		2.3	4	10	3100000	NA	12600
3-CHLOROPROPENE	ND		0.8	4	10	3600	NA	NA
4-METHYL-2-PENTANONE	ND		2 - 2.4	2	5	790000	NA	443000
ACETONE	6		4 - 4.6	4	750	1600000	800	2500
ACETONITRILE	ND		1.9 - 15	180	380	270000	0	1370
ACRYLONITRILE	ND		7.9 - 8	45	96	210	NA	123.93
BENZENE	ND		0.6	2	5	670	2	254.6
BROMODICHLOROMETHANE	ND		0.8	2	5	1000	30	539.78
BROMOFORM	ND		1.3	2	5	62000	40	15900
BROMOMETHANE	ND		1.4 - 5	4	10	3900	10	NA
CARBON DISULFIDE	6		0.8	2	4	360000	2000	94.12
CARBON TETRACHLORIDE	ND		0.9	2	5	240	3	2980
CHLOROBENZENE	ND		0.7	2	5	1000	70	13100
CHLORODIBROMOMETHANE	ND		0.7	2	5	1100	20	NA
CHLOROETHANE	ND		1.8	4	10	3000	NA	NA
CHLOROFORM	4	J	0.9	2	5	240	30	1190
CHLOROMETHANE	ND		0.6	4	10	1200	NA	NA
CHLOROPRENE	ND		0.9	4	10	3600	NA	2.9
CIS-1,2-DICHLOROETHENE	ND		0.9	4	10	43000	20	NA
CIS-1,3-DICHLOROPROPENE	ND		0.8 - 2	2	5	82	0.2	398
DIBROMOMETHANE	ND		0.6	4	10	67000	NA	NA
DICHLORODIFLUOROMETHANE	ND		0.8	2	5	94000	NA	39500
ETHYL METHACRYLATE	ND		0.9	4	10	140000	NA	30000
ETHYLBENZENE	ND		0.7	2	5	230000	700	NA
METHACRYLONITRILE	ND		10	90	190	2100	NA	67.1
METHYL IODIDE	ND		1.1 - 1.7	4	10	NA	NA	1230
METHYL METHACRYLATE	ND		1.5	4	10	2200000	NA	984000
METHYLENE CHLORIDE	2	J	1.7	5	54	8900	1	4050
PENTACHLOROETHANE	ND		1.3	4	10	NA	NA	10700
STYRENE	ND		0.6	2	5	1000	200	4690
TETRACHLOROETHENE	ND		1	2	5	5700	3	9920
TOLUENE	2	J	0.6	2	5	520000	600	5450
TOTAL XYLENES	ND		1.8	2	5	210000	9000	10000
TRANS-1,2-DICHLOROETHENE	ND		0.7	4	10	63000	30	783.73
TRANS-1,3-DICHLOROPROPENE	ND		0.8 - 2	2	5	82	0.2	398
TRANS-1,4-DICHLORO-2-BUTENE	ND		1.6 - 1.7	4	10	7.9	NA	NA
TRICHLOROETHENE	ND		0.5 - 1	2	5	2800	3	12400
TRICHLOROFLUOROMETHANE	ND		2.1	4	10	390000	NA	16400
VINYL ACETATE	ND		2 - 2.3	2	5	430000	8000	12700
VINYL CHLORIDE	ND		0.6	4	10	22	0.7	646
Pesticides / PCBs (ug/kg)								
4,4'-DDD	ND		1.1	2.7	4	2400	800	758.15
4,4'-DDE	ND		1.2	2.7	4	1700	3000	595.87
4,4'-DDT	ND		0.31	2.7	4	1700	2000	17.5
ALDRIN	ND		0.059	1.4	2.1	29	20	3.32
ALPHA-BHC	ND		0.14	1.4	2.1	90	0.03	99.4
ALPHA-CHLORDANE	ND		0.067	1.4	2.1	1600	500	NA
AROCLOR-1016	ND		2.2	35	53	3900	NA	0.332
AROCLOR-1221	ND		3.5	35	53	220	NA	0.332
AROCLOR-1232	ND		3.3	35	53	220	NA	0.332
AROCLOR-1242	ND		5.9	35	53	220	NA	0.332
AROCLOR-1248	ND		8.5	35	53	220	NA	0.332
AROCLOR-1254	ND		2.7	35	53	220	NA	0.332

TABLE 3-5

SOIL MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Maximum Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA SSL for Migration to Ground water	U.S. EPA Region 5 EDQLs
AROCLOR-1260	ND		0.9	35	53	220	NA	0.332
BETA-BHC	ND		0.7	1.4	2.1	320	0.1	3.98
DELTA-BHC	ND		0.076	1.4	2.1	90	NA	9940
DIELDRIN	ND		0.3	2.7	4	30	0.2	2.38
ENDOSULFAN I	ND		0.086	1.4	2.1	370000	900	119.27
ENDOSULFAN II	ND		0.32	2.7	4	370000	900	119.27
ENDOSULFAN SULFATE	ND		1	2.7	4	370000	NA	35.78
ENDRIN	ND		0.35	2.7	4	18000	50	10.1
ENDRIN ALDEHYDE	ND		0.18	2.7	4	18000	NA	10.5
GAMMA-BHC (LINDANE)	ND		0.23	1.4	2.1	440	0.5	5
GAMMA-CHLORDANE	0.55	J	0.2	1.4	1.9	1600	500	NA
HEPTACHLOR	0.94	J	0.14	1	2.4	110	1000	5.98
HEPTACHLOR EPOXIDE	ND		0.71	1.4	2.1	53	30	151.88
METHOXYCHLOR	ND		2.1	14	21	310000	8000	19.9
TOXAPHENE	ND		38	89	130	440	2000	1.19
Radiologicals (pci/g)								
CESIUM-137	0.09		0 - 0.0359	0.007	0.036	0.061	2100000	NA
COBALT-60	ND		0 - 0.0284	0.012	0.028	0.036	NA	NA
EUROPIUM-154	ND		0 - 0.0469	0.013	0.047	0.05	NA	NA
EUROPIUM-155	0.08		0 - 0.244	0.096	0.244	3.8	NA	NA
PROTACTINIUM-234	ND		2.58 - 3.21	2.580	3.210	15000000	NA	NA
THORIUM-230	0.0178	J	.0131 - 0.071	0.015	0.394	3.9	0.3	NA
URANIUM-235	0.12		0 - 0.207	0.102	0.386	0.21	0.039	NA

Shaded cells indicate that the maximum non-detect value exceeds the RBTL for at least one sample.
MDL = Maximum detection limit.
RBTL = Risk-based target limit.
EDQL = Ecological Data Quality Level
ND = Analyte was not detected in any samples.
NA = No value available.

TABLE 3-6

SEDIMENT MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Max Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA Region 5 EDQLs
Explosives, Round 1 (ug/kg)							
1,3,5-TRINITROBENZENE	ND		27.4	476	500	1800000	0.121
1,3-DINITROBENZENE	ND		26.8	476	500	6100	0.924
2,4,6-TRINITROTOLUENE	ND		87.6	476	500	16000	NA
2,4-DINITROTOLUENE	ND		13.1	476	500	120000	75.13
2,6-DINITROTOLUENE	ND		26.2	476	500	61000	20.62
2-AMINO-4,6-DINITROTOLUENE	ND		52.9	476	500	NA	NA
2-NITROTOLUENE	ND		28.3	476	500	370000	NA
3-NITROTOLUENE	ND		40.7	476	500	370000	NA
4-AMINO-2,6-DINITROTOLUENE	ND		115	476	500	NA	NA
4-NITROTOLUENE	ND		28.9	476	500	370000	NA
HMX	54.2	J	30.5	476	500	3100000	NA
NITROBENZENE	ND		25.5	476	500	20000	487.6
RDX	ND		28.2	476	500	4400	NA
TETRYL	ND		82.7	476	500	610000	NA
Herbicides, Round 1 (ug/kg)							
2,4,5-T	8.6	J	3.3	11	14	610000	58700
2,4,5-TP (SILVEX)	3.1	J	1.8	12	14	490000	7350
2,4-D	ND		10	79	99	690000	5.79
DINOSEB	ND		11	22	28	61000	11.78
PENTACHLOROPHENOL	ND		2.2	11	14	3000	30100
Metals, Round 1 (mg/kg)							
ANTIMONY	2	J	0.22 - 0.61	0.48	0.61	31	NA
BERYLLIUM	0.57	J	0.08 - 0.1	0.62	0.62	150	NA
CADMIUM	0.39	J	0.01 - 0.06	0.05	0.23	3	0.596
MERCURY	ND		0.02	0.05	0.09	23	0.174
SELENIUM	0.45		0.26 - 0.38	0.38	0.38	390	NA
SILVER	ND		0.14 - 0.18	0.14	0.18	390	0.5
THALLIUM	0.57		0.43 - 0.56	0.56	0.56	6.3	NA
Metals, Round 2 (mg/kg)							
CADMIUM	ND		0.05	0.05	0.05	3	0.596
SILVER	ND		0.27	0.27	0.27	390	0.5
THALLIUM	ND		0.31	0.31	0.31	6.3	NA
Miscellaneous, Round 1							
1,4-DITHIANE	ND		0	225	282	610000	NA
1,4-OXATHIANE	ND		0	225	282	NA	NA
BIS(2-CHLOROETHYL)SULFIDE	ND		0	225	282	NA	NA
SVOCs, Round 1 (ug/kg)							
1,2,4,5-TETRACHLOROBENZENE	ND		92	370	460	18000	20900
1,2,4-TRICHLOROBENZENE	ND		47	370	460	6000	11700
1,2-DICHLOROBENZENE	ND		35	190	230	370000	231.32
1,3-DICHLOROBENZENE	ND		35	190	230	13000	3010
1,4-DICHLOROBENZENE	ND		40	190	230	3000	1450
1,4-NAPHTHOQUINONE	ND		59	370	460	NA	0.0211
1,4-PHENYLENEDIAMINE	ND		308	930	1200	12000000	0.00568
1-NAPHTHYLAMINE	ND		169	370	460	NA	21.09
2,2'-OXYBIS(1-CHLOROPROPANE)	ND		58	190	230	2500	68.78
2,3,4,6-TETRACHLOROPHENOL	ND		96	370	460	1800000	1510
2,4,5-TRICHLOROPHENOL	ND		109	930	1200	6100000	85.56
2,4,6-TRICHLOROPHENOL	ND		65	370	460	44000	84.84
2,4-DICHLOROPHENOL	ND		114	370	460	1000	133.63
2,4-DIMETHYLPHENOL	ND		182	370	460	1000	304.53
2,4-DINITROPHENOL	ND		384	930	1200	120000	1.33
2,6-DICHLOROPHENOL	ND		104	370	460	NA	3.94
2-ACETYLAMINOFLUORENE	ND		73	190	230	NA	15.32
2-CHLORONAPHTHALENE	ND		56	190	230	4900000	417.23
2-CHLOROPHENOL	ND		69	190	230	6000	11.7
2-METHYLNAPHTHALENE	ND		3.2	190	230	NA	20.2

TABLE 3-6

SEDIMENT MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Max Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA Region 5 EDQLs
2-METHYLPHENOL	ND		126	190	230	3100000	0.826
2-NAPHTHYLAMINE	ND		190	190	230	NA	11.74
2-NITROANILINE	ND		128	470	600	3500	0.222
2-NITROPHENOL	ND		68	370	460	490000	7.77
2-PICOLINE	ND		250	280	350	NA	753.05
3,3'-DICHLOROBENZIDINE	ND		234	370	460	1100	28.22
3,3'-DIMETHYLBENZIDINE	ND		144	370	460	53	2
3-METHYLCHOLANTHRENE	ND		284	420	520	NA	8190000
3-METHYLPHENOL	ND		79	190	230	3100000	0.845
3-NITROANILINE	ND		217	930	1200	NA	0.222
4,6-DINITRO-2-METHYLPHENOL	ND		144	930	1200	NA	10.38
4-AMINOBIPHENYL	ND		135	190	230	NA	5.66
4-BROMOPHENYL PHENYL ETHER	ND		44	370	460	NA	1680
4-CHLORO-3-METHYLPHENOL	ND		231	370	460	NA	388.18
4-CHLOROANILINE	ND		186	370	460	240000	146.08
4-CHLOROPHENYL PHENYL ETHER	ND		116	190	230	NA	656.112
4-METHYLPHENOL	ND		130	190	230	310000	0.808
4-NITROANILINE	ND		348	930	1200	NA	0.222
4-NITROPHENOL	ND		374	930	1200	490000	7.78
5-NITRO-O-TOLUIDINE	ND		128	370	460	15000	NA
7,12-DIMETHYLBENZ(A)ANTHRACENE	ND		249	280	350	NA	66400
A,A-DIMETHYLPHENETHYLAMINE	ND		153	930	1200	61000	8.9
ACENAPHTHENE	139	J	3.9	11.2	13.9	3700000	6.71
ACENAPHTHYLENE	ND		8	11.2	13.9	3700000	5.87
ACETOPHENONE	ND		52	190	230	490	246
ANILINE	ND		140	190	230	85000	0.0338
ANTHRACENE	ND		3.3	11.2	13.9	22000000	46.9
ARAMITE	ND		43	930	1200	19000	0.00111
BENZO(A)ANTHRACENE	14.4		3.9	11.2	13.9	620	31.7
BENZO(A)PYRENE	4.97	J	4.2	11.6	13.9	62	31.9
BENZO(B)FLUORANTHENE	7.7	J	5.7	11.6	13.7	620	10400
BENZO(G,H,I)PERYLENE	21.8	J	4.8	11.2	13.9	56000	170
BENZO(K)FLUORANTHENE	6.26	J	5	11.2	13.9	6200	240
BENZYL ALCOHOL	ND		270	270	270	18000000	33.94
BIS(2-CHLOROETHOXY)METHANE	ND		64	370	460	NA	349.71
BIS(2-CHLOROETHYL)ETHER	ND		49	190	230	210	211.96
BIS(2-ETHYLHEXYL)PHTHALATE	98	J	71	190	230	35000	182
BUTYL BENZYL PHTHALATE	ND		63	190	230	12000000	4190
CHLOROBENZILATE	ND		51	370	460	1800	860.29
CHRYSENE	17.3	J	4.8	11.2	13.9	62000	57.1
DIALLATE	ND		46	370	460	8000	1.51
DIBENZO(A,H)ANTHRACENE	ND		3.7	11.2	13.9	62	6.22
DIBENZOFURAN	ND		71	190	230	290000	1520
DIETHYL PHTHALATE	ND		142	190	230	49000000	8.04
DIMETHYL PHTHALATE	ND		115	190	230	100000000	24.95
DI-N-BUTYL PHTHALATE	ND		113	190	230	6100000	110.5
DI-N-OCTYL PHTHALATE	ND		190	190	230	1200000	40600
DIPHENYLAMINE	ND		111	190	230	1500000	34.6
ETHYL METHANE SULFONATE	ND		59	190	230	NA	0.0161
FLUORANTHENE	4.93	J	3.8	11.6	13.9	2300000	111.3
FLUORENE	ND		3.7	11.2	13.9	2600000	21.2
HEXACHLOROBENZENE	ND		47	370	460	3000	20
HEXACHLOROBUTADIENE	ND		47	370	460	6000	1380
HEXACHLOROCYCLOPENTADIENE	ND		86	370	460	420000	900.74
HEXACHLOROETHANE	ND		40	190	230	35000	2230
HEXACHLOROPHENE	ND		4760	15000	19000	18000	231000
HEXACHLOROPROPENE	ND		126	370	460	NA	0.2
INDENO(1,2,3-CD)PYRENE	12.8		3.2	11.2	13.9	620	200

TABLE 3-6

SEDIMENT MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Max Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA Region 5 EDQLs
ISODRIN	ND		57	370	460	NA	55.16
ISOPHORONE	ND		68	190	230	510000	422.3
ISOSAFROLE	7600		58	380	460	611000	4.12
KEPONE	ND		72	930	1200	27	3.31
METHAPYRILENE	ND		215	930	1200	NA	0.0144
METHYL METHANE SULFONATE	ND		172	470	600	NA	0.00474
NAPHTHALENE	ND		7.9	11.5	13.9	56000	34.6
N-NITROSODIETHYLAMINE	ND		70	190	230	3.2	22.77
N-NITROSODIMETHYLAMINE	ND		121	190	230	9.5	0.00275
N-NITROSO-DI-N-BUTYLAMINE	ND		45	370	460	24	772.04
N-NITROSO-DI-N-PROPYLAMINE	ND		90	190	230	69	0.217
N-NITROSOMETHYLETHYLAMINE	ND		125	190	230	22	0.00485
N-NITROSOMORPHOLINE	ND		63	190	230	NA	0.0037
N-NITROSOPIPERIDINE	ND		73	370	460	NA	0.0226
N-NITROSOPYRROLIDINE	ND		73	190	230	230	0.000908
O,O,O-TRIETHYL PHOSPHOROTHIOATE	ND		87	370	460	NA	188.94
O-TOLUIDINE	ND		86	190	230	2000	0.199
P-(DIMETHYLAMINO)AZOBENZENE	ND		24	370	460	NA	317.99
PENTACHLOROBENZENE	ND		38	370	460	49000	1260
PENTACHLORONITROBENZENE	ND		59	930	1200	1900	18200
PHENACETIN	ND		51	370	460	NA	2.25
PHENANTHRENE	ND		4	11.2	13.9	56000	41.9
PHENOL	ND		99	190	230	37000000	27.26
PYRENE	5.31	J	4.1	11.2	13.9	2300000	53
PYRIDINE	ND		220	220	230	61000	106.17
SAFROLE	ND		78	370	460	NA	164.86
VOCs, Round 1 (ug/kg)							
1,1,1,2-TETRACHLOROETHANE	ND		0.6	3	4	3000	10.89
1,1,1-TRICHLOROETHANE	ND		0.8	3	4	770000	246.85
1,1,2,2-TETRACHLOROETHANE	7		0.6	3	4	380	29.08
1,1,2-TRICHLOROETHANE	ND		0.7	5	8	840	673.51
1,1-DICHLOROETHANE	ND		0.9	3	4	590000	0.575
1,1-DICHLOROETHENE	ND		1.1	5	8	54	23.27
1,2,3-TRICHLOROPROPANE	ND		1.8	3	4	1.4	8.35
1,2-DIBROMO-3-CHLOROPROPANE	ND		1.9	5	8	450	19.98
1,2-DIBROMOETHANE	ND		0.6	3	4	6.9	12.37
1,2-DICHLOROETHANE	ND		0.9	3	4	350	54.18
1,2-DICHLOROPROPANE	ND		0.7	5	8	350	351.61
2-BUTANONE	ND		4	5	8	7300000	136.96
2-HEXANONE	ND		2.3	5	8	3100000	1010
3-CHLOROPROPENE	ND		0.8	5	8	3600	0.266
4-METHYL-2-PENTANONE	ND		2	3	4	790000	544.37
ACETONE	12	J	4	5	7	1600000	453.37
ACETONITRILE	ND		15	200	310	270000	139.05
ACRYLONITRILE	ND		7.9	50	78	210	0.0157
BENZENE	ND		0.6	3	4	670	141.57
BROMODICHLOROMETHANE	ND		0.8	3	4	1000	1.13
BROMOFORM	ND		1.3	3	4	62000	996.27
BROMOMETHANE	ND		1.4	5	8	3900	946.74
CARBON DISULFIDE	ND		0.8	3	4	360000	133.97
CARBON TETRACHLORIDE	ND		0.9	3	4	240	35.73
CHLOROBENZENE	ND		0.7	3	4	1000	61.94
CHLORODIBROMOMETHANE	ND		0.7	3	4	1100	267.61
CHLOROETHANE	ND		1.8	5	8	3000	58600
CHLOROFORM	ND		0.9	3	4	240	27
CHLOROMETHANE	ND		0.6	5	8	1200	0.0785
CHLOROPRENE	ND		0.9	5	8	3600	1.06
CIS-1,2-DICHLOROETHENE	ND		0.9	5	8	43000	208.94

TABLE 3-6

SEDIMENT MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Max Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA Region 5 EDQLs
CIS-1,3-DICHLOROPROPENE	ND		2	3	4	82	2.96
DIBROMOMETHANE	ND		0.6	5	8	67000	0.0859
DICHLORODIFLUOROMETHANE	1	J	0.8	3	4	94000	1.33
ETHYL METHACRYLATE	ND		0.9	5	8	140000	0.602
ETHYLBENZENE	ND		0.7	3	4	230000	0.1
METHACRYLONITRILE	ND		10	100	160	2100	0.0297
METHYL IODIDE	ND		1.1	5	8	NA	0.305
METHYL METHACRYLATE	ND		1.5	5	8	2200000	167.56
METHYLENE CHLORIDE	ND		1.7	5	8	8900	1260
PENTACHLOROETHANE	ND		1.3	5	8	NA	689.18
STYRENE	ND		0.6	3	4	1000	444.96
TETRACHLOROETHENE	ND		1	3	4	5700	195.83
TOLUENE	ND		0.6	3	4	520000	52500
TOTAL XYLENES	ND		1.8	3	4	210000	1880
TRANS-1,2-DICHLOROETHENE	ND		0.7	5	8	63000	208.94
TRANS-1,3-DICHLOROPROPENE	ND		2	3	4	82	2.96
TRANS-1,4-DICHLORO-2-BUTENE	ND		1.7	5	8	7.9	1.82
TRICHLOROETHENE	ND		0.5	3	4	2800	179.56
TRICHLOROFLUOROMETHANE	ND		2.1	5	8	390000	3.07
VINYL ACETATE	ND		2	3	4	430000	12.95
VINYL CHLORIDE	ND		0.6	5	8	22	2
Volatile Organic Compounds, Round 2 (ug/kg)							
1,1,1,2-TETRACHLOROETHANE	ND		0.6	0.6	0.6	3000	10.89
1,1,1-TRICHLOROETHANE	ND		0.8	0.8	0.8	770000	246.85
1,1,2,2-TETRACHLOROETHANE	9		0.6	0.6	0.6	380	29.08
1,1,2-TRICHLOROETHANE	ND		0.7	0.7	0.7	840	673.51
1,1-DICHLOROETHANE	ND		0.9	0.9	0.9	590000	0.575
1,1-DICHLOROETHENE	ND		1.1	1.1	1.1	54	23.27
1,2,3-TRICHLOROPROPANE	ND		1.8	1.8	1.8	1.4	8.35
1,2-DIBROMO-3-CHLOROPROPANE	ND		1.9	1.9	1.9	450	19.98
1,2-DIBROMOETHANE	ND		0.6	0.6	0.6	6.9	12.37
1,2-DICHLOROETHANE	ND		0.9	0.9	0.9	350	54.18
1,2-DICHLOROPROPANE	ND		0.7	0.7	0.7	350	351.61
2-BUTANONE	ND		4	4	4	7300000	136.96
2-HEXANONE	ND		2.3	2.3	2.3	3100000	1010
3-CHLOROPROPENE	ND		0.8	0.8	0.8	3600	0.266
4-METHYL-2-PENTANONE	ND		2	2	2	790000	544.37
ACRYLONITRILE	ND		7.9	7.9	7.9	210	0.0157
BENZENE	ND		0.6	0.6	0.6	670	141.57
BROMODICHLOROMETHANE	ND		0.8	0.8	0.8	1000	1.13
BROMOFORM	ND		1.3	1.3	1.3	62000	996.27
BROMOMETHANE	ND		1.4	1.4	1.4	3900	946.74
CARBON DISULFIDE	2	J	0.8	0.8	0.8	360000	133.97
CARBON TETRACHLORIDE	ND		0.9	0.9	0.9	240	35.73
CHLOROBENZENE	ND		0.7	0.7	0.7	1000	61.94
CHLORODIBROMOMETHANE	ND		0.7	0.7	0.7	1100	267.61
CHLOROETHANE	ND		1.8	1.8	1.8	3000	58600
CHLOROFORM	ND		0.9	0.9	0.9	240	27
CHLOROMETHANE	ND		0.6	0.6	0.6	1200	0.0785
CHLOROPRENE	ND		0.9	0.9	0.9	3600	1.06
CIS-1,2-DICHLOROETHENE	ND		0.9	0.9	0.9	43000	208.94
CIS-1,3-DICHLOROPROPENE	ND		2	2	2	82	2.96
DIBROMOMETHANE	ND		0.6	0.6	0.6	67000	0.0859
DICHLORODIFLUOROMETHANE	8	J	0.8	0.8	0.8	94000	1.33
ETHYL METHACRYLATE	ND		0.9	0.9	0.9	140000	0.602
ETHYLBENZENE	ND		0.7	0.7	0.7	230000	0.1
METHACRYLONITRILE	ND		10	10	10	2100	0.0297
METHYL IODIDE	ND		1.1	1.1	1.1	NA	0.305

TABLE 3-6

SEDIMENT MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Minimum Observed Non-Detect	Max Observed Non-Detect	U.S. EPA Region 9 PRG	U.S. EPA Region 5 EDQLs
METHYL METHACRYLATE	ND		1.5	1.5	1.5	2200000	167.56
METHYLENE CHLORIDE	ND		1.7	1.7	1.7	8900	1260
PENTACHLOROETHANE	ND		1.6	1.6	1.6	NA	689.18
STYRENE	ND		0.6	0.6	0.6	1000	444.96
TETRACHLOROETHENE	ND		1	1	1	5700	195.83
TOLUENE	1	J	0.6	0.6	0.6	520000	52500
TOTAL XYLENES	ND		1.8	1.8	1.8	210000	1880
TRANS-1,2-DICHLOROETHENE	ND		0.7	0.7	0.7	63000	208.94
TRANS-1,3-DICHLOROPROPENE	ND		0.8	0.8	0.8	82	2.96
TRANS-1,4-DICHLORO-2-BUTENE	ND		1.7	1.7	1.7	7.9	1.82
TRICHLOROETHENE	ND		0.5	0.5	0.5	2800	179.56
TRICHLOROFLUOROMETHANE	ND		2.1	2.1	2.1	390000	3.07
VINYL ACETATE	ND		2	2	2	430000	12.95
VINYL CHLORIDE	ND		0.6	0.6	0.6	22	2
Pesticides / PCBs, Round 1 (ug/kg)							
4,4'-DDD	ND		1.1	2.8	3.5	2400	5.53
4,4'-DDE	ND		1.2	2.8	3.5	1700	1.42
4,4'-DDT	ND		0.31	2.8	3.5	1700	1.19
ALDRIN	ND		0.059	1.4	1.8	29	2
ALPHA-BHC	ND		0.14	1.4	1.8	90	6
ALPHA-CHLORDANE	ND		0.067	1.4	1.8	1600	4.5
AROCLOR-1016	ND		2.2	37	46	3900	34.1
AROCLOR-1221	ND		3.5	37	46	220	34.1
AROCLOR-1232	ND		3.3	37	46	220	34.1
AROCLOR-1242	ND		5.9	37	46	220	34.1
AROCLOR-1248	ND		8.5	37	46	220	34.1
AROCLOR-1254	ND		2.7	37	46	220	34.1
AROCLOR-1260	ND	J	0.9	37	46	220	34.1
BETA-BHC	ND		0.7	1.4	1.8	320	5
DELTA-BHC	ND		0.076	1.4	1.8	90	71500
DIELDRIN	ND		0.3	2.8	3.5	30	2
ENDOSULFAN I	ND		0.086	1.4	1.8	370000	0.175
ENDOSULFAN II	ND		0.32	2.8	3.5	370000	0.104
ENDOSULFAN SULFATE	ND		1	2.8	3.5	370000	34.6
ENDRIN	ND		0.35	2.8	3.5	18000	2.67
ENDRIN ALDEHYDE	ND		0.18	2.8	3.5	18000	3200
GAMMA-BHC (LINDANE)	ND		0.23	1.4	1.8	440	0.94
GAMMA-CHLORDANE	ND		0.2	1.4	1.8	1600	4.5
HEPTACHLOR	1.1	J	0.14	1.8	1.8	110	0.6
HEPTACHLOR EPOXIDE	ND		0.71	1.4	1.8	53	0.6
METHOXYCHLOR	ND		2.1	14	18	310000	3.59
TOXAPHENE	ND		38	92	120	440	0.109

Shaded cells indicate that the maximum non-detect value exceeds the RBTL for at least one sample.
PRG = Preliminary remediation goal.
MDL = Maximum detection limit.
RBTL = Risk-based target limit.
EDQL = Ecological Data Quality Level
ND = Analyte was not detected in any samples.
NA = No value available.

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
Explosives, Round 1 (ug/L)						
1,3,5-TRINITROBENZENE	ND		0.078	0.65	0.65	1100
1,3-DINITROBENZENE	ND		0.0629	0.65	0.65	3.6
2,4,6-TRINITROTOLUENE	0.127	J	0.0938	0.65	0.65	2.2
2,4-DINITROTOLUENE	ND		0.17	0.65	0.65	73
2,6-DINITROTOLUENE	ND		0.323	0.65	0.65	36
2-AMINO-4,6-DINITROTOLUENE	ND		0.228	0.65	0.65	2.2
2-NITROTOLUENE	0.202	J	0.134	0.65	0.65	61
3-NITROTOLUENE	ND		0.211	0.65	0.65	61
4-AMINO-2,6-DINITROTOLUENE	0.263	J	0.189	0.65	0.65	2.2
4-NITROTOLUENE	ND		0.136	0.65	0.65	61
HMX	0.201	J	0.0541	0.65	0.65	1800
NITROBENZENE	ND		0.0773	0.65	0.65	3.4
RDX	ND		0.0812	0.65	0.65	0.61
TETRYL	ND		0.168	0.65	0.65	360
Herbicides, Round 1 (ug/L)						
2,4,5-T	ND		0.23	0.8	0.8	360
2,4,5-TP (SILVEX)	ND		0.18	0.5	0.5	290
2,4-D	ND		0.61	2.5	2.5	360
DINOSEB	ND		0.45	1	1	NA
PENTACHLOROPHENOL	ND		0.16	0.5	0.5	0.56
Metals, Round 1 (ug/L)						
ALUMINUM	46.3		15.1 - 1.9	15.1	40.3	36000
ANTIMONY	1.9		1.6 - 3	1.6	4.7	15
ARSENIC	2.2	J	1.5 - 2.6	1.5	3.2	0.045
BARIUM	5.4	J	0.6 - 0.7	0.6	2.9	2600
BERYLLIUM	0.59		0.4 - 0.3	0.4	0.7	73
CADMIUM	0.74		0.1 - 98.6	0.1	0.41	18
CALCIUM	39800	J	19 - 1	19	111	NA
CHROMIUM	0.7		0.6 - 1	0.6	3.6	110
COBALT	1.2		1	1	1.6	2200
COPPER	0.94		0.9 - 25.7	0.9	2.6	1400
IRON	22.1		20.2 - 1.6	20.2	25.7	11000
LEAD	4.3		0.7 - 29.9	0.7	2.4	15
MAGNESIUM	5780	J	29.5 - 0.6	29.5	57.3	NA
MANGANESE	1.5		0.1 - 0.1	0.1	0.6	880
MERCURY	0.1		0.1	0.1	0.13	11
NICKEL	1.4		0.7 - 42.2	0.7	5.7	730
POTASSIUM	1170		34.3 - 2.3	34.3	42.2	NA
SELENIUM	ND		0.8 - 3	0.8	4.2	180
SILVER	0.65	J	0.2 - 18.2	0.2	3	180
SODIUM	3070	J	7 - 0.2	36	36	NA
STRONTIUM	76.5	J	0.1 - 5	0.1	0.2	22000
THALLIUM	2.5		2.4 - 3	2.4	5	2.9
THORIUM-CALC	0.155909		0	0.156773	1.454545	NA
TIN	ND		17.3 - 3	17.3	190	22000
VANADIUM	0.53		0.3 - 9.4	0.3	3.3	260
ZINC	3.9		1.1 - 40.3	1.1	43.8	11000
Metals, Round 2 (ug/L)						
ALUMINUM	180	J	32.1	32.1	32.1	36000
ANTIMONY	ND		5	5	5	15
ARSENIC	ND		3.3	3.3	3.3	0.045
BERYLLIUM	ND		0.3	0.3	0.3	73

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
CADMIUM	ND		0.3	0.3	0.3	18
CHROMIUM	ND		0.5	0.5	0.5	110
COBALT	11.2	J	1.7	1.7	1.7	2200
COPPER	ND		1	1	1	1400
IRON	31		24.2	24.2	24.2	11000
LEAD	ND		2.1	2.1	2.1	15
MERCURY	ND		0.1	0.1	0.1	11
NICKEL	3		0.8	0.8	0.8	730
SELENIUM	ND		2.9	2.9	2.9	180
SILVER	ND		2	2	2	180
THALLIUM	ND		0.6	0.6	0.6	2.9
TIN	ND		29.5	29.5	29.5	22000
VANADIUM	ND		0.9	0.9	0.9	260
ZINC	12.1		2.9	2.9	2.9	11000
Metals (filtered), Round 1 (ug/L)						
ALUMINUM, FILTERED	146		15.1 - 1.9	40.2	87	36000
ANTIMONY, FILTERED	2.1	J	1.6 - 3	1.6	3.1	15
ARSENIC, FILTERED	1.7	J	1.5 - 2.6	1.5	3	0.045
BARIUM, FILTERED	5.4	J	0.6 - 0.7	0.6	0.6	2600
BERYLLIUM, FILTERED	ND		0.4 - 0.3	0.4	0.7	73
CADMIUM, FILTERED	ND		0.1 - 98.6	0.3	0.49	18
CALCIUM, FILTERED	60500	J	19 - 1	19	19	NA
CHROMIUM, FILTERED	1.1		0.6 - 1	0.6	1	110
COBALT, FILTERED	1.7		1	1	1	2200
COPPER, FILTERED	ND		0.9 - 25.7	0.9	1.3	1400
IRON, FILTERED	51.7	J	20.2 - 1.6	20.2	20.3	11000
LEAD, FILTERED	ND		0.7 - 29.9	0.7	1.6	15
MAGNESIUM, FILTERED	5430	J	29.5 - 0.6	29.9	29.9	NA
MANGANESE, FILTERED	13.7		0.1 - 0.1	0.1	0.1	880
MERCURY, FILTERED	0.1		0.1	0.1	0.14	11
NICKEL, FILTERED	4.6		0.7 - 42.2	0.7	5.3	730
POTASSIUM, FILTERED	1100	J	34.3 - 2.3	42.2	42.2	NA
SELENIUM, FILTERED	ND		0.8 - 3	0.8	2.3	180
SILVER, FILTERED	ND		0.2 - 18.2	0.2	3	180
STRONTIUM, FILTERED	96.5	J	0.1 - 5	0.1	0.1	22000
THALLIUM, FILTERED	5.4		2.4 - 3	3.9	5	2.9
TIN, FILTERED	ND		17.3 - 3	17.3	190	22000
VANADIUM, FILTERED	0.77		0.3 - 9.4	0.3	3	260
ZINC, FILTERED	7.1		1.1 - 0	1.1	9.4	11000
Metals (filtered), Round 2 (ug/L)						
ALUMINUM, FILTERED	ND		32.1	32.1	32.1	36000
ANTIMONY, FILTERED	ND		5	5	5	15
ARSENIC, FILTERED	ND		3.3	3.3	3.3	0.045
BERYLLIUM, FILTERED	ND		0.3	0.3	0.3	73
CADMIUM, FILTERED	ND		0.3	0.3	0.3	18
CHROMIUM, FILTERED	ND		0.5	0.5	0.5	110
COBALT, FILTERED	96.8	J	1.7	1.7	1.7	2200
COPPER, FILTERED	ND		1	1	1	1400
LEAD, FILTERED	ND		2.1	2.1	2.1	15
MERCURY, FILTERED	ND		0.1	0.1	0.1	11
NICKEL, FILTERED	208		0.8	0.8	0.8	730
SELENIUM, FILTERED	ND		2.9	2.9	2.9	180
SILVER, FILTERED	ND		2	2	2	180

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
THALLIUM, FILTERED	ND		0.6	0.6	0.6	2.9
TIN, FILTERED	ND		29.5	29.5	29.5	22000
VANADIUM, FILTERED	ND		0.9	0.9	0.9	260
ZINC, FILTERED	65.6		2.9	2.9	2.9	11000
Miscellaneous, Round 1 (ug/L)						
1,4-DITHIANE	ND		0	200	200	360
1,4-OXATHIANE	ND		0	200	200	NA
BIS(2-CHLOROETHYL)SULFIDE	ND		0	200	200	NA
CHLORIDE	ND		---			NA
HARDNESS	ND		---			NA
pH	4.41		0			NA
TOTAL ORGANIC CARBON	1730		0.3	1	1	NA
TOTAL SUSPENDED SOLIDS	ND		---			NA
SVOCs, Round 1 (ug/L)						
1,2,4,5-TETRACHLOROBENZENE	ND		3	10	10	11
1,2,4-TRICHLOROBENZENE	ND		3	10	10	190
1,2-DICHLOROBENZENE	ND		4	5	5	370
1,3-DICHLOROBENZENE	ND		3	5	5	5.5
1,4-DICHLOROBENZENE	ND		4	5	5	0.5
1,4-NAPHTHOQUINONE	ND		1	10	10	NA
1,4-PHENYLENEDIAMINE	ND		0.001	25	25	6900
1-NAPHTHYLAMINE	ND		2	10	10	NA
2,2'-OXYBIS(1-CHLOROPROPANE)	ND		5	5	5	0.27
2,3,4,6-TETRACHLOROPHENOL	ND		5	10	10	1100
2,4,5-TRICHLOROPHENOL	ND		7	25	25	3600
2,4,6-TRICHLOROPHENOL	ND		6	10	10	6.1
2,4-DICHLOROPHENOL	ND		5	10	10	110
2,4-DIMETHYLPHENOL	ND		6	10	10	730
2,4-DINITROPHENOL	ND		6	25	25	73
2,6-DICHLOROPHENOL	ND		3	10	10	NA
2-ACETYLAMINOFLUORENE	ND		1	5	5	NA
2-CHLORONAPHTHALENE	ND		4	5	5	490
2-CHLOROPHENOL	ND		5	5	5	30
2-METHYLNAPHTHALENE	ND		3	5	5	NA
2-METHYLPHENOL	ND		6	6	6	1800
2-NAPHTHYLAMINE	ND		4	5	5	NA
2-NITROANILINE	ND		6	13	13	2.1
2-NITROPHENOL	ND		8	10	10	290
2-PICOLINE	ND		5	5	5	NA
3,3'-DICHLOROBENZIDINE	ND		3	10	10	0.15
3,3'-DIMETHYLBENZIDINE	ND		8	10	10	0.0073
3-METHYLCHOLANTHRENE	ND		1	5	5	NA
3-METHYLPHENOL	ND		5	5	5	1800
3-NITROANILINE	ND		6	25	25	NA
4,6-DINITRO-2-METHYLPHENOL	ND		6	25	25	NA
4-AMINOBIPHENYL	ND		1	5	5	NA
4-BROMOPHENYL PHENYL ETHER	ND		6	10	10	NA
4-CHLORO-3-METHYLPHENOL	ND		7	10	10	NA
4-CHLOROANILINE	ND		6	10	10	150
4-CHLOROPHENYL PHENYL ETHER	ND		4	5	5	NA
4-METHYLPHENOL	ND		5	5	5	180
4-NITROANILINE	ND		3	25	25	NA
4-NITROPHENOL	15	J	6	25	25	290

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
5-NITRO-O-TOLUIDINE	ND		2	10	10	2
7,12-DIMETHYLBENZ(A)ANTHRACENE	ND		2	5	5	NA
A,A-DIMETHYLPHENETHYLAMINE	ND		13	25	25	37
ACENAPHTHENE	0.0793	J	0.071	0.2	0.2	370
ACENAPHTHYLENE	0.763		0.046	0.2	0.2	370
ACETOPHENONE	ND		2	5	5	0.042
ANILINE	ND		7	10	10	12
ANTHRACENE	ND		0.075	0.2	0.2	1800
ARAMITE	ND		2	25	25	2.7
BENZO(A)ANTHRACENE	ND		0.066	0.2	0.2	0.092
BENZO(A)PYRENE	ND		0.084	0.2	0.2	0.0092
BENZO(B)FLUORANTHENE	ND		0.058	0.2	0.2	0.092
BENZO(G,H,I)PERYLENE	ND		0.11	0.2	0.2	6.2
BENZO(K)FLUORANTHENE	ND		0.066	0.2	0.2	0.92
BENZYL ALCOHOL	ND		7	7	7	11000
BIS(2-CHLOROETHOXY)METHANE	ND		4	10	10	NA
BIS(2-CHLOROETHYL)ETHER	ND		5	5	5	0.0098
BIS(2-ETHYLHEXYL)PHTHALATE	5	J	5	5	5	4.8
BUTYL BENZYL PHTHALATE	9	J	4	5	5	7300
CHLOROBENZILATE	ND		1	10	10	0.25
CHRYSENE	ND		0.11	0.2	0.2	9.2
DIALLATE	ND		1	10	10	1.1
DIBENZO(A,H)ANTHRACENE	ND		0.056	0.2	0.2	0.0092
DIBENZOFURAN	ND		4	5	5	24
DIETHYL PHTHALATE	ND		5	5	5	29000
DIMETHYL PHTHALATE	ND		6	6	6	3600
DI-N-BUTYL PHTHALATE	ND		4	5	5	730
DI-N-OCTYL PHTHALATE	ND		5	5	5	910
DIPHENYLAMINE	ND		1	5	5	NA
ETHYL METHANE SULFONATE	ND		2	5	5	220
FLUORANTHENE	ND		0.081	0.2	0.2	1500
FLUORENE	0.0593	J	0.059	0.2	0.2	240
HEXACHLOROBENZENE	ND		5	10	10	0.042
HEXACHLOROBUTADIENE	ND		3	10	10	0.86
HEXACHLOROCYCLOPENTADIENE	ND		1	10	10	260
HEXACHLOROETHANE	5	J	3	5	5	4.8
HEXACHLOROPHENE	ND		373	400	400	NA
HEXACHLOROPROPENE	ND		5	10	10	NA
INDENO(1,2,3-CD)PYRENE	ND		0.061	0.2	0.2	0.092
ISODRIN	ND		1	10	10	NA
ISOPHORONE	ND		5	5	5	71
ISOSAFROLE	ND		1	10	10	NA
KEPONE	ND		1	25	25	0.0037
METHAPYRILENE	ND		16	25	25	NA
METHYL METHANE SULFONATE	ND		2	13	13	NA
NAPHTHALENE	0.0796	J	0.07	0.2	0.2	6.2
N-NITROSODIETHYLAMINE	ND		2	5	5	0.00045
N-NITROSODIMETHYLAMINE	ND		2	5	5	0.0013
N-NITROSO-DI-N-BUTYLAMINE	ND		2	10	10	0.002
N-NITROSO-DI-N-PROPYLAMINE	ND		6	6	6	0.0096
N-NITROSOMETHYLETHYLAMINE	ND		7	7	7	0.0031
N-NITROSOMORPHOLINE	ND		1	5	5	NA
N-NITROSOPIPERIDINE	ND		1	10	10	NA

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
N-NITROSOPYRROLIDINE	ND		2	5	5	0.032
O,O,O-TRIETHYL PHOSPHOROTHIOATE	ND		1	10	10	NA
O-TOLUIDINE	ND		2	5	5	0.28
P-(DIMETHYLAMINO)AZOBENZENE	ND		1	10	10	NA
PENTACHLOROBENZENE	ND		4	10	10	29
PENTACHLORONITROBENZENE	ND		1	25	25	0.26
PHENACETIN	ND		1	10	10	NA
PHENANTHRENE	ND		0.098	0.2	0.2	6.2
PHENOL	ND		4	10	10	22000
PYRENE	ND		0.12	0.2	0.2	180
PYRIDINE	ND		2	10	10	37
SAFROLE	ND		1	10	10	NA
VOCs, Round 1 (ug/L)						
1,1,1,2-TETRACHLOROETHANE	0.3	J	0.1	0.5	500	0.43
1,1,1-TRICHLOROETHANE	ND		0.1	0.5	500	790
1,1,2,2-TETRACHLOROETHANE	0.3	J	0.1	0.5	0.5	0.055
1,1,2-TRICHLOROETHANE	0.4	J	0.3	1	1000	0.2
1,1-DICHLOROETHANE	ND		0.1	0.5	500	810
1,1-DICHLOROETHENE	0.2	J	0.1	1	1000	0.046
1,2,3-TRICHLOROPROPANE	ND		0.3	0.5	500	0.0016
1,2-DIBROMO-3-CHLOROPROPANE	ND		0.3	1	1000	0.048
1,2-DIBROMOETHANE	ND		0.1 - 0.1	0.6	600	0.00076
1,2-DICHLOROETHANE	0.3	J	0.1	0.5	500	0.12
1,2-DICHLOROPROPANE	NA		0.2	1	1000	0.16
2-BUTANONE	NA		1	5	5	1900
2-HEXANONE	NA		1.4	5	5000	1500
3-CHLOROPROPENE	NA		0.2 - 2.4	5	5000	14
4-METHYL-2-PENTANONE	NA		2 - 3.2	3	2500	160
ACETONE	NA		3 - 18.1	5	5	610
ACETONITRILE	NA		0.8 - 21	40	40000	79
ACRYLONITRILE	NA		4.7 - 0.1	10	10	0.039
BENZENE	NA		0.1	0.5	500	0.41
BROMODICHLOROMETHANE	NA		0.2	0.5	500	0.18
BROMOFORM	NA		0.2	0.5	500	8.5
BROMOMETHANE	NA		0.3	1	1000	8.7
CARBON DISULFIDE	NA		0.1 - 0.1	1	1000	1000
CARBON TETRACHLORIDE	NA		0.1	0.5	500	0.17
CHLOROBENZENE	NA		0.1	0.5	500	110
CHLORODIBROMOMETHANE	NA		0.1	0.5	500	0.13
CHLOROETHANE	NA		0.5	1	1000	4.6
CHLOROFORM	0.1	J	0.1	0.2	18	0.16
CHLOROMETHANE	ND		0.3	1	1000	115
CHLOROPRENE	ND		0.1 - 0.5	1	1000	14
CIS-1,2-DICHLOROETHENE	0.9	J	0.5	1	1000	61
CIS-1,3-DICHLOROPROPENE	ND		0.6	3	2500	0.081
DIBROMOMETHANE	ND		0.2	1	1000	61
DICHLORODIFLUOROMETHANE	ND		0.7	0.7	700	390
ETHYL METHACRYLATE	ND		0.1 - 0.1	1	1000	550
ETHYLBENZENE	ND		0.1	0.5	500	1300
METHYL IODIDE	ND		0.8	1	1000	NA
METHYL METHACRYLATE	ND		0.1 - 0.2	1	1000	1400
METHYLENE CHLORIDE	0.2	J	0.2	0.2	1000	43
PENTACHLOROETHANE	ND		0.3 - 2	5	5000	NA

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
STYRENE	ND		0.1	0.5	500	1600
TETRACHLOROETHENE	1	J	0.2	0.5	13	1.1
TOLUENE	0.3	J	0.1	0.5	500	720
TOTAL XYLENES	ND		0.2 - 0.1	3	2500	1400
TRANS-1,2-DICHLOROETHENE	0.3	J	0.1	1	1000	120
TRANS-1,3-DICHLOROPROPENE	ND		0.1 - 1.5	3	2800	0.081
TRANS-1,4-DICHLORO-2-BUTENE	ND		0.4 - 0.1	1	1000	0.0012
TRICHLOROETHENE	0.2	J	0.1	0.5	0.5	1.6
TRICHLOROFLUOROMETHANE	ND		0.4	1	1000	1300
VINYL ACETATE	ND		0.1 - 0.4	3	2500	410
VINYL CHLORIDE	ND		0.4	1	1000	0.02
VOCs, Round 2 (ug/L)						
1,1,1,2-TETRACHLOROETHANE	1		0.1	0.1	0.1	0.43
1,1,1-TRICHLOROETHANE	ND		0.1	0.1	0.1	790
1,1,2,2-TETRACHLOROETHANE	1		0.1	0.1	0.1	0.055
1,1,2-TRICHLOROETHANE	0.6	J	0.3	0.3	0.3	0.2
1,1-DICHLOROETHANE	ND		0.1	0.1	0.1	810
1,1-DICHLOROETHENE	1		0.1	0.1	0.1	0.046
1,2,3-TRICHLOROPROPANE	ND		0.3	0.3	0.3	0.0016
1,2-DIBROMO-3-CHLOROPROPANE	ND		0.3	0.3	0.3	0.048
1,2-DIBROMOETHANE	ND		0.3	0.3	0.3	0.00076
1,2-DICHLOROETHANE	2		0.2	0.2	0.2	0.12
1,2-DICHLOROPROPANE	ND		0.2	0.2	0.2	0.16
2-BUTANONE	ND		0.3	0.3	0.3	1900
2-HEXANONE	ND		0.3	0.3	0.3	1500
3-CHLOROPROPENE	ND		0.1	0.1	0.1	14
4-METHYL-2-PENTANONE	ND		0.4	0.4	0.4	160
ACETONITRILE	ND		0.1	0.1	0.1	79
BENZENE	ND		0.1	0.1	0.1	0.41
BROMODICHLOROMETHANE	ND		0.2	0.2	0.2	0.18
BROMOFORM	ND		0.2	0.2	0.2	8.5
BROMOMETHANE	ND		0.3	0.3	0.3	8.7
CARBON DISULFIDE	ND		0.1	0.1	0.1	1000
CARBON TETRACHLORIDE	ND		0.1	0.1	0.1	0.17
CHLOROBENZENE	ND		0.1	0.1	0.1	110
CHLORODIBROMOMETHANE	ND		0.1	0.1	0.1	0.13
CHLOROETHANE	ND		0.5	0.5	0.5	4.6
CHLOROFORM	0.7	J	0.1	0.1	0.1	0.16
CHLOROMETHANE	ND		0.3	0.3	0.3	1.5
CHLOROPRENE	ND		0.1	0.1	0.1	14
CIS-1,2-DICHLOROETHENE	1		0.5	0.5	0.5	61
CIS-1,3-DICHLOROPROPENE	ND		0.2	0.2	0.2	0.081
DIBROMOMETHANE	ND		0.2	0.2	0.2	61
DICHLORODIFLUOROMETHANE	ND		0.7	0.7	0.7	390
ETHYL METHACRYLATE	ND		0.1	0.1	0.1	550
ETHYLBENZENE	ND		0.1	0.1	0.1	1300
METHYL IODIDE	ND		0.1	0.1	0.1	NA
METHYL METHACRYLATE	ND		0.1	0.1	0.1	1400
METHYLENE CHLORIDE	1	J	0.2	0.2	0.2	4.3
PENTACHLOROETHANE	ND		0.1	0.1	0.1	NA
STYRENE	ND		0.1	0.1	0.1	1600
TETRACHLOROETHENE	1		0.2	0.2	0.2	1.1
TOLUENE	0.5	J	0.1	0.1	0.1	720

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
TOTAL XYLENES	ND		0.1	0.1	0.1	1400
TRANS-1,2-DICHLOROETHENE	0.4	J	0.1	0.1	0.1	120
TRANS-1,3-DICHLOROPROPENE	ND		0.2	0.2	0.2	0.081
TRANS-1,4-DICHLORO-2-BUTENE	ND		0.4	0.4	0.4	0.0012
TRICHLOROETHENE	1		0.1	0.1	0.1	1.6
TRICHLOROFLUOROMETHANE	ND		0.4	0.4	0.4	1300
VINYL ACETATE	ND		0.5	0.5	0.5	410
VINYL CHLORIDE	ND		0.4	0.4	0.4	0.02
Pesticides / PCBs (ug/L)						
4,4'-DDD	ND		0.0093	0.08	0.08	0.28
4,4'-DDE	ND		0.0044	0.08	0.08	0.2
4,4'-DDT	ND		0.0036	0.08	0.08	0.2
ALDRIN	ND		0.0024	0.04	0.04	0.004
ALPHA-BHC	ND		0.0019	0.04	0.04	0.011
ALPHA-CHLORDANE	ND		0.0026	0.04	0.04	0.19
AROCLOR-1016	ND		0.097	1	1	0.96
AROCLOR-1221	ND		0.22	1	1	0.034
AROCLOR-1232	ND		0.097	1	1	0.034
AROCLOR-1242	ND		0.12	1	1	0.034
AROCLOR-1248	ND		0.2	1	1	0.034
AROCLOR-1254	ND		0.12	1	1	0.034
AROCLOR-1260	ND		0.074	1	1	0.034
BETA-BHC	ND		0.0093	0.04	0.04	0.037
DELTA-BHC	ND		0.0019	0.04	0.04	0.011
DIELDRIN	ND		0.0038	0.08	0.08	0.0042
ENDOSULFAN I	ND		0.0024	0.04	0.04	220
ENDOSULFAN II	ND		0.0039	0.08	0.08	220
ENDOSULFAN SULFATE	ND		0.0042	0.08	0.08	220
ENDRIN	ND		0.0042	0.08	0.08	11
ENDRIN ALDEHYDE	ND		0.0054	0.08	0.08	11
GAMMA-BHC (LINDANE)	ND		0.0019	0.04	0.04	0.052
GAMMA-CHLORDANE	0.025	J	0.004	0.04	0.04	0.19
HEPTACHLOR	0.017	J	0.0074	0.013	0.059	0.015
HEPTACHLOR EPOXIDE	ND		0.0022	0.04	0.04	0.0074
METHOXYCHLOR	ND		0.046	0.38	0.38	180
TOXAPHENE	ND		0.55	2.5	2.5	0.061
Radionuclides, ROUND 1 (ug/L)						
ACTINIUM-228	ND		---	27.4	46.2	NA
BISMUTH-212	ND		---	104	127	NA
BISMUTH-214	ND		---	11.3	20.7	NA
CESIUM-137	ND		---	6.59	14.8	NA
COBALT-60	ND		---	8.08	9.32	NA
EUROPIUM-154	ND		---	3.77	11.9	NA
EUROPIUM-155	ND		---	12	18.2	NA
GROSS ALPHA	1.36	J	0.634 - 6.79	0.194	6.06	15 (pCi/L)
GROSS BETA	1.99		0.766 - 0.166	0.479	5.16	4 (mrem)
LEAD-210	ND		---	46.2	142	NA
LEAD-212	ND		---	13.2	19.9	NA
LEAD-214	ND		---	23.4	30.7	NA
POTASSIUM-40	ND		---	46.3	138	NA
PROTACTINIUM-234	ND		---	820	1510	NA
RADIUM-226	ND		---	122	214	NA
THALLIUM-208	ND		---	13.3	39.8	NA

TABLE 3-7

GROUND WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG
THORIUM-228	0.0329		0.0184 - 0.109	0.0216	0.166	0.16
THORIUM-230	ND		0.0124 - 0.154	0.047	0.329	0.37
THORIUM-232	0.0235		0.00796 - 0.154	0.00777	0.154	0.47
THORIUM-234	ND		---	11.3	181	NA
URANIUM-235	ND		---	46.6	69.9	NA

Shaded cells indicate that the maximum non-detect value exceeds the RBTL for at least one sample.
PRG = Preliminary remediation goal.
MDL = Maximum detection limit.
RBTL = Risk-based target limit.
ND = Analyte was not detected in any samples.
NA = Not applicable.
1 - The value presented is for dose, which was provided in lieu of available EPA Region 9 PRGs. The corresponding applicable concentration limit is 50 pCi/L. The 50 pCi/L limit is applicable to drinking water supplies and, therefore, is a conservative limit.

TABLE 3-8

SURFACE WATER MINIMUM AND MAXIMUM DETECTION LIMITS VERSUS RBTLs, ROUND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

PARAMETER	Minimum Detection	Minimum Qualifier	Nominal MDL	Min Observed Non-Detect	Max Observed Non-Detect	Region 9 Tap Water PRG	U.S. EPA Region 5 EDQLs
VOCs (ug/L)							
1,1,1,2-TETRACHLOROETHANE	ND		0.6	0.6	0.6	0.43	90.25
1,1,1-TRICHLOROETHANE	ND		0.7	0.7	0.7	790	88
1,1,2,2-TETRACHLOROETHANE	ND		0.9	0.9	0.9	0.055	13
1,1,2-TRICHLOROETHANE	ND		0.7	0.7	0.7	0.2	650
1,1-DICHLOROETHANE	ND		3.1	3.1	3.1	810	47
1,1-DICHLOROETHENE	ND		0.7	0.7	0.7	0.046	78
1,2,3-TRICHLOROPROPANE	ND		1.4	1.4	1.4	0.0016	12.11
1,2-DIBROMO-3-CHLOROPROPANE	ND		1.4	1.4	1.4	0.048	11.2
1,2-DIBROMOETHANE	ND		0.8	0.8	0.8	0.00076	22.5
1,2-DICHLOROETHANE	ND		0.5	0.5	0.5	0.12	190
1,2-DICHLOROPROPANE	ND		0.7	0.7	0.7	0.16	380
2-HEXANONE	ND		1.4	1.4	1.4	1500	1710
3-CHLOROPROPENE	ND		2.2	2.2	2.2	14	NA
4-METHYL-2-PENTANONE	ND		2	2	2	160	3680
BENZENE	ND		0.6	0.6	0.6	0.41	114
BROMODICHLOROMETHANE	ND		0.7	0.7	0.7	0.18	NA
BROMOFORM	ND		0.7	0.7	0.7	8.5	466
BROMOMETHANE	ND		2.7	2.7	2.7	8.7	NA
CARBON DISULFIDE	ND		1	1	1	1000	84.1
CARBON TETRACHLORIDE	ND		1.1	1.1	1.1	0.17	5.9
CHLOROBENZENE	ND		0.6	0.6	0.6	110	10
CHLORODIBROMOMETHANE	ND		0.5	0.5	0.5	0.13	NA
CHLOROETHANE	ND		2.7	2.7	2.7	4.6	230000
CHLOROFORM	ND		0.9	0.9	0.9	0.16	79
CHLOROMETHANE	ND		2.9	2.9	2.9	4.5	NA
CHLOROPRENE	ND		1	1	1	14	NA
CIS-1,2-DICHLOROETHENE	ND		1	1	1	61	NA
CIS-1,3-DICHLOROPROPENE	ND		0.6	0.6	0.6	0.081	7.9
DIBROMOMETHANE	ND		0.8	0.8	0.8	61	22.5
DICHLORODIFLUOROMETHANE	ND		4.7	4.7	4.7	390	NA
ETHYL METHACRYLATE	ND		1.1	1.1	1.1	550	NA
ETHYLBENZENE	ND		0.6	0.6	0.6	1300	17.2
METHYL IODIDE	ND		0.8	0.8	0.8	NA	NA
METHYL METHACRYLATE	ND		1.7	1.7	1.7	1400	2800
METHYLENE CHLORIDE	ND		0.6	0.6	0.6	4.3	430
PENTACHLOROETHANE	ND		1.4	1.4	1.4	NA	56.42
STYRENE	ND		0.6	0.6	0.6	1600	56
TETRACHLOROETHENE	ND		0.8	0.8	0.8	1.1	8.9
TOLUENE	ND		0.7	0.7	0.7	720	253
TOTAL XYLENES	ND		2.1	2.1	2.1	1400	117
TRANS-1,2-DICHLOROETHENE	ND		0.8	0.8	0.8	120	310
TRANS-1,3-DICHLOROPROPENE	ND		2.8	2.8	2.8	0.081	7.9
TRANS-1,4-DICHLORO-2-BUTENE	ND		1.5	1.5	1.5	0.0012	NA
TRICHLOROETHENE	ND		0.9	0.9	0.9	1.6	75
TRICHLOROFLUOROMETHANE	ND		1.5	1.5	1.5	1300	NA
VINYL ACETATE	ND		1.8	1.8	1.8	410	248.03
VINYL CHLORIDE	ND		1.4	1.4	1.4	0.02	9.2

Shaded cells indicate that the maximum non-detect value exceeds the RBTL for at least one sample.
Blank cell indicates no soil target level available.
MDL = Maximum detection limit.
RBTL = Risk-based target limit.
ND = Analyte was not detected in any samples.
NA = Not applicable.

TABLE 3-9

MEAN PERCENT RECOVERIES OF LABORATORY BIAS INDICATORS
FOR VOLATILE ORGANIC CHEMICALS IN SOIL AND SEDIMENT, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Item	Analyte	Mean %R			
		LCS	LCSD	MS	MSD
1	1,2,3-Trichloropropane	81.4	80.2	68.3	71.0
2	1,4-Dioxane	98.9	105.4	119.5	128.0
3	2-Butanone	105.0	98.7	71.0	68.8
4	2-Hexanone	88.6	87.4	56.8	41.0
5	4-Methyl-2-pentanone	84.6	84.8	69.3	57.3
6	Acetone	80.8	76.8	57.3	54.8
7	Acetonitrile	102.2	100.7	104.5	13333.0
8	Acrolein	80.1	82.2	292.5	289.0
9	Acrylonitrile	84.1	80.3	52.3	51.0
10	Allyl Chloride	78.9	81.0	175.8	186.8
11	Carbon Disulfide	52.6	51.5	101.0	98.0
12	Chloroprene	89.7	95.3	170.5	169.8
13	Ethyl Methacrylate	95.1	98.2	27.7	12.0
14	Isobutyl Alcholol	73.2	74.6	68.8	14288.5
15	Methacrylonitrile	92.2	93.6	68.8	62.3
16	Methyl Iodide	83.2	84.6	70.7	87.7
17	Pentachloroethane	73.5	67.5	176.5	180.0
18	Proprionitrile	359.1	357.2	78.3	10809.8
19	Trans-1,4-Dichloro-2-butene	82.6	80.4	50.5	57.8

Highlighted values are shown for compounds exhibiting at least one significant low bias.
LCS = Laboratory Control Sample
LCSD = Laboratory Control Sample Duplicate
MS = Matrix Spike
MSD = Matrix Spike Duplicate

TABLE 3-10

MEAN PERCENT RECOVERIES OF LABORATORY BIAS INDICATORS FOR VOLATILE ORGANIC CHEMICALS IN GROUND WATER, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Item	Analyte	Mean %R			
		LCS	LCSD	MS	MSD
1	1,1,1,2-Tetrachloroethane	91.1	93.0	68.5	73.5
2	1,1,2,2-Tetrachloroethane	88.6	82.7	77.0	83.5
3	1,1,2-Trichloroethane	90.9	92.3	72.5	80.5
4	1,2,3-Trichloropropane	98.9	101.8	54.5	92.5
5	1,2-Dibromo-3-chloropropane	61.6	51.5	45.0	65.0
6	1,2-Dibromoethane	92.5	95.1	71.5	81.5
7	1,4-Dioxane	75.2	84.3	88.0	80.5
8	2-Butanone	91.2	91.9	56.5	80.0
9	2-Hexanone	83.3	89.3	61.5	236.0
10	4-Methyl-2-pentanone	81.3	81.0	67.5	77.0
11	Acetone	101.9	94.7	75.0	74.0
12	Acetonitrile	117.9	126.5	95.5	95.0
13	Acrolein	79.0	85.7	191.5	99.5
14	Bromoform	90.3	92.8	52.0	70.0
15	Bromomethane	85.5	78.4	73.0	78.5
16	Carbon Disulfide	96.8	29.7	87.0	76.5
17	Chlorobenzene	92.9	92.2	75.0	73.5
18	Chloroethane	107.7	103.6	74.5	84.0
19	Chloromethane	103.7	99.4	71.0	81.0
20	cis-1,2-Dichloroethene	88.4	89.8	71.5	76.0
21	cis-1,2-Dichloropropene	85.5	86.5	72.0	76.0
22	Dibromochloromethane	92.8	96.0	70.0	74.0
23	Dibromomethane	92.5	95.9	74.0	82.0
24	Dichlorofluoromethane	85.3	72.5	69.0	65.5
25	Methyl Methacrylate	48.8	38.3	56.5	54.0
26	Methylene Chloride	114.1	121.5	70.5	81.0
27	Proprionitrile	163.0	176.2	74.5	90.0
28	Styrene	98.9	100.8	67.5	57.0
29	Trans-1,3-Dichloropropene	83.7	85.2	71.5	75.5
30	Trans-1,4-Dichloro-2-butene	122.3	139.2	73.5	104.5
31	Vinyl Acetate	99.3	103.0	66.0	57.5
32	Vinyl Chloride	107.0	106.2	73.5	83.5

Highlighted values are shown for compounds exhibiting at least one significant low bias.
LCS = Laboratory Control Sample
LCSD = Laboratory Control Sample Duplicate
MS = Matrix Spike
MSD = Matrix Spike Duplicate

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 Explosives	1,3-DINITROBENZENE	P	0	0	100	0	0	0	0
	2,4,6-TRINITROTOLUENE	E,P,U	0	0	100	0	0	0	0
	2-NITROTOLUENE	P,U	0	0	100	0	0	0	0
	4-AMINO-2,6-DINITROTOLUENE	P	0	0	100	0	0	0	0
	HMX	P,U	0	0	100	0	0	0	0
	HMX	U	0	0	0	100	0	0	0
	RDX	P,U	0	0	100	0	0	0	0
	RDX	U	0	0	0	100	0	0	0
Round 1 Herbicides	2,4,5-T	D	0	0	0	0	0	100	0
	2,4,5-TP (SILVEX)	D	0	0	0	0	0	100	0
	DINOSEB	C	0	0	0	0	0	100	0
	DINOSEB	C,D	0	0	0	0	0	0	100
Round 1 Metals	MERCURY	A	0	0	0	0	100	0	0
	ALUMINUM	A,D,I	0	0	100	0	0	0	0
	ALUMINUM	D,I	0	0	100	0	0	0	0
	ANTIMONY	A	0	0	0	0	100	0	0
	ARSENIC	A	0	0	0	0	100	0	0
	ARSENIC	K	0	0	50	0	0	50	0
	BARIUM	K	0	0	100	0	0	0	0
	BERYLLIUM	K	0	0	100	0	0	0	0
	CADMIUM	A	0	0	0	0	100	0	0
	CADMIUM	K	0	0	0	0	0	100	0
	CALCIUM	A	0	0	100	0	0	0	0
	CALCIUM	A,D	0	0	100	0	0	0	0
	CHROMIUM	A	0	0	16.7	0	83.3	0	0
	CHROMIUM	D	0	0	0	0	0	100	0
	COBALT	F	0	0	100	0	0	0	0
	COPPER	A	0	0	33.3	0	66.7	0	0
	COPPER	K	0	0	0	0	0	100	0
	IRON	D	0	0	100	0	0	0	0
	LEAD	A	0	0	100	0	0	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 Metals (continued)	MAGNESIUM	A	0	0	100	0	0	0	0
	MANGANESE	A	0	0	100	0	0	0	0
	MANGANESE	A,F	0	0	100	0	0	0	0
	MANGANESE	F	0	0	100	0	0	0	0
	NICKEL	A	0	0	60	0	40	0	0
	POTASSIUM	A	0	0	100	0	0	0	0
	POTASSIUM	A,I	0	0	100	0	0	0	0
	SELENIUM	A	0	0	0	0	100	0	0
	SELENIUM	K	0	0	0	0	0	100	0
	SILVER	A	0	0	100	0	0	0	0
	SODIUM	A	0	0	100	0	0	0	0
	SODIUM	A,D	0	0	100	0	0	0	0
	SODIUM	A,I	0	0	100	0	0	0	0
	SODIUM	D	0	0	100	0	0	0	0
	SODIUM	I	0	0	100	0	0	0	0
	STRONTIUM	A	0	0	100	0	0	0	0
	THALLIUM	K	0	0	0	0	0	100	0
	VANADIUM	A	0	0	0	0	100	0	0
	ZINC	A	0	0	10	0	90	0	0
	ZINC	K	0	0	0	0	0	100	0
Round 1 Metals	ALUMINUM	A	0	0	50	0	50	0	0
	BARIUM	A	0	0	100	0	0	0	0
	CHROMIUM	K	0	0	0	0	0	100	0
	COBALT	A	0	0	50	0	50	0	0
	LEAD	K	0	0	0	0	0	100	0
	SELENIUM	A	0	0	0	0	100	0	0
	SILVER	K	0	0	0	0	0	100	0
	STRONTIUM	A,I	0	0	100	0	0	0	0
	THALLIUM	A	0	0	0	0	100	0	0
Round 1 Metals (filtered)	MERCURY, FILTERED	A	0	0	0	0	100	0	0
	ALUMINUM, FILTERED	A	0	0	0	0	100	0	0
	ANTIMONY, FILTERED	A	0	0	0	0	100	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 Metals (filtered - continued)	ANTIMONY, FILTERED	K	0	0	100	0	0	0	0
	ARSENIC, FILTERED	A	0	0	0	0	100	0	0
	ARSENIC, FILTERED	K	0	0	50	0	0	50	0
	BARIUM, FILTERED	K	0	0	100	0	0	0	0
	CADMIUM, FILTERED	A	0	0	0	0	100	0	0
	CADMIUM, FILTERED	K	0	0	0	0	0	100	0
	CALCIUM, FILTERED	A	0	0	100	0	0	0	0
	COPPER, FILTERED	A	0	0	0	0	100	0	0
	IRON, FILTERED	D	0	0	100	0	0	0	0
	MAGNESIUM, FILTERED	A	0	0	100	0	0	0	0
	MANGANESE, FILTERED	A	0	0	100	0	0	0	0
	NICKEL, FILTERED	A	0	0	40	0	60	0	0
	POTASSIUM, FILTERED	A	0	0	100	0	0	0	0
	POTASSIUM, FILTERED	A,I	0	0	100	0	0	0	0
	SELENIUM, FILTERED	A	0	0	0	0	100	0	0
	SELENIUM, FILTERED	K	0	0	0	0	0	100	0
	SODIUM, FILTERED	A	0	0	100	0	0	0	0
	SODIUM, FILTERED	A,D	0	0	100	0	0	0	0
	SODIUM, FILTERED	D	0	0	100	0	0	0	0
	STRONTIUM, FILTERED	A	0	0	100	0	0	0	0
	THALLIUM, FILTERED	K	0	0	14.3	0	0	85.7	0
	ZINC, FILTERED	A	0	0	0	0	100	0	0
	ZINC, FILTERED	K	0	0	0	0	0	100	0
Round 2 Metals (filtered)	ALUMINUM	A	0	0	0	0	100	0	0
	BARIUM	A	0	0	100	0	0	0	0
	CHROMIUM	K	0	0	0	0	0	100	0
	COBALT	A	0	0	100	0	0	0	0
	LEAD	K	0	0	0	0	0	100	0
	SELENIUM	A	0	0	0	0	100	0	0
	SILVER	K	0	0	0	0	0	100	0
	STRONTIUM	A,I	0	0	100	0	0	0	0
	THALLIUM	A	0	0	0	0	100	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Miscellaneous, Round 1	TOTAL ORGANIC CARBON	G	0	0	100	0	0	0	0
Miscellaneous, Round 2	TOTAL ORGANIC CARBON	G	0	0	100	0	0	0	0
SVOCs	1,4-PHENYLENEDIAMINE	C	0	0	0	0	0	100	0
	3,3'-DICHLOROBENZIDINE	C	0	0	0	0	0	100	0
	3,3'-DIMETHYLBENZIDINE	C	0	0	0	0	0	100	0
	4-NITROQUINOLINE-1-OXIDE	C	0	0	0	0	0	0	100
	7,12-DIMETHYLBENZ(A)ANTHRACENE	C	0	0	0	0	0	100	0
	BIS(2-CHLOROETHOXY)METHANE	D	0	0	0	0	0	100	0
	BIS(2-ETHYLHEXYL)PHTHALATE	A	0	0	100	0	0	0	0
	BIS(2-ETHYLHEXYL)PHTHALATE	P	0	0	100	0	0	0	0
	BUTYL BENZYL PHTHALATE	P	0	0	100	0	0	0	0
	DI-N-BUTYL PHTHALATE	C	0	0	0	0	0	100	0
	DIPHENYLAMINE	E	0	0	0	0	0	100	0
	HEXACHLOROCYCLOPENTADIENE	D	0	0	0	0	0	0	100
	HEXACHLOROPHENE	C	0	0	0	0	0	96	4
	HEXACHLOROPROPENE	C	0	0	0	0	0	100	0
	METHAPYRILENE	C	0	0	0	0	0	0	100
	N-NITROSO-DI-N-PROPYLAMINE	C	0	0	0	0	0	100	0
	N-NITROSOPYRROLIDINE	C	0	0	0	0	0	100	0
	PHENACETIN	C	0	0	0	0	0	100	0
	PRONAMIDE	C	0	0	0	0	0	0	100
Round 1 PAHs	ACENAPHTHENE	D	0	0	0	0	0	100	0
	ACENAPHTHENE	L	0	0	100	0	0	0	0
	ACENAPHTHENE	P	0	0	100	0	0	0	0
	ACENAPHTHYLENE	P	0	0	100	0	0	0	0
	BENZO(A)ANTHRACENE	P,U	0	0	100	0	0	0	0
	BENZO(G,H,I)PERYLENE	C	0	0	0	0	0	100	0
	BENZO(G,H,I)PERYLENE	C,D	0	0	0	0	0	100	0
	BENZO(K)FLUORANTHENE	D	0	0	0	0	0	100	0
	CHRYSENE	D	0	0	0	0	0	100	0
	FLUORENE	P	0	0	100	0	0	0	0
	NAPHTHALENE	P	0	0	100	0	0	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 VOCs	1,1,1,2-TETRACHLOROETHANE	P	0	0	100	0	0	0	0
	1,1,1,2-TETRACHLOROETHANE	P,R	0	0	100	0	0	0	0
	1,1,1,2-TETRACHLOROETHANE	R	0	0	66.7	0	0	33.3	0
	1,1,1-TRICHLOROETHANE	R	0	0	0	0	0	100	0
	1,1,2,2-TETRACHLOROETHANE	C	0	0	0	0	0	100	0
	1,1,2,2-TETRACHLOROETHANE	G	0	0	100	0	0	0	0
	1,1,2,2-TETRACHLOROETHANE	P,R	0	0	100	0	0	0	0
	1,1,2,2-TETRACHLOROETHANE	R	0	0	80	0	0	20	0
	1,1,2-TRICHLOROETHANE	D	0	0	0	0	0	100	0
	1,1,2-TRICHLOROETHANE	P	0	0	100	0	0	0	0
	1,1,2-TRICHLOROETHANE	P,R	0	0	100	0	0	0	0
	1,1,2-TRICHLOROETHANE	R	0	0	100	0	0	0	0
	1,1-DICHLOROETHANE	R	0	0	0	0	0	100	0
	1,1-DICHLOROETHENE	P	0	0	100	0	0	0	0
	1,1-DICHLOROETHENE	P,R	0	0	100	0	0	0	0
	1,1-DICHLOROETHENE	R	0	0	75.0	0	0	25	0
	1,2,3-TRICHLOROPROPANE	C	0	0	0	0	0	100	0
	1,2,3-TRICHLOROPROPANE	R	0	0	0	0	0	100	0
	1,2-DIBROMO-3-CHLOROPROPANE	C	0	0	0	0	0	100	0
	1,2-DIBROMO-3-CHLOROPROPANE	R	0	0	0	0	0	100	0
	1,2-DIBROMOETHANE	R	0	0	0	0	0	100	0
	1,2-DICHLOROETHANE	P	0	0	100	0	0	0	0
	1,2-DICHLOROETHANE	R	0	0	66.7	0	0	33.3	0
	1,2-DICHLOROPROPANE	R	0	0	0	0	0	100	0
	1,4-DIOXANE	C	0	0	0	0	0	0	100
	1,4-DIOXANE	C,D	0	0	0	0	0	0	100
	1,4-DIOXANE	C,E	0	0	0	0	0	0	100
	2-BUTANONE	C	0	0	0	0	0	20	80
	2-BUTANONE	C,D	0	0	0	0	0	0	100
	2-BUTANONE	R	0	0	0	0	0	100	0
	2-HEXANONE	C	0	0	0	0	0	100	0
	2-HEXANONE	C,D,R	0	0	0	0	0	100	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 VOCs (continued)	3-CHLOROPROPENE	C	0	0	0	0	0	100	0
	3-CHLOROPROPENE	R	0	0	0	0	0	100	0
	4-METHYL-2-PENTANONE	C	0	0	0	0	0	100	0
	4-METHYL-2-PENTANONE	R	0	0	0	0	0	100	0
	ACETONE	A,C	0	0	100	0	0	0	0
	ACETONE	C	0	0	9.6	1.9	0	5.8	82.7
	ACETONE	C,P	0	0	100	0	0	0	0
	ACETONITRILE	C	0	0	0	0	0	100	0
	ACETONITRILE	R	0	0	0	0	0	100	0
	ACROLEIN	C	0	0	0	0	0	0	100
	ACRYLONITRILE	C	0	0	0	0	0	0	100
	BENZENE	C	0	0	0	0	0	0	100
	BENZENE	R	0	0	0	0	0	100	0
	BROMODICHLOROMETHANE	R	0	0	0	0	0	100	0
	BROMOFORM	C	0	0	0	0	0	100	0
	BROMOFORM	C,D	0	0	0	0	0	100	0
	BROMOFORM	R	0	0	0	0	0	100	0
	BROMOMETHANE	D	0	0	0	0	0	100	0
	BROMOMETHANE	R	0	0	0	0	0	100	0
	CARBON DISULFIDE	C	0	0	0	0	0	100	0
	CARBON DISULFIDE	D	0	0	0	0	0	100	0
	CARBON DISULFIDE	D,R	0	0	0	0	0	100	0
	CARBON TETRACHLORIDE	C	0	0	0	0	0	100	0
	CARBON TETRACHLORIDE	C,R	0	0	0	0	0	100	0
	CHLOROBENZENE	R	0	0	0	0	0	100	0
	CHLORODIBROMOMETHANE	P	0	0	100	0	0	0	0
	CHLORODIBROMOMETHANE	R	0	0	0	0	0	100	0
	CHLOROETHANE	R	0	0	0	0	0	100	0
	CHLOROFORM	A	10	50	30.0	0	10	0	0
	CHLOROFORM	A,R	0	0	100	0	0	0	0
	CHLOROFORM	P	10	0	90.0	0	0	0	0
	CHLOROFORM	P,R	0	0	100	0	0	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 VOCs (continued)	CHLOROFORM	R	0	0	0	0	0	100	0
	CHLOROMETHANE	P	0	0	100	0	0	0	0
	CHLOROMETHANE	R	0	0	50.0	0	0	50	0
	CHLOROPRENE	C	0	0	0	0	0	100	0
	CHLOROPRENE	R	0	0	0	0	0	100	0
	CIS-1,2-DICHLOROETHENE	D	0	0	0	0	0	100	0
	CIS-1,2-DICHLOROETHENE	P	0	0	100	0	0	0	0
	CIS-1,2-DICHLOROETHENE	R	0	0	80.0	0	0	20	0
	CIS-1,3-DICHLOROPROPENE	D	0	0	0	0	0	100	0
	CIS-1,3-DICHLOROPROPENE	R	0	0	0	0	0	100	0
	DIBROMOMETHANE	R	0	0	0	0	0	100	0
	DICHLORODIFLUOROMETHANE	C	0	0	0	0	0	100	0
	DICHLORODIFLUOROMETHANE	R	0	0	0	0	0	100	0
	ETHYL METHACRYLATE	C	0	0	0	0	0	100	0
	ETHYL METHACRYLATE	R	0	0	0	0	0	100	0
	ETHYLBENZENE	R	0	0	0	0	0	100	0
	ISOBUTANOL	C	0	0	0	0	0	0	100
	METHACRYLONITRILE	C	0	0	0	0	0	0	100
	METHYL IODIDE	C	0	0	0	0	0	100	0
	METHYL IODIDE	R	0	0	0	0	0	100	0
	METHYL METHACRYLATE	C	0	0	0	0	0	100	0
	METHYL METHACRYLATE	R	0	0	0	0	0	100	0
	METHYLENE CHLORIDE	A	0	76.5	0	0	23.5	0	0
	METHYLENE CHLORIDE	C	75	0	0	0	0	25	0
	METHYLENE CHLORIDE	P	0	0	100	0	0	0	0
	METHYLENE CHLORIDE	P,C	0	0	100	0	0	0	0
	METHYLENE CHLORIDE	P,R	0	0	100	0	0	0	0
	METHYLENE CHLORIDE	R	0	0	50.0	0	0	50	0
	PENTACHLOROETHANE	C	0	0	0	0	0	100	0
	PENTACHLOROETHANE	R	0	0	0	0	0	100	0
	PROPIONITRILE	C	0	0	0	0	0	0	100
	PROPIONITRILE	C,D	0	0	0	0	0	0	100

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 VOCs (continued)	STYRENE	D,R	0	0	0	0	0	100	0
	TETRACHLOROETHENE	P	0	0	100	0	0	0	0
	TETRACHLOROETHENE	R	0	0	80.0	0	0	20	0
	TOLUENE	P	0	0	100	0	0	0	0
	TOLUENE	P,R	0	0	100	0	0	0	0
	TOLUENE	R	0	0	0	0	0	100	0
	TOTAL XYLENES	C	0	0	0	0	0	100	0
	TOTAL XYLENES	D	0	0	0	0	0	100	0
	TOTAL XYLENES	D,R	0	0	0	0	0	100	0
	TRANS-1,2-DICHLOROETHENE	C	0	0	0	0	0	100	0
	TRANS-1,2-DICHLOROETHENE	P	0	0	100	0	0	0	0
	TRANS-1,2-DICHLOROETHENE	P,R	0	0	100	0	0	0	0
	TRANS-1,2-DICHLOROETHENE	R	0	0	75.0	0	0	25	0
	TRANS-1,3-DICHLOROPROPENE	C	0	0	0	0	0	100	0
	TRANS-1,3-DICHLOROPROPENE	C,D	0	0	0	0	0	100	0
	TRANS-1,3-DICHLOROPROPENE	R	0	0	0	0	0	100	0
	TRANS-1,4-DICHLORO-2-BUTENE	C	0	0	0	0	0	100	0
	TRANS-1,4-DICHLORO-2-BUTENE	R	0	0	0	0	0	100	0
	TRICHLOROETHENE	D	0	0	100	0	0	0	0
	TRICHLOROETHENE	D,R	0	0	100	0	0	0	0
	TRICHLOROETHENE	G	0	0	100	0	0	0	0
	TRICHLOROETHENE	P	0	0	100	0	0	0	0
	TRICHLOROETHENE	P,R	0	0	100	0	0	0	0
	TRICHLOROETHENE	R	0	0	100	0	0	0	0
	TRICHLOROFLUOROMETHANE	R	0	0	0	0	0	100	0
	VINYL ACETATE	C	0	0	0	0	0	100	0
	VINYL ACETATE	R	0	0	0	0	0	100	0
	VINYL CHLORIDE	R	0	0	0	0	0	100	0
Round 2 VOCs	1,1,2,2-TETRACHLOROETHANE	D	0	0	0	0	0	100	0
	1,1,2-TRICHLOROETHANE	P	0	0	100	0	0	0	0
	1,2-DIBROMO-3-CHLOROPROPANE	C	0	0	0	0	0	100	0
	1,4-DIOXANE	C	0	0	0	0	0	0	100

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 2 VOCs (continued)	1,4-DIOXANE	C,E	0	0	0	0	0	0	100
	2-BUTANONE	C	0	0	0	0	0	0	100
	4-METHYL-2-PENTANONE	C	0	0	0	0	0	100	0
	ACETONE	C	0	0	0	0	0	0	100
	ACETONITRILE	C	0	0	0	0	0	0	100
	ACROLEIN	C	0	0	0	0	0	0	100
	ACRYLONITRILE	C	0	0	0	0	0	0	100
	BROMOFORM	C	0	0	0	0	0	100	0
	BROMOMETHANE	C	0	0	0	0	0	100	0
	BROMOMETHANE	C,D	0	0	0	0	0	100	0
	CHLOROETHANE	C	0	0	0	0	0	100	0
	CHLOROFORM	P	0	0	100	0	0	0	0
	CHLOROMETHANE	C	0	0	0	0	0	100	0
	CIS-1,2-DICHLOROETHENE	P	0	0	100	0	0	0	0
	DICHLORODIFLUOROMETHANE	C	0	0	0	0	0	100	0
	ETHANE	C	0	0	0	0	0	100	0
	ETHENE	C	0	0	100	0	0	0	0
	ISOBUTANOL	C	0	0	0	0	0	0	100
	METHACRYLONITRILE	C	0	0	0	0	0	0	100
	METHANE	C	0	0	12.5	0	0	87.5	0
	METHANE	C,P	0	0	100	0	0	0	0
	METHYL METHACRYLATE	C	0	0	0	0	0	100	0
	METHYLENE CHLORIDE	C	0	0	7.407	0	0	92.59	0
	PENTACHLOROETHANE	C	0	0	0	0	0	100	0
	PROPIONITRILE	C	0	0	0	0	0	0	100
	TETRACHLOROETHENE	D	0	0	0	0	0	100	0
	TOLUENE	P	0	0	100	0	0	0	0
	TRANS-1,2-DICHLOROETHENE	P	0	0	100	0	0	0	0
	TRANS-1,4-DICHLORO-2-BUTENE	C	0	0	0	0	0	100	0
	TRICHLOROETHENE	D	0	0	0	0	0	100	0
	TRICHLOROFLUOROMETHANE	C	0	0	0	0	0	100	0
	VINYL ACETATE	C	0	0	0	0	0	100	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 Pesticides / PCBs	AROCLOR-1016	R	0	0	0	0	0	100	0
	AROCLOR-1221	R	0	0	0	0	0	100	0
	AROCLOR-1232	R	0	0	0	0	0	100	0
	AROCLOR-1242	R	0	0	0	0	0	100	0
	AROCLOR-1248	R	0	0	0	0	0	100	0
	AROCLOR-1254	R	0	0	0	0	0	100	0
	AROCLOR-1260	R	0	0	0	0	0	100	0
	4,4'-DDD	C	0	0	0	0	0	100	0
	4,4'-DDD	C,R	0	0	0	0	0	100	0
	4,4'-DDE	R	0	0	0	0	0	100	0
	4,4'-DDT	C	0	0	0	0	0	100	0
	4,4'-DDT	R	0	0	0	0	0	100	0
	ALDRIN	R	0	0	0	0	0	100	0
	ALPHA-BHC	C	0	0	0	0	0	100	0
	ALPHA-BHC	R	0	0	0	0	0	100	0
	ALPHA-CHLORDANE	R	0	0	0	0	0	100	0
	BETA-BHC	R	0	0	0	0	0	100	0
	DELTA-BHC	R	0	0	0	0	0	100	0
	DIELDRIN	P,U	0	0	100	0	0	0	0
	DIELDRIN	R	0	0	0	0	0	100	0
	ENDOSULFAN I	R	0	0	0	0	0	100	0
	ENDOSULFAN II	R	0	0	0	0	0	100	0
	ENDOSULFAN II	U	0	0	0	100	0	0	0
	ENDOSULFAN SULFATE	C	0	0	0	0	0	100	0
	ENDOSULFAN SULFATE	C,R	0	0	0	0	0	100	0
	ENDRIN	R	0	0	0	0	0	100	0
	ENDRIN ALDEHYDE	R	0	0	0	0	0	100	0
	GAMMA-BHC (LINDANE)	R	0	0	0	0	0	100	0
	GAMMA-CHLORDANE	P,U	0	0	100	0	0	0	0
	GAMMA-CHLORDANE	R	0	0	0	0	0	100	0
	GAMMA-CHLORDANE	U	0	0	100	0	0	0	0
	HEPTACHLOR	A	0	77	0	0	23.0	0	0

TABLE 3-11

AQUEOUS PERCENT QUALIFICATION RATES, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qaulification Code	Qualifier						
			BJ	BU	J	R	U	UJ	UR
Round 1 Pesticides / PCBs (continued)	HEPTACHLOR	P	0	0	100	0	0	0	0
	HEPTACHLOR	R	0	0	0	0	0	100	0
	HEPTACHLOR	R,U	0	0	0	100	0	0	0
	HEPTACHLOR	U	0	0	0	100	0	0	0
	HEPTACHLOR EPOXIDE	R	0	0	0	0	0	100	0
	METHOXYCHLOR	R	0	0	0	0	0	100	0
	TOXAPHENE	R	0	0	0	0	0	100	0
Round 1 Radiologicals	GROSS ALPHA	D	0	0	82	0	0	18	0
	GROSS BETA	A	0	0	0	0	100	0	0
	GROSS BETA	A,D	0	0	100	0	0	0	0
	GROSS BETA	A,D,G	0	0	100	0	0	0	0
	GROSS BETA	D	0	0	100	0	0	0	0
	GROSS BETA	D,A	0	0	100	0	0	0	0
	GROSS BETA	D,G	0	0	100	0	0	0	0
	THORIUM-230	A	0	0	0	0	100	0	0

Qualifier Code Definitions:

A = Lab Blank Contamination.
C = Calibration (i.e., % RSDs, %Ds, ICVs, CCVs, RPDs, RRFs, etc.) Noncompliance.
D = MS/MSD Noncompliance.
E = LCS/LCSD Noncompliance.
F = Lab Duplicate Imprecision.
G = Field Duplicate Imprecision.
I = ICP Serial Dilution Noncompliance.
K = ICP Interference - include ICSAB % R's.
L = Calibration Range Exceedence.
P = Uncertainty near detection limit (< 2 x IDL for inorganics and <CRQL for organics).
R = Surrogates Recovery Noncompliance.
U = Pest/PCD% between columns for positive results.

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
Explosives Round 1	HMX	P	0.0	100.0	0.0	0.0	0.0	0.0
	HMX	P,U	0.0	100.0	0.0	0.0	0.0	0.0
Herbicides Round 1	2,4,5-T	U	0.0	33.3	66.7	0.0	0.0	0.0
	2,4,5-TP (SILVEX)	C	0.0	0.0	0.0	0.0	100.0	0.0
	2,4,5-TP (SILVEX)	C,P,U	0.0	100.0	0.0	0.0	0.0	0.0
	2,4,5-TP (SILVEX)	C,U	0.0	100.0	0.0	0.0	0.0	0.0
	2,4,5-TP (SILVEX)	P	0.0	100.0	0.0	0.0	0.0	0.0
	2,4,5-TP (SILVEX)	U	0.0	100.0	0.0	0.0	0.0	0.0
	2,4-D	C	0.0	100.0	0.0	0.0	0.0	0.0
	2,4-D	D	0.0	0.0	0.0	0.0	100.0	0.0
	2,4-D	P	0.0	100.0	0.0	0.0	0.0	0.0
	2,4-D	U	0.0	33.3	66.7	0.0	0.0	0.0
	DINOSEB	C	0.0	0.0	0.0	0.0	100.0	0.0
	DINOSEB	C,U	0.0	0.0	100.0	0.0	0.0	0.0
	PENTACHLOROPHENOL	U	0.0	0.0	100.0	0.0	0.0	0.0
Metals Round 1	MERCURY	A	0.0	8.3	0.0	91.7	0.0	0.0
	MERCURY	D	0.0	72.2	0.0	0.0	27.8	0.0
	MERCURY	E	0.0	100.0	0.0	0.0	0.0	0.0
	ALUMINUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	ALUMINUM	A,D	0.0	100.0	0.0	0.0	0.0	0.0
	ALUMINUM	A,G	0.0	100.0	0.0	0.0	0.0	0.0
	ALUMINUM	F	0.0	100.0	0.0	0.0	0.0	0.0
	ANTIMONY	A	0.0	0.0	0.0	100.0	0.0	0.0
	ANTIMONY	A,D,K	0.0	100.0	0.0	0.0	0.0	0.0
	ANTIMONY	D	0.0	0.0	0.0	0.0	100.0	0.0
	ANTIMONY	D,K	0.0	100.0	0.0	0.0	0.0	0.0
	ARSENIC	A	0.0	60.0	0.0	40.0	0.0	0.0
	ARSENIC	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	ARSENIC	I	0.0	100.0	0.0	0.0	0.0	0.0
	ARSENIC	K	0.0	100.0	0.0	0.0	0.0	0.0
	BARIUM	F	0.0	100.0	0.0	0.0	0.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	BERYLLIUM	A	0.0	75.0	0.0	25.0	0.0	0.0
	BERYLLIUM	A,K	0.0	100.0	0.0	0.0	0.0	0.0
	BERYLLIUM	F	0.0	100.0	0.0	0.0	0.0	0.0
	CADMIUM	A	0.0	0.0	0.0	100.0	0.0	0.0
	CADMIUM	A,K	0.0	100.0	0.0	0.0	0.0	0.0
	CADMIUM	K	0.0	52.3	0.0	0.0	47.7	0.0
	CALCIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	CALCIUM	A,D	0.0	100.0	0.0	0.0	0.0	0.0
	CALCIUM	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	CALCIUM	F	0.0	100.0	0.0	0.0	0.0	0.0
	CHROMIUM	A,D	0.0	100.0	0.0	0.0	0.0	0.0
	CHROMIUM	G	0.0	100.0	0.0	0.0	0.0	0.0
	COBALT	A	0.0	85.7	0.0	14.3	0.0	0.0
	COBALT	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	COBALT	A,F,K	0.0	100.0	0.0	0.0	0.0	0.0
	COBALT	A,K	0.0	100.0	0.0	0.0	0.0	0.0
	COBALT	K	0.0	100.0	0.0	0.0	0.0	0.0
	COPPER	A	0.0	100.0	0.0	0.0	0.0	0.0
	COPPER	A,D	0.0	100.0	0.0	0.0	0.0	0.0
	COPPER	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	COPPER	A,G	0.0	100.0	0.0	0.0	0.0	0.0
	IRON	G	0.0	100.0	0.0	0.0	0.0	0.0
	LEAD	A	0.0	100.0	0.0	0.0	0.0	0.0
	LEAD	A,G	0.0	100.0	0.0	0.0	0.0	0.0
	LEAD	A,K	0.0	100.0	0.0	0.0	0.0	0.0
	MAGNESIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	MAGNESIUM	A,D	0.0	100.0	0.0	0.0	0.0	0.0
	MAGNESIUM	A,D,F	0.0	100.0	0.0	0.0	0.0	0.0
	MAGNESIUM	D,F	0.0	100.0	0.0	0.0	0.0	0.0
	MANGANESE	A,D,F	0.0	100.0	0.0	0.0	0.0	0.0
	MANGANESE	A,D,F,G	0.0	100.0	0.0	0.0	0.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	MANGANESE	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	MANGANESE	A,F,D	0.0	100.0	0.0	0.0	0.0	0.0
	MANGANESE	F	0.0	100.0	0.0	0.0	0.0	0.0
	NICKEL	A	0.0	100.0	0.0	0.0	0.0	0.0
	POTASSIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	POTASSIUM	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	POTASSIUM	A,F,I	0.0	100.0	0.0	0.0	0.0	0.0
	SELENIUM	A	0.0	0.0	0.0	100.0	0.0	0.0
	SELENIUM	K	0.0	92.9	0.0	0.0	7.1	0.0
	SILVER	A	0.0	0.0	0.0	100.0	0.0	0.0
	SODIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	SODIUM	A,E,I	0.0	100.0	0.0	0.0	0.0	0.0
	SODIUM	A,E,I,K	0.0	100.0	0.0	0.0	0.0	0.0
	SODIUM	A,I	0.0	100.0	0.0	0.0	0.0	0.0
	SODIUM	K	0.0	100.0	0.0	0.0	0.0	0.0
	STRONTIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	STRONTIUM	A,F	0.0	100.0	0.0	0.0	0.0	0.0
	STRONTIUM	A,G	0.0	100.0	0.0	0.0	0.0	0.0
	THALLIUM	K	0.0	100.0	0.0	0.0	0.0	0.0
	VANADIUM	A	0.0	100.0	0.0	0.0	0.0	0.0
	VANADIUM	A,G	0.0	100.0	0.0	0.0	0.0	0.0
	ZINC	A	0.0	100.0	0.0	0.0	0.0	0.0
	ZINC	D	0.0	100.0	0.0	0.0	0.0	0.0
Metals Round 2	ANTIMONY	D,K		100.0		0.0	0.0	0.0
	ARSENIC	G		100.0		0.0	0.0	0.0
	CALCIUM	D		100.0		0.0	0.0	0.0
	CHROMIUM	A,D		100.0		0.0	0.0	0.0
	COPPER	A		100.0		0.0	0.0	0.0
	IRON	G		100.0		0.0	0.0	0.0
	POTASSIUM	I		100.0		0.0	0.0	0.0
	THALLIUM	A		0.0		100.0	0.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	TIN	K		100.0		0.0	0.0	0.0
	VANADIUM	D		100.0		0.0	0.0	0.0
	ZINC	I		100.0		0.0	0.0	0.0
Miscellaneous Round 1	CATION EXCHANGE CAPACITY	D	0.0	100.0	0.0	0.0	0.0	0.0
	PH	H	0.0	100.0	0.0	0.0	0.0	0.0
SVOCs Round 1	1,4-PHENYLENEDIAMINE	C	0.0	0.0	0.0	0.0	100.0	0.0
	2,4-DINITROPHENOL	D	0.0	0.0	0.0	0.0	100.0	0.0
	2-ACETYLAMINOFLUORENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	3,3'-DICHLOROBENZIDINE	D	0.0	0.0	0.0	0.0	100.0	0.0
	3,3'-DICHLOROBENZIDINE	N	0.0	0.0	0.0	0.0	100.0	0.0
	3,3'-DIMETHYLBENZIDINE	N	0.0	0.0	0.0	0.0	100.0	0.0
	3-METHYLCHOLANTHRENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	4-NITROQUINOLINE-1-OXIDE	C	0.0	0.0	0.0	0.0	0.0	100.0
	7,12-DIMETHYLBENZ(A)ANTHRACENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	7,12-DIMETHYLBENZ(A)ANTHRACENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	A,A-DIMETHYLPHENETHYLAMINE	C	0.0	0.0	0.0	0.0	100.0	0.0
	BIS(2-ETHYLHEXYL)PHTHALATE	A	0.0	100.0	0.0	0.0	0.0	0.0
	BIS(2-ETHYLHEXYL)PHTHALATE	D	0.0	0.0	0.0	0.0	100.0	0.0
	BIS(2-ETHYLHEXYL)PHTHALATE	P	0.0	100.0	0.0	0.0	0.0	0.0
	BUTYL BENZYL PHTHALATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROBENZILATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	DI-N-BUTYL PHTHALATE	C	0.0	0.0	0.0	0.0	100.0	0.0
	DI-N-OCTYL PHTHALATE	D	0.0	0.0	0.0	0.0	100.0	0.0
	DI-N-OCTYL PHTHALATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	DIPHENYLAMINE	D	0.0	0.0	0.0	0.0	100.0	0.0
	HEXACHLOROCYCLOPENTADIENE	D	0.0	0.0	0.0	0.0	100.0	0.0
	HEXACHLOROPHENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	HEXACHLOROPHENE	C,N	0.0	0.0	0.0	0.0	100.0	0.0
	HEXACHLOROPROPENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	ISOSAFROLE	P	0.0	100.0	0.0	0.0	0.0	0.0
	KEPONE	N	0.0	0.0	0.0	0.0	100.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	METHAPYRILENE	C	0.0	0.0	0.0	0.0	0.0	100.0
	N-NITROSO-DI-N-PROPYLAMINE	C	0.0	0.0	0.0	0.0	100.0	0.0
	N-NITROSOPYRROLIDINE	C	0.0	0.0	0.0	0.0	100.0	0.0
	PHENACETIN	C	0.0	0.0	0.0	0.0	100.0	0.0
	PRONAMIDE	C	0.0	0.0	0.0	0.0	0.0	100.0
PAHs Round 1	ACENAPHTHENE	D,G,L	0.0	100.0	0.0	0.0	0.0	0.0
	ACENAPHTHENE	G,R	0.0	0.0	0.0	0.0	100.0	0.0
	ACENAPHTHENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	ACENAPHTHENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	ACENAPHTHYLENE	D	0.0	0.0	0.0	0.0	50.0	50.0
	ACENAPHTHYLENE	D,E	0.0	0.0	0.0	0.0	100.0	0.0
	ACENAPHTHYLENE	E	0.0	0.0	0.0	0.0	100.0	0.0
	ACENAPHTHYLENE	E,R	0.0	0.0	0.0	0.0	100.0	0.0
	ACENAPHTHYLENE	G,R	0.0	0.0	0.0	0.0	100.0	0.0
	ACENAPHTHYLENE	R	0.0	0.0	0.0	0.0	83.3	16.7
	ANTHRACENE	D,E	0.0	0.0	0.0	0.0	100.0	0.0
	ANTHRACENE	E	0.0	0.0	0.0	0.0	100.0	0.0
	ANTHRACENE	E,R	0.0	0.0	0.0	0.0	100.0	0.0
	ANTHRACENE	G,R	0.0	0.0	0.0	0.0	100.0	0.0
	ANTHRACENE	R	0.0	0.0	0.0	0.0	83.3	16.7
	BENZO(A)ANTHRACENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)ANTHRACENE	P,R	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)ANTHRACENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	BENZO(A)PYRENE	G	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)PYRENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)PYRENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)PYRENE	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(A)PYRENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	BENZO(B)FLUORANTHENE	D,G,L,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(B)FLUORANTHENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(B)FLUORANTHENE	L,U	0.0	100.0	0.0	0.0	0.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	BENZO(B)FLUORANTHENE	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(B)FLUORANTHENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	BENZO(B)FLUORANTHENE	U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(G,H,I)PERYLENE	G	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(G,H,I)PERYLENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(G,H,I)PERYLENE	L,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(G,H,I)PERYLENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(G,H,I)PERYLENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	BENZO(G,H,I)PERYLENE	U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(K)FLUORANTHENE	D,G	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(K)FLUORANTHENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(K)FLUORANTHENE	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	BENZO(K)FLUORANTHENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	BENZO(K)FLUORANTHENE	U	0.0	100.0	0.0	0.0	0.0	0.0
	CHRYSENE	D	0.0	0.0	0.0	0.0	100.0	0.0
	CHRYSENE	D,G	0.0	100.0	0.0	0.0	0.0	0.0
	CHRYSENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	CHRYSENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	CHRYSENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	DIBENZO(A,H)ANTHRACENE	D	0.0	0.0	0.0	0.0	100.0	0.0
	DIBENZO(A,H)ANTHRACENE	D,E	0.0	0.0	0.0	0.0	100.0	0.0
	DIBENZO(A,H)ANTHRACENE	E	0.0	0.0	0.0	0.0	100.0	0.0
	DIBENZO(A,H)ANTHRACENE	E,R	0.0	0.0	0.0	0.0	100.0	0.0
	DIBENZO(A,H)ANTHRACENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	DIBENZO(A,H)ANTHRACENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	FLUORANTHENE	G	0.0	100.0	0.0	0.0	0.0	0.0
	FLUORANTHENE	G,P,R	0.0	100.0	0.0	0.0	0.0	0.0
	FLUORANTHENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	FLUORANTHENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	FLUORANTHENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	FLUORENE	R	0.0	0.0	0.0	0.0	87.5	12.5

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	INDENO(1,2,3-CD)PYRENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	INDENO(1,2,3-CD)PYRENE	P,R	0.0	100.0	0.0	0.0	0.0	0.0
	INDENO(1,2,3-CD)PYRENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	NAPHTHALENE	D	0.0	0.0	0.0	0.0	50.0	50.0
	NAPHTHALENE	D,E	0.0	0.0	0.0	0.0	0.0	100.0
	NAPHTHALENE	E	0.0	0.0	0.0	0.0	0.0	100.0
	NAPHTHALENE	E,R	0.0	0.0	0.0	0.0	0.0	100.0
	NAPHTHALENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	NAPHTHALENE	R	0.0	0.0	0.0	0.0	85.7	14.3
	PHENANTHRENE	E	0.0	0.0	0.0	0.0	0.0	100.0
	PHENANTHRENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	PHENANTHRENE	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	PHENANTHRENE	R	0.0	0.0	0.0	0.0	87.5	12.5
	PYRENE	D,U	0.0	100.0	0.0	0.0	0.0	0.0
	PYRENE	G	0.0	100.0	0.0	0.0	0.0	0.0
	PYRENE	G,R,U	0.0	100.0	0.0	0.0	0.0	0.0
	PYRENE	L	0.0	100.0	0.0	0.0	0.0	0.0
	PYRENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	PYRENE	R	0.0	0.0	0.0	0.0	85.7	14.3
VOCs Round 1	1,1,2,2-TETRACHLOROETHANE	C	0.0	6.3	0.0	0.0	93.7	0.0
	1,1,2,2-TETRACHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1,2,2-TETRACHLOROETHANE	P	0.0	100.0	0.0	0.0	0.0	0.0
	1,1,2-TRICHLOROETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	1,1-DICHLOROETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	1,2,3-TRICHLOROPROPANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	1,2,3-TRICHLOROPROPANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DIBROMO-3-CHLOROPROPANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DIBROMO-3-CHLOROPROPANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DIBROMOETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	1,4-DIOXANE	C	0.0	0.0	0.0	0.0	0.0	100.0
	2-BUTANONE	C	0.0	2.3	0.0	0.0	97.7	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	2-HEXANONE	C	0.0	0.0	0.0	0.0	100.0	0.0
	2-HEXANONE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	3-CHLOROPROPENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	4-METHYL-2-PENTANONE	C	0.0	0.0	0.0	0.0	100.0	0.0
	4-METHYL-2-PENTANONE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	ACETONE	A,C	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONE	C	0.0	0.0	0.0	0.0	100.0	0.0
	ACETONE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	ACETONE	D	0.0	0.0	0.0	0.0	100.0	0.0
	ACETONITRILE	C	0.0	0.0	0.0	0.0	98.6	1.4
	ACETONITRILE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	ACROLEIN	C	0.0	0.0	0.0	0.0	0.0	100.0
	ACRYLONITRILE	C	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOFORM	C	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOMETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	CARBON TETRACHLORIDE	C	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROFORM	P	0.0	100.0	0.0	0.0	0.0	0.0
	CHLOROMETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROPRENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	DIBROMOMETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	DICHLORODIFLUOROMETHANE	C	0.0	30.0	0.0	0.0	70.0	0.0
	ETHYL METHACRYLATE	C	0.0	0.0	0.0	0.0	100.0	0.0
	ISOBUTANOL	C	0.0	0.0	0.0	0.0	0.0	100.0
	METHACRYLONITRILE	C	0.0	0.0	0.0	0.0	100.0	0.0
	METHYL IODIDE	C	0.0	0.0	0.0	0.0	100.0	0.0
	METHYL METHACRYLATE	C	0.0	0.0	0.0	0.0	100.0	0.0
	METHYLENE CHLORIDE	A	16.7	0.0	0.0	83.3	0.0	0.0
	METHYLENE CHLORIDE	A,C	0.0	100.0	0.0	0.0	0.0	0.0
	METHYLENE CHLORIDE	A,C,P	0.0	100.0	0.0	0.0	0.0	0.0
	METHYLENE CHLORIDE	C	0.0	25.0	0.0	0.0	75.0	0.0
	METHYLENE CHLORIDE	C,P	0.0	100.0	0.0	0.0	0.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	METHYLENE CHLORIDE	P	0.0	100.0	0.0	0.0	0.0	0.0
	PENTACHLOROETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	PENTACHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	PROPIONITRILE	C	0.0	0.0	0.0	0.0	0.0	100.0
	TETRACHLOROETHENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	TOLUENE	A	0.0	0.0	0.0	100.0	0.0	0.0
	TOLUENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	TOLUENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	TRANS-1,4-DICHLORO-2-BUTENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	TRICHLOROFLUOROMETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
VOCs Round 2	1,1,1,2-TETRACHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1,1-TRICHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1,2,2-TETRACHLOROETHANE	D	0.0	0.0	0.0	0.0	100.0	0.0
	1,1,2,2-TETRACHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1,2-TRICHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1-DICHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,1-DICHLOROETHENE	D	0.0	0.0	0.0	0.0	100.0	0.0
	1,1-DICHLOROETHENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2,3-TRICHLOROPROPANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DIBROMO-3-CHLOROPROPANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DIBROMOETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DICHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,2-DICHLOROPROPANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	1,4-DIOXANE	C	0.0	0.0	0.0	0.0	0.0	100.0
	2-BUTANONE	N	0.0	0.0	0.0	0.0	100.0	0.0
	2-HEXANONE	C	0.0	0.0	0.0	0.0	100.0	0.0
	2-HEXANONE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	2-HEXANONE	C,N	0.0	0.0	0.0	0.0	100.0	0.0
	2-HEXANONE	C,P	0.0	100.0	0.0	0.0	0.0	0.0
	3-CHLOROPROPENE	C	0.0	0.0	0.0	0.0	100.0	0.0
	3-CHLOROPROPENE	N	0.0	0.0	0.0	0.0	100.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	4-METHYL-2-PENTANONE	N	0.0	0.0	0.0	0.0	100.0	0.0
	ACETONE	C	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONE	C,D,L	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONE	C,L	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONE	C,L,N	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONE	C,N	0.0	100.0	0.0	0.0	0.0	0.0
	ACETONITRILE	C	0.0	0.0	0.0	0.0	0.0	100.0
	ACROLEIN	C	0.0	0.0	0.0	0.0	0.0	100.0
	ACRYLONITRILE	C	0.0	0.0	0.0	0.0	0.0	100.0
	ACRYLONITRILE	N	0.0	0.0	0.0	0.0	100.0	0.0
	BENZENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	BROMODICHLOROMETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOFORM	N	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOMETHANE	C	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOMETHANE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	BROMOMETHANE	C,N	0.0	0.0	0.0	0.0	100.0	0.0
	CARBON DISULFIDE	D,P	0.0	100.0	0.0	0.0	0.0	0.0
	CARBON DISULFIDE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CARBON DISULFIDE	N,P	0.0	100.0	0.0	0.0	0.0	0.0
	CARBON DISULFIDE	P	0.0	100.0	0.0	0.0	0.0	0.0
	CARBON TETRACHLORIDE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROBENZENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLORODIBROMOMETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROFORM	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROMETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CHLOROPRENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CIS-1,2-DICHLOROETHENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	CIS-1,3-DICHLOROPROPENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	DIBROMOMETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	DICHLORODIFLUOROMETHANE	N	0.0	33.3	0.0	0.0	66.7	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	ETHYL METHACRYLATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	ETHYLBENZENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	ISOBUTANOL	C	0.0	0.0	0.0	0.0	0.0	100.0
	METHACRYLONITRILE	N	0.0	0.0	0.0	0.0	100.0	0.0
	METHYL IODIDE	C	0.0	0.0	0.0	0.0	100.0	0.0
	METHYL IODIDE	C,N	0.0	0.0	0.0	0.0	100.0	0.0
	METHYL METHACRYLATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	METHYLENE CHLORIDE	C	0.0	0.0	0.0	0.0	100.0	0.0
	METHYLENE CHLORIDE	C,D	0.0	0.0	0.0	0.0	100.0	0.0
	METHYLENE CHLORIDE	C,N	0.0	0.0	0.0	0.0	100.0	0.0
	PENTACHLOROETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	PROPIONITRILE	C	0.0	0.0	0.0	0.0	0.0	100.0
	STYRENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TETRACHLOROETHENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TOLUENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TOLUENE	N,P	0.0	100.0	0.0	0.0	0.0	0.0
	TOLUENE	P	0.0	100.0	0.0	0.0	0.0	0.0
	TOTAL XYLENES	N	0.0	0.0	0.0	0.0	100.0	0.0
	TRANS-1,2-DICHLOROETHENE	D	0.0	0.0	0.0	0.0	100.0	0.0
	TRANS-1,2-DICHLOROETHENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TRANS-1,3-DICHLOROPROPENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TRANS-1,4-DICHLORO-2-BUTENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TRICHLOROETHENE	N	0.0	0.0	0.0	0.0	100.0	0.0
	TRICHLOROFLUOROMETHANE	N	0.0	0.0	0.0	0.0	100.0	0.0
	VINYL ACETATE	N	0.0	0.0	0.0	0.0	100.0	0.0
	VINYL CHLORIDE	N	0.0	0.0	0.0	0.0	100.0	0.0
Pesticides / PCBs	AROCLOR-1260	P	0.0	100.0	0.0	0.0	0.0	0.0
	4,4'-DDD	G	0.0	0.0	0.0	0.0	100.0	0.0
	4,4'-DDD	G,P,U	0.0	100.0	0.0	0.0	0.0	0.0
	4,4'-DDE	D	0.0	0.0	0.0	0.0	100.0	0.0
	4,4'-DDT	C	0.0	0.0	0.0	0.0	100.0	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR
	DELTA-BHC	D	0.0	0.0	0.0	0.0	100.0	0.0
	ENDOSULFAN II	C	0.0	0.0	0.0	0.0	100.0	0.0
	ENDRIN	D	0.0	0.0	0.0	0.0	100.0	0.0
	ENDRIN ALDEHYDE	C	0.0	0.0	0.0	0.0	100.0	0.0
	ENDRIN ALDEHYDE	D	0.0	0.0	0.0	0.0	0.0	100.0
	GAMMA-CHLORDANE	P	0.0	100.0	0.0	0.0	0.0	0.0
	GAMMA-CHLORDANE	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	GAMMA-CHLORDANE	U	0.0	33.3	66.7	0.0	0.0	0.0
	HEPTACHLOR	A	1.0	0.0	0.0	0.0	0.0	0.0
	HEPTACHLOR	P	0.0	100.0	0.0	0.0	0.0	0.0
	HEPTACHLOR	P,U	0.0	100.0	0.0	0.0	0.0	0.0
	HEPTACHLOR	U	0.0	75.0	25.0	0.0	0.0	0.0
Radiological	ACTINIUM-228	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	BISMUTH-212	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	BISMUTH-214	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	CESIUM-137	H	0.0	0.0	0.0	0.0	100.0	0.0
	COBALT-60	H	0.0	0.0	0.0	0.0	100.0	0.0
	EUROPIUM-154	H	0.0	0.0	0.0	0.0	100.0	0.0
	EUROPIUM-155	H	0.0	81.8	0.0	0.0	18.2	0.0
	LEAD-210	H	0.0	100.0	0.0	0.0	0.0	0.0
	LEAD-212	H	0.0	100.0	0.0	0.0	0.0	0.0
	LEAD-214	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	POTASSIUM-40	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	PROTACTINIUM-234	H	0.0	9.1	0.0	0.0	90.9	0.0
	RADIUM-226	H	0.0	100.0	0.0	0.0	0.0	0.0
	THALLIUM-208	G,H	0.0	100.0	0.0	0.0	0.0	0.0
	THORIUM-230	A	0.0	26.7	0.0	73.3	0.0	0.0
	THORIUM-230	A,E	0.0	100.0	0.0	0.0	0.0	0.0
	THORIUM-230	E	0.0	100.0	0.0	0.0	0.0	0.0
	THORIUM-234	H	0.0	100.0	0.0	0.0	0.0	0.0
	URANIUM-235	H	0.0	9.1	0.0	0.0	90.9	0.0

TABLE 3-12

SOIL AND SEDIMENT PERCENT QUALIFICATION RATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Fraction	Parameter	Qualification Code	Qualifier					
			BU	J	R	U	UJ	UR

Qualifier Code Definitions:

A = Lab Blank Contamination.
C = Calibration (i.e., % RSDs, %Ds, ICVs, CCVs, RPDs, RRFs, etc.) Noncompliance.
D = MS/MSD Noncompliance.
E = LCS/LCSD Noncompliance.
F = Lab Duplicate Imprecision.
G = Field Duplicate Imprecision.
H = Holding Time Exceedance.
I = ICP Serial Dilution Noncompliance.
K = ICP Interference - include ICSAB % R's.
L = Calibration Range Exceedence.
N = Internal Standard Noncompliance.
P = Uncertainty near detection limit (< 2 x IDL for inorganics and <CRQL for organics).
R = Surrogates Recovery Noncompliance.
U = %D between columns for positive results.

TABLE 3-13

STATISTICAL SUMMARY OF ANALYTICAL RESULTS
OF BACKGROUND RADIONUCLIDE SAMPLE DATA SET
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Metal (pCi/g)	Frequency of Detection	Minimum Detection	Maximum Detection	Average of All Results[1]	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level[2]	Frequency of Exceedance[3]
ACTINIUM-228	10/10	0.77	2.11	1.43	1.43	BG1SBP0305	Normal	2.45	NA	NA
BISMUTH-212	10/10	1.18	2.36	1.72	1.72	BG1SBP0305	Lognormal	3.10	NA	NA
BISMUTH-214	10/10	0.7	1.54	1.19	1.19	BG1SBP0305	Normal	1.79	NA	NA
CESIUM-137	0/10	NA	NA	0.026	NA	NA	NA	NA	0.0438	NA
COBALT-60	0/10	NA	NA	0.021	NA	NA	NA	NA	NA	NA
EUROPIUM-154	0/10	NA	NA	0.028	NA	NA	NA	NA	NA	NA
EUROPIUM-155	8/10	0.07	0.37	0.13	0.15	BG1SBP1004	Lognormal	0.80	0.90	0/10
LEAD-210	10/10	0.53	1.37	0.86	0.86	BG1SBP0305	Lognormal	2.77	0.0409	10/10
LEAD-212	10/10	0.86	2.15	1.41	1.41	BG1SBP0305	Lognormal	2.77	NA	NA
LEAD-214	10/10	0.7	1.49	1.16	1.16	BG1SBP0305	Normal	1.76	NA	NA
POTASSIUM-40	10/10	11.7	27.4	17.7	17.7	BG1SBP0305	Lognormal	36.7	0.137	10/10
PROTACTINIUM-234	1/10	6.98	6.98	3.46	6.98	BG1SBP1004	Normal	7.82	NA	NA
RADIUM-226	10/10	1.36	3.68	2.18	2.18	BG1SBP0305	Lognormal	4.81	0.0131	10/10
THALLIUM-208	10/10	0.78	1.81	1.20	1.20	BG1SBP0305	Lognormal	2.30	NA	NA
THORIUM-228	3/3	0.387	0.45	0.42	0.42	01SB210610	Normal	0.67	0.0144	3/3
THORIUM-230	3/3	0.0764	0.289	0.21	0.21	01SB210206	Normal	1.08	3.93	0/3
THORIUM-232	3/3	0.359	0.455	0.40	0.40	01SB210610	Lognormal	1.00	3.44	0/3
THORIUM-234	10/10	0.83	2.1	1.51	1.51	BG1SBP0204	Normal	2.70	NA	NA
URANIUM-235	1/10	0.2	0.2	0.16	0.20	BG1SBP1004	Normal	0.27	0.206	0/10

Notes:
NA - Not applicable.

1 This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.
2 Value is based on the most conservative of the human health and ecological risk-based SSLs.
3 Exceedances are defined as detected values above the SRBTL.

TABLE 3-14

THALLIUM REANALYSIS RESULTS, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Sample Number	Original Concentration	Re-analysis Concentration	Units	Ratio (New/Old)	Comments
Ground Water					
01GW0701	4.6	0.60 UJ	µg/L	NA	
01GW2001	5.1	3.0 UJ	µg/L	NA	Reanalysis result based on 5X diluted sample
01GW2001-F	7.7 J	3.0 UJ	µg/L	NA	Reanalysis result based on 5X diluted sample
01GW2401	4.4	0.60 UJ	µg/L	NA	
Surface Soil					
01SS030002[1]	2.8	0.13 J	mg/kg	0.046	
01SS190002[1]	2.7 J	0.07 J	mg/kg	0.026	
Subsurface Soil					
01SB020610[1]	2.7	0.07 J	mg/kg	0.026	
01SB080610[1]	5.3 J	0.16 J	mg/kg	0.030	
01SB140610[1]	1.1	0.06 UJ	mg/kg	NA	
Sediment					
01SD01	4.3	0.10 J	mg/kg	0.023	
01SD02	7.1	0.10 J	mg/kg	0.023	

1 180-day holding time was exceeded by 12 to 24 days for the soil and sediment sample re-analyses, resulting in J qualifier.

NA = ratio is not applicable because one of the results is non-detected.

FIGURE 3-1

HISTOGRAM OF SOIL AND SEDIMENT THORIUM-228/THORIUM-232 RATIOS, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

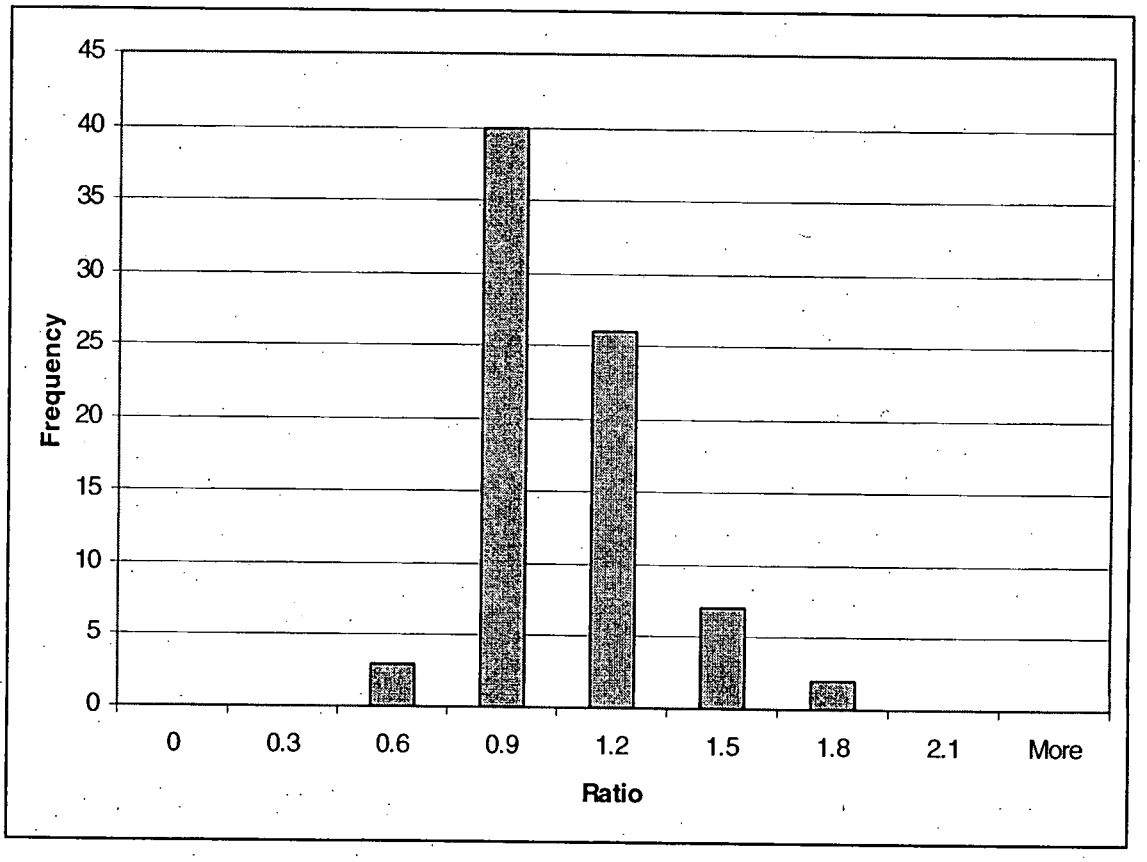
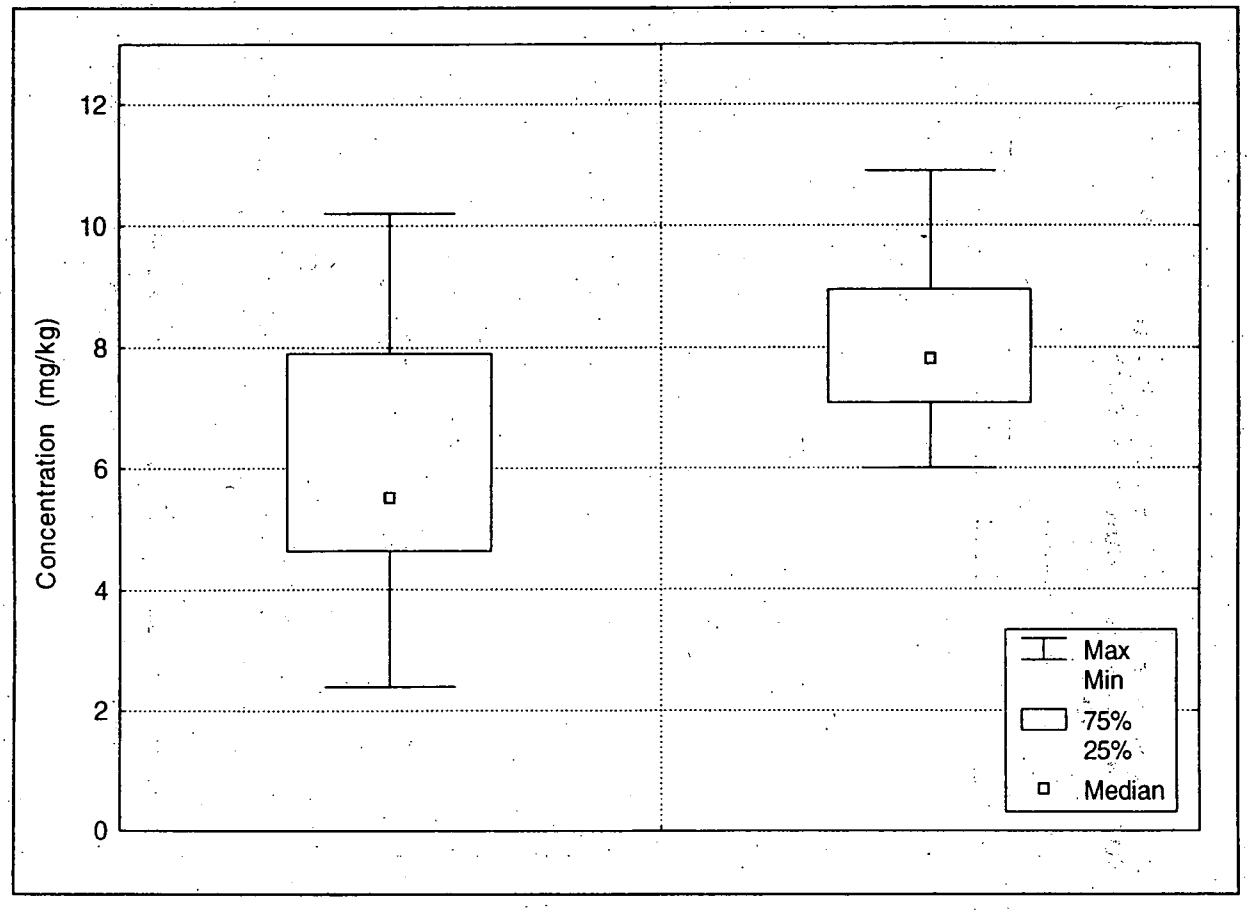


FIGURE 3-2

EVALUATION OF SURFACE SOIL ARSENIC CONCENTRATIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

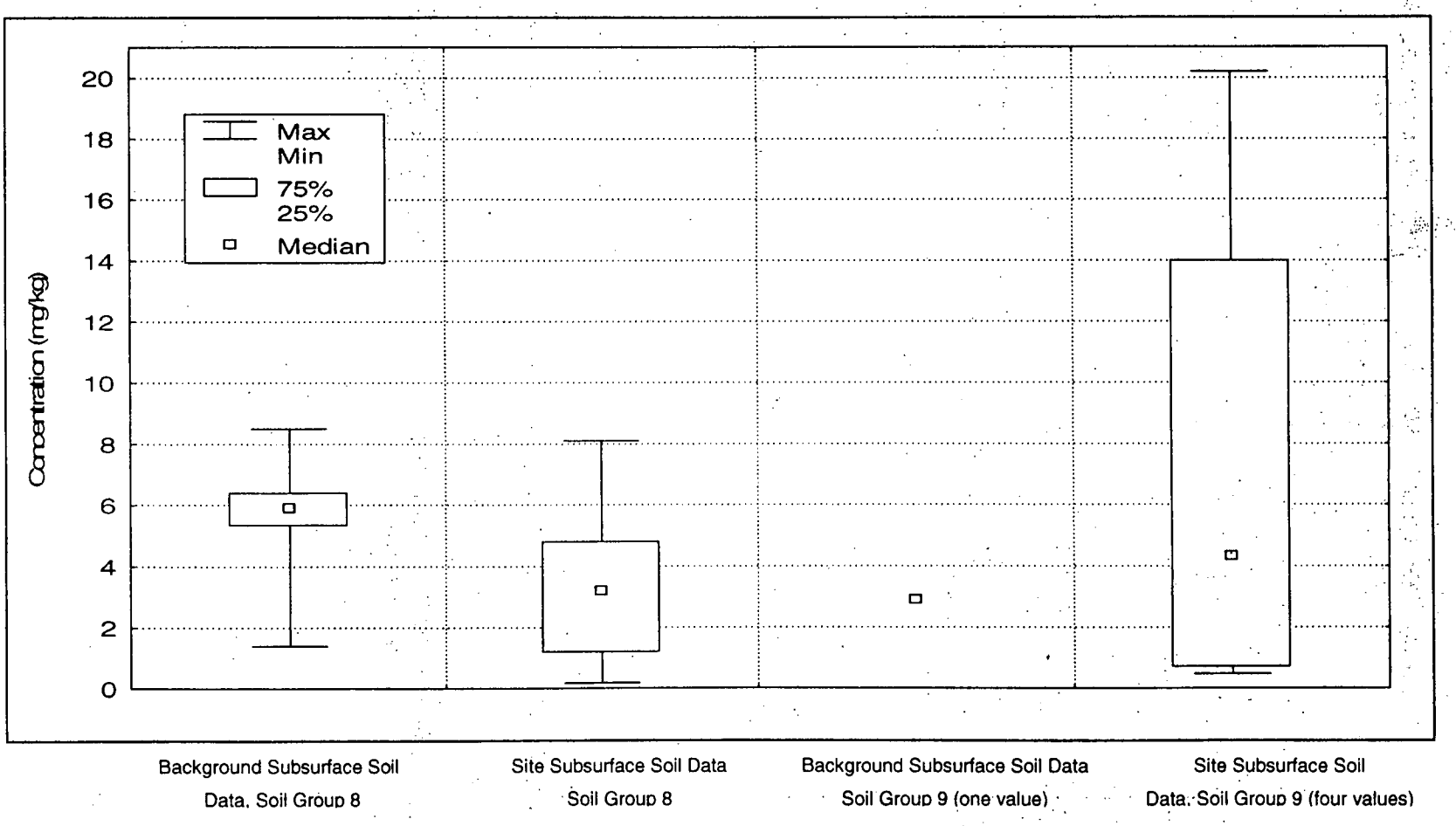


Background Surface Soil Data
Soil Group 3

Site Surface Soil Data
Soil Group 3

FIGURE 3-3

EVALUATION OF SUBSURFACE SOIL ARSENIC CONCENTRATIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA



4.0 SELECTION OF CHEMICALS OF POTENTIAL CONCERN

4.1 SUMMARY OF DETECTED CHEMICALS

Summaries of chemicals detected in surface soil, subsurface soil, ground water, surface water, and sediment during the Phase III RFI are presented in Tables 4-1 through 4-5, respectively. Each numerical concentration was combined with its alphabetic data validation flag, if any, into a single entry to concisely show the reported concentration and its status after data validation.

Each table presents the concentrations across all samples for any chemical that exceeded its sample-specific detection limit in at least one sample. This means that at least one of the samples in a given table shows the concentration of a particular analyte greater than the detection limit.

Table entries containing a validation flag of "R" or "UR" represent chemicals that may or may not actually be present in the sample; analytical problems were severe enough to cause those values to be rejected for quantitative use. Data qualified in this manner are not used in the quantitative risk assessment. Section 3.0 of this report addresses data validation and general data quality in more detail.

The tables show that, although the number of target analytes that were detected in at least one sample is relatively large, few analytes were detected consistently (i.e., across many samples) in a given medium. The following section describes how the analytical results and their frequencies of detection were evaluated to select those chemicals that were evaluated to represent the extent of site contamination and to perform the quantitative risk assessments.

4.2 SELECTION OF HUMAN HEALTH RISK CHEMICALS OF POTENTIAL CONCERN

The selection of COPCs is a qualitative screening process used to limit the number of chemicals and exposure routes quantitatively evaluated in the HHRA to those site-related constituents that dominate overall potential risks. Screening of site data against risk-based concentrations and background levels is used to focus the risk assessment on significant chemicals and exposure routes.

In general, a chemical was selected as a COPC and retained for further quantitative risk evaluation in the HHRA if the maximum detected concentration in a sampled medium exceeded a conservative screening concentration(s) and the chemical was determined to be present at concentrations exceeding background levels, if appropriate (i.e., inorganics and radionuclides). Chemicals eliminated from further evaluation through this process were assumed to present minimal risks to potential human receptors.

4.2.1 Derivation of Screening Criteria

Several types of screening levels were used to identify COPCs for the MGBG. Screening concentrations based on U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) (U.S. EPA, 2000d), Indiana Department of Environmental Management (IDEM) and U.S. EPA criteria were used. The risk-based screening concentrations corresponded to a systemic hazard quotient (HQ) of 0.1 (for non-carcinogens) or an ILCR of 1×10^{-6} (for carcinogens). Region 9 PRGs are based on an HQ of 1.0, and the other screening concentrations are based on an HQ of 0.1. PRGs used as screening levels for non-carcinogenic chemicals were conservatively divided by a factor of 10 to account for the potential cumulative effects of several (10) chemicals affecting the same target organ or producing the same adverse non-carcinogenic health effect. The screening levels used for each medium in the risk assessment are briefly discussed below.

Soil

The following criteria were used to select COPCs for chemical constituents in surface and subsurface soil:

- U.S. EPA Region 9 PRGs for Residential Soil (U.S. EPA, 2000d)
- U.S. EPA generic soil screening levels (SSLs) for migration to ground water (U.S. EPA, 1996)
- U.S. EPA generic SSLs for transfers from soil to air (U.S. EPA, 1996)
- IDEM residential default closure levels for direct contact (IDEM, 2001)
- IDEM residential default closure levels for migration to ground water (IDEM, 2001)

The following criteria were used for COPC screening of radionuclides in soil:

- Risk-based screening levels for ingestion of soil (U.S. EPA, 2000c)
- Risk-based screening levels for ingestion of produce (U.S. EPA, 2000c)
- Risk-based screening levels for external exposure (U.S. EPA, 2000c)
- SSLs for migration from soil to groundwater (U.S. EPA, 2000c)
- SSLs for inhalation of fugitive dusts (U.S. EPA, 2000c)

If criteria for radionuclides were not available, they were developed using U.S. EPA guidance and calculation tools provided on two Internet sites: Superfund Risk Assessment Soil Screening Calculations (http://risk.lsd.ornl.gov/calc_start.htm) and the Risk Assessment Information System (RAIS) (http://risk.lsd.ornl.gov/prg/prg_document.shtml).

The lowest of the three risk-based screening levels for direct contact was used for the COPC screening of surface and subsurface soil. Calculations of the screening levels and SSLs for radionuclides are presented in Appendix G.1

If the maximum concentration of a constituent exceeded any of these criteria (and for inorganics, if the constituent was considered to be present at concentrations greater than background levels), the chemical was selected as a COPC for soil and carried through to the quantitative risk assessment (See Table 4-6).

Because of the different exposure scenarios for potential human receptors, COPCs were identified separately for surface and subsurface soil. Surface soil is defined as soil collected from 0 to 2 feet bgs, and subsurface soil is defined as soil collected from depths greater than 2 feet bgs.

Site soil data were compared to U.S. EPA generic SSLs for transfers from soil to air to identify whether a quantitative analysis of the inhalation exposure pathway was warranted. If the maximum soil concentration of a chemical exceeded the SSL, a quantitative evaluation of potential risks from inhalation was performed. Otherwise, the risks associated with the inhalation pathway was considered insignificant, and the exposure pathway is eliminated from further evaluation.

Sediment

No specific screening levels exist for human exposure to sediment. COPCs for sediment were selected by comparing detected site concentrations to the following:

- U.S. EPA Region 9 PRGs for residential soil (U.S. EPA, 2000d)
- IDEM residential default closure levels for direct contact (IDEM, 2001)

COPC screening of radionuclides in sediment was performed using the two direct contact criteria for soil listed above. The lowest of the two risk-based screening levels for direct contact are presented in the COPC screening table for sediment.

A chemical detected in sediment was selected as a COPC for sediment if the maximum detected concentration exceeded the screening levels and the upstream/background concentrations. The background comparison, presented in Section 3.4.2, was limited to naturally occurring inorganics and radionuclides only. U.S. EPA generic SSLs for transfers from soil to air and for migration to ground water

were not considered to be appropriate for sediment screening because of high moisture content associated with sediment matrices.

The risk-based screening levels and health-based standards used in the COPC selection for soil and sediment are presented in Table 4-6.

Ground Water

The screening levels used to select COPCs for ground water included:

- U.S. EPA Region 9 PRGs for tap water (U.S. EPA, 2000d)
- IDEM residential default closure levels for ground water (IDEM, 2001)
- U.S. EPA Maximum Contaminant Levels (MCLs) (U.S. EPA, 2002)

Risk-based screening levels and MCLs are not available for the two radionuclides detected in ground water, thorium-228 and thorium-232. Therefore, risk-based concentrations were developed for these constituents using U.S. EPA guidance and calculation tools provided on the Internet at: Risk Assessment Information System (RAIS) (http://risk.lsd.ornl.gov/prg).

If the maximum concentration of a constituent exceeded any of these criteria (and, for inorganics, if the constituent was considered to be present at concentrations greater than background levels), the chemical was selected as a COPC and carried through to the quantitative risk assessment.

Risk-based COPC screening levels for tap water ingestion, which are based on daily, residential exposure assumptions, were used to select COPCs for ground water and surface water. In general, the use of tap water screening levels is regarded as a highly conservative approach to COPC selection at the MGBG because ground water at the site is not used as a potable drinking water source. Currently, there is no direct exposure to ground water at the MGBG.

The risk-based screening levels and health-based standards used in the COPC selection for ground water are presented in Table 4-7.

Surface Water

No chemical constituents were detected in the two site surface water samples analyzed; therefore, COPC selection was not performed for surface water.

Lead as a COPC

Limited criteria are available to evaluate the potential risks associated with lead. There are no risk-based concentrations for this chemical because U.S. EPA has not derived toxicity values for lead. However, recommended screening levels are available for lead in soil that are used to indicate the need for response activities. Guidance from both the Office of Prevention, Pesticides, and Toxic Substances (OPPTS) and the Office of Solid Waste and Emergency Response (OSWER) recommends 400 mg/kg as the lowest screening level for lead-contaminated soil in a residential setting where children are frequently present (U.S. EPA, 1994c). OPPTS identifies 2,000 to 5,000 mg/kg as an appropriate range for areas where contact with soil by children in a residential setting is less frequent. A value of 400 mg/kg was used as a screening level for soil and sediment.

Guidance from the U.S. EPA Technical Review Workgroup for Lead indicated that "a reasonable screening level for soil lead at commercial/industrial (i.e., non-residential) sites is 750 mg/kg" for a typical non-contact intensive worker (U.S. EPA, 1999a). This value was not used as a screening level but was used to provide a qualitative evaluation of lead.

The Safe Drinking Water Act action level of 15 µg/L was used as the screening level for lead in ground water.

Essential Nutrients and Chemicals without Toxicity Criteria

The essential nutrients calcium, magnesium, potassium, and sodium were not included in the COPC screening process for the MGBG. These inorganic chemicals are naturally abundant in environmental matrices and are only toxic at high doses. In addition, because of the lack of toxicity criteria, risk-based COPC screening levels are not available for some compounds [e.g., acenaphthylene, benzo(g,h,i)perylene, 2-methylnaphthalene, and phenanthrene]. Surrogates were selected for these chemicals based on similar chemical structures. Acenaphthene was used as a surrogate for acenaphthylene, and pyrene was selected as a surrogate for benzo(g,h,i)perylene and phenanthrene.

Sodium was detected in ground water at a maximum concentration of 117 mg/L and an average concentration of 41.6 mg/L. Assuming that adults ingest 2 liters of water per day and children ingest 1.5 liters per day, this corresponds to a maximum daily intake of 234 mg/day for adults and 175.5 mg/day for children. These intake rates are below the recommended daily allowances (RDAs) for sodium-sensitive adults (500 mg/day) and for children (225-300 mg/day). Therefore, the concentrations of

sodium in ground water at MGBG would not be expected to cause adverse health effects. The EPA (USEPA, April 2002) recommends that "the sodium concentration in drinking water not exceed a range of 30 to 60 mg/L because of possible adverse effects on taste at higher concentrations". The EPA requires Public Water Systems that exceed 20 mg/L to notify local and State public health officials. The EPA guidance was developed for those individuals restricted to a total sodium intake of 500 mg/day and should not be extrapolated to the entire population (USEPA, April 2002). Based on EPA recommendations, the concentrations of sodium detected in ground water at the MGBG could potentially affect sensitive individuals. However, the concentrations are more likely to affect taste and render the ground water undrinkable. Therefore, based on taste considerations, it is unlikely that ground water at the site would be used as a source of potable water, thereby minimizing potential health effects.

The maximum detected concentration of calcium in ground water at the MGBG was 344 mg/L, which corresponds to a maximum daily intake of 688 mg/day (assuming that a person drinks two liters of water per day). This intake rate is below the RDA for calcium (1,000 mg/day); therefore, the concentrations of calcium in ground water at MGBG would not be expected to cause adverse health effects.

The maximum detected concentration of potassium in ground water at the MGBG was 15.5 mg/L, which corresponds to a maximum daily intake of 31 mg/day (assuming that a person drinks two liters of water per day). This intake rate is well below the RDA for potassium (2,000 mg/day); therefore, the concentrations of potassium in ground water at MGBG would not be expected to cause adverse health effects.

The maximum detected concentration of magnesium in ground water at the MGBG was 250 mg/L, and the average concentration was 71.5 mg/L. These correspond to a maximum daily intake of 500 mg/day and an average intake of 143 mg/day (assuming that a person drinks two liters of water per day). The maximum intake rate slightly exceeds the range of RDAs for magnesium, 310 mg/day for women to 400 mg/day for men. The maximum intake rate exceeds the RDAs in only 1 of 37 ground water samples. Note that the RDA is not an indicator of adverse health effects, but an estimated safe and adequate daily dietary intake expected to satisfy the needs of 50 percent of the people in a given age group. Based on this discussion and the fact that the ground water at the MGBG is likely not potable because of sodium levels, the concentrations of magnesium in ground water at MGBG would not be expected to cause adverse health effects.

An evaluation of essential nutrient levels in soil and sediment samples collected at MGBG indicates that maximum daily intakes for these media would be significantly less than RDA values.

Determination of Site-Related Chemicals

Inorganic chemicals found at concentrations indicative of background levels were not considered to be site-related contaminants and were not retained as COPCs for the quantitative risk assessment. The methodology for determining whether concentrations of inorganics detected in site media were within background levels was presented in Section 3.4.2.

4.2.2 Surface Soil (0 to 2 Feet Depth)

Five VOCs, 11 SVOCs, two pesticides, two herbicides, 23 metals, and 14 radionuclides were detected in surface soil samples collected at the MGBG including the anomaly excavation samples. The maximum detected surface soil concentrations were compared to U.S. EPA Region 9 PRGs for residential exposures, IDEM residential default closure levels for direct contact, and the calculated risk-based screening levels for radionuclides in Table 4-8. The following chemicals were detected in the surface soil at maximum concentrations exceeding the direct contact risk-based COPC screening levels, and therefore, were retained as COPCs for surface soil at the MGBG:

- Inorganics – aluminum and iron

The maximum concentrations of manganese, cesium-137, lead-210, potassium-40, radium-226, and thorium-228 also exceeded the direct contact screening criteria; however, reported concentrations were within site-specific background concentrations. Therefore, these analytes were not retained as COPCs for direct contact exposures to surface soil at the MGBG.

As indicated in the footnote to Table 4-8, thallium was eliminated as a COPC because re-analyses of the samples with the greatest reported thallium concentrations (e.g., 2.8 mg/kg in Sample 01SS030002) resulted in thallium concentrations much less than the initial analyses (0.13 mg/kg in Sample 01SS030002). The results of the re-analysis indicated that concentrations of thallium at the site were within background levels. Therefore, thallium was eliminated as a COPC.

A comparison of the maximum detected surface soil concentrations to U.S. EPA SSLs for chemical migration from soil to air is presented in Table 4-9. Concentrations reported for all chemicals were less than the U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from surface soil at the MGBG were not evaluated quantitatively in the HHRA.

The maximum detected surface soil concentrations were compared to U.S. EPA SSLs for chemical migration from soil to ground water and IDEM residential default closure levels for migration to ground water in Table 4-9. The following chemicals were detected in surface soil at maximum concentrations that exceeded the COPC screening levels for migration from soil to ground water, and therefore, were retained as COPCs for surface soil at the MGBG:

- VOCs – methylene chloride
- Inorganics – selenium

Selenium was not detected in ground water samples collected at the MGBG.

Concentrations of antimony, barium, cadmium, chromium, nickel, lead-210, radium-226, thorium-232, and uranium-235 also exceeded screening criteria; however, reported concentrations of these metals were within site-specific background concentrations. Therefore, these inorganics were not retained as COPCs for the soil-to-ground water migration pathway. Note that USEPA and/or IDEM soil to ground water SSLs are not currently available for aluminum, cobalt, manganese, and thorium. However, the concentrations of these metals, with the exception of iron, were determined to be within background levels, and iron has been identified as a COPC on the basis of direct contact. Therefore, the risk assessment for surface soil is not affected by the lack of SSLs for these metals.

As indicated in Table 4-9, the maximum concentration of thorium-230 exceeded its soil screening level and background concentrations in the initial background comparison. However, it was determined that thorium-230 concentrations represent background levels and this radionuclide was not selected as a COPC as explained in Section 3.4.7.

4.2.3 Subsurface Soil (Depths Greater than 2 Feet)

Four VOCs, 14 SVOCs, one energetic, 2 pesticides, 24 metals including natural thorium, and 14 radionuclides were detected in subsurface soil samples collected at the MGBG. The maximum detected subsurface soil concentrations were compared to U.S. EPA Region 9 PRGs for residential exposures, IDEM residential default closure levels for direct contact, and the calculated risk-based screening levels for radionuclides in Table 4-10. The following chemicals were detected in subsurface soil at maximum concentrations exceeding the direct contact risk-based COPC screening levels, and therefore, were retained as COPCs for subsurface soil at the MGBG:

- PAHs - benzo(a)pyrene

- Inorganics - aluminum, iron, manganese

The maximum concentrations of lead-210, potassium-40, radium-226, and thorium-228 also exceeded the direct contact screening criteria; however, reported concentrations were within background concentrations; therefore, these parameters were not retained as COPCs for direct contact exposures to subsurface soil at the MGBG.

The maximum detected subsurface soil concentrations were compared to U.S. EPA SSLs for chemical migration from soil to air in Table 4-11. Concentrations reported for all chemicals were less than the U.S. EPA SSLs for soil to air; therefore, exposures through inhalation of fugitive dust emissions from subsurface soil at the MGBG were not evaluated quantitatively in the HHRA.

The maximum detected subsurface soil concentrations were compared to U.S. EPA SSLs for chemical migration from soil to ground water and IDEM residential default closure levels for migration to ground water in Table 4-11. The following chemicals were detected in subsurface soil at maximum concentrations that exceeded the COPC screening levels for migration from soil to ground water, and therefore, were retained as COPCs for subsurface soil at the MGBG:

- VOCs - 1,1,2,2-PCA, methylene chloride
- PAHs – benzo(a)anthracene, benzo(b)fluoranthene
- Inorganics – barium, cadmium, chromium, nickel, selenium

Benzo(a)anthracene, benzo(b)fluoranthene, and selenium were not detected in ground water at the MBGB.

Concentrations of lead-210, radium-226, and thorium-232 also exceeded screening criteria; however, reported concentrations were within background concentrations. Therefore, these constituents were not retained as COPCs for the soil-to-ground water migration pathway. U.S. EPA and IDEM soil to ground water SSLs are not currently available or could not be developed for aluminum, cobalt, iron, manganese, thorium, and six radionuclides (see Table 4-11). However, the concentrations of the six radionuclides were determined to be within background levels, and aluminum, iron, manganese were identified as COPCs on the basis of direct contact and are evaluated in the quantitative risk assessment. Therefore, the risk assessment for subsurface soil is not affected by the lack of SSLs for these constituents.

As indicated in Tables 4-10 and 4-11, the maximum concentrations of arsenic and thallium exceeded screening criteria and background concentrations in the initial background comparison. However, these

metals were not identified as COPCs because reanalysis of surface soil samples for thallium by graphite furnace atomic absorption (GFAA) and an additional review of arsenic data indicated that the concentrations of arsenic and thallium were within background levels. The issues regarding arsenic and thallium are further discussed in Sections 3.4.4 and 3.4.5, respectively.

As indicated in Table 4-11, the maximum concentration of thorium-230 exceeded its soil screening level and background concentrations in the initial background comparison. However, it was determined that thorium-230 concentrations represent background levels and this radionuclide was not selected as a COPC, as explained in Section 3.4.7.

4.2.4 Ground Water

Fourteen VOCs (including ethene and methane which were analyzed for the purpose of monitoring natural attenuation of chlorinated VOCs), eight SVOCs, four energetics, two pesticides, 24 total inorganics, and four radionuclides were detected in ground water samples collected from the surficial aquifer. A comparison of the maximum detected ground water concentrations to U.S. EPA Region 9 PRGs for ingestion of tap water, EPA MCLs, and IDEM ground water closure levels is presented in Table 4-12. The following chemicals were detected in ground water at maximum concentrations that exceeded the COPC screening levels, and therefore, were retained as COPCs for ground water at the MGBG:

- VOCs – 1,1,1,2-PCA, 1,1,2,2-PCA 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloroform, cis-1,2-dichloroethene, tetrachloroethene, TCE
- SVOCs – bis(2-ethylhexyl) phthalate, hexachloroethane
- Energetics – 4-amino-2,6-dinitrotoluene
- Pesticides – heptachlor
- Inorganics – aluminum, antimony, arsenic, iron, manganese, nickel, strontium

As indicated in Table 4-12, the maximum concentration of thorium-228 exceeded the risk-based screening concentration. However, thorium-228 was not selected as COPC for the following reasons: thorium-228 was detected in 3 of 16 samples and only the concentration in one sample (0.17 pCi/L) slightly exceeded the risk-based concentration (0.16 pCi/L) (the average concentration for all samples was 0.05 pCi/L); the maximum concentration of thorium-228 was detected at well location 01T02 but it was not detected in a sample collected three days later from the same location; although background data for ground water are not available for the site, concentrations of thorium-228 were within background levels for other media (i.e., surface soil, subsurface soil, and sediment); and the levels of thorium-228

detected in ground water at the site were within background levels reported in the literature (ASTDR, 1999). Thallium was not selected as a COPC based on reanalysis of some samples (see Section 3.4.5).

No chemicals were eliminated as COPCs for ground water on the basis of background because upgradient well data were not available for the site.

4.2.5 Sediment

Five VOCs, 12 SVOCs, one energetic, one pesticide, one PCB, two herbicides, 24 inorganics including natural thorium, and three thorium radionuclides were detected in sediment samples collected at MGBG. The maximum detected sediment concentrations are compared to U.S. EPA Region 9 PRGs for residential exposures, IDEM residential default closure levels for direct contact, and the calculated risk-based screening levels for radionuclides in Table 4-13. No chemicals were detected in sediment at maximum concentrations that exceeded the direct contact risk-based COPC screening levels; therefore, no chemicals were retained as COPCs for sediment at the MGBG.

Concentrations of aluminum, arsenic, chromium, iron, manganese, thallium, thorium-228, and thorium-232 exceeded the screening criteria; however, reported concentrations were within background concentrations. Therefore, these metals were not retained as COPCs for direct contact exposures to sediment at the MGBG.

As indicated in Table 4-13, the maximum concentration of thallium exceeded the risk-based screening level; however, reanalysis of the sediment samples by GFAA indicated that the concentrations of thallium were less than its screening level. The elimination of thallium as a COPC is further discussed in Section 3.4.5.

4.2.6 Surface Water

No chemical constituents were detected in the two surface water samples collected at the site; therefore, no chemicals were selected as COPCs for surface water.

4.2.7 Summary

Table 4-14 summarizes the chemicals retained as COPCs for soil, ground water, sediment, and surface water at the MGBG. Risk Assessment Guidance for Superfund (RAGS) Part D tables for COPC selection are included in Appendix G.2.

4.3 SELECTION OF ECOLOGICAL RISK CHEMICALS OF POTENTIAL CONCERN

The selection of COPCs is a qualitative screening process used to limit the number of chemicals and exposure routes quantitatively evaluated in the ecological risk assessment (ERA) to those site-related constituents that dominate overall potential risks. Site data were screened against ecological risk-based concentrations and background levels to focus the risk assessment on significant chemicals and exposure routes.

Screening concentrations based on U.S. EPA Region 5 EDQLs (U.S. EPA, 1999b) were used for sediment and surface soil. These values provide initial screening levels that are protective of ecological receptors (e.g. plants, invertebrates, mammals) (U.S. EPA, 1999b)

In general, a chemical was selected as an ecological COPC and retained for further quantitative risk evaluation in the ERA if the maximum detected concentration in a sampled medium exceeded the EDQL and the chemical was determined to be present at concentrations statistically exceeding background concentrations, if appropriate (e.g., inorganics and radionuclides). A chemical was also retained as a COPC if the detected concentration exceeded background levels and no EDQL was available for that chemical. Chemicals eliminated from further evaluation at this time were assumed to present minimal risks to potential ecological receptors.

As discussed in more detail in Section 8.0 of this report, the only media evaluated in the ERA were sediment and surface soil. Surface water samples were analyzed for VOCs; however, results were all less than detection limits. Ground water and subsurface soil were not evaluated in the ERA because most ecological receptors are not exposed directly to the ground water or subsurface soil.

4.3.1 Essential Nutrients and Chemicals Without Toxicity Criteria

The essential nutrients, calcium, magnesium, potassium, and sodium were not included as COPCs for the MGBG. These inorganic chemicals are naturally abundant in environmental matrices and are toxic only in very high doses. In addition, risk-based COPC screening levels are not available for these chemicals because of a lack of toxicity data. Chemicals without EDQLs were retained as COPCs for further evaluation in Step 3a of the ERA process.

4.3.2 Determination of Site-Related Chemicals

Chemicals found at concentrations indicative of background levels were not considered to be site-related contaminants and were not retained as COPCs for the quantitative risk assessment. The methodology

for determining whether concentrations of inorganics detected in site media were within background levels was presented in Section 3.4.2.

4.3.2.1 Surface Soil

Five VOCs, 11 SVOCs, two pesticides, two herbicides, 23 metals, and 14 total radionuclides were detected in surface soil samples collected at the MGBG including the anomaly excavation samples. A comparison of the maximum detected surface soil metals concentrations to U.S. EPA Region 5 SSLs is presented in Table 4-15. The following chemicals were detected at maximum concentrations in surface soil that exceeded ecological screening levels, and therefore, were retained as COPCs for surface soil at the MGBG.

- Semivolatile organics – Isosafrole
- Herbicides – 2,4-D
- Inorganics – Copper, selenium, vanadium, and zinc

Concentrations of antimony, arsenic, barium, cadmium, chromium, cobalt, lead, mercury, nickel, thallium, and thallium-GF exceeded associated screening criteria; however, reported concentrations were within site-specific background concentrations. Therefore, these chemicals were not retained as ecological COPCs for surface soil at the MGBG.

The following chemicals were also retained as COPCs for surface soil at the MGBG because no surface soil EDQLs were available. They will be further evaluated in step 3a of the ERA process.

- Metals – Aluminum and iron

4.3.2.2 Sediment

Five VOCs, 12 SVOCs, one energetic, one pesticide, one PCB, two herbicides, 24 metals (including natural thorium), and three thorium radionuclides were detected in sediment samples collected at the MGBG. A comparison of the maximum detected sediment concentrations to U.S. EPA Region 5 sediment screening levels is presented in Table 4-16. The following chemicals were detected in sediment at maximum concentrations that exceeded the ecological screening levels, and therefore, were retained as COPCs for sediment at the MGBG.

- Volatile organics – Acetone and dichlorodifluoromethane

- Semivolatile organics – Acenaphthene and isosafrole
- Pesticides – Heptachlor

Concentrations of arsenic, chromium, copper, lead, and nickel exceeded the screening criteria; however, reported concentrations of these metals were within site-specific background concentrations. Therefore, these metals were not retained as COPCs for direct contact exposure risks to sediment at the MGBG.

Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) was retained as a COPC for sediment at MGBG because no sediment EDQL was available.

4.3.2.3 Surface Water

No VOCs were detected in the surface water samples taken at the MGBG; therefore, no COPCs were associated with the surface water at the MGBG.

4.4 OVERALL SUMMARY OF HUMAN HEALTH AND ECOLOGICAL COPCS

Table 4-17 summarizes the overall list of chemicals retained as COPCs for both the HH and ecological risk assessment. Chemicals retained as HH COPCs are designated with an "H" and chemicals retained as ecological COPCs are designated with an "E".

TABLE 4-1

SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB01	01SB02	01SB03	01SB04	01SB05	01SB06	01SB07	01SB08	01SB09	01SB10	01SB11	01SB12	01SB13
Sample	01SS010002	01SS020002	01SS030002	01SS040002	01SS050002	01SS060002	01SS070002	01SS080002	01SS090002	01SS100002	01SS110002	01SS120002	01SS130002
Matrix	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
Depth Range (bgs)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/27/2001	8/27/2001	8/21/2001	8/26/2001	8/27/2001	8/22/2001	8/25/2001	8/24/2001
VOCs (ug/kg)													
2-Butanone	6 UJ	5 UJ	5 UJ	6 UJ	5 UJ	38	6 U	6 U	6 UJ	5 UJ	6 U	6 UJ	71 J
Acetone	6 UJ	5 UJ	5 UJ	6 UJ	5 UJ	680 UJ	130 J	6 UJ	6 UJ	5 UJ	6 UJ	6 U	650 U
Carbon Disulfide	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	4 U
Methylene Chloride	6 UJ	5 UJ	5 UJ	6 U	39 U	61 J	41 J	6 UJ	25 U	13 J	6 UJ	6 UJ	9
Toluene	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 UJ	3 U	3 U	2 J
SVOCs (ug/kg)													
7,12-Dimethylbenz(a)Anthracene	320 UJ	310 U	310 U	310 U	300 U	320 U	300 U	290 U	310 U	300 UJ	300 U	310 U	350 U
Acenaphthene	12.8 U	12.5 U	12.5 U	12.4 U	15.8	70.8	11.8 U	11.4 U	12.3 U	11.8 U	11.8 U	12.4 U	14 U
Benzo(a)Pyrene	12.8 U	12.5 U	12.5 U	12.4 U	12.1 U	12.7 U	11.8 U	11.4 U	11.9 J	11.8 U	11.8 U	12.4 U	14 U
Benzo(g,h,i)Perylene	12.8 U	12.5 U	12.5 U	12.4 U	12.1 U	12.7 U	11.8 U	11.4 U	11.8 J	11.8 U	11.8 U	12.4 U	14 U
Benzo(k)Fluoranthene	12.8 U	12.5 U	12.5 U	12.4 U	12.1 U	12.7 U	11.8 U	11.4 U	12.3 U	11.8 U	11.8 U	12.4 U	14 U
bis(2-Ethylhexyl) phthalate	220 U	210 U	210 U	210 U	200 U	210 U	200 U	190 U	420	200 U	89 J	210 U	240 U
Dibenzo(a,h)Anthracene	12.8 U	12.5 U	12.5 U	12.4 UJ	12.1 U	12.7 U	11.8 U	11.4 UJ	12.3 U	11.8 U	11.8 UJ	12.4 U	14 U
Fluoranthene	12.8 U	12.5 U	12.5 U	12.4 U	12.1 U	12.7 U	11.8 U	11.4 U	3.98 J	11.8 U	11.8 U	12.4 U	14 U
Indeno(1,2,3-cd) pyrene	12.8 U	12.5 U	12.5 U	12.4 U	12.1 U	12.7 U	11.8 U	11.4 U	4.55 J	11.8 U	11.8 U	12.4 U	14 U
Isosafrole	430 U	410 U	420 U	410 U	46000	3200	400 U	380 U	410 U	390 U	2700	420 U	470 U
Pyrene	12.8 U	12.5 U	12.5 U	14.6 J	12.1 U	12.7 U	11.8 U	11.4 U	12.3 U	11.8 U	11.8 U	12.4 U	14 U
Pesticides/PCBs (ug/kg)													
gamma-Chlordane	5.6 R	1.6 U	1.6 U	0.55 J	1.6 U	1.7 U	1.5 U	1.5 U	1.6 U	3.4 R	1.5 U	0.62 J	0.89 J
Heptachlor	1.4 J	1.2 J	1.3 J	1.6 U	1.4 J	3.8 R	1.5 U	1.8	1.3 J	1.6	1.3 J	1.4 BU	1.5 BU
Herbicides (ug/kg)													
2,4,5-TP (Silvex)	13 U	12 U	13 U	12 U	12 U	13 U	12 U	12 UJ	12 U	12 U	15 J	12 U	14 U
2,4-D	36 R	38 J	35 J	87 U	85 U	100 R	83 U	81 U	87 U	83 U	82 U	87 U	130
Inorganics (mg/kg)													
Aluminum	9670 J	13200 J	13200 J	14900 J	12300 J	13700	15900	14700 J	10100 J	19400	13400 J	12700 J	12700 J
Antimony	1.7 J	0.53 U	0.66 U	0.88 U	0.50 U	0.61 U	1.3 U	0.81 U	0.60 U	1.4 U	0.67 U	0.20 UJ	0.62 U
Arsenic	7.0 J	10.9 J	10.3 J	9.0 J	7.9 J	7.7 J	8.8 J	7.6	7.2 J	9.3 J	8.0	6.9 J	7.1 J
Barium	69.2 J	82.8 J	45.1 J	66.4	56.6 J	157	71.8	130	75.5 J	66.0	104	122	109
Beryllium	0.50 J	0.52 J	0.40 J	0.63 J	0.41 J	0.96	0.30	0.88 J	0.47 J	0.21	0.88 J	1.0 J	0.79 J
Cadmium	0.42 J	0.04 UJ	0.04 UJ	0.49 J	0.15 J	0.05 U	0.05 U	0.01 U	0.27 J	0.22 J	0.01 U	0.25 J	0.30 J
Calcium	8440 J	5010 J	510 J	1480 J	891 J	1300 J	557 J	578 J	24100 J	27900 J	678 J	1190 J	3450 J
Chromium	13.4	17.0	17.8	17.6 J	16.2	15.8	19.1	14.7	14.5	22.8	13.4	12.2 J	13.6 J
Cobalt	9.9	8.2	5.1	10.9 J	5.2	20.7	10.4	12.9 J	6.5	7.2	15.5 J	17.7 J	20.2 J
Copper	12.1 J	16.5 J	16.5 J	14.0 J	13.9 J	10.1	15.9	12.1 J	13.1 J	18.5	11.6 J	10.1 J	8.7 J
Iron	16300	24600	25500	23100	20300	18100	24000	19100	18300	24700	19000	15700	16300
Lead	20.4	16.2	14.7	19.0	17.2	19.0	15.5	15.0 J	13.1	17.2	16.2 J	16.1	19.0
Magnesium	1820 J	3060 J	2470 J	2160 J	1900 J	1600 J	2380 J	1890 J	3790 J	5260 J	1760 J	1360 J	2340 J
Manganese	588 J	453 J	232 J	420 J	305 J	2010	489	920 J	369 J	380	991 J	1230 J	1270 J
Mercury	0.04 J	0.05 J	0.06 J	0.05 J	0.05 J	0.05 J	0.05 J	0.05	0.07 J	0.07 J	0.06	0.03 U	0.05 U
Nickel	10.1	11.9	13.9	12.4 J	11.2	16.0	13.8	15.6	10.1	13.7	13.9	13.2 J	13.8 J
Potassium	668 J	587 J	755 J	817 J	596 J	709 J	837 J	849 J	540 J	1310 J	674 J	672 J	671 J
Selenium	0.62 J	0.88 J	1.2 J	1.4 U	0.79 J	0.69	1.3	0.49 J	0.58 J	1.1	0.51 J	0.99 U	1.0 U
Sodium	355 J	350 J	296 J	325 J	219 J	614	603	386 J	290 J	648	358 J	342 J	418 J
Strontium	11.3 J	11.5 J	7.0 J	8.8 J	8.5 J	11.2 J	10.3 J	9.4 J	24.7 J	33.5 J	8.4 J	8.8 J	10.1 J
Thallium	0.85	1.8	2.8	2.2 J	1.8	1.4	0.57 U	0.87 J	1.2	0.55 U	1.4 J	1.0 J	1.4 J
Thorium-Calc	2.531818	3.995455	3.881818	6.436364	3.895455	3.963636	4.3	3.25	4.690909	4.886364	4.5	5.440909	3.140909

TABLE 4-1

SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB01	01SB02	01SB03	01SB04	01SB05	01SB06	01SB07	01SB08	01SB09	01SB10	01SB11	01SB12	01SB13
Sample	01SS010002	01SS020002	01SS030002	01SS040002	01SS050002	01SS060002	01SS070002	01SS080002	01SS090002	01SS100002	01SS110002	01SS120002	01SS130002
Matrix	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
Depth Range (bgs)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/27/2001	8/27/2001	8/21/2001	8/26/2001	8/27/2001	8/22/2001	8/25/2001	8/24/2001
Tin	24.5 U	22.7 U	23.1 U	23.7 U	22.3 U	2.5 U	2.5	3.9	23.4 U	2.6	3.8	23.6 U	27.0 U
Vanadium	23.8	32.1	30.3	32.2	28.9	31.9	37.5	30.7 J	24.5	44.5	28.5 J	26.8	26.9
Zinc	41.7 J	50.6 J	49.3 J	49.8 J	37.9 J	55.9	57.7	51.1	41.4 J	67.8	45.2	42.4 J	41.7 J
Miscellaneous Parameters													
Cation Exchange Capacity (meq/100g	13.9	NA	12.8	NA	12.2	NA	23.4 J	NA	NA	NA	NA	NA	24.4 J
pH (S.U.)	7.8 J	NA	5.4 J	NA	5.2 J	NA	5	NA	NA	NA	NA	NA	5.8
Total Radionuclides (pCi/g)													
Actinium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cesium-137	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-210	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium-208	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thorium-228	0.257	0.433	0.388	0.730	0.357	0.417	0.467	0.320	0.480	0.502	0.458	0.623	0.337
Thorium-230	0.0178 J	0.052 J	0.0342 U	0.621 J	0.0345 U	0.0414	0.0490	0.385 J	0.0198 J	0.0688	0.473 J	0.474 J	0.0898 U
Thorium-232	0.300	0.446	0.466	0.686	0.500	0.455	0.479	0.395	0.552	0.573	0.532	0.574	0.354
Thorium-234	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-235	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-1

SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB14	01SB15	01SB16	01SB17	01SB18	01SB19	01SB20	01SB21	01TPL	01TPL	01TPL	01TPS
Sample	01SS140002	01SS150002	01SS160002	01SS170002	01SS180002	01SS190002	01SS200002	01SS210002	01TPL01	01TPL02	01TPL03	01TPS04
Matrix	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
Depth Range (bgs)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	1 - 1.5	1 - 1.5	1 - 1.5	1 - 1.5
Risk	Site	Site	Site	Site	Site	Site	Site	Background	Site	Site	Site	Site
Sample Date	8/24/2001	8/22/2001	8/21/2001	8/24/2001	8/24/2001	8/24/2001	8/21/2001	8/21/2001	8/27/2001	8/27/2001	8/27/2001	8/27/2001
VOCs (ug/kg)												
2-Butanone	6 UJ	6 U	5 U	10 UJ	8 UJ	7 UJ	6 U	NA	5 UJ	6 UJ	5 UJ	6 UJ
Acetone	6 UJ	6 UJ	5 UJ	750 U	180	90	21 J	NA	5 UJ	6 UJ	5 UJ	6 UJ
Carbon Disulfide	3 U	3 U	3 U	6	4 U	4 U	3 U	NA	3 U	3 U	3 U	3 U
Methylene Chloride	47	6 UJ	2 J	14 J	13 J	7 J	15 J	NA	5 UJ	6 UJ	5 UJ	26 U
Toluene	3 U	3 U	3 U	5 U	4 U	4 U	3 U	NA	3 U	3 U	3 U	3 U
SVOCs (ug/kg)												
7,12-Dimethylbenz(a)Anthracene	320 U	300 U	310 U	260 J	280 U	320 U	310 U	NA	1500 UJ	300 U	310 U	310 U
Acenaphthene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	12.3 U	12.1 U	12.5 U	12.4 U
Benzo(a)Pyrene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	5.85 J	12.1 U	12.5 U	12.4 U
Benzo(g,h,i)Perylene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	9.3 J	12.1 U	12.5 U	12.4 U
Benzo(k)Fluoranthene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	14.1 J	12.1 U	12.5 U	12.4 U
bis(2-Ethylhexyl) phthalate	210 U	200 U	210 U	270 U	83 J	210 U	210 U	NA	1000 U	200 U	210 U	210 U
Dibenzo(a,h)Anthracene	12.6 UJ	12.1 UJ	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	5.76 J	12.1 U	12.5 U	12.4 U
Fluoranthene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	4.39 J	12.1 U	12.5 U	12.4 U
Indeno(1,2,3-cd) pyrene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	4.52 J	12.1 U	12.5 U	12.4 U
Isosafrole	420 U	400 U	410 U	540 U	410	420 U	400 J	NA	2000 U	400 U	410 U	150 J
Pyrene	12.6 UJ	12.1 U	12.3 U	15.8 U	11.2 UJ	12.5 UJ	12.4 U	NA	4.1 J	12.1 U	12.5 U	12.4 U
Pesticides/PCBs (ug/kg)												
gamma-Chlordane	0.9 J	3 R	1.6 U	1.1 J	0.71 J	0.81 J	1.6 U	NA	NA	NA	NA	NA
Heptachlor	2 BU	2	1.4 J	2.4 BU	1 BU	1.2 BU	2.4	NA	NA	NA	NA	NA
Herbicides (ug/kg)												
2,4,5-TP (Silvex)	13 U	5.9 J	12 U	16 U	11 U	13 U	13 U	NA	NA	NA	NA	NA
2,4-D	88 U	85 U	86 U	210	69 J	90 U	88 U	NA	NA	NA	NA	NA
Inorganics (mg/kg)												
Aluminum	16200 J	17200 J	12200	15300 J	9400 J	12400 J	13800	NA	9820 J	9900 J	9570 J	12400 J
Antimony	0.48 U	0.89 U	0.51 U	0.36 U	0.49 U	0.55 U	0.54 U	NA	0.34 U	0.45 U	0.40 U	0.28 U
Arsenic	8.9 J	9.1	8.3	10.8 J	6.0 J	7.9 J	7.5	NA	6.9 J	6.4 J	6.2 J	7.1 J
Barium	69.6	76.2	104	169	49.9	42.9	112	NA	117 J	118 J	114 J	131 J
Beryllium	0.63 J	0.59 U	0.72 J	1.0 J	0.45 J	0.38 J	0.78 J	NA	0.93 J	0.77 J	0.86 J	0.72 J
Cadmium	0.17 J	0.01 U	0.05 UJ	1.3 J	0.09 J	0.15 J	0.05 UJ	NA	0.14 J	0.05 J	0.04 UJ	0.11 J
Calcium	1010 J	1050 J	2520	1450 J	421 J	579 J	946	NA	12600 J	18800 J	4810 J	1120 J
Chromium	16.8 J	19.3	13.9	24.3 J	12.1 J	15.9 J	14.1	NA	12.8	13.1	11.5	14.0
Cobalt	8.0 J	8.3 J	11.6	18.8 J	8.8 J	3.2 J	20.3	NA	22.3	19.0	16.2	18.6
Copper	14.5 J	17.6 J	12.6 J	12.6 J	8.1 J	12.3 J	10.9 J	NA	7.4 J	7.9 J	9.1 J	10.5 J
Iron	23500	23500	19900	24600	17200	22800	18000	NA	15400	14600	15000	17600
Lead	15.6	12.9 J	16.5	20.0	11.4	11.0	18.1	NA	21.6	17.6	17.8	16.3
Magnesium	2220 J	2380 J	1780	1930 J	1050 J	1850 J	1570	NA	1540 J	1830 J	1190 J	1500 J
Manganese	291 J	382 J	629	1420 J	427 J	114 J	1220	NA	1720 J	1540 J	1290 J	1070 J
Mercury	0.05 U	0.07	0.07 U	0.04 U	0.04 U	0.10 U	0.05 U	NA	0.04 J	0.03 J	0.04 J	0.04 J
Nickel	12.6 J	12.2	11.7	16.0 J	6.9 J	8.1 J	13.4	NA	12.1	11.1	10.9	13.9
Potassium	846 J	823 J	668 J	853 J	436 J	575 J	846 J	NA	503 J	519 J	479 J	676 J
Selenium	1.0 U	0.62 J	0.38 U	1.5 U	0.68 U	0.87 U	0.49	NA	0.76 J	0.72 J	0.74 J	0.70 J
Sodium	348 J	384 J	304	452 J	329 J	426 J	400	NA	336 J	283 J	351 J	297 J
Strontium	9.0 J	10.4 J	11.9 J	13.7 J	5.0 J	6.8 J	8.8 J	NA	15.9 J	20.2 J	9.5 J	12.8 J
Thallium	2.6 J	1.5 J	1.6	2.5 J	1.9 J	2.7 J	1.6	NA	0.69	0.61 U	0.62 U	0.99
Thorium-Calc	1.895455	4.036364	4.581818	4.2	3.572727	3.563636	3.704545	3.590909	4.727273	3.763636	4.113636	4.318182

TABLE 4-1

SUMMARY OF CHEMICALS DETECTED IN SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB14	01SB15	01SB16	01SB17	01SB18	01SB19	01SB20	01SB21	01TPL	01TPL	01TPL	01TPS
Sample	01SS140002	01SS150002	01SS160002	01SS170002	01SS180002	01SS190002	01SS200002	01SS210002	01TPL01	01TPL02	01TPL03	01TPS04
Matrix	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil	Surface Soil
Depth Range (bgs)	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	0 - 2	1 - 1.5	1 - 1.5	1 - 1.5	1 - 1.5
Risk	Site	Site	Site	Site	Site	Site	Site	Background	Site	Site	Site	Site
Sample Date	8/24/2001	8/22/2001	8/21/2001	8/24/2001	8/24/2001	8/24/2001	8/21/2001	8/21/2001	8/27/2001	8/27/2001	8/27/2001	8/27/2001
Tin	23.8 U	3.8	3.1	29.2 U	21.6 U	23.4 U	3.4	NA	23.2 U	23.1 U	23.7 U	22.8 U
Vanadium	31.7	35.7 J	28.1	36.2	24.8	30.4	28.6	NA	24.8	23.6	22.8	29.2
Zinc	49.8 J	50.9	42.5	54.9 J	25.1 J	34.3 J	45.3	NA	41.2 J	35.5 J	38.6 J	46.3 J
Miscellaneous Parameters												
Cation Exchange Capacity (meq/100g	NA	NA	NA	NA	NA	NA	11.2	NA	NA	NA	NA	NA
pH (S.U.)	NA	NA	NA	NA	NA	NA	5.0 J	NA	7.5 J	NA	NA	NA
Total Radionuclides (pCi/g)												
Actinium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.92	0.97	NA
Bismuth-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.91	0.94	NA
Bismuth-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.68	0.74	NA
Cesium-137	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0359 U	0.09	NA
Lead-210	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.47	0.52	NA
Lead-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.83	0.86	NA
Lead-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.71	0.69	NA
Potassium-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.94	9.76	NA
Radium-226	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.56	1.68	NA
Thallium-208	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.77	0.81	NA
Thorium-228	0.227	0.387	0.490	0.427	0.416	0.299	0.436	0.431	0.483	0.377	0.353	0.449
Thorium-230	0.0554 U	0.562 J	0.475	0.0395 U	0.0345 U	0.0848 U	0.578	0.0764	0.0278 J	0.0179 J	0.023 J	0.0215 J
Thorium-232	0.190	0.501	0.518	0.497	0.370	0.485	0.379	0.359	0.557	0.451	0.552	0.501
Thorium-234	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.00	1.73	NA
Uranium-235	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.12	0.14	NA

Calc = Calculated value.
NA = Not analyzed
U - Indicates that the chemical was not detected at the numerical detection limit (sample-specific quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.
UJ - Indicates that the chemical was not detected. However, the detection limit (sample-specific quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.
J - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The laboratory-reported concentration is considered to be an estimate of the true concentration.
R - Indicates that the chemical may or may not be present. The positive analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies.
BU - Indicates that the chemical was detected in this sample as well as the associated laboratory method blank, but has been qualified non-detected result as a laboratory blank contamination (i.e., concentration was less than the blank action level).
MEQ - milliequivalents
S.U. - Standard units.

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB01	01SB02	01SB02	01SB03	01SB04	01SB04	01SB05	01SB05	01SB06	01SB06
Sample	01SB010206	01SB020206	01SB020610	01SB030206	01SB040206	01SB040610	01SB050206	01SB050610	01SB060206	01SB060610
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	2 - 6	2 - 6	6 - 9.5	2 - 6	2 - 6	6 - 10	2 - 6	6 - 8.5	2 - 6	6 - 10
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/27/2001	8/27/2001
VOCs (ug/kg)										
1,1,2,2-Tetrachloroethane	3 UJ	3 UJ	3 UJ	3 U	2 UJ	3 UJ	3 U	3 UJ	3 U	3 U
Acetone	6 UJ	5 UJ	5 UJ	5 UJ	4 UJ	5 UJ	5 UJ	5 UJ	32 J	9 J
Chloroform	3 U	3 U	3 U	3 U	2 U	3 U	3 U	3 U	3 U	3 U
Methylene Chloride	40 BU	20 U	6 U	9 U	3 J	5 U	54 U	48 BU	58 J	46 J
SVOCs (ug/kg)										
Acenaphthene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	30.3	4.34 J
Anthracene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Benzo(a)Anthracene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Benzo(a)Pyrene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Benzo(b)Fluoranthene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Benzo(g,h,i)Perylene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
bis(2-Ethylhexyl) phthalate	200 U	200 U	180 U	210 U	190 U	190 U	180 U	110 J	200 U	200 U
Chrysene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Fluoranthene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Fluorene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Indeno(1,2,3-cd)Pyrene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Naphthalene	11.7 U	8.85 J	10.9 U	8.52 J	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Phenanthrene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Pyrene	11.7 U	12.1 U	10.9 U	12.3 U	11 U	11 U	10.7 U	11.2 U	12 U	12 U
Energetics (ug/kg)										
HMX	476 U	500 U	476 U	476 U	476 U	476 U	454 U	476 U	454 U	476 U
Pesticides/PCBs (ug/kg)										
gamma-Chlordane	1.5 U	1.6 U	NA	1.6 U	1.4 U	NA	1.4 U	NA	1.5 U	NA
Heptachlor	1.4 J	1.2 J	NA	1.2 J	1.2 BU	NA	0.96 J	NA	1 J	NA
Inorganics (mg/kg)										
Aluminum	8350 J	7610 J	3180 J	9130 J	8280 J	4100 J	4890 J	3730 J	18100	7010
Arsenic	3.2 J	2.9 J	0.36 U	4.8 J	4.7 J	0.88 U	5.1 J	2.3 U	7.7 J	2.0 J
Barium	64.9 J	35.5 J	58.2 J	38.1 J	30.9	52.0	15.7 J	14.9 J	52.8	28.3
Beryllium	0.37 J	0.38 J	1.2 J	0.45 J	0.38 J	1.1 J	0.34 J	0.42 J	0.38	1.5
Cadmium	0.04 J	0.76	0.03 UJ	1.1	0.21 J	0.35 J	0.03 UJ	0.03 UJ	0.05 U	0.05 U
Calcium	43200 J	485 J	487 J	553 J	461 J	540 J	121 J	69.6 J	629 J	673 J
Chromium	12.2	11.5	8.7	14.6	12.7 J	10.7 J	9.0	7.7	24.0	21.3
Cobalt	2.6	3.4	25.8	3.5	2.9 J	14.6 J	5.5	4.3	8.0	22.3
Copper	10.6 J	10.2 J	12.8 J	11.3 J	9.5 J	13.1 J	6.8 J	7.6 J	14.2	17.5
Iron	12400	13900	30800	18300	15000	24800 J	18000	13200	27700	22400
Lead	8.3	18.6	15.4	36.9	9.9	10.6	6.2	7.9	16.0	12.6
Magnesium	4670 J	1320 J	1030 J	1480 J	1390 J	1130 J	395 J	311 J	1830 J	1530 J
Manganese	69.6 J	70.1 J	379 J	107 J	86.4 J	270 J	133 J	100 J	251	408
Mercury	0.02 UJ	0.02 UJ	0.02 UJ	0.02 UJ	0.02 U	0.02 U	0.02 J	0.02 J	0.07 J	0.03 J
Nickel	6.5	8.3	32.7	7.2	7.5 J	26.6 J	11.2	9.2	11.5	39.3
Potassium	358 J	420 J	488 J	371 J	393 J	752 J	305 J	427 J	792 J	1190 J
Selenium	0.12 J	0.21 J	0.85 J	0.45 J	0.45 U	0.90 U	0.32 J	0.28 J	1.7	0.71
Sodium	365 J	392 J	357 J	411 J	332 J	347 J	240 J	251 J	657	755
Strontium	46.0 J	5.7 J	4.0 J	6.9 J	5.6 J	4.8 J	2.0 J	1.3 J	11.6 J	12.5 J
Thallium	0.84	1.0	2.7	1.5	1.7 J	2.7	1.7	1.1	0.55 U	0.58 U
Thorium-Calc	3.790909	3.604545	5.181818	3.818182	6.427273	5.054545	2.195455	3.068182	4.795455	6.936364

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB01	01SB02	01SB02	01SB03	01SB04	01SB04	01SB05	01SB05	01SB06	01SB06
Sample	01SB010206	01SB020206	01SB020610	01SB030206	01SB040206	01SB040610	01SB050206	01SB050610	01SB060206	01SB060610
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	2 - 6	2 - 6	6 - 9.5	2 - 6	2 - 6	6 - 10	2 - 6	6 - 8.5	2 - 6	6 - 10
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/26/2001	8/27/2001	8/27/2001
Tin	22.5 U	23.1 U	20.1 U	23.5 U	21.1 U	21.0 U	19.9 U	21.4 U	2.4	2.3 U
Vanadium	18.7	18.7	9.2	27.7	21.6	9.4	13.8	8.9	42.6	14.7
Zinc	31.3 J	23.9 J	70.9 J	22.1 J	23.1 J	62.0 J	49.8 J	29.4 J	43.6	72.1
Miscellaneous Parameters										
Cation Exchange Capacity (meq/100g)	12.9	NA	NA	18.2	NA	NA	20.1	18.7	NA	NA
pH (S.U.)	7.1 J	NA	NA	5.1 J	NA	NA	4.4 J	5.1 J	NA	NA
Total Radionuclides (pCi/g)										
Actinium-228	1.11	1.27	NA	1.07	1.01	NA	NA	NA	NA	NA
Bismuth-212	1.30	1.07	NA	1.13	0.98	NA	NA	NA	NA	NA
Bismuth-214	0.87	0.85	NA	0.73	0.73	NA	NA	NA	NA	NA
Europium-155	0.242 U	0.09	NA	0.244 U	0.08	NA	NA	NA	NA	NA
Lead-210	0.45	0.57	NA	0.65	0.36	NA	NA	NA	NA	NA
Lead-212	1.00	1.13	NA	1.00	0.95	NA	NA	NA	NA	NA
Lead-214	0.87	0.83	NA	0.72	0.75	NA	NA	NA	NA	NA
Potassium-40	5.98	9.23	NA	9.05	8.48	NA	NA	NA	NA	NA
Radium-226	1.79	1.90	NA	1.68	1.66	NA	NA	NA	NA	NA
Thallium-208	0.91	1.04	NA	0.94	0.91	NA	NA	NA	NA	NA
Thorium-228	0.359	0.393	0.477	0.343	0.781	0.494	0.207	0.332	0.512	0.654
Thorium-230	0.0522 U	0.0646 U	0.0661 J	0.113 J	0.485 J	0.520 J	0.0386 J	0.0332 J	0.0536 U	0.140
Thorium-232	0.475	0.400	0.663	0.497	0.633	0.618	0.276	0.343	0.543	0.872
Thorium-234	1.10	1.14	NA	1.88	1.00	NA	NA	NA	NA	NA

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB07	01SB08	01SB08	01SB09	01SB10	01SB11	01SB11	01SB12	01SB12	01SB13
Sample	01SB070206	01SB080206	01SB080610	01SB090206	01SB100206	01SB110206	01SB110610	01SB120206	01SB120610	01SB130206
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	2 - 5	2 - 6	6 - 10	2 - 6	2 - 6	2 - 6	6 - 10	2 - 6	6 - 10	2 - 6
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/27/2001	8/21/2001	8/21/2001	8/27/2001	8/27/2001	8/22/2001	8/22/2001	8/25/2001	8/25/2001	8/24/2001
VOCs (ug/kg)										
1,1,2,2-Tetrachloroethane	3 U	3 U	3 U	2 J	3 UJ	3 U	3 U	3 U	3 U	3 U
Acetone	29 J	5 UJ	5 UJ	5 UJ	5 UJ	6 UJ	5 UJ	6	5 U	36
Chloroform	3 U	3 U	3 U	4 J	3 U	3 U	3 U	3 U	3 U	3 U
Methylene Chloride	86 J	21 J	16 J	45 U	50 J	26 J	15 J	15 J	13 J	10
SVOCs (ug/kg)										
Acenaphthene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Anthracene	13.5 U	11.6 UJ	11.3 UJ	11.6 U	11.6 U	11.8 UJ	11.3 UJ	11.1 U	11 U	12.7 UJ
Benzo(a)Anthracene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Benzo(a)Pyrene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Benzo(b)Fluoranthene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Benzo(g,h,i)Perylene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
bis(2-Ethylhexyl) phthalate	230 U	200 U	190 U	5600	200 U	200 U	190 U	190 U	190 U	210 U
Chrysene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Fluoranthene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Fluorene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Indeno(1,2,3-cd)Pyrene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Naphthalene	13.5 U	11.6 UR	11.3 UR	10.2 J	11.6 U	11.8 UR	11.3 UR	11.1 U	11 U	12.7 UJ
Phenanthrene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Pyrene	13.5 U	11.6 U	11.3 U	11.6 U	11.6 U	11.8 U	11.3 U	11.1 U	11 U	12.7 UJ
Energetics (ug/kg)										
HMX	476 U	70.6 J	476 U	476 U	476 U	500 U	500 U	500 U	476 U	476 U
Pesticides/PCBs (ug/kg)										
gamma-Chlordane	1.8 U	1.5 U	NA	1.5 U	1.5 U	1.5 U	NA	0.82 J	NA	2.6 J
Heptachlor	1.5 J	1.6 J	NA	1.2 J	0.94 J	1.5 J	NA	1 BU	NA	1.5 BU
Inorganics (mg/kg)										
Aluminum	12700	7030 J	4290 J	10100 J	14200	11900 J	4530 J	8210 J	4330 J	9510 J
Arsenic	6.7 J	4.2	0.48 J	4.1 J	2.7 J	8.1	3.1	3.4 J	1.7 U	5.3 J
Barium	55.4	26.3	23.6	34.8 J	51.2	44.0	28.1	27.9	52.2	39.7
Beryllium	0.24	0.31 U	1.6 J	0.55 J	0.24	0.42 U	0.32 U	0.33 J	0.47 J	0.35 J
Cadmium	0.05 U	0.01 U	0.01 U	0.03 UJ	0.04 U	0.01 U	0.01 U	0.16 J	0.16	0.04 J
Calcium	549 J	262 J	362 J	901 J	10000 J	332 J	557 J	305 J	485 J	263 J
Chromium	18.7	10.4	15.0	14.9	17.6	15.9	10.3	11.3 J	8.5 J	12.7 J
Cobalt	5.5	2.0 J	16.8 J	2.6	4.0	4.0 J	1.3 J	3.0 J	3.9 J	3.4 J
Copper	14.4	9.4 J	25.3 J	10.7 J	11.4	12.7 J	9.1 J	7.4 J	7.8 J	10.8 J
Iron	24400	12600	71500	15800	15700	23600	16200	12800	8750	17800
Lead	12.2	8.0 J	7.6 J	10.3	10.5	11.9 J	9.6 J	10.5	9.8	9.2
Magnesium	2350 J	826 J	395 J	1210 J	1840 J	1750 J	512 J	1120 J	663 J	1630 J
Manganese	250	45.4 J	329 J	20.3 J	137	180 J	21.7 J	157 J	20.9 J	131 J
Mercury	0.02 J	0.04	0.03	0.02 J	0.02 J	0.06	0.03	0.03 J	0.02 U	0.03 U
Nickel	11.5	4.5	24.9	6.7	8.8	8.1	3.2	5.6 J	8.2 J	8.2 J
Potassium	617 J	441 J	754 J	353 J	615 J	553 J	207 J	381 J	449 J	504 J
Selenium	1.4	0.31 J	1.3 J	0.36 J	1.1	0.41 J	0.34 J	0.48 U	0.18 U	0.55 U
Sodium	567	359 J	379 J	342 J	706	336 J	343 J	329 J	379 J	391 J
Strontium	10.2 J	5.0 J	4.4 J	9.9 J	17.5 J	6.1 J	4.1 J	5.2 J	4.9 J	5.4 J
Thallium	0.63 U	1.1 J	5.3 J	1.5	0.53 U	2.1	1.4 J	1.1 J	1.0	1.8 J
Thorium-Calc	4.222727	3.436364	2.931818	3.977273	5.222727	3.340909	4.836364	4.736364	4.481818	3.409091

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB07	01SB08	01SB08	01SB09	01SB10	01SB11	01SB11	01SB12	01SB12	01SB13
Sample	01SB070206	01SB080206	01SB080610	01SB090206	01SB100206	01SB110206	01SB110610	01SB120206	01SB120610	01SB130206
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	2 - 5	2 - 6	6 - 10	2 - 6	2 - 6	2 - 6	6 - 10	2 - 6	6 - 10	2 - 6
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/27/2001	8/21/2001	8/21/2001	8/27/2001	8/27/2001	8/22/2001	8/22/2001	8/25/2001	8/25/2001	8/24/2001
Tin	2.5 U	3.6	4.0	21.8 U	2.8	3.3	2.3	20.4 U	21.1 U	24.0 U
Vanadium	32.9	18.3 J	15.9 J	26.8	28.1	29.4 J	20.5 J	20.9	10.2	22.2
Zinc	46.9	18.1	129	16.2 J	43.3	34.2	15.0	17.6 J	26.1 J	31.7 J
Miscellaneous Parameters										
Cation Exchange Capacity (meq/100g)	19.2 J	NA	NA	NA	NA	NA	NA	NA	NA	14.8 J
pH (S.U.)	5	NA	NA	NA	NA	NA	NA	NA	NA	4.8
Total Radionuclides (pCi/g)										
Actinium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Europium-155	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-210	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium-208	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thorium-228	0.355	0.242	0.400	0.400	0.537	0.319	0.502	0.504	0.507	0.291
Thorium-230	0.164	0.334 J	0.385 J	0.0427 U	0.111	0.434 J	0.637 J	0.394 U	0.360 U	0.421 J
Thorium-232	0.574	0.514	0.245	0.475	0.612	0.416	0.562	0.538	0.479	0.459
Thorium-234	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB13	01SB14	01SB14	01SB15	01SB15	01SB16	01SB16	01SB17	01SB17	01SB18
Sample	01SB130610	01SB140206	01SB140610	01SB150206	01SB150610	01SB160206	01SB160610	01SB170206	01SB170610	01SB180206
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	6 - 10	2 - 6	6 - 8	2 - 6	6 - 10	2 - 6	6 - 10	2 - 6	6 - 9.7	2 - 6
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/24/2001	8/24/2001	8/24/2001	8/22/2001	8/22/2001	8/21/2001	8/21/2001	8/24/2001	8/24/2001	8/24/2001
VOCs (ug/kg)										
1,1,2,2-Tetrachloroethane	3 U	3 UJ	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Acetone	17	5 UJ	5 U	5 UJ	5 UJ	5 UJ	5 UJ	11	14	26
Chloroform	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U
Methylene Chloride	5 J	5 J	47	14 J	16 J	13 J	11 J	7 J	4 J	7 J
SVOCs (ug/kg)										
Acenaphthene	11.9 U	14.2	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Anthracene	11.9 U	11.6 U	11.4 U	11.9 UJ	12 UJ	12 U	11.8 U	12.7 U	11.4 UR	12 U
Benzo(a)Anthracene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Benzo(a)Pyrene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Benzo(b)Fluoranthene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Benzo(g,h,i)Perylene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
bis(2-Ethylhexyl) phthalate	200 U	200 U	190 U	200 U	200 U	200 U	97 J	180 U	190 U	210 U
Chrysene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Fluoranthene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Fluorene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Indeno(1,2,3-cd)Pyrene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Naphthalene	11.9 U	11.6 U	11.4 U	11.9 UR	12 UR	12 UR	11.8 UR	12.7 U	11.4 UR	12 U
Phenanthrene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Pyrene	11.9 U	11.6 U	11.4 U	11.9 U	12 U	12 U	11.8 U	12.7 U	11.4 UR	12 U
Energetics (ug/kg)										
HMX	454 U	476 U	476 U	476 U	476 U	476 U	454 U	454 U	476 U	476 U
Pesticides/PCBs (ug/kg)										
gamma-Chlordane	NA	0.64 J	NA	1.6 U	NA	3 J	NA	0.65 J	NA	0.98 J
Heptachlor	NA	1.4 BU	NA	2 J	NA	1.9	NA	2.1 BU	NA	1 BU
Inorganics (mg/kg)										
Aluminum	4090 J	7630 J	3270 J	8610 J	4280 J	9900	5760	10600 J	6800 J	4700 J
Arsenic	2.0 U	2.8 J	1.7 U	4.7	0.85	4.4	7.8	7.2 J	1.2 U	1.8 U
Barium	34.3	30.8	21.4	36.3	41.7	32.7	34.1	43.7	300	31.4
Beryllium	0.36 J	0.34 J	0.22 U	0.38 U	0.69 J	0.27 U	0.33 U	0.38 J	0.58 J	0.34 J
Cadmium	0.04	0.04 J	0.05	0.01 U	0.01 U	0.05 UJ	0.59 J	0.20 J	0.04	0.04 U
Calcium	475 J	314 J	251 J	350 J	1080 J	3250	834	393 J	912 J	223 J
Chromium	7.5 J	12.1 J	6.9 J	15.5	6.4 J	12.7	9.8	12.7 J	8.7 J	8.0 J
Cobalt	2.2 J	2.4 J	1.7 J	3.4 J	8.1 J	2.7 J	1.4 J	4.5 J	4.3 J	2.6 J
Copper	7.5 J	6.7 J	4.3 J	9.6 J	9.5 J	9.8 J	7.6 J	12.8 J	6.8 J	9.4 J
Iron	8200	11700	6540	19500	9730 J	17400	12000	18800	4940	8540
Lead	8.8	12.0	6.1	12.0 J	5.8 J	10.3	18.0	12.8	9.8	8.4
Magnesium	640 J	945 J	477 J	1430 J	1150 J	1760	617	1900 J	1300 J	683 J
Manganese	12.8 J	114 J	23.3 J	155 J	32.2 J	66.4	12.3	177 J	12.9 J	15.6 J
Mercury	0.02 U	0.02 U	0.02 U	0.04	0.03	0.05 U	0.03 U	0.02 U	0.02 U	0.02 U
Nickel	6.0 J	4.9 J	4.0 J	6.8	12.1	6.0	3.4	9.1 J	10.5 J	6.8 J
Potassium	531 J	329 J	359 J	356 J	488 J	417 J	254 J	574 J	550 J	570 J
Selenium	0.52 U	0.52 U	0.28 U	0.28 UJ	0.28 U	0.38 U	0.38 U	0.65 U	0.22 U	0.35 U
Sodium	349 J	318 J	329 J	360 J	351 J	356	355	379 J	441 J	385 J
Strontium	4.1 J	5.1 J	3.2 J	4.7 J	5.3 J	7.8 J	5.2 J	6.4 J	11.3 J	3.5 J
Thallium	0.86	1.3 J	1.1	1.4 J	1.0	2.2	1.4	1.8 J	0.75	1.1
Thorium-Calc	3.118182	3.586364	3.377273	3.077273	4.840909	3.495455	4.586364	3.513636	4.109091	4.704545

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB13	01SB14	01SB14	01SB15	01SB15	01SB16	01SB16	01SB17	01SB17	01SB18
Sample	01SB130610	01SB140206	01SB140610	01SB150206	01SB150610	01SB160206	01SB160610	01SB170206	01SB170610	01SB180206
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	6 - 10	2 - 6	6 - 8	2 - 6	6 - 10	2 - 6	6 - 10	2 - 6	6 - 9.7	2 - 6
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/24/2001	8/24/2001	8/24/2001	8/22/2001	8/22/2001	8/21/2001	8/21/2001	8/24/2001	8/24/2001	8/24/2001
Tin	22.6 U	22.1 U	21.4 U	3.4	3.6	2.7	2.3 U	23.9 U	21.8 U	22.3 U
Vanadium	10.4	21.7	7.4	25.2 J	7.2 J	22.4	16.1	26.4	7.1	10.1
Zinc	20.6 J	15.7 J	18.0 J	26.8	31.8	22.8	11.2	36.8 J	29.0 J	25.6 J
Miscellaneous Parameters										
Cation Exchange Capacity (meq/100g)	11 J	NA	NA	NA	NA	NA	NA	NA	NA	NA
pH (S.U.)	5.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Radionuclides (pCi/g)										
Actinium-228	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bismuth-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Europium-155	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-210	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-212	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead-214	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Potassium-40	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thallium-208	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thorium-228	0.298	0.331	0.378	0.308	0.627	0.266	0.535	0.360	0.480	0.452
Thorium-230	0.284 J	0.0540 U	0.257 J	0.539 J	0.474 J	0.438	0.349	0.0428 U	0.0683 U	0.265 J
Thorium-232	0.388	0.458	0.365	0.369	0.438	0.503	0.474	0.413	0.424	0.583
Thorium-234	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB18	01SB19	01SB19	01SB20	01SB20	01SB21	01SB21
Sample	01SB180610	01SB190206	01SB190610	01SB200206	01SB200610	01SB210206	01SB210610
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	6 - 8	2 - 6	6 - 8	2 - 6	6 - 8	0 - 2	6 - 10
Risk	Site	Site	Site	Site	Site	Background	Background
Sample Date	8/24/2001	8/24/2001	8/24/2001	8/21/2001	8/21/2001	8/21/2001	8/21/2001
VOCs (ug/kg)							
1,1,2,2-Tetrachloroethane	3 U	4 U	3 U	3 U	3 U	NA	NA
Acetone	42	20	31	5 UJ	5 UJ	NA	NA
Chloroform	3 U	4 U	3 U	3 U	3 U	NA	NA
Methylene Chloride	6 J	7 J	5 J	12 J	9 J	NA	NA
SVOCs (ug/kg)							
Acenaphthene	12.3 U	14.8 U	11.8 U	11.7 U	12.1 U	NA	NA
Anthracene	12.3 U	14.8 U	11.8 U	11.7 U	41.5	NA	NA
Benzo(a)Anthracene	12.3 U	14.8 U	11.8 U	11.7 U	153 J	NA	NA
Benzo(a)Pyrene	12.3 U	14.8 U	11.8 U	11.7 U	181 J	NA	NA
Benzo(b)Fluoranthene	12.3 U	14.8 U	11.8 U	11.7 U	318 J	NA	NA
Benzo(g,h,i)Perylene	12.3 U	14.8 U	11.8 U	11.7 U	160 J	NA	NA
bis(2-Ethylhexyl) phthalate	210 U	250 U	200 U	200 U	210 U	NA	NA
Chrysene	12.3 U	14.8 U	11.8 U	11.7 U	108 J	NA	NA
Fluoranthene	12.3 U	14.8 U	11.8 U	11.7 U	540 J	NA	NA
Fluorene	12.3 U	14.8 U	11.8 U	11.7 U	22.3	NA	NA
Indeno(1,2,3-cd)Pyrene	12.3 U	14.8 U	11.8 U	11.7 U	68.1	NA	NA
Naphthalene	12.3 U	14.8 U	11.8 U	11.7 UR	12.1 UR	NA	NA
Phenanthrene	12.3 U	14.8 U	11.8 U	11.7 U	278 J	NA	NA
Pyrene	12.3 U	14.8 U	11.8 U	11.7 U	306 J	NA	NA
Energetics (ug/kg)							
HMX	454 U	476 U	476 U	500 U	500 U	NA	NA
Pesticides/PCBs (ug/kg)							
gamma-Chlordane	NA	1.9 U	NA	1.6 U	NA	NA	NA
Heptachlor	NA	1.3 BU	NA	1.4 J	NA	NA	NA
Inorganics (mg/kg)							
Aluminum	4490 J	12500 J	1420 J	11700	10100	NA	NA
Arsenic	2.3 U	3.5 J	20.2 J	5.0 J	1.5 J	NA	NA
Barium	40.1	85.1	11.3	35.3	47.6	NA	NA
Beryllium	0.43 J	0.52 J	0.22 U	0.48 U	0.76 J	NA	NA
Cadmium	0.05	0.07 J	0.20	0.05 UJ	0.05 UJ	NA	NA
Calcium	385 J	510 J	222 J	271	427	NA	NA
Chromium	11.0 J	15.3 J	6.8 J	18.6	14.6	NA	NA
Cobalt	8.2 J	2.3 J	0.60 U	4.3	5.5	NA	NA
Copper	8.9 J	9.1 J	6.5 J	11.3 J	13.4 J	NA	NA
Iron	7420	19100	7360	26100	25400	NA	NA
Lead	10.5	12.1	8.4	14.7	11.6	NA	NA
Magnesium	909 J	1240 J	193 J	1380	1050	NA	NA
Manganese	109 J	48.1 J	8.6 J	172	36.8	NA	NA
Mercury	0.02 U	0.02 U	0.02 U	0.03 U	0.03 U	NA	NA
Nickel	12.1 J	5.8 J	1.6 J	7.5	10.4	NA	NA
Potassium	594 J	382 J	233 J	488 J	460 J	NA	NA
Selenium	0.33 U	0.55 U	0.31 U	0.37 U	0.40	NA	NA
Sodium	426 J	446 J	321 J	399	456	NA	NA
Strontium	4.3 J	6.7 J	2.1 J	5.3 J	7.1 J	NA	NA
Thallium	0.99	1.7 J	0.94	2.1	2.6	NA	NA
Thorium-Calc	3.85	2.436364	3.922727	1.872727	4.277273	3.527273	4.113636

TABLE 4-2

SUMMARY OF CHEMICALS DETECTED IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SB18	01SB19	01SB19	01SB20	01SB20	01SB21	01SB21
Sample	01SB180610	01SB190206	01SB190610	01SB200206	01SB200610	01SB210206	01SB210610
Matrix	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil	Subsurface Soil
Depth Range (bgs)	6 - 8	2 - 6	6 - 8	2 - 6	6 - 8	0 - 2	6 - 10
Risk	Site	Site	Site	Site	Site	Background	Background
Sample Date	8/24/2001	8/24/2001	8/24/2001	8/21/2001	8/21/2001	8/21/2001	8/21/2001
Tin	23.9 U	27.0 U	22.5 U	3.3	3.2	NA	NA
Vanadium	8.2	28.1	10.3	32.1	21.3	NA	NA
Zinc	37.0 J	20.4 J	9.3 J	26.7	42.6	NA	NA
Miscellaneous Parameters							
Cation Exchange Capacity (meq/100g)	NA	NA	NA	11.5	20.1	NA	NA
pH (S.U.)	NA	NA	NA	5.0 J	5.1 J	NA	NA
Total Radionuclides (pCi/g)							
Actinium-228	NA	NA	NA	NA	NA	NA	NA
Bismuth-212	NA	NA	NA	NA	NA	NA	NA
Bismuth-214	NA	NA	NA	NA	NA	NA	NA
Europium-155	NA	NA	NA	NA	NA	NA	NA
Lead-210	NA	NA	NA	NA	NA	NA	NA
Lead-212	NA	NA	NA	NA	NA	NA	NA
Lead-214	NA	NA	NA	NA	NA	NA	NA
Potassium-40	NA	NA	NA	NA	NA	NA	NA
Radium-226	NA	NA	NA	NA	NA	NA	NA
Thallium-208	NA	NA	NA	NA	NA	NA	NA
Thorium-228	0.467	0.226	0.485	0.167	0.392	0.387	0.450
Thorium-230	0.0747 U	0.0148 U	0.126 U	0.0418	0.136	0.289	0.254
Thorium-232	0.380	0.310	0.378	0.245	0.549	0.389	0.455
Thorium-234	NA	NA	NA	NA	NA	NA	NA

Calc = Calculated value.
NA = Not analyzed
U - Indicates that the chemical was not detected at the numerical detection limit (sample-specific quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.
UJ - Indicates that the chemical was not detected. However, the detection limit (sample-specific quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.
J - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The laboratory-reported concentration is considered to be an estimate of the true concentration.
UR - Indicates that the chemical may or may not be present. The nondetected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration noncompliances, and extremely low quality control recoveries).
BU - Indicates that the chemical was detected in this sample as well as the associated laboratory method blank, but has been qualified non-detected result as a laboratory blank contamination (i.e., concentration was less than the blank action level).
bgs - below ground surface.
MEQ - milliequivalents
S.U. - Standard units.

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-01	01-01	01-02	01-02	01-03	01-03	01-03	01-04	01-04	01-05	01-05
Nsample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Sample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/6/2001	6/2/2002	9/8/2001	6/17/2002	9/7/2001	9/7/2001	6/1/2002	8/28/2001	6/1/2002	9/19/2001	6/15/2002
VOCs (ug/L)											
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	500 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	38000	30	0.5 U	NA	0.5 U	0.5 U	0.5 U	9 J	8
1,1,2-Trichloroethane	1 UJ	1 U	1000 U	0.6 J	1 U	NA	1 U	1 U	1 U	9 J	11
1,1-Dichloroethene	1 U	1 U	1000 U	1 U	1 U	NA	1 U	1 U	1 U	0.2 J	1 U
1,2-Dichloroethane	0.5 U	0.5 U	500 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	0.5 U	0.5 U	840 J	1	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.2 BU	0.5 U
cis-1,2-Dichloroethene	1 UJ	1 U	1000 U	1 U	1 U	NA	1 U	1 U	1 U	2 J	2
Ethene	NA	NA	NA	1 U	NA	NA	NA	NA	NA	NA	NA
Methane	NA	NA	NA	1 UJ	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	1 BU	1 UJ	1000 U	1 UJ	0.3 BU	NA	1 UJ	5 BU	1 UJ	1 U	1 UJ
Tetrachloroethene	0.5 U	0.5 U	370 J	1	0.5 U	NA	0.5 U	0.5 U	0.5 U	2 J	2
Toluene	0.5 U	0.5 U	500 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	1 U	1 U	1000 U	1 U	1 U	NA	1 U	1 U	1 U	0.3 J	1 U
Trichloroethene	0.5 U	0.5 U	16000	20	0.5 U	NA	0.5 U	0.5 U	0.5 U	550 J	840
SVOCs (ug/L)											
4-Nitrophenol	25 U	NA	25 U	NA	25 U	NA	NA	25 U	NA	15 J	NA
Acenaphthene	0.2 UJ	NA	0.2 U	NA	0.2 U	NA	NA	0.0793 J	NA	0.2 U	NA
Acenaphthylene	0.2 U	NA	0.763	NA	0.2 U	NA	NA	0.2 U	NA	0.2 U	NA
bis(2-Ethylhexyl) phthalate	7 J	NA	5 U	NA	5 U	NA	NA	5 U	NA	5 U	NA
Butyl Benzyl Phthalate	5 U	NA	5 U	NA	5 U	NA	NA	5 U	NA	5 U	NA
Fluorene	0.2 U	NA	0.0593 J	NA	0.2 U	NA	NA	0.2 U	NA	0.2 U	NA
Hexachloroethane	5 U	NA	5 J	NA	5 U	NA	NA	5 U	NA	5 U	NA
Naphthalene	0.2 U	NA	0.579	NA	0.2 U	NA	NA	0.2 U	NA	0.2 U	NA
Energertics (ug/L)											
2,4,6-Trinitrotoluene	0.65 U	NA	0.65 U	NA	0.65 U	NA	NA	0.65 U	NA	0.65 U	NA
2-Nitrotoluene	0.65 U	NA	0.202 J	NA	0.65 U	NA	NA	0.65 U	NA	0.65 U	NA
4-Amino-2,6-Dinitrotoluene	0.65 U	NA	0.65 U	NA	0.65 U	NA	NA	0.65 U	NA	0.263 J	NA
HMX	0.201 J	NA	0.65 U	NA	0.65 U	NA	NA	0.65 U	NA	0.65 U	NA
Pesticides/PCBs (ug/L)											
gamma-Chlordane	0.025 J	NA	0.04 U	NA	0.075 J	NA	NA	0.04 U	NA	0.04 U	NA
Heptachlor	0.042 BU	NA	0.04 U	NA	0.059 U	NA	NA	0.013 BU	NA	0.05 BU	NA
Total Metals (ug/L)											
Aluminum	68.8	NA	40.2 U	21.2 U	5700	NA	NA	40.2 U	NA	40.3 U	NA
Antimony	1.6 U	NA	1.6 U	5.1 U	1.6 U	NA	NA	1.9	NA	3.0	NA
Arsenic	1.5 U	NA	1.5 U	2.2 U	7.9	NA	NA	2.5 U	NA	1.5 U	NA
Barium	29.1	NA	134	32.4 J	258	NA	NA	17.1	NA	25.0	NA
Beryllium	0.40 U	NA	0.40 U	0.30 U	0.59	NA	NA	0.40 U	NA	0.40 U	NA
Cadmium	0.30 U	NA	0.74	0.60 U	0.94	NA	NA	0.30 U	NA	0.30 U	NA
Calcium	105000 J	NA	121000 J	21800	60200 J	NA	NA	89100	NA	196000	NA
Chromium	0.60 U	NA	0.61 U	0.80 U	7.1 J	NA	NA	0.60 U	NA	0.70 U	NA
Cobalt	11.1	NA	3.1	1.1 U	14.1	NA	NA	1.0 U	NA	3.0	NA
Copper	0.90 U	NA	0.90 U	3.2 U	14.5 J	NA	NA	0.90 U	NA	0.90 U	NA
Iron	1410	NA	22.1	27.0 U	8670	NA	NA	24.9	NA	319	NA
Lead	1.6 U	NA	1.6 U	2.8 U	8.2 J	NA	NA	1.6 U	NA	1.6 U	NA
Magnesium	72400 J	NA	72100 J	8970	18000 J	NA	NA	59800	NA	151000	NA
Manganese	2450 J	NA	434 J	22.0	2670 J	NA	NA	1.5	NA	590	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-01	01-01	01-02	01-02	01-03	01-03	01-03	01-04	01-04	01-05	01-05
Nsample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Sample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/6/2001	6/2/2002	9/8/2001	6/17/2002	9/7/2001	9/7/2001	6/1/2002	8/28/2001	6/1/2002	9/19/2001	6/15/2002
Mercury	0.10 U	NA	0.10 U	0.10 U	0.10 U	NA	NA	0.10 U	NA	0.15	NA
Nickel	10.2 J	NA	41.4 J	3.0	31.9 J	NA	NA	0.70 U	NA	6.9	NA
Potassium	3010	NA	1530	446	4300	NA	NA	1310	NA	2800 J	NA
Silver	3.0 U	NA	3.0 U	1.8 U	3.0 U	NA	NA	3.0 U	NA	0.70 U	NA
Sodium	48500 J	NA	102000 J	5550	10700 J	NA	NA	80800	NA	117000	NA
Strontium	265 J	NA	257 J	75.2 J	158 J	NA	NA	148 J	NA	347 J	NA
Thallium	5.0 UJ	NA	5.0 UJ	0.60 U	5.0 UJ	NA	NA	5.0 U	NA	4.1	NA
Thorium-Calc	0.605454 U	NA	1.454545 U	NA	0.362727 U	0.404091 U	NA	0.585 U	NA	0.809773	NA
Vanadium	3.0 U	NA	3.0 U	0.80 U	11.8	NA	NA	3.0 U	NA	0.50 U	NA
Zinc	11.3 U	NA	61.9 J	8.3 U	43.8 U	NA	NA	1.1 U	NA	1.7 U	NA
Dissolved Metals (ug/L)											
Aluminum	NA	NA	NA	NA	NA	40.2 U	NA	NA	NA	NA	NA
Antimony	NA	NA	NA	NA	NA	1.6 U	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA	2.3	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA	215	NA	NA	NA	NA	NA
Calcium	NA	NA	NA	NA	NA	60500 J	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA	0.60 U	NA	NA	NA	NA	NA
Cobalt	NA	NA	NA	NA	NA	8.3	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	288	NA	NA	NA	NA	NA
Magnesium	NA	NA	NA	NA	NA	16600 J	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA	2740 J	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA	0.10 U	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	17.7 J	NA	NA	NA	NA	NA
Potassium	NA	NA	NA	NA	NA	3630	NA	NA	NA	NA	NA
Sodium	NA	NA	NA	NA	NA	7100 J	NA	NA	NA	NA	NA
Strontium	NA	NA	NA	NA	NA	153 J	NA	NA	NA	NA	NA
Thallium	NA	NA	NA	NA	NA	5.0 UJ	NA	NA	NA	NA	NA
Vanadium	NA	NA	NA	NA	NA	3.0 U	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA	6.2 U	NA	NA	NA	NA	NA
Total Radionuclides (pCi/L)											
Gross Alpha	4.82 J	NA	3.00 UJ	NA	1.50 J	NA	NA	2.05 J	NA	3.35 U	NA
Gross Beta	11.8 J	NA	3.18	NA	6.79	NA	NA	4.86 U	NA	4.46 U	NA
Thorium-228	0.0875 U	NA	0.166 U	NA	0.0399 U	0.0528 U	NA	0.108 U	NA	0.0863 U	NA
Thorium-232	0.0457 U	NA	0.154 U	NA	0.0399 U	0.0361 U	NA	0.0207 U	NA	0.135	NA
Miscellaneous Parameters (mg/L)											
Chloride	NA	NA	NA	4.1	NA	NA	NA	NA	NA	NA	NA
Hardness	560.3	NA	599.0	91.4	224.4	NA	NA	468.7	NA	1111.2	NA
Hardness, Filtered	NA	NA	NA	NA	NA	219.4	NA	NA	NA	NA	NA
Total Organic Carbon	4.5 J	NA	7.8 J	3.6 J	35.3 J	NA	NA	3.7	NA	4.78	NA
Field Parameters (mg/L)											
Alkalinity	NA	NA	NA	50	NA	NA	NA	NA	NA	NA	NA
Carbon Dioxide	NA	NA	NA	75	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	0.95	NA	1.6	4.5	0.84	NA	NA	0.63	NA	2.37	NA
Dissolved Oxygen - Meter	NA	1.28	NA	7.57	NA	NA	6.77	NA	5.61	NA	9.06
Ferrous Iron	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA
Hydrogen Sulfide	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA
Manganese(+2)	NA	NA	NA	0.4	NA	NA	NA	NA	NA	NA	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-01	01-01	01-02	01-02	01-03	01-03	01-03	01-04	01-04	01-05	01-05
Nsample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Sample	01GW0101	01GW0102	01GW0201	01GW0202	01GW0301	01GW0301-F	01GW0302	01GW0401	01GW0402	01GW0501	01GW0502
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/6/2001	6/2/2002	9/8/2001	6/17/2002	9/7/2001	9/7/2001	6/1/2002	8/28/2001	6/1/2002	9/19/2001	6/15/2002
Nitrate	NA	NA	NA	0.08	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	0.008	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	25	NA	NA	NA	NA	NA	NA	NA
Sulfide	NA	NA	NA	0.01	NA	NA	NA	NA	NA	NA	NA
Field Parameters											
Oxidation Reduction Potential (MV)	393	168	480	488	-152	NA	-6	490	575	490.4	50
pH (S.U.)	6.00	5.77	6.17	5.89	6.26	NA	6.58	6.7	6	6	6.86
Specific Conductance (MS/CM)	1.007	0.873	1.659	0.209	0.486	NA	0.207	0.922	1.466	2.37	2.112
Temperature (C)	15.38	14.8	17.5	15.1	17.4	NA	12.77	18.7	16.62	15.46	12.93
Turbidity (NTU)	4.7	4.3	3.3	2	14	NA	21	1.5	0.1	2.6	4.2

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-06	01-06	01-07	01-08	01-08	01-09	01-09	01-10	01-10	01-10	01-11
Nsample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Sample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/4/2001	6/2/2002	9/18/2001	9/18/2001	6/3/2002	9/7/2001	6/3/2002	9/8/2001	9/8/2001	6/11/2002	8/22/2001
VOCs (ug/L)											
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	3
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 UJ	3	0.5 U	0.5 U	0.5 U	NA	0.5 U	170
1,1,2-Trichloroethane	1 U	1 U	1 U	0.6 J	3	1 U	1 U	1 U	NA	1 U	5
1,1-Dichloroethene	1 U	1 U	1 U	1 UJ	1 U	1 U	1 U	1 U	NA	1 U	0.7 J
1,2-Dichloroethane	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	4
Chloroform	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	15
cis-1,2-Dichloroethene	1 U	1 U	1 U	1 UJ	1 U	1 U	1 U	1 U	NA	1 U	5
Ethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	3 BU	1 UJ	1 U	1 UJ	1 UJ	0.8 BU	1 UJ	0.5 U	NA	1 UJ	6 BU
Tetrachloroethene	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	6
Toluene	0.5 U	0.5 U	1	0.5 UJ	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U
trans-1,2-Dichloroethene	1 U	1 U	1 U	1 UJ	1 U	1 U	1 U	1 U	NA	1 U	2
Trichloroethene	0.5 U	0.5 U	0.5 U	4 J	7	0.5 U	0.5 U	0.4 J	NA	0.5 U	180 J
SVOCs (ug/L)											
4-Nitrophenol	25 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	25 U
Acenaphthene	0.2 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0896 J
Acenaphthylene	0.2 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U
bis(2-Ethylhexyl) phthalate	5 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	15 J
Butyl Benzyl Phthalate	5 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	9 J
Fluorene	0.2 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U
Hexachloroethane	5 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	5 U
Naphthalene	0.0796 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.103 J
Energertics (ug/L)											
2,4,6-Trinitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U
2-Nitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U
4-Amino-2,6-Dinitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U
HMX	0.171 R	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U
Pesticides/PCBs (ug/L)											
gamma-Chlordane	0.04 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04 U
Heptachlor	0.049 BU	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.023 J
Total Metals (ug/L)											
Aluminum	40.2 U	NA	1330	40.3 U	NA	162	NA	40.2 U	NA	NA	1370 J
Antimony	1.6 U	NA	1.6 U	1.6 U	NA	1.6 U	NA	2.1 U	NA	NA	4.7 U
Arsenic	3.2 U	NA	2.7	1.5 U	NA	1.5 U	NA	1.5 U	NA	NA	3.6
Barium	21.3	NA	156	19.4	NA	16.0	NA	41.7	NA	NA	45.4
Beryllium	0.40 U	NA	0.40 U	0.40 U	NA	0.40 U	NA	0.40 U	NA	NA	0.70 U
Cadmium	0.30 U	NA	0.30 U	0.30 U	NA	0.30 U	NA	0.30 U	NA	NA	0.41 U
Calcium	170000	NA	77100	66100	NA	39800 J	NA	113000 J	NA	NA	95100
Chromium	0.60 U	NA	1.5	0.70 U	NA	0.98 U	NA	0.60 U	NA	NA	3.6 U
Cobalt	1.0 U	NA	6.4	2.7	NA	1.2	NA	2.7	NA	NA	17.8
Copper	0.90 U	NA	2.9	0.90 U	NA	0.90 U	NA	0.90 U	NA	NA	2.6 U
Iron	398	NA	1410	6370	NA	624	NA	673	NA	NA	1160 J
Lead	1.6 U	NA	1.6 U	1.6 U	NA	1.6 U	NA	1.6 U	NA	NA	0.70 U
Magnesium	156000	NA	22000	23400	NA	10400 J	NA	20400 J	NA	NA	5780 J
Manganese	37.9	NA	1500	886	NA	144 J	NA	987 J	NA	NA	303 J

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-06	01-06	01-07	01-08	01-08	01-09	01-09	01-10	01-10	01-10	01-11
Nsample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Sample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/4/2001	6/2/2002	9/18/2001	9/18/2001	6/3/2002	9/7/2001	6/3/2002	9/8/2001	9/8/2001	6/11/2002	8/22/2001
Mercury	0.10 U	NA	0.24	0.13	NA	0.10 U	NA	0.10 U	NA	NA	0.13 U
Nickel	2.6	NA	17.6	4.1	NA	11.5 J	NA	8.5 J	NA	NA	10.5
Potassium	2790	NA	10400 J	2370 J	NA	1170	NA	2070	NA	NA	1350 J
Silver	3.0 U	NA	1.1	0.71	NA	3.0 U	NA	3.0 U	NA	NA	0.65 J
Sodium	17200	NA	12500	6100	NA	3070 J	NA	7900 J	NA	NA	5830 J
Strontium	958 J	NA	576 J	211 J	NA	76.5 J	NA	214 J	NA	NA	98.8 J
Thallium	5.0 U	NA	4.6	3.6	NA	5.0 UJ	NA	5.0 UJ	NA	NA	3.9 U
Thorium-Calc	0.328864	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.228182
Vanadium	3.0 U	NA	1.1	0.50 U	NA	3.0 U	NA	3.0 U	NA	NA	3.3 U
Zinc	1.1 U	NA	8.6	8.2	NA	9.4 U	NA	3.6 U	NA	NA	27.4
Dissolved Metals (ug/L)											
Aluminum	NA	NA	NA	NA	NA	NA	NA	NA	40.2 U	NA	NA
Antimony	NA	NA	NA	NA	NA	NA	NA	NA	3.1 U	NA	NA
Arsenic	NA	NA	NA	NA	NA	NA	NA	NA	1.5 U	NA	NA
Barium	NA	NA	NA	NA	NA	NA	NA	NA	41.0	NA	NA
Calcium	NA	NA	NA	NA	NA	NA	NA	NA	115000 J	NA	NA
Chromium	NA	NA	NA	NA	NA	NA	NA	NA	0.60 U	NA	NA
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	2.4	NA	NA
Iron	NA	NA	NA	NA	NA	NA	NA	NA	414	NA	NA
Magnesium	NA	NA	NA	NA	NA	NA	NA	NA	20400 J	NA	NA
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	1010 J	NA	NA
Mercury	NA	NA	NA	NA	NA	NA	NA	NA	0.10 U	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA	8.7 J	NA	NA
Potassium	NA	NA	NA	NA	NA	NA	NA	NA	1990	NA	NA
Sodium	NA	NA	NA	NA	NA	NA	NA	NA	7640 J	NA	NA
Strontium	NA	NA	NA	NA	NA	NA	NA	NA	212 J	NA	NA
Thallium	NA	NA	NA	NA	NA	NA	NA	NA	5.0 UJ	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	3.0 U	NA	NA
Zinc	NA	NA	NA	NA	NA	NA	NA	NA	7.0 U	NA	NA
Total Radionuclides (pCi/L)											
Gross Alpha	5.26 J	NA	1.08 U	1.49 J	NA	1.87 J	NA	2.46 J	NA	NA	4.76 J
Gross Beta	5.16 U	NA	14.2	2.58	NA	2.32 U	NA	3.53	NA	NA	8.28 J
Thorium-228	0.0408	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0329
Thorium-232	0.0631 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0346 U
Miscellaneous Parameters (mg/L)											
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hardness	1066.9	NA	283.1	261.4	NA	142.2	NA	366.2	NA	NA	261.3
Hardness, Filtered	NA	NA	NA	NA	NA	NA	NA	NA	371.2	NA	NA
Total Organic Carbon	6.21	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Field Parameters (mg/L)											
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Dioxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	0.69	NA	0.38	0.39	NA	0.71	NA	0.72	NA	NA	1.01
Dissolved Oxygen - Meter	NA	2.56	NA	NA	0.73	NA	1.55	NA	NA	1.76	NA
Ferrous Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen Sulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese(+2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-06	01-06	01-07	01-08	01-08	01-09	01-09	01-10	01-10	01-10	01-11
Nsample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Sample	01GW0601	01GW0602	01GW0701	01GW0801	01GW0802	01GW0901	01GW0902	01GW1001	01GW1001-F	01GW1002	01GW1101
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/4/2001	6/2/2002	9/18/2001	9/18/2001	6/3/2002	9/7/2001	6/3/2002	9/8/2001	9/8/2001	6/11/2002	8/22/2001
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Field Parameters											
Oxidation Reduction Potential (MV)	109	142	221.5	39.6	-51	618.1	433	71	NA	-16	444.8
pH (S.U.)	5.25	6.61	6.9	6.28	6.75	4.41	5.26	6.33	NA	6.87	5.74
Specific Conductance (MS/CM)	1.67	1.466	0.518	0.546	0.404	0.272	0.088	0.699	NA	0.812	0.444
Temperature (C)	14.62	14.98	13.86	14.39	13.29	15.4	14.47	21.89	NA	15.1	17.15
Turbidity (NTU)	2.6	1.3	4.9	5	4.2	4.8	8.3	8.9	NA	2.4	27

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-11	01-11	01-12	01-13	01-13	01-14	01-14	01-15	01-15	01-17	01-18
Nsample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Sample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/22/2001	6/14/2002	9/5/2001	9/5/2001	9/5/2001	8/24/2001	6/5/2002	9/5/2001	6/15/2002	9/19/2001	9/20/2001
VOCs (ug/L)											
1,1,1,2-Tetrachloroethane	NA	0.5 U	7 U	0.5 U	NA	0.5 U	0.5 U	13 U	1	0.3 J	0.5 U
1,1,2,2-Tetrachloroethane	NA	1	230	9 J	NA	8	0.5 U	250	230	10 J	0.3 J
1,1,2-Trichloroethane	NA	1 U	13 U	1 U	NA	0.4 J	1 U	14 J	16	0.8 J	1 U
1,1-Dichloroethene	NA	1 U	13 U	1 U	NA	1 U	1 U	25 U	1	0.4 J	1 U
1,2-Dichloroethane	NA	0.5 U	7 U	0.5 U	NA	0.3 J	0.5 U	13 U	9	1 J	0.5 U
Chloroform	NA	0.7 J	9 BJ	0.5 BU	NA	0.1 J	0.5 U	18 U	6	4 J	0.5 U
cis-1,2-Dichloroethene	NA	1 U	13 U	1 U	NA	0.9 J	1	25 U	9	1 J	1 U
Ethene	NA	1 U	NA	NA	NA	NA	NA	NA	1 U	NA	NA
Methane	NA	1 UJ	NA	NA	NA	NA	NA	NA	24 J	NA	NA
Methylene Chloride	NA	1 J	5 BU	0.5 BU	NA	2 BU	1 UJ	53 BU	1 UJ	1 U	0.2 J
Tetrachloroethene	NA	2	7 U	0.5 U	NA	0.5 U	0.5 U	13 U	5	1 J	0.5 U
Toluene	NA	0.7 J	7 U	0.5 U	NA	0.5 U	0.5 U	13 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	NA	1 U	13 U	1 U	NA	0.3 J	0.4 J	25 U	3	0.7 J	1 U
Trichloroethene	NA	15	190	8 J	NA	20	26	310	360	45 J	5 J
SVOCs (ug/L)											
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	25 U	25 U
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U	0.2 U
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U	0.2 U
bis(2-Ethylhexyl) phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	5 J	5 U
Butyl Benzyl Phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	5 U	5 U
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U	0.2 U
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	5 U	5 U
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.2 U	0.2 U
Energertics (ug/L)											
2,4,6-Trinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.127 J	0.65 U
2-Nitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U	0.65 U
4-Amino-2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U	0.65 U
HMX	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65 U	0.65 U
Pesticides/PCBs (ug/L)											
gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.04 U	0.04 U
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.041 BU	0.032 BU
Total Metals (ug/L)											
Aluminum	NA	180 J	447	40.2 U	NA	40.2 U	NA	46.3	21.2 U	40.3 U	249
Antimony	NA	5.1 U	1.6 U	1.6 U	NA	4.1 U	NA	3.1	5.1 U	1.6 U	2.0
Arsenic	NA	2.2 U	1.5 U	1.5 U	NA	1.5 U	NA	1.5 U	2.2 U	1.5 U	1.5 U
Barium	NA	21.8 J	15.0	24.9	NA	15.1	NA	24.3	29.9 J	9.7	26.5
Beryllium	NA	0.30 U	0.40 U	0.40 U	NA	0.40 U	NA	0.40 U	0.30 U	0.40 U	0.40 U
Cadmium	NA	0.60 U	0.30 U	0.30 U	NA	0.30 U	NA	0.30 U	0.60 U	0.30 U	0.30 U
Calcium	NA	7640	86000	107000	NA	154000 J	NA	145000	162000	46000	93800
Chromium	NA	0.80 U	1.7 U	0.60 U	NA	0.60 UJ	NA	0.60 U	0.80 U	0.83	0.79
Cobalt	NA	1.1 U	1.9	4.6	NA	27.8 J	NA	10.8	4.3 U	1.9	4.3
Copper	NA	3.2 U	0.90 U	0.90 U	NA	0.90 U	NA	0.90 U	3.2 U	0.90 U	0.90 U
Iron	NA	151	487	488	NA	44600	NA	16700	11600	89.6	4090
Lead	NA	2.8 U	1.6 U	1.6 U	NA	1.6 U	NA	1.6 U	2.8 U	1.6 U	1.6 U
Magnesium	NA	2720	25000	17800	NA	59200 J	NA	48600	52300	36500	16300
Manganese	NA	14.9	401	647	NA	6050 J	NA	3860	1970	4.7	736

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-11	01-11	01-12	01-13	01-13	01-14	01-14	01-15	01-15	01-17	01-18
Nsample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Sample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/22/2001	6/14/2002	9/5/2001	9/5/2001	9/5/2001	8/24/2001	6/5/2002	9/5/2001	6/15/2002	9/19/2001	9/20/2001
Mercury	NA	0.10 U	0.10 U	0.10 U	NA	0.10 U	NA	0.10 U	0.10 U	0.12	0.10 U
Nickel	NA	2.7 U	64.7	19.5	NA	52.2	NA	12.7	5.1	0.70 U	4.3
Potassium	NA	797	1340	1330	NA	2560 J	NA	1980	2450	1200 J	1720 J
Silver	NA	1.8 U	3.0 U	3.0 U	NA	3.0 U	NA	3.0 U	1.8 U	0.90	0.88
Sodium	NA	1510	14800	7290	NA	54700 J	NA	35200	49900	61700	27000
Strontium	NA	33.1 J	132 J	132 J	NA	277 J	NA	253 J	310 J	124 J	109 J
Thallium	NA	1.3 U	5.0 U	5.0 U	NA	5.0 U	NA	5.0 U	0.60 U	5.1	2.5
Thorium-Calc	0.377273 U	NA	NA	NA	NA	NA	NA	NA	NA	0.578636 U	0.683182 U
Vanadium	NA	0.80 U	3.0 U	3.0 U	NA	3.0 U	NA	3.0 U	0.80 U	0.50 U	0.75
Zinc	NA	8.3 U	23.2	17.9	NA	24.0 U	NA	1.1 U	8.3 U	1.7 U	4.3
Dissolved Metals (ug/L)											
Aluminum	87.0 U	NA	NA	NA	40.2 U	NA	NA	NA	NA	NA	NA
Antimony	2.1 U	NA	NA	NA	1.6 U	NA	NA	NA	NA	NA	NA
Arsenic	3.0 U	NA	NA	NA	2.1 U	NA	NA	NA	NA	NA	NA
Barium	36.2	NA	NA	NA	23.5	NA	NA	NA	NA	NA	NA
Calcium	93100	NA	NA	NA	102000	NA	NA	NA	NA	NA	NA
Chromium	1.0 U	NA	NA	NA	0.60 U	NA	NA	NA	NA	NA	NA
Cobalt	1.0 U	NA	NA	NA	3.0	NA	NA	NA	NA	NA	NA
Iron	51.7 J	NA	NA	NA	252	NA	NA	NA	NA	NA	NA
Magnesium	5430 J	NA	NA	NA	17100	NA	NA	NA	NA	NA	NA
Manganese	22.4 J	NA	NA	NA	538	NA	NA	NA	NA	NA	NA
Mercury	0.14 U	NA	NA	NA	0.10 U	NA	NA	NA	NA	NA	NA
Nickel	4.9 U	NA	NA	NA	16.1	NA	NA	NA	NA	NA	NA
Potassium	1100 J	NA	NA	NA	1270	NA	NA	NA	NA	NA	NA
Sodium	5000 J	NA	NA	NA	7130	NA	NA	NA	NA	NA	NA
Strontium	96.5 J	NA	NA	NA	128 J	NA	NA	NA	NA	NA	NA
Thallium	3.9 U	NA	NA	NA	5.0 U	NA	NA	NA	NA	NA	NA
Vanadium	0.30 U	NA	NA	NA	3.0 U	NA	NA	NA	NA	NA	NA
Zinc	9.4 U	NA	NA	NA	13.5	NA	NA	NA	NA	NA	NA
Total Radionuclides (pCi/L)											
Gross Alpha	NA	NA	2.04 J	1.68 J	NA	5.57	NA	3.92 J	NA	1.24 U	2.30 J
Gross Beta	NA	NA	3.81 U	3.28 U	NA	6.38	NA	9.25 J	NA	1.58 U	2.78
Thorium-228	0.0493 U	NA	NA	NA	NA	NA	NA	NA	NA	0.0710 U	0.0893 U
Thorium-232	0.0337 U	NA	NA	NA	NA	NA	NA	NA	NA	0.0563 U	0.0610 U
Miscellaneous Parameters (mg/L)											
Chloride	NA	0.60	NA	NA	NA	NA	NA	NA	56.8	NA	NA
Hardness	NA	30.3	317.7	340.5	NA	628.3	NA	562.2	619.9	265.2	301.3
Hardness, Filtered	254.8	NA	NA	NA	325.1	NA	NA	NA	NA	NA	NA
Total Organic Carbon	NA	2.9 J	NA	NA	NA	NA	NA	NA	4.4 J	NA	NA
Field Parameters (mg/L)											
Alkalinity	NA	15	NA	NA	NA	NA	NA	NA	250	NA	NA
Carbon Dioxide	NA	60	NA	NA	NA	NA	NA	NA	58	NA	NA
Dissolved Oxygen	NA	2	1.56	0.38	NA	0.08	NA	0.702	0.3	2.82	0.86
Dissolved Oxygen - Meter	NA	3.55	NA	NA	NA	NA	2.41	NA	8.35	NA	NA
Ferrous Iron	NA	0.01	NA	NA	NA	NA	NA	NA	8.8	NA	NA
Hydrogen Sulfide	NA	0	NA	NA	NA	NA	NA	NA	0	NA	NA
Manganese(+2)	NA	0.7	NA	NA	NA	NA	NA	NA	1.7	NA	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-11	01-11	01-12	01-13	01-13	01-14	01-14	01-15	01-15	01-17	01-18
Nsample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Sample	01GW1101-F	01GW1102	01GW1201	01GW1301	01GW1301-F	01GW1401	01GW1402	01GW1501	01GW1502	01GW1701	01GW1801
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/22/2001	6/14/2002	9/5/2001	9/5/2001	9/5/2001	8/24/2001	6/5/2002	9/5/2001	6/15/2002	9/19/2001	9/20/2001
Nitrate	NA	0.29	NA	NA	NA	NA	NA	NA	0	NA	NA
Nitrite	NA	0	NA	NA	NA	NA	NA	NA	0	NA	NA
Sulfate	NA	12	NA	NA	NA	NA	NA	NA	> 80	NA	NA
Sulfide	NA	0.01	NA	NA	NA	NA	NA	NA	0	NA	NA
Field Parameters											
Oxidation Reduction Potential (MV)	NA	562	466	206	NA	-156	-57	75.2	-71	474	93.8
pH (S.U.)	NA	5.32	5.89	6.44	NA	6.50	6.34	6.59	6.42	5.54	6.94
Specific Conductance (MS/CM)	NA	0.065	0.643	0.608	NA	1.47	1.083	1.352	1.396	0.824	0.768
Temperature (C)	NA	16.17	18.3	16.34	NA	16.5	14.24	14.74	16.92	16.5	16.77
Turbidity (NTU)	NA	4.4	4.1	6	NA	4	16	3.9	2	3.7	31

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-18	01-19	01-20	01-20	01-21	01-22	01-23	01-23	01-23 [1]	01-23	01-24
Nsample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301RE	01GW2302	01GW2401
Sample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301	01GW2302	01GW2401
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/20/2001	9/18/2001	9/20/2001	9/20/2001	9/5/2001	9/19/2001	9/7/2001	9/7/2001	9/7/2001	6/4/2002	9/20/2001
VOCs (ug/L)											
1,1,1,2-Tetrachloroethane	NA	5 J	0.5 U	NA	0.5 U	2 J	0.5 U	NA	NA	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	NA	270	30 J	NA	0.5 U	150 J	0.5 U	NA	NA	0.5 U	0.5 U
1,1,2-Trichloroethane	NA	9 J	0.6 J	NA	1 U	4 J	1 U	NA	NA	1 U	1 U
1,1-Dichloroethene	NA	2 J	1 U	NA	1 U	0.8 J	1 U	NA	NA	1 U	1 U
1,2-Dichloroethane	NA	10 J	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	NA	0.5 U	0.5 U
Chloroform	NA	27 J	0.5 BU	NA	0.5 U	15 J	0.5 U	NA	NA	0.5 U	0.5 U
cis-1,2-Dichloroethene	NA	8 J	1 U	NA	1 U	4 J	1 U	NA	NA	1 U	1 U
Ethene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	NA	0.4 J	0.3 J	NA	0.5 BU	0.3 J	0.2 U	NA	NA	1 UJ	1 U
Tetrachloroethene	NA	6 J	0.5 U	NA	0.5 U	3 J	0.5 U	NA	NA	0.5 U	0.5 U
Toluene	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	NA	NA	0.5 U	0.5 U
trans-1,2-Dichloroethene	NA	3 J	1 U	NA	1 U	2 J	1 U	NA	NA	1 U	1 U
Trichloroethene	NA	300	30 J	NA	0.5 U	120 J	0.5 U	NA	NA	0.5 U	0.4 J
SVOCs (ug/L)											
4-Nitrophenol	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
bis(2-Ethylhexyl) phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Butyl Benzyl Phthalate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hexachloroethane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Energetics (ug/L)											
2,4,6-Trinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2-Nitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4-Amino-2,6-Dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
HMX	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pesticides/PCBs (ug/L)											
gamma-Chlordane	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Metals (ug/L)											
Aluminum	NA	62.6	40.3 U	NA	40.2 U	40.3 U	40.2 U	NA	NA	NA	107
Antimony	NA	1.6 U	1.6 U	NA	1.6 U	1.6 U	1.6 U	NA	NA	NA	1.6 U
Arsenic	NA	1.5 U	1.5 U	NA	1.5 U	1.5 U	1.5 U	NA	NA	NA	1.5 U
Barium	NA	9.5	13.4	NA	30.3	9.9	5.4 J	NA	NA	NA	88.1
Beryllium	NA	0.40 U	0.40 U	NA	0.40 U	0.40 U	0.40 U	NA	NA	NA	0.40 U
Cadmium	NA	0.30 U	0.30 U	NA	0.30 U	0.30 U	0.30 U	NA	NA	NA	0.30 U
Calcium	NA	110000	244000	NA	128000	112000	282000 J	NA	NA	NA	75800
Chromium	NA	1.6	1.2	NA	0.60 U	0.70	0.60 U	NA	NA	NA	0.70 U
Cobalt	NA	1.0 U	1.6	NA	1.0 U	1.0 U	1.0 U	NA	NA	NA	6.6
Copper	NA	0.90 U	0.90 U	NA	0.90 U	0.90 U	0.90 UJ	NA	NA	NA	0.94
Iron	NA	134	158	NA	15300	20.3 U	1050	NA	NA	NA	4460
Lead	NA	1.6 U	1.6 U	NA	1.6 U	1.6 U	1.6 U	NA	NA	NA	1.6 U
Magnesium	NA	45700	148000	NA	64300	50000	139000 J	NA	NA	NA	27300
Manganese	NA	6.0	44.5	NA	977	2.9	446 J	NA	NA	NA	949

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-18	01-19	01-20	01-20	01-21	01-22	01-23	01-23	01-23 [1]	01-23	01-24
Nsample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301RE	01GW2302	01GW2401
Sample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301	01GW2302	01GW2401
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/20/2001	9/18/2001	9/20/2001	9/20/2001	9/5/2001	9/19/2001	9/7/2001	9/7/2001	9/7/2001	6/4/2002	9/20/2001
Mercury	NA	0.12	0.10 U	NA	0.10 U	0.12	0.10 U	NA	NA	NA	0.10
Nickel	NA	2.5	27.3	NA	1.4	2.3	3.5 U	NA	NA	NA	13.6
Potassium	NA	1370 J	5440 J	NA	6060	1320 J	6150	NA	NA	NA	2370 J
Silver	NA	0.87	0.70 U	NA	3.0 U	0.70 U	3.0 U	NA	NA	NA	0.70
Sodium	NA	71600	22000	NA	14800	81900	29300 J	NA	NA	NA	10400
Strontium	NA	137 J	333 J	NA	948 J	185 J	823 J	NA	NA	NA	325 J
Thallium	NA	3.9	5.1	NA	5.0 U	3.0	5.0 UJ	NA	NA	NA	4.4
Thorium-Calc	1.095 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	NA	0.53	0.53	NA	3.0 U	0.50 U	3.0 U	NA	NA	NA	0.58
Zinc	NA	7.0	5.0	NA	1.1 U	3.9	1.1 UJ	NA	NA	NA	3.9
Dissolved Metals (ug/L)											
Aluminum	40.3 U	NA	NA	40.3 U	NA	NA	NA	40.2 U	NA	NA	NA
Antimony	1.6 U	NA	NA	2.1 J	NA	NA	NA	2.3 U	NA	NA	NA
Arsenic	1.5 U	NA	NA	1.5 UJ	NA	NA	NA	1.7 J	NA	NA	NA
Barium	24.8	NA	NA	12.9	NA	NA	NA	5.4 J	NA	NA	NA
Calcium	96600	NA	NA	275000	NA	NA	NA	279000 J	NA	NA	NA
Chromium	0.70 U	NA	NA	1.1	NA	NA	NA	0.60 U	NA	NA	NA
Cobalt	3.2	NA	NA	1.0 U	NA	NA	NA	1.0 U	NA	NA	NA
Iron	748	NA	NA	20.3 U	NA	NA	NA	150	NA	NA	NA
Magnesium	16700	NA	NA	173000	NA	NA	NA	138000 J	NA	NA	NA
Manganese	765	NA	NA	13.7	NA	NA	NA	386 J	NA	NA	NA
Mercury	0.10 U	NA	NA	0.10	NA	NA	NA	0.10 U	NA	NA	NA
Nickel	4.6	NA	NA	27.2	NA	NA	NA	1.4 U	NA	NA	NA
Potassium	1770 J	NA	NA	5480 J	NA	NA	NA	5940	NA	NA	NA
Sodium	27500	NA	NA	23600	NA	NA	NA	28800 J	NA	NA	NA
Strontium	109 J	NA	NA	366 J	NA	NA	NA	807 J	NA	NA	NA
Thallium	5.4	NA	NA	7.7 J	NA	NA	NA	5.0 UJ	NA	NA	NA
Vanadium	0.50 U	NA	NA	0.77	NA	NA	NA	3.0 U	NA	NA	NA
Zinc	7.1	NA	NA	7.6	NA	NA	NA	1.1 UJ	NA	NA	NA
Total Radionuclides (pCi/L)											
Gross Alpha	NA	2.01 U	4.73 U	NA	2.60 J	2.06 U	8.53 J	NA	NA	4.89	1.36 J
Gross Beta	NA	2.52 U	9.81	NA	7.78 J	2.40 U	50.2 J	NA	8.35	12.3	1.99
Thorium-228	0.149 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thorium-232	0.0919 U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous Parameters (mg/L)											
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hardness	NA	462.9	1218.7	NA	584.4	485.6	1276.6	NA	NA	NA	301.7
Hardness, Filtered	310.0	NA	NA	1399.1	NA	NA	NA	1264.9	NA	NA	NA
Total Organic Carbon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Field Parameters (mg/L)											
Alkalinity	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Dioxide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	NA	2.07	2.67	NA	1.19	1.55	1.58	NA	NA	NA	0.54
Dissolved Oxygen - Meter	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.01	NA
Ferrous Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen Sulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese(+2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-18	01-19	01-20	01-20	01-21	01-22	01-23	01-23	01-23 [1]	01-23	01-24
Nsample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301RE	01GW2302	01GW2401
Sample	01GW1801-F	01GW1901	01GW2001	01GW2001-F	01GW2101	01GW2201	01GW2301	01GW2301-F	01GW2301	01GW2302	01GW2401
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/20/2001	9/18/2001	9/20/2001	9/20/2001	9/5/2001	9/19/2001	9/7/2001	9/7/2001	9/7/2001	6/4/2002	9/20/2001
Nitrate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfide	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Field Parameters											
Oxidation Reduction Potential (MV)	NA	434	327	NA	28.1	511	433.2	NA	NA	3	78.5
pH (S.U.)	NA	6.43	7.14	NA	5.61	6.41	4.99	NA	NA	6.28	6.69
Specific Conductance (MS/CM)	NA	1.162	1.567	NA	1.1	1.281	2.161	NA	NA	1.648	0.679
Temperature (C)	NA	16.8	15	NA	14.73	16.46	17.79	NA	NA	15.91	15.02
Turbidity (NTU)	NA	3.4	11	NA	4.2	1.7	30	NA	NA	9.1	2

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-25	01-25	01-25	01-26	01-26	01-26	01-27	01-27	01C01	01C01	01T02
Nsample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Sample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/8/2001	6/14/2002	6/14/2002	9/6/2001	9/6/2001	6/4/2002	9/8/2001	9/8/2001	8/25/2001	6/11/2002	9/19/2001
VOCs (ug/L)											
1,1,1,2-Tetrachloroethane	2 J	1	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	32	24	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5 U	2	NA	1 U	NA	1 U	1 U	NA	1 U	1 U	1 U
1,1-Dichloroethene	5 U	1 U	NA	1 U	NA	1 U	1 U	NA	1 U	1 U	1 U
1,2-Dichloroethane	3 U	2	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
Chloroform	7 J	6	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.3 BU
cis-1,2-Dichloroethene	5 U	2	NA	1 U	NA	1 U	1 U	NA	1 U	1 U	1 U
Ethene	NA	1 U	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methane	NA	1 UJ	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	1 U	1 J	NA	1 U	NA	1 UJ	0.3 BU	NA	1 BU	1 UJ	0.2 J
Tetrachloroethene	3 U	1	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
Toluene	3 U	0.7 J	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.6 J
trans-1,2-Dichloroethene	5 U	0.8 J	NA	1 U	NA	1 U	1 U	NA	1 U	1 U	1 U
Trichloroethene	65 J	74	NA	0.5 U	NA	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.2 J
SVOCs (ug/L)											
4-Nitrophenol	25 U	NA	NA	NA	NA	NA	NA	NA	25 U	NA	25 U
Acenaphthene	0.2 U	NA	NA	NA	NA	NA	NA	NA	0.108 J	NA	0.2 U
Acenaphthylene	0.2 U	NA	NA	NA	NA	NA	NA	NA	0.2 U	NA	0.2 U
bis(2-Ethylhexyl) phthalate	5 U	NA	NA	NA	NA	NA	NA	NA	5 U	NA	5 U
Butyl Benzyl Phthalate	5 U	NA	NA	NA	NA	NA	NA	NA	5 U	NA	5 U
Fluorene	0.2 U	NA	NA	NA	NA	NA	NA	NA	0.2 U	NA	0.2 U
Hexachloroethane	5 U	NA	NA	NA	NA	NA	NA	NA	5 U	NA	5 U
Naphthalene	0.2 U	NA	NA	NA	NA	NA	NA	NA	0.2 U	NA	0.2 U
Energertics (ug/L)											
2,4,6-Trinitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	0.65 U	NA	0.65 U
2-Nitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	0.65 U	NA	0.65 U
4-Amino-2,6-Dinitrotoluene	0.65 U	NA	NA	NA	NA	NA	NA	NA	0.65 U	NA	0.275 J
HMX	0.65 U	NA	NA	NA	NA	NA	NA	NA	0.65 U	NA	0.65 U
Pesticides/PCBs (ug/L)											
gamma-Chlordane	0.04 U	NA	NA	NA	NA	NA	NA	NA	0.04 U	NA	0.04 U
Heptachlor	0.02 U	NA	NA	NA	NA	NA	NA	NA	0.017 J	NA	0.051 BU
Total Metals (ug/L)											
Aluminum	40.2 U	21.2 U	NA	170	NA	NA	163	NA	40.2 U	NA	1580
Antimony	1.6 U	5.1 U	NA	1.7 U	NA	NA	2.6 U	NA	1.6 U	NA	1.6 U
Arsenic	1.5 U	2.2 U	NA	1.5 U	NA	NA	1.5 U	NA	1.6 U	NA	2.2 J
Barium	10.3	10 J	NA	21.2	NA	NA	54.9	NA	39.2	NA	59.0
Beryllium	0.40 U	0.30 U	NA	0.40 U	NA	NA	0.40 U	NA	0.40 U	NA	0.70 J
Cadmium	0.30 U	0.60 U	NA	0.30 U	NA	NA	0.30 U	NA	0.30 U	NA	0.30 UJ
Calcium	120000 J	131000	NA	149000 J	NA	NA	138000 J	NA	72800 J	NA	304000
Chromium	0.60 U	0.80 U	NA	0.60 U	NA	NA	0.62 U	NA	0.80	NA	5.4
Cobalt	1.0 U	1.1 U	NA	4.0	NA	NA	2.6	NA	1.0 U	NA	55.8
Copper	0.90 U	3.2 U	NA	0.90 U	NA	NA	0.98 U	NA	0.90 U	NA	4.9
Iron	20.2 U	27.0 U	NA	3560	NA	NA	941	NA	37.8	NA	19500
Lead	1.6 U	2.8 U	NA	1.6 U	NA	NA	1.6 U	NA	1.6 U	NA	4.3
Magnesium	52800 J	56000	NA	71900 J	NA	NA	62000 J	NA	26500	NA	218000
Manganese	43.3 J	4.0	NA	3410 J	NA	NA	1150 J	NA	24.8 J	NA	8040

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-25	01-25	01-25	01-26	01-26	01-26	01-27	01-27	01C01	01C01	01T02
Nsample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Sample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/8/2001	6/14/2002	6/14/2002	9/6/2001	9/6/2001	6/4/2002	9/8/2001	9/8/2001	8/25/2001	6/11/2002	9/19/2001
Mercury	0.10 U	0.10 U	NA	0.10 U	NA	NA	0.10 U	NA	0.10 U	NA	0.12
Nickel	2.0 U	2.7 U	NA	5.7 U	NA	NA	4.0 U	NA	1.5	NA	115
Potassium	1860	1760	NA	3650	NA	NA	2300	NA	1300 J	NA	14300 J
Silver	3.0 U	1.8 U	NA	3.0 U	NA	NA	3.0 U	NA	3.0 U	NA	0.70 U
Sodium	87000 J	73400	NA	64400 J	NA	NA	57300 J	NA	5710 J	NA	81500
Strontium	209 J	229 J	NA	375 J	NA	NA	266 J	NA	228 J	NA	3820 J
Thallium	5.0 UJ	0.60 U	NA	5.0 UJ	NA	NA	5.0 UJ	NA	5.0 U	NA	2.4 UJ
Thorium-Calc	0.845 U	NA	NA	NA	NA	NA	NA	NA	0.672273 U	NA	1.495455
Vanadium	3.0 U	0.80 U	NA	3.0 U	NA	NA	3.0 U	NA	3.0 U	NA	1.4
Zinc	1.1 U	8.3 U	NA	5.3 U	NA	NA	1.6 U	NA	4.5 U	NA	32.1
Dissolved Metals (ug/L)											
Aluminum	NA	NA	80.5 U	NA	146	NA	NA	40.2 U	NA	NA	NA
Antimony	NA	NA	5.1 U	NA	1.6 U	NA	NA	1.6 U	NA	NA	NA
Arsenic	NA	NA	2.2 U	NA	1.5 U	NA	NA	1.5 U	NA	NA	NA
Barium	NA	NA	9.9 J	NA	21.6	NA	NA	50.4	NA	NA	NA
Calcium	NA	NA	123000	NA	158000 J	NA	NA	136000 J	NA	NA	NA
Chromium	NA	NA	0.80 U	NA	0.60 U	NA	NA	0.60 U	NA	NA	NA
Cobalt	NA	NA	1.1 U	NA	4.0	NA	NA	1.7	NA	NA	NA
Iron	NA	NA	123	NA	3270	NA	NA	416	NA	NA	NA
Magnesium	NA	NA	52700	NA	76500 J	NA	NA	60000 J	NA	NA	NA
Manganese	NA	NA	10.4	NA	3610 J	NA	NA	1070 J	NA	NA	NA
Mercury	NA	NA	0.10 U	NA	0.10 U	NA	NA	0.10 U	NA	NA	NA
Nickel	NA	NA	2.7 U	NA	5.3 U	NA	NA	3.1 U	NA	NA	NA
Potassium	NA	NA	1690	NA	3860	NA	NA	2190	NA	NA	NA
Sodium	NA	NA	70200	NA	66900 J	NA	NA	54100 J	NA	NA	NA
Strontium	NA	NA	192 J	NA	395 J	NA	NA	259 J	NA	NA	NA
Thallium	NA	NA	0.60 U	NA	5.0 UJ	NA	NA	5.0 UJ	NA	NA	NA
Vanadium	NA	NA	0.80 U	NA	3.0 U	NA	NA	3.0 U	NA	NA	NA
Zinc	NA	NA	8.3 U	NA	1.1 U	NA	NA	1.1 U	NA	NA	NA
Total Radionuclides (pCi/L)											
Gross Alpha	2.59 UJ	NA	NA	4.28 J	NA	NA	2.32 UJ	NA	3.26 J	NA	10.5 J
Gross Beta	2.50 U	NA	NA	7.97 J	NA	NA	2.70	NA	4.03 U	NA	20.8
Thorium-228	0.119 U	NA	NA	NA	NA	NA	NA	NA	0.0933 U	NA	0.172
Thorium-232	0.0669 U	NA	NA	NA	NA	NA	NA	NA	0.0546 U	NA	0.157
Miscellaneous Parameters (mg/L)											
Chloride	NA	42.8	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hardness	517.1	557.7	NA	668.1	NA	NA	599.9	NA	290.9	NA	1656.8
Hardness, Filtered	NA	NA	524.1	NA	709.6	NA	NA	586.7	NA	NA	NA
Total Organic Carbon	NA	4.7 J	NA	NA	NA	NA	NA	NA	2.9	NA	1.73
Field Parameters (mg/L)											
Alkalinity	NA	250	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Dioxide	NA	25	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dissolved Oxygen	0.74	0.4	NA	0.75	NA	NA	2.89	NA	0.12	NA	7.67
Dissolved Oxygen - Meter	NA	0.63	NA	NA	NA	2.66	NA	NA	NA	2.28	NA
Ferrous Iron	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hydrogen Sulfide	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese(+2)	NA	0.3	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01-25	01-25	01-25	01-26	01-26	01-26	01-27	01-27	01C01	01C01	01T02
Nsample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Sample	01GW2501	01GW2502	01GW2502-F	01GW2601	01GW2601-F	01GW2602	01GW2701	01GW2701-F	01GWC0101	01GWC0102	01GWT0201
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	9/8/2001	6/14/2002	6/14/2002	9/6/2001	9/6/2001	6/4/2002	9/8/2001	9/8/2001	8/25/2001	6/11/2002	9/19/2001
Nitrate	NA	0.21	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrite	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate	NA	> 80	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfide	NA	0.02	NA	NA	NA	NA	NA	NA	NA	NA	NA
Field Parameters											
Oxidation Reduction Potential (MV)	433	232	NA	543.9	NA	7	396.1	NA	365.7	565	346
pH (S.U.)	6.4	7.02	NA	7	NA	6.34	6.06	NA	6.97	6.9	5.4
Specific Conductance (MS/CM)	1.289	1.363	NA	1.428	NA	1.129	1.297	NA	0.522	0.394	2.948
Temperature (C)	20.58	14.5	NA	17.1	NA	15.42	17.01	NA	16.34	16.42	14.4
Turbidity (NTU)	5	14	NA	24	NA	16	16	NA	1.7	0.6	3.6

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01T02	01T02	01T02	01T03	01T04	01T05
Nsample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Sample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site
Sample Date	9/22/2001	6/12/2002	6/12/2002	6/17/2002	6/15/2002	6/15/2002
VOCs (ug/L)						
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	0.5 U	0.5 U	NA	0.5 U	0.5 U	2
1,1,2-Trichloroethane	1 U	1 U	NA	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	NA	1 U	1 U	1 U
1,2-Dichloroethane	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
Chloroform	0.2 BU	0.5 U	NA	0.5 U	0.5 U	1
cis-1,2-Dichloroethene	1 U	1 U	NA	1 U	1 U	1 U
Ethene	NA	2 J	NA	1 U	1 U	1 U
Methane	NA	0.9 J	NA	1 UJ	1 UJ	1 UJ
Methylene Chloride	1 U	1 UJ	NA	1 UJ	1 UJ	1 UJ
Tetrachloroethene	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U
Toluene	0.3 J	0.5 J	NA	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	1 U	1 U	NA	1 U	1 U	1 U
Trichloroethene	0.2 J	0.5 U	NA	1	0.5 U	2
SVOCs (ug/L)						
4-Nitrophenol	25 U	NA	NA	NA	NA	NA
Acenaphthene	0.2 U	NA	NA	NA	NA	NA
Acenaphthylene	0.2 U	NA	NA	NA	NA	NA
bis(2-Ethylhexyl) phthalate	5 U	NA	NA	NA	NA	NA
Butyl Benzyl Phthalate	5 U	NA	NA	NA	NA	NA
Fluorene	0.2 U	NA	NA	NA	NA	NA
Hexachloroethane	5 U	NA	NA	NA	NA	NA
Naphthalene	0.2 U	NA	NA	NA	NA	NA
Energetics (ug/L)						
2,4,6-Trinitrotoluene	0.65 U	NA	NA	NA	NA	NA
2-Nitrotoluene	0.65 U	NA	NA	NA	NA	NA
4-Amino-2,6-Dinitrotoluene	0.65 U	NA	NA	NA	NA	NA
HMX	0.65 U	NA	NA	NA	NA	NA
Pesticides/PCBs (ug/L)						
gamma-Chlordane	0.04 U	NA	NA	NA	NA	NA
Heptachlor	0.034 U	NA	NA	NA	NA	NA
Total Metals (ug/L)						
Aluminum	40.3 U	57.8 U	NA	21.2 U	21.2 U	21.2 U
Antimony	1.6 U	5.1 U	NA	5.1 U	5.1 U	5.1 U
Arsenic	1.5 UJ	2.2 U	NA	2.2 U	2.2 U	2.2 U
Barium	17.8	16.6 J	NA	40.1 J	33.1 J	22.8 J
Beryllium	0.40 U	0.30 U	NA	0.30 U	0.30 U	0.30 U
Cadmium	0.30 UJ	0.60 U	NA	0.60 U	0.60 U	0.60 U
Calcium	330000	344000	NA	87700	70400	147000
Chromium	0.70 U	0.80 UJ	NA	0.80 U	0.80 U	0.80 U
Cobalt	66.3	126 J	NA	1.2 U	1.1 U	11.2 J
Copper	0.90 U	3.2 U	NA	3.2 U	3.2 U	3.2 U
Iron	10600	14800	NA	27.0 U	27.0 U	31.0
Lead	1.6 U	2.8 UJ	NA	2.8 U	2.8 U	2.8 U
Magnesium	242000	250000	NA	59900	21500	233000
Manganese	9170	9600	NA	45.2	5.9	5420

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01T02	01T02	01T02	01T03	01T04	01T05
Nsample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Sample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site
Sample Date	9/22/2001	6/12/2002	6/12/2002	6/17/2002	6/15/2002	6/15/2002
Mercury	0.11	0.10 U	NA	0.10 U	0.10 U	0.10 U
Nickel	124	273	NA	9.3	2.7 U	75.1
Potassium	15500 J	15300	NA	4830	1720	4130
Silver	0.70 U	1.8 UJ	NA	1.8 U	1.8 U	1.8 U
Sodium	84000	69700	NA	4300	4050	110000
Strontium	3990 J	3910 J	NA	329 J	172 J	468 J
Thallium	2.4 UJ	2.1 U	NA	0.60 U	0.60 U	0.6 U
Thorium-Calc	0.155909	NA	NA	NA	NA	NA
Vanadium	0.50 U	0.80 U	NA	0.80 U	0.80 U	0.80 U
Zinc	16.4	103	NA	8.3 U	8.3 U	12.1
Dissolved Metals (ug/L)						
Aluminum	NA	NA	21.2 U	NA	NA	NA
Antimony	NA	NA	5.1 U	NA	NA	NA
Arsenic	NA	NA	2.2 U	NA	NA	NA
Barium	NA	NA	13.8 J	NA	NA	NA
Calcium	NA	NA	349000	NA	NA	NA
Chromium	NA	NA	0.80 UJ	NA	NA	NA
Cobalt	NA	NA	96.8 J	NA	NA	NA
Iron	NA	NA	20300	NA	NA	NA
Magnesium	NA	NA	254000	NA	NA	NA
Manganese	NA	NA	9650	NA	NA	NA
Mercury	NA	NA	0.10 U	NA	NA	NA
Nickel	NA	NA	208	NA	NA	NA
Potassium	NA	NA	15200	NA	NA	NA
Sodium	NA	NA	70700	NA	NA	NA
Strontium	NA	NA	4040. J	NA	NA	NA
Thallium	NA	NA	2.1 U	NA	NA	NA
Vanadium	NA	NA	0.80 U	NA	NA	NA
Zinc	NA	NA	65.6	NA	NA	NA
Total Radionuclides (pCi/L)						
Gross Alpha	6.06 U	8.22	NA	2.60 U	0.906 U	4.83 U
Gross Beta	19.3	18.8	NA	3.75	1.69	5.21
Thorium-228	0.0216 U	NA	NA	NA	NA	NA
Thorium-232	0.0235	NA	NA	NA	NA	NA
Miscellaneous Parameters (mg/L)						
Chloride	NA	94.4	NA	2.1	1.6	127
Hardness	1820.6	1888.5	NA	465.7	264.3	1326.6
Hardness, Filtered	NA	NA	1917.4	NA	NA	NA
Total Organic Carbon	2.38	9.2 J	NA	3.7 J	2.6 J	5.1 J
Field Parameters (mg/L)						
Alkalinity	NA	120	NA	275	150	70
Carbon Dioxide	NA	350	NA	18	12	225
Dissolved Oxygen	6.7	1.5	NA	0.7	2	3
Dissolved Oxygen - Meter	NA	10.17	NA	7.72	2.63	3.92
Ferrous Iron	NA	8.5	NA	0.01	0.01	0.07
Hydrogen Sulfide	NA	0	NA	0	0	0
Manganese(+2)	NA	> 22	NA	0.3	0	6.2

TABLE 4-3

SUMMARY OF CHEMICALS DETECTED IN GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01T02	01T02	01T02	01T03	01T04	01T05
Nsample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Sample	01GWT0202	01GWT0203	01GWT0203-F	01GWT0301	01GWT0401	01GWT0501
Matrix	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water	Ground Water
Risk	Site	Site	Site	Site	Site	Site
Sample Date	9/22/2001	6/12/2002	6/12/2002	6/17/2002	6/15/2002	6/15/2002
Nitrate	NA	0.04	NA	0.32	1.28	0.38
Nitrite	NA	0	NA	0.008	0	0.006
Sulfate	NA	> 80	NA	> 80	54	> 80
Sulfide	NA	0.04	NA	0	0	0
Field Parameters						
Oxidation Reduction Potential (MV)	343	98	NA	404	272	228
pH (S.U.)	5.42	5.68	NA	7.23	7.45	5.77
Specific Conductance (MS/CM)	2.929	2.686	NA	0.739	0.482	2.61
Temperature (C)	15.9	14.99	NA	13.9	13.4	13.8
Turbidity (NTU)	2.6	18	NA	2.7	0.7	2.3

Calc = Calculated value.
NA = Not analyzed
U - Indicates that the chemical was not detected at the numerical detection limit (sample-specific quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.
UJ - Indicates that the chemical was not detected. However, the detection limit (sample-specific quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.
J - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The laboratory-reported concentration is considered to be an estimate of the true concentration.
UR - Indicates that the chemical may or may not be present. The nondetected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration noncompliances, and extremely low quality control recoveries).
BU - Indicates that the chemical was detected in this sample as well as the associated laboratory method blank, but has been qualified non-detected result as a laboratory blank contamination (i.e., concentration was less than the blank action level).
bgs - below ground surface.
MEQ - milliequivalents
S.U. - Standard units.

TABLE 4-4

SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SD01[1]	01SD01	01SD02	01SD03	01SD03	01SD04	01SD05	01SD06	01SD07	01SD08	01SD09	01SD10	01SD11	01SD12
Nsample	01SD0101	01SD0102	01SD0201	01SD0301	01SD0302	01SD0401	01SD0501	01SD0601	01SD0701	01SD0801	01SD0902	01SD1002	01SD1102	01SD1202
Sample	01SD01	01SD0102	01SD02	01SD03	01SD0302	01SD04	01SD05	01SD06	01SD07	01SD08	01SD0902	01SD1002	01SD1102	01SD1202
Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Depth Range	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Risk	Background	Background	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/14/2001	6/17/2002	8/14/2001	8/14/2001	6/17/2002	8/14/2001	8/14/2001	8/14/2001	8/14/2001	8/14/2001	6/17/2002	6/17/2002	6/17/2002	6/17/2002
VOCs (ug/kg)														
1,1,2,2-Tetrachloroethane	3 U	3 UJ	3 U	7	9	4 U	3 UJ	4 U	3 U	4 U	4 U	3 UJ	3 UJ	4 UJ
Acetone	5 UJ	290 J	5 UJ	6 UJ	510 J	7 UJ	5 UJ	12 J	5 UJ	7 UJ	190 J	230 J	540 J	630 J
Carbon Disulfide	3 U	2 J	3 U	3 U	2 J	4 U	3 U	4 U	3 U	4 U	4 U	3 UJ	2 J	4 UJ
Dichlorodifluoromethane	3 UJ	3 U	3 J	1 J	4 U	4 UJ	3 UJ	4 UJ	3 UJ	2 J	4 U	8 J	3 UJ	4 UJ
Toluene	3 U	3 U	3 U	3 U	2 J	4 U	3 U	4 U	3 U	4 U	1 J	3 UJ	1 J	4 UJ
SVOCs (ug/kg)														
Acenaphthene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	139 J	13.8 U	NA	NA	NA	NA
Benzo(a)Anthracene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	14.4	13.8 U	NA	NA	NA	NA
Benzo(a)Pyrene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	7.05 J	4.97 J	27.5 J	6.73 J	NA	NA	NA	NA
Benzo(b)Fluoranthene	11.8 U	NA	11.6 U	9.95 J	NA	13.7 U	11.7 U	7.7 J	120 J	22.5 J	NA	NA	NA	NA
Benzo(g,h,i)Perylene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	21.8 J	13.8 U	NA	NA	NA	NA
Benzo(k)Fluoranthene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	8.96 J	11.2 U	14.6 J	6.26 J	NA	NA	NA	NA
bis(2-Ethylhexyl) Phthalate	200 U	NA	190 U	230 U	NA	230 U	190 U	190 U	190 UJ	98 J	NA	NA	NA	NA
Chrysene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	17.3 J	13.8 U	NA	NA	NA	NA
Fluoranthene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	4.93 J	5.39 J	18.4 J	7.83 J	NA	NA	NA	NA
Indeno(1,2,3-cd)Pyrene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	12.8	13.8 U	NA	NA	NA	NA
Isosafrole	390 U	NA	380 U	450 U	NA	450 U	380 U	7600	380 U	460 U	NA	NA	NA	NA
Pyrene	11.8 U	NA	11.6 U	13.9 U	NA	13.7 U	11.7 U	11.2 U	24 J	5.31 J	NA	NA	NA	NA
Energertics (ug/kg)														
HMX	476 U	NA	54.2 J	422 J	NA	86.7 J	134 J	500 U	476 U	500 U	NA	NA	NA	NA
Pesticides/PCBs (ug/kg)														
Aroclor-1260	38 U	NA	38 U	46 U	NA	45 U	38 U	37 U	19 J	45 U	NA	NA	NA	NA
Heptachlor	0.95 J	NA	1.7	1.8 U	NA	1.4 J	1.2 J	2.5	1.1 J	1.8 U	NA	NA	NA	NA
Herbicides (ug/kg)														
2,4,5-T	12 U	NA	12 U	14 U	NA	8.6 J	12 U	11 U	11 U	14 U	NA	NA	NA	NA
2,4,5-TP (Silvex)	16	NA	12	14 U	NA	14 U	12 U	11 J	3.1 J	14 U	NA	NA	NA	NA
Inorganics (mg/kg)														
Aluminum	9670	7360	8790	6770	NA	7470	9270	8190	11700	13700	NA	NA	NA	NA
Antimony	1.2 J	1.6 J	2.0 J	0.59 UJ	NA	0.58 UJ	0.51 UJ	0.48 UJ	0.50 UJ	0.61 UJ	NA	NA	NA	NA
Arsenic	31.9	28.4 J	31.1	27.9	NA	6.5	4.4	5.5	8.1	6.7	NA	NA	NA	NA
Barium	105	93.1	92.4	47.4	NA	105	120	120	94.6	80.7	NA	NA	NA	NA
Beryllium	1.4 J	1.7	1.7 J	0.65 J	NA	0.84 J	0.80 J	0.78 J	0.57 J	0.62 U	NA	NA	NA	NA
Cadmium	0.05 UJ	0.06 U	0.05 UJ	0.05 UJ	NA	0.05 UJ	0.23 U	0.39 J	0.05 UJ	0.06 UJ	NA	NA	NA	NA
Calcium	1000	894 J	769	941	NA	1690	2630	1960	3020	5520	NA	NA	NA	NA
Chromium	30.5	40.8 J	45.1	15.0	NA	13.5	9.4	10.2	13.7	17.4	NA	NA	NA	NA
Cobalt	25.0	27.4	28.8	6.9	NA	17.8	15.3	17.5	12.2	7.4	NA	NA	NA	NA
Copper	17.6 J	14.7 J	19.4 J	16.9 J	NA	11.0 J	10.1 J	9.5 J	16.1 J	14.6 J	NA	NA	NA	NA
Iron	45700	76500 J	76900	28600	NA	20000	12500	12300	19900	21700	NA	NA	NA	NA
Lead	24.8	26.3	32.0	22.2	NA	19.1	16.1	26.7	16.5	28.2	NA	NA	NA	NA
Magnesium	1520	1190	1060	1050	NA	1030	1200	1090	1820	1940	NA	NA	NA	NA
Manganese	1490	1890	1640	278	NA	1230	1250	1330	607	341	NA	NA	NA	NA

TABLE 4-4

SUMMARY OF CHEMICALS DETECTED IN SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SD01[1]	01SD01	01SD02	01SD03	01SD03	01SD04	01SD05	01SD06	01SD07	01SD08	01SD09	01SD10	01SD11	01SD12
Nsample	01SD0101	01SD0102	01SD0201	01SD0301	01SD0302	01SD0401	01SD0501	01SD0601	01SD0701	01SD0801	01SD0902	01SD1002	01SD1102	01SD1202
Sample	01SD01	01SD0102	01SD02	01SD03	01SD0302	01SD04	01SD05	01SD06	01SD07	01SD08	01SD0902	01SD1002	01SD1102	01SD1202
Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
Depth Range	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
Risk	Background	Background	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site	Site
Sample Date	8/14/2001	6/17/2002	8/14/2001	8/14/2001	6/17/2002	8/14/2001	8/14/2001	8/14/2001	8/14/2001	8/14/2001	6/17/2002	6/17/2002	6/17/2002	6/17/2002
Nickel	37.1	38.7	35.9	12.1	NA	15.6	13.7	11.3	11.9	13.7	NA	NA	NA	NA
Potassium	875 J	6.6 J	703 J	1100 J	NA	604 J	623 J	497 J	583 J	915 J	NA	NA	NA	NA
Selenium	0.66	2.1	1.2	0.92	NA	0.66	0.38 U	0.45	0.59	1.0	NA	NA	NA	NA
Sodium	265	308	345 J	416	NA	334	335	298	311	402	NA	NA	NA	NA
Strontium	10.2 J	8.8	8.1 J	10.6 J	NA	9.6 J	11.2 J	8.2 J	8.7 J	14.5 J	NA	NA	NA	NA
Thallium	4.3	0.57 U	7.1	2.2	NA	1.2	0.56 U	0.57	2.0	1.5	NA	NA	NA	NA
Thallium-GF	0.10 J	NA	0.10 J	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Thorium-Calc	9.304545	NA	9.395455	12.454545	NA	7.745455	7.540909	6.468182	6.527273	7.313636	NA	NA	NA	NA
Tin	3.6	1.9 J	3.4	3.6	NA	3.4	3.1	3.2	3.0	3.7	NA	NA	NA	NA
Vanadium	32.5	43.6 J	45.8	20.4	NA	20.5	18.9	19.6	27.0	31.5	NA	NA	NA	NA
Zinc	79.2	71.7 J	78.0	35.6	NA	42.5	41.2	47.8	46.1	70.2	NA	NA	NA	NA
Total Radiologicals (pCi/g)														
Thorium-228	0.937	1.09	1.15	1.49	NA	1.08	0.868	0.705	0.694	0.781	NA	NA	NA	NA
Thorium-230	1.20 J	0.908	1.14 J	1.26 J	NA	0.832 J	0.791 J	1.08 J	0.937 J	1.05 J	NA	NA	NA	NA
Thorium-232	1.11	1.13	0.917	1.25	NA	0.624	0.791	0.718	0.742	0.828	NA	NA	NA	NA
Miscellaneous Parameters														
Cation Exchange Capacity (MEQ/1)	11.1	NA	17.9	22.0	NA	22.9	45.5	26.9	22.6	58.6	NA	NA	NA	NA
pH (S.U.)	5.8 J	NA	5.6 J	5.5 J	NA	6.1 J	7.0 J	6.2 J	7.3 J	7.1 J	NA	NA	NA	NA
Total Organic Carbon (mg/kg)	5950	NA	5580	17600	NA	21600	34900	24500	14300	49600	NA	NA	NA	NA

1 Upgradient location.
Calc = Calculated value.
NA = Not analyzed
U - Indicates that the chemical was not detected at the numerical detection limit (sample-specific quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is also added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.
UJ - Indicates that the chemical was not detected. However, the detection limit (sample-specific quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.
J - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The laboratory-reported concentration is considered to be an estimate of the true concentration.
UR - Indicates that the chemical may or may not be present. The nondetected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration noncompliances, and extremely low quality control recoveries).
BU - Indicates that the chemical was detected in this sample as well as the associated laboratory method blank, but has been qualified non-detected result as a laboratory blank contamination (i.e., concentration was less than the blank action level).
bgs - below ground surface.
MEQ - milliequivalents
S.U. - Standard units.

TABLE 4-5

SUMMARY OF PARAMETERS DETECTED IN SURFACE WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Location	01SW01[1]	01SW02	01SW04[1]	01SW05
Nsample	01SW0102	01SW0202	01SW0402	01SW0502
Sample	01SW0102	01SW0202	01SW0402	01SW0502
Matrix	Surface Water	Surface Water	Surface Water	Surface Water
Risk	Background	Site	Background	Site
Sample Date	6/17/2002	6/17/2002	6/18/2002	6/17/2002
Field Parameters				
Dissolved Oxygen - Meter (MG/L)	6.63	2.94	7.59	7.96
Oxidation Reduction Potential (MV)	335.9	278.4	274	291
pH (S.U.)	6.6	6.41	7.08	6.37
Specific Conductance (MS/CM)	0.114	0.121	0.114	0.058
Temperature (C)	17.08	17.53	16.4	16.79
Turbidity (NTU)	5.1	5.4	3.8	1.2

1 Upgradient location.

TABLE 4-6

SCREENING CRITERIA USED IN SELECTION OF HUMAN HEALTH COPCs - SOIL/SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	EPA Region 9 PRG [1] Residential	EPA Soil Screening Levels [2] Soil to Ground Water	EPA Soil Screening Levels [2] Soil to Air	IDEM [3] Residential	IDEM [3] Soil to Ground Water
VOCs (ug/kg)						
79-34-5	1,1,2,2-Tetrachloroethane	380 C	0.2	600	5000 C	7 C
78-93-3	2-Butanone	7300000 N	NA	NA	20000000 N	11000 N
67-64-1	Acetone	1600000 N	800	100000000	3900000 N	3100 N
75-15-0	Carbon Disulfide	360000 N	2000	720000	900000 N	10000 N
67-66-3	Chloroform	240 C	30	300	910 C	590 C
75-71-8	Dichlorofluoromethane	94000 N	NA	NA	NA	NA
75-09-2	Methylene Chloride	8900 C	1 C	13000 C	120000 C	23 C
108-88-3	Toluene	520000 sat	600	650000	1700000 N	12000 N
1330-20-7	Total Xylenes	210000 sat	9000	410000	4800000 N	190000 N
SVOCs (ug/kg)						
57-97-6	7,12-Dimethylbenz(a)anthracene	N	NA	NA	NA	NA
83-32-9	Acenaphthene	3700000 N	29000	NA	9500000 N	130000 N
120-12-7	Anthracene	22000000 N	590000	NA	47000000 N	51000 N
56-55-3	Benzo(a)anthracene	620 C	80	NA	5000 C	19000 C
50-32-8	Benzo(a)pyrene	62 C	400	NA	500 C	8200 C
205-99-2	Benzo(b)fluoranthene	620 C	200	NA	5000 C	57000 C
191-24-2	Benzo(g,h,i)perylene	2300000 [4] N	NA	NA	5500000 [4] N	NA
207-08-9	Benzo(k)fluoranthene	6200 C	2000	NA	50000 C	39000 C
117-81-7	bis(2-ethylhexyl) phthalate	35000 C	180000	31000000	300000 C.	3600000 C
218-01-9	Chrysene	62000 C	8000	NA	500000 C	25000 C
53-70-3	Dibenzo(a,h)anthracene	62 C	80	NA	500 C	18000 C
206-44-0	Fluoranthene	2300000 N	210000	NA	6300000 N	880000 N
86-73-7	Fluorene	2600000 N	28000	NA	6300000 N	170000 N
193-39-5	Indeno(1,2,3-cd)pyrene	620 C	700	NA	5000 C	3100 C
120-58-1	Isosafrole					
91-20-3	Naphthalene	56000 N	4000	NA	3200000 N	700 N
85-01-8	Phenanthrene	2300000 [4] N	NA	NA	5500000 [4]	NA
129-00-0	Pyrene	2300000 N	210000	NA	5500000 N	570000 N
Energetics (mg/kg)						
2691-41-0	HMX	3100 N	NA	NA	NA	NA
Pesticides (ug/kg)						
11096-82-5	Aroclor-1260	220 C	NA	NA	180 C	6200 C
5103-74-2	gamma-Chlordane	1600 C	500 C	20000 C	17000 C	9600 C
76-44-8	Heptachlor	110 C	1000 C	4000 C	540 C	23000 C
Herbicides (ug/kg)						
93-76-5	2,4,5-T	610000 N	NA	NA	NA	NA
93-72-1	2,4,5-TP (SILVEX)	490000 N	NA	NA	NA	NA
94-75-7	2,4-D	690000 N	NA	NA	NA	NA
Inorganics (mg/kg)						
7429-90-5	Aluminum	76000 N	NA	NA	NA	NA
7440-36-0	Antimony	31 N	0.3	NA	140 N	5.4 N
7440-38-2	Arsenic	0.39 N	1	750	3.9 C	29 C
7440-39-3	Barium	5400 N	82	690000	23000 N	1600 N
7440-41-7	Beryllium	150 N	3	1300	680 N	63 C
7440-43-9	Cadmium	37 N	0.4	1800	12 N	7.5 C
7440-70-2	Calcium	NA	NA	NA	NA	NA
7440-47-3	Chromium VI	30 C	2	270	430 C	38 C
7440-48-4	Cobalt	4700 N	NA	NA	NA	NA
7440-50-8	Copper	2900 N	NA	NA	13000 N	580 N
7439-89-6	Iron	23000 N	NA	NA	NA	NA
7439-92-1	Lead	400 N	NA	NA	400	81
7439-95-4	Magnesium	NA	NA	NA	NA	NA
7439-96-5	Manganese	1800 N	NA	NA	NA	NA
7439-97-6	Mercury	23(5) N	0.1	10	55 N	2.1 N
7440-02-0	Nickel	1600 N	7	13000	6900 N	950 C
7440-09-7	Potassium	NA	NA	NA	NA	NA

TABLE 4-6

SCREENING CRITERIA USED IN SELECTION OF HUMAN HEALTH COPCs - SOIL/SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	EPA Region 9 PRG [1] Residential	EPA Soil Screening Levels [2]		IDEM [3]	
			Soil to Ground Water	Soil to Air	Residential	Soil to Ground Water
7782-49-2	Selenium	390 N	0.3	NA	1700 N	5.2 N
7440-22-4	Silver	390 N	2	NA	1700 N	31 N
7440-23-5	Sodium	NA	NA	NA	NA	NA
7440-28-0	Thallium	5.2 N	0.04	NA	31 N	2.8 N
7440-31-5	Tin	47000 N	NA	NA	NA	NA
7440-62-2	Vanadium	550 N	300	NA	NA	NA
7440-66-6	Zinc	23000 N	620	NA	100000 N	14000 N
Radionuclides (pCi/g)[6]						
14331-83-0	Actinium-228	730 C	NA C	NA	NA	NA
14913-49-6	Bismuth-212	23000 C	NA C	NA	NA	NA
14733-03-0	Bismuth-214	8200 C	NA C	NA	NA	NA
10045-97-3	Cesium-137	0.061 C	2.8 C	1530000	NA	NA
14391-16-3	Europium-155	3.8 C	NA	NA	NA	NA
14255-04-0	Lead-210	0.063 C	0.00055 C	1310	NA	NA
15092-94-1	Lead-212	3800 C	3500000 C	NA	NA	NA
15067-28-4	Lead-214	46000 C	1.4E+11 C	NA	NA	NA
13966-00-2	Potassium-40	0.14 C	NA C	1760000	NA	NA
13982-63-3	Radium-226	0.013 C	0.016 C	1570	NA	NA
14913-50-9	Thallium-208	23000 C	NA C	NA	NA	NA
14274-82-9	Thorium-228	0.16 C	3.3 C	127	NA	NA
14269-63-7	Thorium-230	3.9 C	0.3 C	637	NA	NA
7440-29-1	Thorium-232	3.4 C	0.3 C	419	NA	NA
15065-10-8	Thorium-234	2200 C	4100 C	NA	NA	NA
15117-96-1	Uranium-235	0.21 C	0.039 C	1800	NA	NA

Notes:
1 - U.S. EPA Region 9 Preliminary Remediation Goal Table, November 1, 2000 (Cancer benchmark value = 1E-06, HI = 1.0).
2 - U.S. EPA Soil Screening Level Guidance: Technical Background Document. May 1996. A dilution attenuation factor of 1 is used for the soil to ground water criteria.
3 - IDEM, RISC residential closure levels for ground water, July 2001.
4 - Pyrene. Value used as a surrogate.
5 - No U.S. EPA Region 9 PRG available, value is from U.S. EPA Region 3 Risk-Based Concentration Table, April 2, 2002.
6 - Criteria for radiological parameters obtained from Soil Screening Guidance for Radionuclides (U.S. EPA, 2002).
sat - Saturation concentration.
N - Noncarcinogenic.
C - Carcinogenic.
NA - No criterion available.

TABLE 4-7

SCREENING CRITERIA USED IN SELECTION OF HUMAN HEALTH COPCs - GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	U.S. EPA Region 9 PRG [1] Tap Water	U.S. EPA MCL [2]	IDEM Ground Water Residential [3]
VOCs (ug/L)				
630-20-6	1,1,1,2-Tetrachloroethane	0.43 C	NA	6.9 C
79-34-5	1,1,2,2-Tetrachloroethane	0.055 C	NA	0.9 C
79-00-5	1,1,2-Trichloroethane	0.20 C	5	5
75-35-4	1,1-Dichloroethene	0.046 C	7	7
107-06-2	1,2-Dichloroethane	0.12 C	5	5
67-66-3	Chloroform	0.16 C	80	100
156-59-2	cis-1,2-Dichloroethene	61 N	70	70
75-09-2	Methylene Chloride	4.3 C	5	5
127-18-4	Tetrachloroethene	1.1 C	5	5
108-88-3	Toluene	72 N	1000	1000
156-60-5	trans-1,2-Dichloroethene	12 N	100	100
79-01-6	Trichloroethene	1.6 C	5	5
74-85-1	Ethene	NA	NA	NA
74-82-8	Methane	NA	NA	NA
SVOCs (ug/L)				
100-02-7	4-Nitrophenol	290 N	NA	NA
83-32-9	Acenaphthene	370 N	NA	NA
208-96-8	Acenaphthylene	370 [4] N	NA	NA
117-81-7	bis(2-ethylhexyl) phthalate	4.8 C	6	6
85-68-7	Butyl Benzyl Phthalate	7300 N	NA	2700 N
86-73-7	Fluorene	240 N	NA	310 N
67-72-1	Hexachloroethane	4.8 C	NA	37 C
91-20-3	Naphthalene	6.2 N	NA	8.3 N
Energetics (ug/L)				
118-96-7	2,4,6-Trinitrotoluene	2.2 C	NA	NA
88-72-2	2-Nitrotoluene	61 N	NA	NA
19406-51-0	4-amino-2,6-Dinitrotoluene	2.2 [5] N	NA	NA
2691-41-0	HMX	1800 N	NA	NA
Pesticides/PCBs (ug/L)				
5103-74-2	gamma-Chlordane	0.19 C	2	2
76-44-8	Heptachlor	0.015 C	0.4	0.4
Inorganics (ug/L)				
7429-90-5	Aluminum	36000 N	50 to 200 [6]	NA
7440-36-0	Antimony	15 N	6	6
7440-38-2	Arsenic	0.045 C	10	50
7440-39-3	Barium	2600 N	2000	2000
7440-41-7	Beryllium	73 N	4	4
7440-43-9	Cadmium	18 N	5	5
7440-70-2	Calcium	NA	NA	NA
7440-47-3	Chromium VI	110 N	100	100
7440-48-4	Cobalt	2200 N	NA	NA

TABLE 4-7

SCREENING CRITERIA USED IN SELECTION OF HUMAN HEALTH COPCs - GROUND WATER
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	U.S. EPA Region 9 PRG [1] Tap Water	U.S. EPA MCL [2]	IDEM Ground Water Residential [3]
7440-50-8	Copper	1400 N	1300	1300
7439-89-6	Iron	11000 N	300 [6]	NA
7439-92-1	Lead	15 [7]	15	15
7439-95-4	Magnesium	NA	NA	NA
7439-96-5	Manganese	880 N	50 [6]	NA
7439-97-6	Mercury	11[5] N	2	2
7440-02-0	Nickel	730 N	NA	730 N
7440-09-7	Potassium	NA	NA	NA
7782-49-2	Selenium	180 N	50	50
7440-23-5	Sodium	NA	NA	NA
7440-24-6	Strontium	22000 N	NA	NA
7440-28-0	Thallium	2.4 N	2	2
7440-31-5	Tin	22000 N	NA	NA
7440-62-2	Vanadium	260 N	NA	NA
7440-66-6	Zinc	11000 N	5000 [6]	11000 N
Radionuclides (pCi/L)				
TTNUS006	Gross Alpha	NA	15	NA
TTNUS007	Gross Beta	NA	NA	NA
14274-82-9	Thorium-228	NA	NA	NA
TTNUS097	Thorium-232	NA	NA	NA
Miscellaneous Parameters (mg/L)				
16887-00-6	Chloride	NA	250 [6]	NA
14797-55-8	Nitrate	10	10	NA
14797-65-0	Nitrite	1	1	NA
14808-79-8	Sulfate	NA	250[6]	NA

1 - U.S. EPA Region 9 PRG Table, November 1, 2000 (Cancer benchmark value = 1E-06, HI = 1.0).
2 - U.S. EPA Drinking Water Regulations and Health Advisories, Summer 2002.
3 - IDEM, RISC residential closure levels for ground water, July 2001.
4 - Acenaphthene value used as a surrogate.
5 - No U.S. EPA Region 9 PRG available, value is from U.S. EPA Region 3 Risk-Based Concentration table, April
6 - Secondary MCL.
7 - Action level (U.S. EPA, 2002).
N - Noncarcinogenic.
C - Carcinogenic.
NA - No criterion available.

TABLE 4-8

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ?(4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
VOCs (mg/kg)																
78-93-3	2-Butanone	0.038	-	0.071	J	01SS130002	2/24	0.005 - 0.01	0.071	NA	730	N	20000	IDEM	No	BSL
67-64-1	Acetone	0.021	J	0.18	-	01SS180002	4/24	0.005 - 0.75	0.18	NA	160	N	3900	IDEM	No	BSL
75-15-0	Carbon Disulfide	0.006	-	0.006	-	01SS170002	1/24	0.003 - 0.004	0.006	NA	36	N	900	IDEM	No	BSL
75-09-2	Methylene Chloride	0.002	J	0.061	J	01SS060002	10/24	0.005 - 0.039	0.061	NA	8.9	C	120	IDEM	No	BSL
108-88-3	Toluene	0.002	J	0.002	J	01SS130002	1/24	0.003 - 0.005	0.002	NA	520	sat	1700	IDEM	No	BSL
SVCOs (mg/kg)																
57-97-6	7,12-Dimethylbenz(a)anthracene	0.26	J	0.26	J	01SS170002	1/24	0.28 - 1.5	0.26	NA	NA		NA	IDEM	No	NTX
83-32-9	Acenaphthene	0.0158	-	0.0708	-	01SS060002	2/24	0.0112 - 0.0158	0.0708	NA	370	N	9500	IDEM	No	BSL
50-32-8	Benzo(a)pyrene	0.00585	J	0.0119	J	01SS090002	2/24	0.0112 - 0.0158	0.0119	NA	0.062	C	0.5	IDEM	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.0093	J	0.0118	J	01SS090002	2/24	0.0112 - 0.0158	0.0118	NA	230(7)	N	5500(7)	IDEM	No	BSL
207-08-9	Benzo(k)fluoranthene	0.0141	J	0.0141	J	01TPL01	1/24	0.0112 - 0.0158	0.0141	NA	6.2	C	50	IDEM	No	BSL
117-81-7	bis(2-Ethylhexyl) phthalate	0.083	J	0.42	-	01SS090002	3/24	0.19 - 1	0.42	NA	35	C	300	IDEM	No	BSL
53-70-3	Dibenzo(a,h)anthracene	0.00576	J	0.00576	J	01TPL01	1/24	0.0112 - 0.0158	0.00576	NA	0.062	C	0.5	IDEM	No	BSL
206-44-0	Fluoranthene	0.00398	J	0.00439	J	01TPL01	2/24	0.0112 - 0.0158	0.00439	NA	230	N	6300	IDEM	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.00452	J	0.00455	J	01SS090002	2/24	0.0112 - 0.0158	0.00455	NA	0.62	C	5	IDEM	No	BSL
120-58-1	Isosafrole	0.15	J	46	-	01SS050002	6/24	0.38 - 2	46	NA	611	N	NA	IDEM	No	BSL
129-00-0	Pyrene	0.0041	J	0.0146	J	01SS040002	2/24	0.0112 - 0.0158	0.0146	NA	230	N	5500	IDEM	No	BSL
Pesticides/PCBs (mg/kg)																
5103-74-2	gamma-Chlordane	0.00055	J	0.0011	J	01SS170002	7/17	0.0015 - 0.0017	0.0011	NA	1.6	C	17	IDEM	No	BSL
76-44-8	Heptachlor	0.0012	J	0.0024	-	01SS200002	11/19	0.001 - 0.0024	0.0024	NA	0.11	C	0.54	IDEM	No	BSL
Herbicides (mg/kg)																
93-72-1	2,4,5-TP (Silvex)	0.0059	J	0.015	J	01SS110002	2/20	0.011 - 0.016	0.015	NA	49	N	NA	IDEM	No	BSL
94-75-7	2,4-D	0.035	J	0.21	-	01SS170002	5/18	0.081 - 0.09	0.21	NA	69	N	NA	IDEM	No	BSL
Inorganics (mg/kg)																
7429-90-5	Aluminum	9400	J	19400	-	01SS100002	24/24	---	19400	Yes	7600	N	NA	IDEM	Yes	ASL
7440-36-0	Antimony	1.7	J	1.7	J	01SS010002	1/24	0.2 - 1.4	1.7	No	3.1	N	140	IDEM	No	BSL,BKG
7440-38-2	Arsenic	6	J	10.9	J	01SS020002	24/24	---	10.9	No	0.39	C	3.9	IDEM	No	BKG(11)
7440-39-3	Barium	42.9	-	169	-	01SS170002	24/24	---	169	No	540	N	23000	IDEM	No	BSL,BKG
7440-41-7	Beryllium	0.21	-	1	J	01SS170002, 01SS120002	23/24	0.59	1	Yes	15	N	680	IDEM	No	BSL
7440-43-9	Cadmium	0.05	J	1.3	J	01SS170002	14/24	0.01 - 0.05	1.3	No	3.7	N	12	IDEM	No	BSL,BKG
7440-70-2	Calcium	421	J	27900	J	01SS100002	24/24	---	27900	Yes	NA	N	NA	IDEM	No	NUT
7440-47-3	Chromium	11.5	-	24.3	J	01SS170002	24/24	---	24.3	No	30(8)	C	430(8)	IDEM	No	BSL,BKG
7440-48-4	Cobalt	3.2	J	22.3	-	01TPL01	24/24	---	22.3	No	470	N	NA	IDEM	No	BSL,BKG
7440-50-8	Copper	7.4	J	18.5	-	01SS100002	24/24	---	18.5	Yes	290	N	13000	IDEM	No	BSL
7439-89-6	Iron	14600	-	25500	-	01SS030002	24/24	---	25500	Yes	2300	N	NA	IDEM	Yes	ASL
7439-92-1	Lead	11	-	21.6	-	01TPL01	24/24	---	21.6	No	400(9)	N	400(9)	IDEM	No	BSL,BKG
7439-95-4	Magnesium	1050	J	5260	J	01SS100002	24/24	---	5260	Yes	NA	N	NA	IDEM	No	NUT
7439-96-5	Manganese	114	J	2010	-	01SS060002	24/24	---	2010	No	180	N	NA	IDEM	No	BKG
7439-97-6	Mercury	0.03	J	0.07	J	01SS090002, 01SS150002, 01SS100002	16/24	0.03 - 0.1	0.07	No	2.3(10)	N	55(10)	IDEM	No	BSL,BKG
7440-02-0	Nickel	6.9	J	16	J	01SS170002, 01SS060002	24/24	---	16	No	160	N	6900	IDEM	No	BSL,BKG
7440-09-7	Potassium	436	J	1310	J	01SS100002	24/24	---	1310	No	NA	N	NA	IDEM	No	NUT, BKG
7782-49-2	Selenium	0.49	-	1.3	-	01SS070002	16/24	0.38 - 1.5	1.3	Yes	39	N	1700	IDEM	No	BSL
7440-23-5	Sodium	219	J	648	-	01SS100002	24/24	---	648	Yes	NA	N	NA	IDEM	No	NUT
7440-24-6	Strontium	5	J	33.5	J	01SS100002	24/24	---	33.5	No	4700	N	NA	IDEM	No	BSL,BKG
7440-28-0	Thallium	0.69	-	2.8	-	01SS030002	20/24	0.55 - 0.62	2.8	No	0.52	N	31	IDEM	No	BKG(11)
7440-28-0	Thallium - GF	0.07	J	0.13	J	01SS030002	2/2	---	0.13	No	0.52	N	31	IDEM	No	BSL,BKG(11)
7440-29-1	Thorium-Calc	1.90	-	6.44	-	01SS040002	25/25	---	6.44	No	NA	N	NA	IDEM	No	BKG, NTX
7440-31-5	Tin	2.5	-	3.9	-	01SS080002	7/24	2.5 - 29.2	3.9	Yes	4700	N	NA	IDEM	No	BSL
7440-62-2	Vanadium	22.8	-	44.5	-	01SS100002	24/24	---	44.5	Yes	55	N	NA	IDEM	No	BSL
7440-66-6	Zinc	25.1	J	67.8	-	01SS100002	24/24	---	67.8	Yes	2300	N	100000	IDEM	No	BSL

TABLE 4-8

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ?(4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
Total Radiologicals (pCi/g)																
14331-83-0	Actinium-228	0.92	-	0.97	-	01TPL03	2/2	---	0.97	No	730	C	NA	IDEM	No	BSL,BKG
14913-49-6	Bismuth-212	0.91	-	0.94	-	01TPL03	2/2	---	0.94	No	23000	C	NA	IDEM	No	BSL,BKG
14733-03-0	Bismuth-214	0.68	-	0.74	-	01TPL03	2/2	---	0.74	No	8200	C	NA	IDEM	No	BSL,BKG
10045-97-3	Cesium-137	0.09	-	0.09	-	01TPL03	1/2	0.0359	0.09	No	0.061	C	NA	IDEM	No	BKG
14255-04-0	Lead-210	0.47	-	0.52	-	01TPL03	2/2	---	0.52	No	0.063	C	NA	IDEM	No	BKG
15092-94-1	Lead-212	0.83	-	0.86	-	01TPL03	2/2	---	0.86	No	3800	C	NA	IDEM	No	BSL,BKG
15067-28-4	Lead-214	0.69	-	0.71	-	01TPL02	2/2	---	0.71	No	46000	C	NA	IDEM	No	BSL,BKG
13966-00-2	Potassium-40	9.76	-	9.94	-	01TPL02	2/2	---	9.94	No	0.14	C	NA	IDEM	No	BKG
13982-63-3	Radium-226	1.56	-	1.68	-	01TPL03	2/2	---	1.68	No	0.013	C	NA	IDEM	No	BKG
14913-50-9	Thallium-208	0.77	-	0.81	-	01TPL03	2/2	---	0.81	No	23000	C	NA	IDEM	No	BSL,BKG
14274-82-9	Thorium-228	0.227	-	0.73	-	01SS040002	25/25	---	0.73	No	0.16	C	NA	IDEM	No	BKG
14269-63-7	Thorium-230	0.0178	J	0.621	J	01SS040002	18/25	0.0342 - 0.0898	0.621	No	3.9	C	NA	IDEM	No	BSL,BKG(12)
7440-29-1	Thorium-232	0.19	-	0.686	-	01SS040002	25/25	---	0.686	No	3.4	C	NA	IDEM	No	BSL,BKG
15065-10-8	Thorium-234	1	-	1.73	-	01TPL03	2/2	---	1.73	No	2200	C	NA	IDEM	No	BSL,BKG
15117-96-1	Uranium-235	0.12	-	0.14	-	01TPL03	2/2	---	0.14	No	0.21	C	NA	IDEM	No	BSL,BKG

Shaded cells indicate that the specified criterion or background level has been exceeded or that the chemical has been selected as a COPC.

Footnotes:
1 Only the original of the duplicate sample pair was used for COPC selection. The duplicate was used for quality control purposes only.
2 Values presented are sample-specific detection limits.
3 The maximum detected concentration is used for screening purposes.
4 To determine whether metal concentrations were within background levels, soil concentrations were compared to base-wide background data presented in the Base-wide Background Soil Investigation Report (TtNUS, Inc., 2001a) by means of the Wilcoxon Rank Sum Test. If the Wilcoxon Test determined that a constituent concentration was not significanty different from background, that chemical was not selected as a COPC.
5 Risk-based soil COPC screening level for residential land use based on a target Hazard Quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (U.S. EPA, Region 9, 2000d and U.S. EPA, 2000c).
6 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and/or an ARAR/TBC(s) and background levels.
7 Pyrene is used as a surrogate for benzo(g,h,i)perylene.
8 Hexavalent chromium.
9 OSWER soil screening level for residential land use (U.S. EPA, 1994c)
10 Value is for mercuric chloride (U.S. EPA, Region 3, April 2002)
11 Reevaluation demonstrated that this chemical does not exceed background concentrations. See Section 3.4.4 (arsenic) and Section 3.4.5 (thallium).
12 The rationale for the elimination of Thorium-230 on the basis of background in presented in Section 3.4.7.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered.
C = Carcinogen.
CAS = Chemical abstract services.
COPC = Chemical of potential concern.
GF = Graphite furnace atomic absorption reanalysis.
IDEM = Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential levels for direct contact with soil (IDEM, July 2001).
J = Estimated value.
N = Noncarcinogen
NA = Not applicable/not available.
sat = Soil saturation concentration.

Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level/ARAR/TBC.

For Elimination as a COPC:
BKG = Within background levels.
BSL = Below COPC screening level/ARAR/TBC.
NTX = No toxicity information.
NUT = Essential nutrient.

TABLE 4-9

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - MIGRATION FROM SURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NWSC CRANE
CRANE, INDIANA
PAGE 1 OF 2

CAS Number	Chemical	Minimum Concentration [1]		Maximum Concentration [1]		Location of Maximum Concentration	Detection Frequency [1]	Range of Nondetects [2]	Concentration Used for Screening [3]	Site Above Background ?[4]	U.S. EPA Generic SSL for Migration to Ground Water [5]		U.S. EPA Generic SSL for Soil to Air [5]	IDEM SSL for Migration to Ground Water [6]	COPC	Rationale for Contaminant Deletion or Selection [7]
VOCs (mg/kg)																
78-93-3	2-Butanone	0.038	-	0.071	J	01SS130002	2/24	0.005 - 0.01	0.071	NA	NA	N	NA	11	No	BSL
67-64-1	Acetone	0.021	J	0.18	-	01SS180002	4/24	0.005 - 0.75	0.18	NA	0.8	N	100000	3.1	No	BSL
75-15-0	Carbon Disulfide	0.006	-	0.006	-	01SS170002	1/24	0.003 - 0.004	0.006	NA	2	N	720	10	No	BSL
75-09-2	Methylene Chloride	0.002	J	0.061	J	01SS060002	10/24	0.005 - 0.039	0.061	NA	0.001	C	13	0.023	Yes	ASL
108-88-3	Toluene	0.002	J	0.002	J	01SS130002	1/24	0.003 - 0.005	0.002	NA	0.6	N	650	12	No	BSL
SVOCs (mg/kg)																
57-97-6	7,12-Dimethylbenz(a)anthracene	0.26	J	0.26	J	01SS170002	1/24	0.28 - 1.5	0.26	NA	NA		NA	NA	No	BSL
83-32-9	Acenaphthene	0.0158	-	0.0708	-	01SS060002	2/24	0.0112 - 0.0158	0.0708	NA	29	N	NA	130	No	BSL
50-32-8	Benzo(a)pyrene	0.00585	J	0.0119	J	01SS090002	2/24	0.0112 - 0.0158	0.0119	NA	0.4	C	NA	8.2	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.0093	J	0.0118	J	01SS090002	2/24	0.0112 - 0.0158	0.0118	NA	210(8)	N	NA	570(8)	No	BSL
207-08-9	Benzo(k)fluoranthene	0.0141	J	0.0141	J	01TPL01	1/24	0.0112 - 0.0158	0.0141	NA	2	C	NA	39	No	BSL
117-81-7	Bis(2-Ethylhexyl)phthalate	0.083	J	0.42	-	01SS090002	3/24	0.19 - 1	0.42	NA	180	C	31000	3600	No	BSL
53-70-3	Dibenzo(a,h)anthracene	0.00576	J	0.00576	J	01TPL01	1/24	0.0112 - 0.0158	0.00576	NA	0.08	C	NA	18	No	BSL
206-44-0	Fluoranthene	0.00398	J	0.00439	J	01TPL01	2/24	0.0112 - 0.0158	0.00439	NA	210	N	NA	880	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.00452	J	0.00455	J	01SS090002	2/24	0.0112 - 0.0158	0.00455	NA	0.7	C	NA	3.1	No	BSL
120-58-1	Isosafrole	0.15	J	46	-	01SS050002	6/24	0.38 - 2	46	NA	NA		NA	NA	No	NTX
129-00-0	Pyrene	0.0041	J	0.0146	J	01SS040002	2/24	0.0112 - 0.0158	0.0146	NA	210	N	NA	570	No	BSL
Pesticides/PCBs (mg/kg)																
5103-74-2	gamma-Chlordane	0.00055	J	0.0011	J	01SS170002	7/17	0.0015 - 0.0017	0.0011	NA	0.5	C	20	9.6	No	BSL
76-44-8	Heptachlor	0.0012	J	0.0024	-	01SS200002	11/19	0.001 - 0.0024	0.0024	NA	1	C	4	23	No	BSL
Herbicides (mg/kg)																
93-72-1	2,4,5-TP (Silvex)	0.0059	J	0.015	J	01SS110002	2/20	0.011 - 0.016	0.015	NA	NA	N	NA	NA	No	BSL
94-75-7	2,4-D	0.035	J	0.21	-	01SS170002	5/18	0.081 - 0.09	0.21	NA	NA	N	NA	NA	No	BSL
Inorganics (mg/kg)																
7429-90-5	Aluminum	9400	J	19400	-	01SS100002	24/24	---	19400	Yes	NA	N	NA	NA	No	NS, BKG
7440-36-0	Antimony	1.7	J	1.7	J	01SS010002	1/24	0.2 - 1.4	1.7	No	0.3	N	NA	5.4	No	BKG
7440-38-2	Arsenic	6	J	10.9	J	01SS020002	24/24	---	10.9	Yes	1	C	750	29	No	BKG(9)
7440-39-3	Barium	42.9	-	169		01SS170002	24/24	---	169	No	82	N	690000	1600	No	BKG
7440-41-7	Beryllium	0.21	-	1	J	01SS170002, 01SS120002	23/24	0.59	1	Yes	3	N	1300	63	No	BSL
7440-43-9	Cadmium	0.05	J	1.3	J	01SS170002	14/24	0.01 - 0.05	1.3	No	0.4	N	1800	7.5	No	BKG
7440-70-2	Calcium	421	J	27900	J	01SS100002	24/24	---	27900	Yes	NA	N	NA	NA	No	NUT
7440-47-3	Chromium	11.5	-	24.3	J	01SS170002	24/24	---	24.3	No	2	N	270	38	No	BKG
7440-48-4	Cobalt	3.2	J	22.3	-	01TPL01	24/24	---	22.3	No	NA	N	NA	NA	No	NS, BKG
7440-50-8	Copper	7.4	J	18.5	-	01SS100002	24/24	---	18.5	Yes	NA	N	NA	580	No	BSL
7439-89-6	Iron	14600	-	25500	-	01SS030002	24/24	---	25500	Yes	NA	N	NA	NA	No	NTX
7439-92-1	Lead	11	-	21.6	-	01TPL01	24/24	---	21.6	No	NA	N	NA	81	No	BSL,BKG
7439-95-4	Magnesium	1050	J	5260	J	01SS100002	24/24	---	5260	Yes	NA	N	NA	NA	No	NUT
7439-96-5	Manganese	114	J	2010	-	01SS060002	24/24	---	2010	No	NA	N	NA	NA	No	NS, BKG
7439-97-6	Mercury	0.03	J	0.07	J	01SS090002, 01SS150002, 01SS100002	16/24	0.03 - 0.1	0.07	No	100	N	10	2.1	No	BSL,BKG
7440-02-0	Nickel	6.9	J	16	J	01SS170002, 01SS060002	24/24	---	16	No	7	N	13000	950	No	BKG
7440-09-7	Potassium	436	J	1310	J	01SS100002	24/24	---	1310	No	NA	N	NA	NA	No	NUT, BKG
7782-49-2	Selenium	0.49	-	1.3	-	01SS070002	16/24	0.38 - 1.5	1.3	Yes	0.3	N	NA	5.2	Yes	ASL
7440-23-5	Sodium	219	J	648	-	01SS100002	24/24	---	648	Yes	NA	N	NA	NA	No	NUT
7440-24-6	Strontium	5	J	33.5	J	01SS100002	24/24	---	33.5	No	NA	N	NA	NA	No	BSL,BKG
7440-28-0	Thallium	0.69	-	2.8	-	01SS030002	20/24	0.55 - 0.62	2.8	Yes	0.04	N	NA	2.8	No	BKG(9)
7440-28-0	Thallium - GF	0.07	J	0.13	J	01SS030002	2/2	---	0.13	No	0.04	N	NA	2.8	No	BKG(9)
7440-29-1	Thorium-Calc	1.90	-	6.44	-	01SS040002	25/25	---	6.44	No	NA	N	NA	NA	No	NTX, BKG

TABLE 4-9

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - MIGRATION FROM SURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NWSC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ?(4)	U.S. EPA Generic SSL for Migration to Ground Water (5)		U.S. EPA Generic SSL for Soil to Air (5)	IDEM SSL for Migration to Ground Water (6)	COPC	Rationale for Contaminant Deletion or Selection (7)
7440-31-5	Tin	2.5	-	3.9	-	01SS080002	7/24	2.5 - 29.2	3.9	Yes	NA	N	NA	NA	No	BSL
7440-62-2	Vanadium	22.8	-	44.5	-	01SS100002	24/24	---	44.5	Yes	300	N	NA	NA	No	BSL
7440-66-6	Zinc	25.1	J	67.8	-	01SS100002	24/24	---	67.8	Yes	620	N	NA	14000	No	BSL
Total Radiologicals (pCi/g)																
14331-83-0	Actinium-228	0.92	-	0.97	-	01TPL03	2/2	---	0.97	No	NA	C	1.10E+10	NA	No	BSL,BKG
14913-49-6	Bismuth-212	0.91	-	0.94	-	01TPL03	2/2	---	0.94	No	NA	C	4.20E+10	NA	No	BSL,BKG
14733-03-0	Bismuth-214	0.68	-	0.74	-	01TPL03	2/2	---	0.74	No	NA	C	3.40E+11	NA	No	BSL,BKG
10045-97-3	Cesium-137	0.09	-	0.09	-	01TPL03	1/2	0.0359	0.09	No	2.8	C	2.10E+06	NA	No	BSL,BKG
14255-04-0	Lead-210	0.47	-	0.52	-	01TPL03	2/2	---	0.52	No	5.50E-04	C	2000	NA	No	BKG
15092-94-1	Lead-212	0.83	-	0.86	-	01TPL03	2/2	---	0.86	No	3.50E+06	C	5.40E+08	NA	No	BSL,BKG
15067-28-4	Lead-214	0.69	-	0.71	-	01TPL02	2/2	---	0.71	No	1.40E+11	C	2.00E+11	NA	No	BSL,BKG
13966-00-2	Potassium-40	9.76	-	9.94	-	01TPL02	2/2	---	9.94	No	NA	C	1.80E+05	NA	No	BSL,BKG
13982-63-3	Radium-226	1.56	-	1.68	-	01TPL03	2/2	---	1.68	No	0.016	C	1600	NA	No	BKG
14913-50-9	Thallium-208	0.77	-	0.81	-	01TPL03	2/2	---	0.81	No	NA	C	NA	NA	No	BSL,BKG
14274-82-9	Thorium-228	0.227	-	0.73	-	01SS040002	25/25	---	0.73	No	3.3	C	1400	NA	No	BSL,BKG
14269-63-7	Thorium-230	0.0178	J	0.621	J	01SS040002	18/25	0.0342 - 0.0898	0.621	No	0.3	C	640	NA	No	BKG(10)
7440-29-1	Thorium-232	0.19	-	0.686	-	01SS040002	25/25	---	0.686	No	0.3	C	420	NA	No	BKG
15065-10-8	Thorium-234	1	-	1.73	-	01TPL03	2/2	---	1.73	No	4100	C	1.90E+08	NA	No	BSL,BKG
15117-96-1	Uranium-235	0.12	-	0.14	-	01TPL03	2/2	---	0.14	No	0.039	C	1800	NA	No	BKG

Shaded cells indicate that the specified criterion or background level hs been exceeded or that the chemical has been selected as a COPC.

Footnotes:
1 Only the original of the duplicate sample pair was used for COPC selection. The duplicate was used for quality control purposes only.
2 Values presented are sample-specific detection limits.
3 The maximum detected concentration is used for screening purposes.
4 To determine whether metal concentrations were within background levels, soil concentrations were compared to base-wide background data presented in the Base-wide Background Soil Investigation Report (TtNUS, Inc., 2001a) by means of the Wilcoxon Rank Sum Test. If the Wilcoxon Test determined that a constituent concentration was not significanty different from background, that chemical was not selected as a COPC.
5 Soil Screening Guidance: Technical Background Document. (U.S. EPA, 1996). The migration to groundwater value represents a dilution and attenuation factor (DAF) of 1.
6 Residential levels for migration from soil to groundwater (IDEM, 2001).
7 The chemical is selected as a COPC if the maximum detected concentration exceeds any screening level and background levels.
8 Pyrene is used as a surrogate for benzo(g,h,i)perylene.
9 Reevaluation demonstrated that this chemical does not exceed background concentrations. See Section 3.4.4 (arsenic) and Section 3.4.5 (thallium).
10 The rationale for the elimination of Thorium-230 on the basis of background in presented in Section 3.4.7.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/to be considered.
C = Carcinogen,
CAS = Chemical abstract services.
COPC = Chemical of potential concern.
GF = Graphite furnace atomic absorption reanalysis.
IDEM = Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential levels for migration from soil to ground water (IDEM, July 2001).
J = Estimated value.
N = Noncarcinogen.
NA = Not applicable/not available.
sat = Soil saturation concentration.

Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level/ARAR/TBC.

For Elimination as a COPC:
BKG = Within background levels.
BSL = Below COPC screening level/ARAR/TBC.
NTX = No toxicity information.
NUT = Essential nutrient.
NS = Soil Screening Levels have not been determined for these constituents.

TABLE 4-10

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SUBSURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ?(4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
VOCs (mg/kg)																
79-34-5	1,1,2,2-Tetrachloroethane	0.002	J	0.002	J	01SB090206	1/35	0.002 - 0.004	0.002	NA	0.38	C	5	IDEM	No	BSL
67-64-1	Acetone	0.006	-	0.042	-	01SB180610	12/35	0.004 - 0.006	0.042	NA	160	N	3900	IDEM	No	BSL
67-66-3	Chloroform	0.004	J	0.004	J	01SB090206	1/35	0.002 - 0.004	0.004	NA	0.24	C	0.91	IDEM	No	BSL
75-09-2	Methylene Chloride	0.003	J	0.086	J	01SB070206	27/35	0.005 - 0.054	0.086	NA	8.9	C	120	IDEM	No	BSL
SVOCs (mg/kg)																
83-32-9	Acenaphthene	0.00434	J	0.0303	-	01SB060206	3/34	0.0107 - 0.0148	0.0303	NA	370	N	9500	IDEM	No	BSL
120-12-7	Anthracene	0.0415	-	0.0415	-	01SB200610	1/34	0.0107 - 0.0148	0.0415	NA	2200	N	47000	IDEM	No	BSL
56-55-3	Benzo(a)anthracene	0.153	J	0.153	J	01SB200610	1/34	0.0107 - 0.0148	0.153	NA	0.62	C	5	IDEM	No	BSL
50-32-8	Benzo(a)pyrene	0.181	J	0.181	J	01SB200610	1/34	0.0107 - 0.0148	0.181	NA	0.062	C	0.5	IDEM	Yes	ASL
205-99-2	Benzo(b)fluoranthene	0.318	J	0.318	J	01SB200610	1/34	0.0107 - 0.0148	0.318	NA	0.62	C	5	IDEM	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.16	J	0.16	J	01SB200610	1/34	0.0107 - 0.0148	0.16	NA	230(7)	N	5500(7)	IDEM	No	BSL
117-81-7	bis(2-Ethylhexyl) phthalate	0.097	J	5.6	-	01SB090206	3/35	0.18 - 0.25	5.6	NA	35	C	300	IDEM	No	BSL
218-01-9	Chrysene	0.108	J	0.108	J	01SB200610	1/34	0.0107 - 0.0148	0.108	NA	62	C	500	IDEM	No	BSL
206-44-0	Fluoranthene	0.54	J	0.54	J	01SB200610	1/34	0.0107 - 0.0148	0.54	NA	230	N	6300	IDEM	No	BSL
86-73-7	Fluorene	0.0223	-	0.0223	-	01SB200610	1/34	0.0107 - 0.0148	0.0223	NA	260	N	6300	IDEM	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.0681	-	0.0681	-	01SB200610	1/34	0.0107 - 0.0148	0.0681	NA	0.62	C	5	IDEM	No	BSL
91-20-3	Naphthalene	0.00852	J	0.0102	J	01SB090206	3/24	0.0107 - 0.0148	0.0102	NA	5.6	N	3200	IDEM	No	BSL
85-01-8	Phenanthrene	0.278	J	0.278	J	01SB200610	1/34	0.0107 - 0.0148	0.278	NA	230(7)	N	5500(7)	IDEM	No	BSL
129-00-0	Pyrene	0.306	J	0.306	J	01SB200610	1/34	0.0107 - 0.0148	0.306	NA	230	N	5500	IDEM	No	BSL
Energetics (mg/kg)																
2691-41-0	HMX	0.0706	J	0.0706	J	01SB080206	1/35	0.454 - 0.5	0.0706	NA	310	N	NA	IDEM	No	BSL
Pesticides/PCBs (mg/kg)																
5103-74-2	gamma-Chlordane	0.00064	J	0.003	J	01SB160206	6/20	0.0014 - 0.0019	0.003	NA	1.6	C	17	IDEM	No	BSL
76-44-8	Heptachlor	0.00094	J	0.002	J	01SB150206	13/20	0.001 - 0.0021	0.002	NA	0.11	C	0.54	IDEM	No	BSL
Inorganics (mg/kg)																
7429-90-5	Aluminum	1420	J	18100	-	01SB060206	35/35	---	18100	Yes	7600	N	NA	IDEM	Yes	ASL
7440-38-2	Arsenic	0.48	J	20.2	J	01SB190610	26/35	0.36 - 2.3	20.2	Yes	0.39	C	3.9	IDEM	No	BKG(11)
7440-39-3	Barium	11.3	-	300	-	01SB170610	35/35	---	300	Yes	540	N	23000	IDEM	No	BSL
7440-41-7	Beryllium	0.24	-	1.6	J	01SB080610	26/35	0.22 - 0.48	1.6	Yes	15	N	680	IDEM	No	BSL
7440-43-9	Cadmium	0.04	J	1.1	-	01SB030206	17/35	0.01 - 0.05	1.1	Yes	3.7	N	12	IDEM	No	BSL
7440-70-2	Calcium	69.6	J	43200	J	01SB010206	35/35	---	43200	Yes	NA	N	NA	IDEM	No	NUT
7440-47-3	Chromium	6.4	J	24	-	01SB060206	35/35	---	24	Yes	30(8)	C	430(8)	IDEM	No	BSL
7440-48-4	Cobalt	1.3	J	25.8	-	01SB020610	34/35	0.6	25.8	Yes	470	N	NA	IDEM	No	BSL
7440-50-8	Copper	4.3	J	25.3	J	01SB080610	35/35	---	25.3	Yes	290	N	13000	IDEM	No	BSL
7439-89-6	Iron	4940	-	71500	-	01SB080610	35/35	---	71500	Yes	2300	N	NA	IDEM	Yes	ASL
7439-92-1	Lead	5.8	J	36.9	-	01SB030206	35/35	---	36.9	Yes	400		400	IDEM	No	BSL
7439-95-4	Magnesium	193	J	4670	J	01SB010206	35/35	---	4670	Yes	NA	N	NA	IDEM	No	NUT
7439-96-5	Manganese	8.6	J	408	-	01SB060610	35/35	---	408	Yes	180	N	NA	IDEM	Yes	ASL
7439-97-6	Mercury	0.02	J	0.07	J	01SB060206	14/35	0.02 - 0.05	0.07	Yes	2.3(9)	N	55(9)	IDEM	No	BSL
7440-02-0	Nickel	1.6	J	39.3	-	01SB060610	35/35	---	39.3	Yes	160	N	6900	IDEM	No	BSL
7440-09-7	Potassium	207	J	1190	J	01SB060610	35/35	---	1190	Yes	NA	N	NA	IDEM	No	NUT
7782-49-2	Selenium	0.12	J	1.7	-	01SB060206	16/35	0.18 - 0.9	1.7	Yes	39	N	1700	IDEM	No	BSL
7440-23-5	Sodium	240	J	755	-	01SB060610	35/35	---	755	Yes	NA	N	NA	IDEM	No	NUT
7440-24-6	Strontium	1.3	J	46	J	01SB010206	35/35	---	46	No	4700	N	NA	IDEM	No	BSL,BKG
7440-28-0	Thallium	0.75	-	5.3	J	01SB080610	31/35	0.53 - 0.63	5.3	Yes	0.52	N	31	IDEM	No	BKG(11)
7440-28-0	Thallium - GF	0.07	J	0.16	J	01SB080610	2/3	0.53 - 0.63	0.16	No	0.52	N	31	IDEM	No	BSL
7440-29-1	Thorium-Calc	1.87	-	6.94	-	01SB060610	37/37	---	6.94	No	NA	N	NA	IDEM	No	NTX, BKG
7440-31-5	Tin	2.3	-	4	-	01SB080610	11/35	2.3 - 27	4	Yes	4700	N	NA	IDEM	No	BSL
7440-62-2	Vanadium	7.1	-	42.6	-	01SB060206	35/35	---	42.6	Yes	55	N	NA	IDEM	No	BSL
7440-66-6	Zinc	9.3	J	129	-	01SB080610	35/35	---	129	Yes	2300	N	100000	IDEM	No	BSL
Total Radiologicals (pCi/g)																
14331-83-0	Actinium-228	1.01	-	1.27	-	01SB020206	4/4	---	1.27	No	730	C	NA	IDEM	No	BSL,BKG
14913-49-6	Bismuth-212	0.98	-	1.3	-	01SB010206	4/4	---	1.3	No	23000	C	NA	IDEM	No	BSL,BKG

TABLE 4-10

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SUBSURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 2 OF 2

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ?(4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
14733-03-0	Bismuth-214	0.73	-	0.87	-	01SB010206	4/4	---	0.87	No	8200	C	NA	IDEM	No	BSL,BKG
14391-16-3	Europium-155	0.08	-	0.09	-	01SB020206	2/4	0.242 - 0.244	0.09	No	3.8	C	NA	IDEM	No	BSL,BKG
14255-04-0	Lead-210	0.36	-	0.65	-	01SB030206	4/4	---	0.65	No	0.063	C	NA	IDEM	No	BKG
15092-94-1	Lead-212	0.95	-	1.13	-	01SB020206	4/4	---	1.13	No	3800	C	NA	IDEM	No	BSL,BKG
15067-28-4	Lead-214	0.72	-	0.87	-	01SB010206	4/4	---	0.87	No	46000	C	NA	IDEM	No	BSL,BKG
13966-00-2	Potassium-40	5.98	-	9.23	-	01SB020206	4/4	---	9.23	No	0.14	C	NA	IDEM	No	BKG
13982-63-3	Radium-226	1.66	-	1.9	-	01SB020206	4/4	---	1.9	No	0.013	C	NA	IDEM	No	BKG
14913-50-9	Thallium-208	0.91	-	1.04	-	01SB020206	4/4	---	1.04	No	23000	C	NA	IDEM	No	BSL,BKG
14274-82-9	Thorium-228	0.167	-	0.781	-	01SB040206	37/37	---	0.781	No	0.16	C	NA	IDEM	No	BKG
14269-63-7	Thorium-230	0.0332	J	0.637	J	01SB110610	25/37	0.0148 - 0.394	0.637	No	3.9	C	NA	IDEM	No	BSL,BKG(12)
7440-29-1	Thorium-232	0.245	-	0.872	-	01SB060610	37/37	---	0.872	No	3.4	C	NA	IDEM	No	BSL,BKG
15065-10-8	Thorium-234	1	-	1.88	-	01SB030206	4/4	---	1.88	No	2200	C	NA	IDEM	No	BSL,BKG

Shaded cells indicate that the specified criterion or background level has been exceeded or that the chemical has been selected as a COPC.

Footnotes:
1 Only the original of the duplicate sample pair was used for COPC selection. The duplicate was used for quality control purposes only.
2 Values presented are sample-specific detection limits.
3 The maximum detected concentration is used for screening purposes.
4 To determine whether metal concentrations were within background levels, soil concentrations were compared to base-wide background data presented in the Basewide Background Soil Investigation Report (TtNUS, Inc., 2001a) by means of the Wilcoxon Rank Sum Test. If the Wilcoxon Test determined that a constituent concentration was not significanty different from background, that chemical was not selected as a COPC.
5 The risk-based soil COPC screening level for residential land use is presented. The value is based on a target Hazard Quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (U.S. EPA, Region 9, 2000d and U.S. EPA, 2000c).
6 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and/or an ARAR/TBC(s) and background levels.
7 Pyrene is used as a surrogate for benzo(g,h,i)perylene and phenanthrene.
8 Hexavalent chromium.
9 OSWER soil screening level for residential land use (U.S. EPA, 1994)
10 Value is for mercuric chloride (U.S. EPA, Region 3, April 2002)
11 Reevaluation demonstrated that this chemical does not exceed background concentrations. See Section 3.4.4 (arsenic) and Section 3.4.5 (thallium).
12 The rationale for the elimination of Thorium-230 on the basis of background in presented in Section 3.4.7.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/to be considered.
C = Carcinogen.
CAS = Chemical abstract services.
COPC = Chemical of potential concern.
GF = Graphite furnace atomic absorption reanalysis.
IDEM = Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential levels for direct contact with soil (IDEM, 2001).
J = Estimated value.
N = Noncarcinogen
NA = Not applicable/bot available.
sat = Soil saturation concentration.

Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level/ARAR/TBC.

For Elimination as a COPC:
BKG = Within background levels.
BSL = Below COPC screening level/ARAR/TBC.
NTX = No toxicity information.
NUT = Essential nutrient.

TABLE 4-11

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - MIGRATION FROM SUBSURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NWSC CRANE
CRANE, INDIANA
PAGE 1 OF 2

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ? (4)	USEPA Generic SSL for Migration to Ground Water (5)		U.S. EPA Generic SSL for Soil to Air (6)	IDEM SSL for Migration to Ground Water (6)	COPC	Rationale for Contaminant Deletion or Selection (7)
VOCs (mg/kg)																
79-34-5	1,1,2,2-Tetrachloroethane	0.002	J	0.002	J	01SB090206	1/35	0.002 - 0.004	0.002	NA	0.0002	C	0.6	0.007	Yes	ASL
67-64-1	Acetone	0.006		0.042		01SB180610	12/35	0.004 - 0.006	0.042	NA	0.8	N	100000	3.1	No	BSL
67-66-3	Chloroform	0.004	J	0.004	J	01SB090206	1/35	0.002 - 0.004	0.004	NA	0.03	C	0.3	0.59	No	BSL
75-09-2	Methylene Chloride	0.003	J	0.086	J	01SB070206	27/35	0.005 - 0.054	0.086	NA	0.001	C	13	0.023	Yes	ASL
SVOCs (mg/kg)																
83-32-9	Acenaphthene	0.00434	J	0.0303		01SB060206	3/34	0.0107 - 0.0148	0.0303	NA	29	N	NA	130	No	BSL
120-12-7	Anthracene	0.0415		0.0415		01SB200610	1/34	0.0107 - 0.0148	0.0415	NA	590	N	NA	51	No	BSL
56-55-3	Benzo(a)anthracene	0.153	J	0.153	J	01SB200610	1/34	0.0107 - 0.0148	0.153	NA	0.08	C	NA	19	Yes	ASL
50-32-8	Benzo(a)pyrene	0.181	J	0.181	J	01SB200610	1/34	0.0107 - 0.0148	0.181	NA	0.4	C	NA	8.2	No	BSL
205-99-2	Benzo(b)fluoranthene	0.318	J	0.318	J	01SB200610	1/34	0.0107 - 0.0148	0.318	NA	0.2	C	NA	57	Yes	ASL
191-24-2	Benzo(g,h,i)perylene	0.16	J	0.16	J	01SB200610	1/34	0.0107 - 0.0148	0.16	NA	210(8)	N	NA	570(8)	No	BSL
117-81-7	bis(2-Ethylhexyl) phthalate	0.097	J	5.6		01SB090206	3/35	0.18 - 0.25	5.6	NA	180	C	31000	3600	No	BSL
218-01-9	Chrysene	0.108	J	0.108	J	01SB200610	1/34	0.0107 - 0.0148	0.108	NA	8	C	NA	25	No	BSL
206-44-0	Fluoranthene	0.54	J	0.54	J	01SB200610	1/34	0.0107 - 0.0148	0.54	NA	210	N	NA	880	No	BSL
86-73-7	Fluorene	0.0223		0.0223		01SB200610	1/34	0.0107 - 0.0148	0.0223	NA	28	N	NA	170	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.0681		0.0681		01SB200610	1/34	0.0107 - 0.0148	0.0681	NA	0.7	C	NA	3.1	No	BSL
91-20-3	Naphthalene	0.00852	J	0.0102	J	01SB090206	3/24	0.0107 - 0.0148	0.0102	NA	4	N	NA	0.7	No	BSL
85-01-8	Phenanthrene	0.278	J	0.278	J	01SB200610	1/34	0.0107 - 0.0148	0.278	NA	210(8)	N	NA	570(8)	No	BSL
129-00-0	Pyrene	0.306	J	0.306	J	01SB200610	1/34	0.0107 - 0.0148	0.306	NA	210	N	NA	570	No	BSL
Energetics (mg/kg)																
2691-41-0	HMX	0.0706	J	0.0706	J	01SB080206	1/35	0.454 - 0.5	0.0706	NA	NA	N	NA	NA	No	NTX
Pesticides/PCBs (mg/kg)																
5103-74-2	gamma-Chlordane	0.00064	J	0.003	J	01SB160206	6/20	0.0014 - 0.0019	0.003	NA	0.5	C	20	9.6	No	BSL
76-44-8	Heptachlor	0.00094	J	0.002	J	01SB150206	13/20	0.001 - 0.0021	0.002	NA	1	C	4	23	No	BSL
Inorganics (mg/kg)																
7429-90-5	Aluminum	1420	J	18100		01SB060206	35/35	---	18100	Yes	NA	N	NA	NA	No	NTX
7440-38-2	Arsenic	0.48	J	20.2	J	01SB190610	26/35	0.36 - 2.3	20.2	No	1	C	750	29	No	BKG(9)
7440-39-3	Barium	11.3		300		01SB170610	35/35	---	300	Yes	82	N	690000	1600	Yes	ASL
7440-41-7	Beryllium	0.24		1.6	J	01SB080610	26/35	0.22 - 0.48	1.6	Yes	3	N	1300	63	No	BSL
7440-43-9	Cadmium	0.04	J	1.1		01SB030206	17/35	0.01 - 0.05	1.1	Yes	0.4	N	1800	7.5	Yes	ASL
7440-70-2	Calcium	69.6	J	43200	J	01SB010206	35/35	---	43200	Yes	NA	N	NA	NA	No	NUT
7440-47-3	Chromium	6.4	J	24		01SB060206	35/35	---	24	Yes	2	C	270	38	Yes	ASL
7440-48-4	Cobalt	1.3	J	25.8		01SB020610	34/35	0.6	25.8	Yes	NA	N	NA	NA	No	NTX
7440-50-8	Copper	4.3	J	25.3	J	01SB080610	35/35	---	25.3	Yes	NA	N	NA	580	No	BSL
7439-89-6	Iron	4940		71500		01SB080610	35/35	---	71500	Yes	NA	N	NA	NA	No	NTX
7439-92-1	Lead	5.8	J	36.9		01SB030206	35/35	---	36.9	Yes	NA		NA	81	No	BSL
7439-95-4	Magnesium	193	J	4670	J	01SB010206	35/35	---	4670	Yes	NA	N	NA	NA	No	NUT
7439-96-5	Manganese	8.6	J	408		01SB060610	35/35	---	408	Yes	NA	N	NA	NA	No	NTX
7439-97-6	Mercury	0.02	J	0.07	J	01SB060206	14/35	0.02 - 0.05	0.07	Yes	NA	N	NA	2.1	No	BSL
7440-02-0	Nickel	1.6	J	39.3		01SB060610	35/35	---	39.3	Yes	7	N	13000	950	Yes	ASL
7440-09-7	Potassium	207	J	1190	J	01SB060610	35/35	---	1190	Yes	NA	N	NA	NA	No	NUT
7782-49-2	Selenium	0.12	J	1.7		01SB060206	16/35	0.18 - 0.9	1.7	Yes	0.3	N	NA	5.2	Yes	ASL
7440-23-5	Sodium	240	J	755		01SB060610	35/35	---	755	Yes	NA	N	NA	NA	No	NUT
7440-24-6	Strontium	1.3	J	46	J	01SB010206	35/35	---	46	No	NA	N	NA	NA	No	NS, BKG
7440-28-0	Thallium	0.75		5.3	J	01SB080610	31/35	0.53 - 0.63	5.3	No	0.04	N	NA	2.8	No	BKG(9)
7440-28-0	Thallium - GF	0.07	J	0.16	J	01SB080610	2/3	0.53 - 0.63	0.16	No	0.04	N	NA	2.8	No	BKG(9)
7440-29-1	Thorium-Calc	1.87		6.94		01SB060610	37/37	---	6.94	No	NA	N	NA	NA	No	NTX, BKG
7440-31-5	Tin	2.30		4.00		01SB080610	11/35	2.3 - 27	4.00	Yes	NA	N	NA	NA	No	NTX
7440-62-2	Vanadium	7.1		42.6		01SB060206	35/35	---	42.6	Yes	300	N	NA	NA	No	BSL
7440-66-6	Zinc	9.3	J	129		01SB080610	35/35	---	129	Yes	620	N	NA	14000	No	BSL
Total Radiologicals (pCi/g)																
14331-83-0	Actinium-228	1.01		1.27		01SB020206	4/4	---	1.27	No	NA	C	1.10E+10	NA	No	BKG, NTX
14913-49-6	Bismuth-212	0.98		1.3		01SB010206	4/4	---	1.3	No	NA	C	4.20E+10	NA	No	BKG, NTX
14733-03-0	Bismuth-214	0.73		0.87		01SB010206	4/4	---	0.87	No	NA	C	3.40E+11	NA	No	BKG, NTX
14391-16-3	Europium-155	0.08		0.09		01SB020206	2/4	0.242 - 0.244	0.09	No	NA	C	5.20E_06	NA	No	BKG, NTX

TABLE 4-11

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - MIGRATION FROM SUBSURFACE SOIL, ROUND 1
SWMU 01 - MUSTARD GAS BURIAL GROUND
NWSC CRANE
CRANE, INDIANA
PAGE 2 OF 2

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ? (4)	USEPA Generic SSL for Migration to Ground Water (5)		U.S. EPA Generic SSL for Soil to Air (5)	IDEM SSL for Migration to Ground Water (6)	COPC	Rationale for Contaminant Deletion or Selection (7)
14255-04-0	Lead-210	0.36		0.65		01SB030206	4/4	---	0.65	No	0.00055	C	2000	NA	No	BKG
15092-94-1	Lead-212	0.95		1.13		01SB020206	4/4	---	1.13	No	3500000	C	5.40E_08	NA	No	BSL,BKG
15067-28-4	Lead-214	0.72		0.87		01SB010206	4/4	---	0.87	No	1.4E+11	C	2.00E+11	NA	No	BSL,BKG
13966-00-2	Potassium-40	5.98		9.23		01SB020206	4/4	---	9.23	No	NA	C	1.80E+06	NA	No	BKG, NTX
13982-63-3	Radium-226	1.66		1.9		01SB020206	4/4	---	1.9	No	0.016	C	1600	NA	No	BKG
14913-50-9	Thallium-208	0.91		1.04		01SB020206	4/4	---	1.04	No	NA	C	NA	NA	No	BKG, NTX
14274-82-9	Thorium-228	0.167		0.781		01SB040206	37/37	---	0.781	No	3.3	C	1400	NA	No	BSL,BKG
14269-63-7	Thorium-230	0.0332	J	0.637	J	01SB110610	25/37	0.0148 - 0.394	0.637	No	0.3	C	640	NA	No	BKG(10)
7440-29-1	Thorium-232	0.245		0.872		01SB060610	37/37	---	0.872	No	0.3	C	420	NA	No	BKG
15065-10-8	Thorium-234	1		1.88		01SB030206	4/4	---	1.88	No	4100	C	1.90E+08	NA	No	BSL,BKG

Shaded cells indicate that the specified criterion or background level hs been exceeded or that the chemical has been selected as a COPC.

Footnotes:
1 Only the original of the duplicate sample pair was used for COPC selection. The duplicate was used for quality control purposes only.
2 Values presented are sample-specific detection limits.
3 The maximum detected concentration is used for screening purposes.
4 To determine whether metal concentrations were within background levels, soil concentrations were compared to base-wide background data presented in the Base-wide Background Soil Investigation Report (TtNUS, Inc., 2001a) by means of the Wilcoxon Rank Sum Test. If the Wilcoxon Test determined that a constituent concentration was not significanty different from background, that chemical was not selected as a COPC.
5 Soil Screening Guidance: Technical Background Document. (U.S. EPA, May 1996). The migration to groundwater value represents a dilution and attenuation factor (DAF) of 1.
6 Residential levels for migration from soil to groundwater (IDEM, 2001).
7 The chemical is selected as a COPC if the maximum detected concentration exceeds any screening level and background levels.
8 Pyrene is used as a surrogate for benzo(g,h,i)perylene and phenanthrene.
9 Reevaluation demonstrated that this chemical does not exceed background concentrations. See Section 3.4.4 (arsenic) and Section 3.4.5 (thallium).
10 The rationale for the elimination of Thorium-230 on the basis of background in presented in Section 3.4.7.

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/to be considered.
C = Carcinogen.
CAS = Chemical abstract services.
COPC = Chemical of potential concern.
GF = Graphite furnace atomic absorption reanalysis.
IDEM = Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential levels for migration from soil to ground water (IDEM, 2001).
J = Estimated value.
N = Nocarcinogen.
NA = Not applicable/not available.
sat = Soil saturation concentration.

Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level/ARAR/TBC.

For Elimination as a COPC:
BKG = Within background levels.
BSL = Below COPC screening level/ARAR/TBC.
NTX = No toxicity information.
NUT = Essential nutrient.
NS = Soil Screening Levels have not been determined for these constituents.

TABLE 4-12

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUND WATER, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 4

CAS Number	Chemical	Minimum Concentration [1]		Maximum Concentration [1]		Sample No. of Maximum Concentration	Detection Frequency [1]	Range of Nondetects[2]	Concentration Used for Screening[3]	Background Value[4]	Risk-Based COPC Screening Level[5]		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection[6]
VOCs (ug/L)																
630-20-6	1,1,1,2-Tetrachloroethane	0.3	J	5	J	01GW1901	7/49	0.5 - 500	5	NA	0.43	C	--- 6.9	FED-MCL IDEM	Yes	ASL
79-34-5	1,1,2,2-Tetrachloroethane	0.3	J	38000	-	01GW0201	20/49	0.5	38000	NA	0.055	C	--- 0.9	FED-MCL IDEM	Yes	ASL
79-00-5	1,1,2-Trichloroethane	0.4	J	16	-	01GW1502	14/49	1 - 1000	16	NA	0.2	C	5 5	FED-MCL IDEM	Yes	ASL
75-35-4	1,1-Dichloroethene	0.2	J	2	J	01GW1901	6/49	1 - 1000	2	NA	0.046	C	7 7	FED-MCL IDEM	Yes	ASL
107-06-2	1,2-Dichloroethane	0.3	J	10	J	01GW1901	6/49	0.5 - 500	10	NA	0.12	C	5 5	FED-MCL IDEM	Yes	ASL
67-66-3	Chloroform	0.1	J	840	J	01GW0201	13/49	0.2 - 18	840	NA	0.16	C	80 100	FED-MCL IDEM	Yes	ASL
156-59-2	cis-1,2-Dichloroethene	0.9	J	9	-	01GW1502	10/49	1 - 1000	9	NA	6.1	N	70 70	FED-MCL IDEM	Yes	ASL
75-09-2	Methylene Chloride	0.2	J	1	J	01GW1102	7/49	0.2 - 1000	1	NA	4.3	C	5 5	FED-MCL IDEM	No	BSL
127-18-4	Tetrachloroethene	1	-	370	J	01GW0201	11/49	0.5 - 13	370	NA	1.1	C	5 5	FED-MCL IDEM	Yes	ASL
108-88-3	Toluene	0.3	J	1	-	01GW0701	6/49	0.5 - 500	1	NA	72	N	1000 1000	FED-MCL IDEM	No	BSL
156-60-5	trans-1,2-Dichloroethene	0.3	J	3	-	01GW1502	9/49	1 - 1000	3	NA	12	N	100 100	FED-MCL IDEM	No	BSL
79-01-6	Trichloroethene	0.2	J	16000	-	01GW0201	27/49	0.5	16000	NA	1.6	C	5 5	FED-MCL IDEM	Yes	ASL
74-85-1	Ethene	2	J	2	J	01GWT0203	1/8	1	2	NA	NA		NA ---	FED-MCL IDEM	No	NTX
74-82-8	Methane	0.9	J	24	J	01GW1502	2/8	1	24	NA	NA		NA ---	FED-MCL IDEM	No	NTX
SVOCs (ug/L)																
100-02-7	4-Nitrophenol	15	J	15	J	01GW0501	1/13	25	15	NA	29	N	NA ---	FED-MCL IDEM	No	BSL
83-32-9	Acenaphthene	0.0793	J	0.108	J	01GWC0101	3/13	0.2	0.108	NA	37	N	NA 460	FED-MCL IDEM	No	BSL
208-96-8	Acenaphthylene	0.763	-	0.763	-	01GW0201	1/13	0.2	0.763	NA	37	N	NA 460	FED-MCL IDEM	No	BSL
117-81-7	bis(2-Ethylhexyl) phthalate	5	J	15	J	01GW1101	3/13	5	15	NA	4.8	C	6 6	FED-MCL IDEM	Yes	ASL
85-68-7	Butyl Benzyl Phthalate	9	J	9	J	01GW1101	1/13	5	9	NA	730	N	--- 2700	FED-MCL IDEM	No	BSL
86-73-7	Fluorene	0.0593	J	0.0593	J	01GW0201	1/13	0.2	0.0593	NA	24	N	--- 310	FED-MCL IDEM	No	BSL
67-72-1	Hexachloroethane	5	J	5	J	01GW0201	1/13	5	5	NA	4.8	C	--- 37	FED-MCL IDEM	Yes	ASL
91-20-3	Naphthalene	0.0796	J	0.579	-	01GW0201	3/13	0.2	0.579	NA	0.62	N	--- 8.3	FED-MCL IDEM	No	BSL
Energetics (ug/L)																
118-96-7	2,4,6-Trinitrotoluene	0.127	J	0.127	J	01GW1701	1/13	0.65	0.127	NA	2.2	C	NA ---	FED-MCL IDEM	No	BSL
88-72-2	2-Nitrotoluene	0.202	J	0.202	J	01GW0201	1/13	0.65	0.202	NA	6.1	N	NA ---	FED-MCL IDEM	No	BSL
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.263	J	0.275	J	01GWT0201	2/13	0.65	0.275	NA	0.22(7)	N	NA ---	FED-MCL IDEM	Yes	ASL
2691-41-0	HMX	0.201	J	0.201	J	01GW0101	1/12	0.65	0.201	NA	180	N	NA ---	FED-MCL IDEM	No	BSL

TABLE 4-12

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUND WATER, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration [1]		Maximum Concentration [1]		Sample No. of Maximum Concentration	Detection Frequency [1]	Range of Nondetects[2]	Concentration Used for Screening[3]	Background Value[4]	Risk-Based COPC Screening Level[5]		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection[6]
Pesticides/PCBs (ug/L)																
5103-74-2	gamma-Chlordane	0.025	J	0.075	J	01GW0301	2/13	0.04	0.075	NA	0.19	C	2 2	FED-MCL IDEM	No	BSL
76-44-8	Heptachlor	0.017	J	0.023	J	01GW1101	2/13	0.013 - 0.059	0.023	NA	0.015	C	0.4 0.4	FED-MCL IDEM	Yes	ASL
Total Metals (ug/L)																
7429-90-5	Aluminum	46.3	-	5700	-	01GW0301	14/37	21.2 - 57.8	5700	NA	3600	N	50(8) ---	FED-SMCL IDEM	Yes	ASL
7440-36-0	Antimony	1.9	-	3.1	-	01GW1501	4/37	1.6 - 5.1	3.1	NA	1.5	N	6 6	FED-MCL IDEM	Yes	ASL
7440-38-2	Arsenic	2.2	J	7.9	-	01GW0301	4/37	1.5 - 3.2	7.9	NA	0.045	C	10 10	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	5.4	J	258	-	01GW0301	37/37	---	258	NA	260	N	2000 2000	FED-MCL IDEM	No	BSL
7440-41-7	Beryllium	0.59	-	0.7	J	01GWT0201	2/37	0.3 - 0.7	0.7	NA	7.3	N	4 4	FED-AL IDEM	No	BSL
7440-43-9	Cadmium	0.74	-	0.94	-	01GW0301	2/37	0.3 - 0.6	0.94	NA	1.8	N	5 5	FED-MCL IDEM	No	BSL
7440-70-2	Calcium	7640	-	344000	-	01GWT0203	37/37	---	344000	NA	NA	N	--- ---	FED-MCL IDEM	No	NUT
7440-47-3	Chromium	0.7	-	7.1	J	01GW0301	9/37	0.6 - 3.6	7.1	NA	11(9)	N	100 100	FED-MCL IDEM	No	BSL
7440-48-4	Cobalt	1.2	-	126	J	01GWT0203	23/37	1 - 4.3	126	NA	220	N	--- ---	FED-MCL IDEM	No	BSL
7440-50-8	Copper	0.94	-	14.5	J	01GW0301	4/37	0.9 - 3.2	14.5	NA	140	N	1300 1300	FED-AL IDEM	No	BSL
7439-89-6	Iron	22.1	-	44600	-	01GW1401	31/37	20.2 - 27	44600	NA	1100	N	300(8) ---	FED-SMCL IDEM	Yes	ASL
7439-92-1	Lead	4.3	-	8.2	J	01GW0301	2/37	0.7 - 2.8	8.2	NA	NA	N	15 15	FED-AL IDEM	No	BSL
7439-95-4	Magnesium	2720	-	250000	-	01GWT0203	37/37	---	250000	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7439-96-5	Manganese	1.5	-	9600	-	01GWT0203	37/37	---	9600	NA	88	N	50(8) ---	FED-SMCL IDEM	Yes	ASL
7439-97-6	Mercury	0.1	-	0.24	-	01GW0701	9/37	0.1 - 0.13	0.24	NA	1.1(10)	N	2 2	FED-MCL IDEM	No	BSL
7440-02-0	Nickel	1.4	-	273	-	01GWT0203	28/37	0.7 - 5.7	273	NA	73	N	--- 730	FED-MCL IDEM	Yes	ASL
7440-09-7	Potassium	446	-	15500	J	01GWT0202	37/37	---	15500	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7440-22-4	Silver	0.65	J	1.1	-	01GW0701	7/37	0.7 - 3	1.1	NA	18	N	100 180	FED-SMCL IDEM	No	BSL
7440-23-5	Sodium	1510	-	117000	-	01GW0501	37/37	---	117000	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7440-24-6	Strontium	33.1	J	3990	J	01GWT0202	37/37	---	3990	NA	2200	N	--- ---	FED-MCL IDEM	Yes	ASL
7440-28-0	Thallium	2.5	-	5.1	-	01GW1701	9/37	0.6 - 5	5.1	NA	0.24	N	2 2	FED-MCL IDEM	No	**
7440-28-0	Thallium - GF	0.6	UJ	3	UJ	NA	0/3	0.6 - 3	NA	NA	0.24	N	2 2	FED-MCL IDEM	No	**
CALC004	Thorium-Calc	0.16	-	1.50	-	01GWT0201	5/16	0.36 - 1.45	1.50	NA	NA	N	--- ---	FED-MCL IDEM	No	NTX
7440-62-2	Vanadium	0.53	-	11.8	-	01GW0301	7/37	0.5 - 3.3	11.8	NA	26	N	--- ---	FED-MCL IDEM	No	BSL

TABLE 4-12

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUND WATER, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration [1]		Maximum Concentration [1]		Sample No. of Maximum Concentration	Detection Frequency [1]	Range of Nondetects[2]	Concentration Used for Screening[3]	Background Value[4]	Risk-Based COPC Screening Level[5]		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection[6]
7440-66-6	Zinc	3.9	-	103	-	01GWT0203	15/37	1.1 - 43.8	103	NA	1100	N	5000(8) 11000	FED-SMCL IDEM	No	BSL
Dissolved Metals (ug/L)																
7429-90-5	Aluminum	146	-	146	-	01GW2601-F	1/11	21.2 - 87	146	NA	3600	N	300(8) ---	FED-SMCL IDEM	Yes	ASL
7440-36-0	Antimony	2.1	J	2.1	J	01GW2001-F	1/11	1.6 - 5.1	2.1	NA	1.5	N	6 6	FED-MCL IDEM	Yes	ASL
7440-38-2	Arsenic	1.7	J	2.3	-	01GW0301-F	2/11	1.5 - 3	2.3	NA	0.045	C	5 50	FED-MCL IDEM	Yes	ASL
7440-39-3	Barium	5.4	J	215	-	01GW0301-F	11/11	---	215	NA	260	N	2000 2000	FED-MCL IDEM	No	BSL
7440-70-2	Calcium	60500	J	349000	-	01GWT0203-F	11/11	---	349000	NA	NA	N	--- ---	FED-MCL IDEM	No	NUT
7440-47-3	Chromium	1.1	-	1.1	-	01GW2001-F	1/11	0.6 - 1	1.1	NA	11(9)	N	100 100	FED-MCL IDEM	No	BSL
7440-48-4	Cobalt	1.7	-	96.8	J	01GWT0203-F	7/11	1 - 1.1	96.8	NA	220	N	--- ---	FED-MCL IDEM	No	BSL
7439-89-6	Iron	51.7	J	20300	-	01GWT0203-F	10/11	20.3	20300	NA	1100	N	300(8) ---	FED-SMCL IDEM	Yes	ASL
7439-95-4	Magnesium	5430	J	254000	-	01GWT0203-F	11/11	---	254000	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7439-96-5	Manganese	10.4	-	9650	-	01GWT0203-F	11/11	---	9650	NA	88	N	300(8) ---	FED-SMCL IDEM	Yes	ASL
7439-97-6	Mercury	0.1	-	0.1	-	01GW2001-F	1/11	0.1 - 0.14	0.1	NA	1.1(10)	N	2 2	FED-AL IDEM	No	BSL
7440-02-0	Nickel	4.6	-	208	-	01GWT0203-F	6/11	1.4 - 5.3	208	NA	73	N	--- 730	FED-MCL IDEM	Yes	ASL
7440-09-7	Potassium	1100	J	15200	-	01GWT0203-F	11/11	---	15200	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7440-23-5	Sodium	5000	J	70700	-	01GWT0203-F	11/11	---	70700	NA	NA	N	NA ---	FED-MCL IDEM	No	NUT
7440-24-6	Strontium	96.5	J	4040	J	01GWT0203-F	11/11	---	4040	NA	2200	N	--- ---	FED-MCL IDEM	Yes	ASL
7440-28-0	Thallium	5.4	-	7.7	J	01GW2001-F	2/11	0.6 - 5	7.7	NA	0.24	N	2 2	FED-MCL IDEM	No	**
7440-28-0	Thallium - GF	3	UJ	3	UJ	NA	0/1	3	NA	NA	0.24	N	2 2	FED-MCL IDEM	No	**
7440-62-2	Vanadium	0.77	-	0.77	-	01GW2001-F	1/11	0.3 - 3	0.77	NA	26	N	--- ---	FED-MCL IDEM	No	BSL
7440-66-6	Zinc	7.1	-	65.6	-	01GWT0203-F	4/11	1.1 - 9.4	65.6	NA	1100	N	5000(8) 11000	FED-SMCL IDEM	No	BSL
Total Radionuclides (pCi/L)																
TTNUS006	Gross Alpha	1.36	J	10.5	J	01GWT0201	21/34	0.906 - 6.06	10.5	NA	NA		15 ---	FED-MCL IDEM	No	BSL
TTNUS007	Gross Beta	1.69	-	50.2	J	01GW2301	24/35	1.58 - 5.16	50.2	NA	NA		NA ---	FED-MCL IDEM	No	NTX
14274-82-9	Thorium-228	0.0329	-	0.172	-	01GWT0201	3/16	0.0216 - 0.166	0.172	NA	0.16		NA ---	FED-MCL IDEM	No	***
TTNUS097	Thorium-232	0.0235	-	0.157	-	01GWT0201	3/16	0.0207 - 0.154	0.157	NA	0.47		NA ---	FED-MCL IDEM	No	BSL

TABLE 4-12

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - GROUND WATER, ROUNDS 1 AND 2
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Sample No. of Maximum Concentration	Detection Frequency (1)	Range of Nondetects(2)	Concentration Used for Screening(3)	Background Value(4)	Risk-Based COPC Screening Level(5)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection(6)
Field Parameters (mg/L)															
14797-55-8	Nitrate	---	-	1.28	-	01GWT0401	8/8	---	1.28	NA	10	10 ---	FED-SMCL IDEM	No	BSL
14797-65-0	Nitrite	---	-	0.008	-	01GWT0301,	8/8	---	0.008	NA	1	1 ---	FED-SMCL IDEM	No	BSL
14808-79-8	Sulfate	12	-	80	-	5 LOCATIONS	8/8	---	80	NA	NA	250 ---	FED-SMCL IDEM	No	BSL

Shaded cells indicate that the specified criterion or background level was exceeded and the chemical was selected as a COPC.

Footnotes:

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 Values presented are sample-specific quantitation limits.
3 The maximum detected concentration is used for screening purposes.
4 Background data are not available for SWMU 1.
5 Risk-based COPC screening level for tap water use based on a target hazard quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (U.S. EPA, Region 9, 2000c).
6 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and/or an ARAR/TBC(s).
7 Value is for aminodinitrotoluenes (U.S. EPA, Region 3, April 2002)
8 Secondary MCL, based on aesthetic water quality (i.e., color, odor, taste, etc.).
9 Screening level is based on PRG for hexavalent chromium.
10 Value is for mercuric chloride (U.S. EPA, Region 3, April 2002)

Definitions:

ARAR/TBC = Applicable or Relevant and Appropriate Requirement/To Be Considered.
C = Carcinogen.
CAS = Chemical abstract services.
COPC = Chemical of Potential Concern.
GF = Graphite furnace atomic absorption reanalysis.
J = Estimated value.
N = Noncarcinogen.
NA = Not Analyzed / Not Applicable.
ND = Not Detected.
FED-AL = Federal Action Level (U.S. EPA, 2002).
FED-MCL = Federal Maximum Contaminant Level (U.S. EPA, 2002).
IDEM = Indiana Department of Environmental Management, Risk Inegrated System of Closure (RISC) residential closure levels for groundwater (IDEM, 2001).
UJ = Estimated detection limit.

Rationale Codes:

For Selection as a COPC:
ASL = Above COPC Screening Level/ARAR/TBC

For Elimination as a COPC:
BKG = Within Background Levels
BSL = Below COPC Screening Level/ARAR/TBC
NTX = No Toxicity Information
NUT = Essential Nutrient

** Thallium was not detected in the GFAA reanalyses of select samples and was not selected as a COPC. See discussion in Section 3.4-5 .
*** See Section 4.2.4.

TABLE 4-13

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SEDIMENT, ROUNDS 1 AND 2
SWMU 01, MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ? (4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
VOCs (mg/kg)																
79-34-5	1,1,2,2-Tetrachloroethane	0.007		0.009		01SD0302	2/12	0.003 -0.004	0.009	NA	0.38	C	5	IDEM	No	BSL
67-64-1	Acetone	0.012	J	0.63	J	01SD1202	6/12	0.005 -0.007	0.63	NA	160	N	3900	IDEM	No	BSL
75-15-0	Carbon Disulfide	0.002	J	0.002	J	01SD0302, 01SD1102	2/12	0.003 -0.004	0.002	NA	36	N	900	IDEM	No	BSL
75-71-8	Dichlorodifluoromethane	0.001	J	0.008	J	01SD1002	4/12	0.003 -0.004	0.008	NA	9.4	N	NA	IDEM	No	BSL
108-88-3	Toluene	0.001	J	0.002	J	01SD0302	3/12	0.003 -0.004	0.002	NA	520	sat	1700	IDEM	No	BSL
SVOCs (mg/kg)																
83-32-9	Acenaphthene	0.139	J	0.139	J	01SD0701	1/7	0.0112 - 0.139	0.139	NA	370	N	9500	IDEM	No	BSL
56-55-3	Benzo(a)anthracene	0.0144		0.0144		01SD0701	1/7	0.0112 - 0.139	0.0144	NA	0.62	C	5	IDEM	No	BSL
50-32-8	Benzo(a)pyrene	0.00497	J	0.0275	J	01SD0701	4/7	0.0116 - 0.139	0.0275	NA	0.062	C	0.5	IDEM	No	BSL
205-99-2	Benzo(b)fluoranthene	0.0077	J	0.12	J	01SD0701	4/7	0.0116 - 0.137	0.12	NA	0.62	C	5	IDEM	No	BSL
191-24-2	Benzo(g,h,i)perylene	0.0218	J	0.0218	J	01SD0701	1/7	0.0112 - 0.139	0.0218	NA	230	N	5500	IDEM	No	BSL
207-08-9	Benzo(k)fluoranthene	0.00626	J	0.0146	J	01SD0701	3/7	0.0112 - 0.139	0.0146	NA	6.2	C	50	IDEM	No	BSL
117-81-7	bis(2-ethylhexyl) phthalate	0.098	J	0.098	J	01SD0801	1/7	0.19 - 0. 23	0.098	NA	35	C	300	IDEM	No	BSL
218-01-9	Chrysene	0.0173	J	0.0173	J	01SD0701	1/7	0.0112 - 0.139	0.0173	NA	62	C	500	IDEM	No	BSL
206-44-0	Fluoranthene	0.00493	J	0.0184	J	01SD0701	4/7	0.0116 - 0.139	0.0184	NA	230	N	6300	IDEM	No	BSL
193-39-5	Indeno(1,2,3-cd)pyrene	0.0128		0.0128		01SD0701	1/7	0.0112 - 0.139	0.0128	NA	0.62	C	5	IDEM	No	BSL
120-58-1	Isosafrole	7.6		7.6		01SD0601	1/7	0.38 - 0.46	7.6	NA	611	N	NA	IDEM	No	BSL
129-00-0	Pyrene	0.00531	J	0.024	J	01SD0701	2/7	0.0112 - 0.139	0.024	NA	230	N	5500	IDEM	No	BSL
Energetics (mg/kg)																
2691-41-0	HMX	0.0542	J	0.422	J	01SD0301	4/7	0.476 - 0.5	0.422	NA	310	N	NA	IDEM	No	BSL
Pesticides/PCBs (mg/kg)																
11096-82-5	Aroclor-1260	0.019	J	0.019	J	01SD0701	1/7	0.037 - 0.046	0.019	NA	0.22	C	NA	IDEM	No	BSL
76-44-8	Heptachlor	0.0011	J	0.0025		01SD0601	5/7	0.0018	0.0025	NA	0.11	C	0.54	IDEM	No	BSL
Herbicides (mg/kg)																
93-76-5	2,4,5-T	0.0086	J	0.0086	J	01SD0401	1/7	0.011 - 0.014	0.0086	NA	61	N	NA	IDEM	No	BSL
93-72-1	2,4,5-TP (Silvex)	0.0031	J	0.012		01SD0201	3/7	0.012 - 0.014	0.012	NA	49	N	NA	IDEM	No	BSL
Inorganics (mg/kg)																
7429-90-5	Aluminum	6770		13700		01SD0801	7/7	---	13700	No	7600	N	NA	IDEM	No	BKG
7440-36-0	Antimony	2	J	2	J	01SD0201	1/7	0.48 - 0.61	2	No	3.1	N	140	IDEM	No	BSL,BKG
7440-38-2	Arsenic	4.4		31.1		01SD0201	7/7	---	5.3	No	0.39	C	3.9	IDEM	No	BKG
7440-39-3	Barium	47.4		120		01SD0601, 01SD0501	7/7	---	120	No	540	N	23000	IDEM	No	BSL,BKG
7440-41-7	Beryllium	0.57	J	1.7	J	01SD0201	6/7	0.62	1.7	No	15	N	680	IDEM	No	BSL,BKG
7440-43-9	Cadmium	0.39	J	0.39	J	01SD0601	1/7	0.05 - 0.23	0.39	No	3.7	N	12	IDEM	No	BSL,BKG
7440-70-2	Calcium	769		5520		01SD0801	7/7	---	5520	No	NA		NA	IDEM	No	NUT, BKG
7440-47-3	Chromium	9.4		45.1		01SD0201	7/7	---	45.1	No	30(8)	C	430(8)	IDEM	No	BKG
7440-48-4	Cobalt	6.9		28.8		01SD0201	7/7	---	28.8	No	470	N	NA	IDEM	No	BSL,BKG
7440-50-8	Copper	9.5	J	19.4	J	01SD0201	7/7	---	19.4	No	290	N	13000	IDEM	No	BSL,BKG
7439-89-6	Iron	12300		76900		01SD0201	7/7	---	76900	No	2300	N	NA	IDEM	No	BKG
7439-92-1	Lead	16.1		32		01SD0201	7/7	---	32	No	400(9)		400(9)	IDEM	No	BSL,BKG
7439-95-4	Magnesium	1030		1940		01SD0801	7/7	---	1940	No	NA	N	NA	IDEM	No	NUT, BKG
7439-96-5	Manganese	278		1640		01SD0201	7/7	---	1640	No	180	N	NA	IDEM	No	BKG
7440-02-0	Nickel	11.3		35.9		01SD0201	7/7	---	35.9	No	160	N	6900	IDEM	No	BSL,BKG
7440-09-7	Potassium	497	J	1100	J	01SD0301	7/7	---	1100	No	NA		NA	IDEM	No	NUT, BKG
7782-49-2	Selenium	0.45		1.2		01SD0201	6/7	0.38	1.2	No	39	N	1700	IDEM	No	BSL,BKG
7440-23-5	Sodium	298		416		01SD0301	7/7	---	416	Yes	NA		NA	IDEM	No	NUT
7440-24-6	Strontium	8.1	J	14.5	J	01SD0801	7/7	---	14.5	No	4700	N	NA	IDEM	No	BSL,BKG
7440-28-0	Thallium	0.57		7.1		01SD0201	6/7	0.56	7.1	No	0.52	N	31	IDEM	No	BKG
TTNUS331	Thallium-GF	0.1	J	0.1	J	01SD0201	1/1	---	0.1	No	0.52	N	31	IDEM	No	BSL,BKG
CALC004	Thorium-Calc	6.47		12.45		01SD0301	7/7	---	12.45	No	NA		NA	IDEM	No	BKG, NTX
7440-31-5	Tin	3		3.7		01SD0801	7/7	---	3.7	No	4700	N	NA	IDEM	No	BSL,BKG
7440-62-2	Vanadium	18.9		45.8		01SD0201	7/7	---	45.8	No	55	N	NA	IDEM	No	BSL,BKG
7440-66-6	Zinc	35.6		78		01SD0201	7/7	---	78	No	2300	N	100000	IDEM	No	BSL,BKG

TABLE 4-13

OCCURRENCE, DISTRIBUTION, AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN - DIRECT CONTACT WITH SEDIMENT, ROUNDS 1 AND 2
SWMU 01, MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Location of Maximum Concentration	Detection Frequency (1)	Range of Nondetects (2)	Concentration Used for Screening (3)	Site Above Background ? (4)	Risk-Based COPC Screening Level (5)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC	Rationale for Contaminant Deletion or Selection (6)
Total Radiologicals (pCi/g)																
14274-82-9	Thorium-228	0.694		1.49		01SD0301	7/7	---	1.49	No	0.16	C	NA	IDEM	No	BKG
14269-63-7	Thorium-230	0.791	J	1.26	J	01SD0301	7/7	---	1.26	No	3.9	C	NA	IDEM	No	BSL,BKG
TTNUS097	Thorium-232	0.624		1.25		01SD0301	7/7	---	1.25	No	3.4	C	NA	IDEM	No	BSL,BKG

Shaded cells indicate that the specified criterion or background level has been exceeded and the chemical has been selected as a COPC.

Footnotes:
1 Only the original of the duplicate sample pair was used for COPC selection. The duplicate was used for quality control purposes only.
2 Values presented are sample-specific detection limits.
3 The maximum detected concentration is used for screening purposes.
4 To determine whether metal concentrations were within background levels, sediment concentrations were compared to sediment background concentrations by means of the Wilcoxon Rank Sun Test. If the Wilcoxon Test determined that a constituent concentration was not significanty different from background, that chemical was not selected as a COPC.
5 The risk-based soil COPC screening level for residential land use is presented. The value is based on a target Hazard Quotient of 0.1 for noncarcinogens (denoted with a "N" flag) or an incremental cancer risk of 1E-6 for carcinogens (denoted with a "C" flag) (U.S. EPA, Region 9, 2000d and U.S. EPA, 2000c).
6 The chemical is selected as a COPC if the maximum detected concentration exceeds the risk-based COPC screening level and/or an ARAR/TBC(s) and background levels.
7 Pyrene is used as a surrogate for benzo(g,h,i)perylene.
8 Screening level is based on PRG for hexavalent chromium.
9 OSWER soil screening level for residential land use (U.S. EPA, 1994)

Definitions:
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/to be considered.
C = Carcinogen.
CAS = Chemical abstract services.
COPC = Chemical of potential concern.
GF = Graphite furnace atomic absorption reanalysis.
IDEM = Indiana Department of Environmental Management, Risk Integrated System of Closure (RISC) residential levels for direct contact with soil (IDEM, 2001).
J = Estimated value.
N = Noncarcinogen
NA = Not applicable/not available.
sat = Soil saturation concentration.

Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level/ARAR/TBC.

For Elimination as a COPC:
BKG = Within background levels.
BSL = Below COPC screening level/ARAR/TBC.
NTX = No toxicity information.
NUT = Essential nutrient.

TABLE 4-14

CHEMICALS RETAINED AS COPCs FOR HUMAH HEALTH RISK ASSESSMENT
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	Surface Soil			Subsurface Soil			Ground Water	Sediment	Surface Water
	Direct Contact	Soil to Air	Soil to Ground Water	Direct Contact	Soil to Air	Soil to Ground Water			
VOCs									
1,1,1,2-Tetrachloroethane						X	X		
1,1,2,2-Tetrachloroethane							X		
1,1,2-Trichloroethane							X		
1,1-Dichloroethene							X		
1,2-Dichloroethane							X		
Chloroform							X		
cis-1,2-Dichloroethene							X		
Methylene Chloride			X			X			
Tetrachloroethene							X		
Trichloroethene							X		
SVOCs									
Benzo(a)anthracene						X			
Benzo(a)pyrene				X					
Benzo(b)fluoranthene						X			
bis(2-Ethylhexyl) phthalate							X		
Hexachloroethane							X		
Pesticides									
Heptachlor							X		
Energetics									
4-Amino-2,6-Dinitrotoluene							X		
Inorganics									
Aluminum	X			X			X		
Antimony							X		
Arsenic							X		
Barium						X			
Cadmium						X			
Chromium						X			
Iron	X			X			X		
Manganese				X			X		
Nickel						X	X		
Selenium			X			X			
Strontium							X		

Notes
X - Indicates chemical was retained as a COPC.

TABLE 4-15

ECOLOGICAL RISK SCREENING COPC SELECTION - SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Chemical	Frequency of Detection (1)	Minimum Concentration	Maximum Concentration (2)	Location of Maximum Concentration	Average of Positive Detects	Average of All Results	Above Background? (3)	Surface Soil COPC Screening Level (4)	Ecological Effects Quotient (5)	COPC?	Rationale for Contaminant Deletion or Selection (6)
VOCs (ug/kg)											
2-Butanone	2/24	38 -	71 J	01SS130002	54.5	3.8	NA	89600	0.001	No	BSL
Acetone	4/24	21 J	180 -	01SS180002	105	8.9	NA	2500	0.1	No	BSL
Carbon Disulfide	1/24	6 -	6 -	01SS170002	6	1.6	NA	94	0.1	No	BSL
Methylene Chloride	10/24	2 J	61 J	01SS060002	22.2	6.9	NA	4050	0.02	No	BSL
Toluene	1/24	2 J	2 J	01SS130002	2	1.6	NA	5450	0.0004	No	BSL
SVOCs (ug/kg)											
7,12-Dimethylbenz(a)Anthracene	1/24	260 J	260 J	01SS170002	260	168	NA	16300	0.02	No	BSL
Acenaphthene	2/24	15.8 -	70.8 -	01SS060002	43.3	7.1	NA	682000	0.0001	No	BSL
Benzo(a)Pyrene	2/24	5.85 J	11.9 J	01SS090002	8.9	6.4	NA	1520	0.01	No	BSL
Benzo(g,h,i)Perylene	2/24	9.3 J	11.8 J	01SS090002	10.6	6.5	NA	119000	0.0001	No	BSL
Benzo(k)Fluoranthene	1/24	14.1 J	14.1 J	01TPL01	14.1	6.4	NA	148000	0.0001	No	BSL
bis(2-Ethylhexyl) phthalate	3/24	83 J	420 -	01SS090002	197	117	NA	926	0.5	No	BSL
Dibenzo(a,h)Anthracene	1/24	5.76 J	5.76 J	01TPL01	5.8	6.2	NA	18400	0.0003	No	BSL
Fluoranthene	2/24	3.98 J	4.39 J	01TPL01	4.2	6	NA	122000	0.00004	No	BSL
Indeno(1,2,3-cd)Pyrene	2/24	4.52 J	4.55 J	01SS090002	4.5	6.1	NA	109000	0.00004	No	BSL
Isosafrole	6/24	150 J	46000 -	01SS050002	8810	363	NA	9940	4.6	Yes	ASL
Pyrene	2/24	4.1 J	14.6 J	01SS040002	9.4	6.3	NA	78500	0.0002	No	BSL
Pesticides/PCBs (ug/kg)											
gamma-Chlordane	7/17	0.55 J	1.1 J	01SS170002	0.8	0.8	NA	224	0.005	No	BSL
Heptachlor	11/19	1.2 J	2.4 -	01SS200002	1.6	1.1	NA	5.98	0.4	No	BSL
Herbicides (ug/kg)											
2,4,5-TP (SILVEX)	2/20	5.9 J	15 J	01SS110002	10.5	6.5	NA	109	0.1	No	BSL
2,4-D	5/18	35 J	210 -	01SS170002	96.4	50.1	NA	27.3	7.7	Yes	ASL
Inorganics (mg/kg)											
Aluminum	24/24	9400 J	19400 -	01SS100002	13086	12841	Yes	---	---	Yes	NTX
Antimony	1/24	1.7 J	1.7 J	01SS010002	1.7	0.3	No	0.1	11.9	No	BKG
Arsenic	24/24	6 J	10.9 J	01SS020002	8	7.9	No	5.7	1.9	No	BKG
Barium	24/24	42.9 -	169 -	01SS170002	94.1	87.9	No	1.04	163	No	BKG
Beryllium	23/24	0.21 -	1 J	01SS120002 01SS170002	0.7	0.6	Yes	1.1	0.9	No	BSL
Cadmium	14/24	0.05 J	1.3 J	01SS170002	0.3	0.1	No	0.002	586	No	BKG
Calcium	24/24	421 J	27900 J	01SS100002	5058	2035	Yes	---	---	No	NT
Chromium	24/24	11.5 -	24.3 J	01SS170002	15.7	15.4	No	0.4	61	No	BKG
Cobalt	24/24	3.2 J	22.3 -	01TPL01	12.7	11.3	No	0.14	159	No	BKG
Copper	24/24	7.4 J	18.5 -	01SS100002	12.4	12	Yes	2.96	6.3	Yes	ASL
Iron	24/24	14600 -	25500 -	01SS030002	19879	19566	Yes	---	---	Yes	NTX
Lead	24/24	11 -	21.6 -	01TPL01	16.6	16.3	No	0.05	402	No	BKG
Magnesium	24/24	1050 J	5260 J	01SS100002	2110	1977	Yes	---	---	No	NT

TABLE 4-15

ECOLOGICAL RISK SCREENING COPC SELECTION - SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Chemical	Frequency of Detection [1]	Minimum Concentration	Maximum Concentration [2]	Location of Maximum Concentration	Average of Positive Detects	Average of All Results	Above Background? [3]	Surface Soil COPC Screening Level [4]	Ecological Effects Quotient [5]	COPC?	Rationale for Contaminant Deletion or Selection [6]
Manganese	24/24	114 J	2010 -	01SS060002	823	651	No	---	---	No	BKG
Mercury	16/24	0.03 J	0.07 -	01SS150002 01SS100002 01SS090002	0.1	0.04	No	0.07	1	No	BKG
Nickel	24/24	6.9 J	16 -	01SS060002 01SS170002	12.4	12.2	No	13.6	1.2	No	BKG
Potassium	24/24	436 J	1310 J	01SS100002	705	684	No	---	---	No	BKG
Selenium	16/24	0.49 -	1.3 -	01SS070002	0.8	0.6	Yes	0.03	47	Yes	ASL
Sodium	24/24	219 J	648 -	01SS100002	380	367	Yes	---	---	No	NT
Strontium	24/24	5 J	33.5 J	01SS100002	12	11	No	---	---	No	BKG
Thallium	20/24	0.69 -	2.8 -	01SS030002	1.6	1.2	No	0.06	49.2	No	BKG
Thallium-GF	2/2	0.07 J	0.13 J	01SS030002	0.1	0.1	No	0.06	2.3	No	BKG
Thorium-Calc	24/24	1.895455 -	6.436364 -	01SS040002	4.1	4.0	No	---	---	No	BKG
Tin	7/24	2.5 -	3.9 -	01SS080002	3.3	7.4	Yes	7.6	0.5	No	BSL
Vanadium	24/24	22.8 -	44.5 -	01SS100002	29.8	29.4	Yes	1.6	28	Yes	ASL
Zinc	24/24	25.1 J	67.8 -	01SS100002	45.7	44.8	Yes	6.6	10.2	Yes	ASL
Total Radionuclides (pCi/g)											
Actinium-228	2/2	0.92 -	0.97 -	01TPL03	0.9	0.9	No	---	---	No	BKG
Bismuth-212	2/2	0.91 -	0.94 -	01TPL03	0.9	0.9	No	---	---	No	BKG
Bismuth-214	2/2	0.68 -	0.74 -	01TPL03	0.7	0.7	No	---	---	No	BKG
Cesium-137	1/2	0.09 -	0.09 -	01TPL03	0.1	0.04	No	---	---	No	BKG
Lead-210	2/2	0.47 -	0.52 -	01TPL03	0.5	0.5	No	---	---	No	BKG
Lead-212	2/2	0.83 -	0.86 -	01TPL03	0.8	0.8	No	---	---	No	BKG
Lead-214	2/2	0.69 -	0.71 -	01TPL02	0.7	0.7	No	---	---	No	BKG
Potassium-40	2/2	9.76 -	9.94 -	01TPL02	9.9	9.8	No	---	---	No	BKG
Radium-226	2/2	1.56 -	1.68 -	01TPL03	1.6	1.6	No	---	---	No	BKG
Thallium-208	2/2	0.77 -	0.81 -	01TPL03	0.8	0.8	No	---	---	No	BKG
Thorium-228	24/24	0.227 -	0.73 -	01SS040002	0.4	0.4	No	---	---	No	BKG
Thorium-230	17/24	0.0178 J	0.621 J	01SS040002	0.2	0.1	No	---	---	No	BKG
Thorium-232	24/24	0.19 -	0.686 -	01SS040002	0.5	0.5	No	---	---	No	BKG
Thorium-234	2/2	1 -	1.73 -	01TPL03	1.4	1.3	No	---	---	No	BKG
Uranium-235	2/2	0.12 -	0.14 -	01TPL03	0.1	0.1	No	---	---	No	BKG

* Arsenic and Thallium results were further investigated as described in Sections 3.4.4 and 3.4.5 and found to be within background concentrations.

Shading indicates that the constituent was selected as a COPC.

TABLE 4-15

ECOLOGICAL RISK SCREENING COPC SELECTION - SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Chemical	Frequency of Detection (1)	Minimum Concentration	Maximum Concentration (2)	Location of Maximum Concentration	Average of Positive Detects	Average of All Results	Above Background? (3)	Surface Soil COPC Screening Level (4)	Ecological Effects Quotient (5)	COPC?	Rationale for Contaminant Deletion or Selection (6)

Footnotes:
1 Only the original of duplicate samples was used for COPC selection. The duplicate was used for quality control purposes only.
2 The maximum detected concentration was used for screening purposes.
3 Refer to Section 3.4.2 for discussion of the method used to calculate background exceedences.
4 Region 5 EDQLs (U.S. EPA, 1999b)
5 Refer to Section 8.3.2 for ecological effects quotient calculation.
6 Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level.
NTX = No toxicity information available.

For Elimination as a COPC:
BKG = Below site background level.
BSL = Below COPC screening level.
NT = Nontoxic.
COPC = Chemical of Potential Concern.

TABLE 4-16

ECOLOGICAL RISK SCREENING COPC SELECTION - SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Chemical	Frequency of Detection [1]	Minimum Concentration	Maximum Concentration [2]	Location of Maximum Concentration	Average of Positive Detects	Average of All Results	Above Background? [3]	Sediment COPC Screening Level [4]	Ecological Effects Quotient [5]	COPC?	Rationale for Contaminant Deletion or Selection [6]
VOCs (ug/kg)											
1,1,2,2-Tetrachloroethane	2/12	7 -	9 -	01SD0302	8	2.2	NA	29.08	0.3	No	BSL
Acetone	6/12	12 J	630 J	01SD1202	352	24.7	NA	453.37	1.4	Yes	ASL
Carbon Disulfide	2/12	2 J	2 J	01SD0302 01SD1102	2	1.8	NA	133.97	0.01	No	BSL
Dichlorodifluoromethane	4/12	1 J	8 J	01SD1002	3.5	2	NA	1.33	6	Yes	ASL
Toluene	3/12	1 J	2 J	01SD0302	1.3	1.6	NA	52500	0.00004	No	BSL
SVOCs (ug/kg)											
Acenaphthene	1/7	139 J	139 J	01SD0701	139	9.8	NA	6.71	21	Yes	ASL
Benzo(a)Anthracene	1/7	14.4 -	14.4 -	01SD0701	14.4	7.1	NA	31.7	0.5	No	BSL
Benzo(a)Pyrene	4/7	4.97 J	27.5 J	01SD0701	11.6	7.8	NA	31.9	0.9	No	BSL
Benzo(b)Fluoranthene	4/7	7.7 J	120 J	01SD0701	40	12.5	NA	10400	0.01	No	BSL
Benzo(g,h,i)Perylene	1/7	21.8 J	21.8 J	01SD0701	21.8	7.5	NA	170	0.1	No	BSL
Benzo(k)Fluoranthene	3/7	6.26 J	14.6 J	01SD0701	9.9	7.4	NA	240	0.1	No	BSL
bis(2-Ethylhexyl) phthalate	1/7	98 J	98 J	01SD0801	98	101	NA	182	0.5	No	BSL
Chrysene	1/7	17.3 J	17.3 J	01SD0701	17.3	7.3	NA	57.1	0.3	No	BSL
Fluoranthene	4/7	4.93 J	18.4 J	01SD0701	9.1	7.3	NA	111.3	0.2	No	BSL
Indeno(1,2,3-cd)Pyrene	1/7	12.8 -	12.8 -	01SD0701	12.8	7	NA	200	0.1	No	BSL
Isosafrole	1/7	7600 -	7600 -	01SD0601	7600	347	NA	4.12	1845	Yes	ASL
Pyrene	2/7	5.31 J	24 J	01SD0701	14.7	7.3	NA	53	0.5	No	BSL
Energertics (ug/kg)											
HMX	4/7	54.2 J	422 J	01SD0301	174	169	NA	---	---	Yes	NTX
Pesticides/PCBs (ug/kg)											
Aroclor-1260	1/7	19 J	19 J	01SD0701	19	20.4	NA	34.1	0.6	No	BSL
Heptachlor	5/7	1.1 J	2.5 -	01SD0601	1.6	1.3	NA	0.6	4.2	Yes	ASL
Herbicides (ug/kg)											
2,4,5-T	1/7	8.6 J	8.6 J	01SD0401	8.6	6.4	NA	58700	0.0001	No	BSL
2,4,5-TP (Silvex)	3/7	3.1 J	12 -	01SD0201	8.7	7	NA	7350	0.002	No	BSL
Inorganics (mg/kg)											
Aluminum	7/7	6770 -	13700 -	01SD0801	9413	9160	No	---	---	No	BKG
Antimony	1/7	2 J	2 J	01SD0201	2	0.4	No	---	---	No	BKG
Arsenic	7/7	4.4 -	31.1 -	01SD0201	12.9	9.6	No	5.9	5.3	No	BKG
Barium	7/7	47.4 -	120 -	01SD0601 01SD0501	94.3	90.7	No	---	---	No	BKG
Beryllium	6/7	0.57 J	1.7 J	01SD0201	0.9	0.7	No	---	---	No	BKG
Cadmium	1/7	0.39 J	0.39 J	01SD0601	0.4	0.05	No	0.596	0.7	No	BKG/BSL
Calcium	7/7	769 -	5520 -	01SD0801	2361	1944	No	---	---	No	NT
Chromium	7/7	9.4 -	45.1 -	01SD0201	17.8	15.4	No	26	1.7	No	BKG
Cobalt	7/7	6.9 -	28.8 -	01SD0201	15.1	13.6	No	50	0.6	No	BKG/BSL
Copper	7/7	9.5 J	19.4 J	01SD0201	13.9	13.5	No	16	1.2	No	BKG
Iron	7/7	12300 -	76900 -	01SD0201	27414	22501	No	---	---	No	BKG
Lead	7/7	16.1 -	32 -	01SD0201	23	22.3	No	31	1.0	No	BKG

TABLE 4-16

ECOLOGICAL RISK SCREENING COPC SELECTION - SEDIMENT
SWMU 01 - MUSTARD GAS BURIAL GROUNDS
NSWC CRANE
CRANE, INDIANA

Chemical	Frequency of Detection [1]	Minimum Concentration	Maximum Concentration [2]	Location of Maximum Concentration	Average of Positive Detects	Average of All Results	Above Background? [3]	Sediment COPC Screening Level [4]	Ecological Effects Quotient [5]	COPC?	Rationale for Contaminant Deletion or Selection [6]
Magnesium	7/7	1030	1940 -	01SD0801	1313	1269	No	---	---	No	NT
Manganese	7/7	278 -	1640 -	01SD0201	954	791	No	---	---	No	BKG
Nickel	7/7	11.3 -	35.9 -	01SD0201	16.3	15	No	16	2.2	No	BKG
Potassium	7/7	497 J	1100 J	01SD0301	718	693	No	---	---	No	NT
Selenium	6/7	0.45 -	1.2 -	01SD0201	0.8	0.6	No	---	---	No	BKG
Sodium	7/7	298 -	416 -	01SD0301	349	346	Yes	---	---	No	NT
Strontium	7/7	8.1 J	14.5 J	01SD0801	10.1	9.9	No	---	---	No	BKG
Thallium	6/7	0.57 -	7.1 -	01SD0201	2.4	1.4	No	---	---	No	BKG
Thallium-GF	1/1	0.1 J	0.1 J	01SD0201	0.1	0.1	No	---	---	No	BKG
Thorium-Calc	7/7	6.468182 -	12.454545 -	01SD0301	8.2	8	No	---	---	No	BKG
Tin	7/7	3 -	3.7 -	01SD0801	3.3	3.3	No	---	---	No	BKG
Vanadium	7/7	18.9 -	45.8 -	01SD0201	26.2	25	No	---	---	No	BKG
Zinc	7/7	35.6 -	78 -	01SD0201	51.6	49.7	No	120	0.7	No	BKG/BSL
Total Radionuclides (pCi/g)											
Thorium-228	7/7	0.694 -	1.49 -	01SD0301	1	0.9	No	---	---	No	BKG
Thorium-230	7/7	0.791 J	1.26 J	01SD0301	1	1	No	---	---	No	BKG
Thorium-232	7/7	0.624 -	1.25 -	01SD0301	0.8	0.8	No	---	---	No	BKG

* Arsenic and Thallium results were further investigated as described in Sections 3.4.4 and 3.4.5 and found to be within background concentrations.

Shading indicates the constituent was selected as a COPC.

Footnotes:
1 Only the original of duplicate samples was used for COPC selection. The duplicate was used for quality control purposes only.
2 The maximum detected concentration was used for screening purposes.
3 Refer to Section 3.4.2 for discussion of the method used to calculate background exceedences.
4 Region 5 EDQLs (U.S. EPA, 1999b).
5 Refer to Section 8.3.2 for ecological effects quotient calculation.
6 Rationale Codes:
For Selection as a COPC:
ASL = Above COPC screening level.
NTX = No toxicity information available.

For Elimination as a COPC:
BKG = Below site background level.
BSL = Below COPC screening level.
NT = Nontoxic.

Definitions:
COPC = Chemical of potential concern.

TABLE 4-17

SUMMARY OF MEDIUM-SPECIFIC COPCs
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	Surface Soil	Subsurface Soil	Ground Water	Sediment
VOCs				
1,1,1,2-Tetrachloroethane			H	
1,1,2,2-Tetrachloroethane		H	H	
1,1,2-Trichloroethane			H	
1,1-Dichloroethene			H	
1,2-Dichloroethene			H	
Acetone				E
Chloroform			H	
cis-1,2-Dichloroethene			H	
Dichlorodifluoromethane				E
Methylene Chloride	H	H		
Tetrachloroethene			H	
Trichloroethene			H	
SVOCs				
Acenaphthene				E
Benzo(a)anthracene		H		
Benzo(b)fluoranthene		H		
Benzo(a)pyrene		H		
bis(2-ethylhexyl) phthalate			H	
Hexachloroethane			H	
Isosafrole	E			E
Herbicides				
2,4-D	E			
Pesticides				
Heptachlor			H	E
Energetics				
4-Amino-2,6-Dinitrotoluene			H	
HMX				E
Metals				
Aluminum	E,H	H	H	
Antimony			H	
Arsenic			H	
Barium		H		
Cadmium		H		
Chromium		H		
Copper	E			
Iron	E,H	H	H	
Manganese		H	H	
Nickel		H	H	
Selenium	E,H	H		
Strontium			H	
Vanadium	E			
Zinc	E			
Dissolved Metals				
Aluminum			H	
Antimony			H	
Arsenic			H	
Iron			H	
Manganese			H	
Nickel			H	
Strontium			H	

Notes:
E indicates that the chemical was retained as a COPC for the ecological risk assessent.
H indicates that the chemical was retained as a COPC for the human health risk assessment.

5.0 NATURE AND EXTENT OF CONTAMINATION

Surface and subsurface soil, ground water, and sediment samples were collected during Round 1 of the Phase III RFI. Surface water was not available and could not be sampled in 2001 (Round 1). The chemical analyses performed on individual samples were selected based on the history of site operations and U.S. EPA requirements for conducting a RFI. Areas that were known as potentially contaminated with particular chemicals were analyzed for those and related chemicals as presented in Table 2-2 of Section 2.

During Round 2, ground water and sediment were re-sampled to obtain extended spatial coverage of the MGBG study area and to supplement or to verify previously observed contaminant and background chemical concentrations. Surface water was present in 2002 (Round 2) in the intermittent streams located within the study area, so surface water samples were also collected where possible. The analyses selected for 2002 samples were based on the results of the 2001 sampling and the need to fill data gaps for the RFI. Because many fractions of chemicals did not appear to present any significant human health or ecological risk after Round 1, the analyte list was narrowed considerably in 2002. The contaminants of primary interest in 2002 were VOCs. It appeared that natural attenuation of ground water VOCs could be occurring at the MGBG, so analyses were also conducted in 2002 for parameters that may be useful in estimating the extent of natural attenuation.

Based on analytical data obtained during 2001 and 2002, the nature and extent of COPCs and related chemicals such as chemical degradation products are discussed on a matrix-specific basis in the following subsections.

Figures 5-1 through 5-10 are environmental medium-specific presentations of chemical concentrations. Chemicals shown are the COPCs and related chemicals such as degradation products. In some cases, a parent compound and its degradation product(s) may have been present but only degradation product(s) concentrations exceeded COPC screening levels. In those cases, parent compound concentrations are also presented so the relationships between parent and daughter compounds could be seen. On the tag maps (Figures 5-1 through 5-5 and Figure 5-10) COPCs for the medium of interest are shown at each sampling location where they were analyzed and detected. If a chemical was not detected, or its concentration was not measured at a particular location, it is not shown. Rejected data are also not shown, but are summarized in Section 3.0 with the reasons for rejection.

Figures 5-1 through 5-10 are environmental media-specific spatial presentations of chemical concentrations. Chemicals shown are the COPCs and related chemicals such as degradation products. In this project, all detected degradation products were, themselves, COPCs. All COPCs for the medium of interest are plotted at each sampling location where they were analyzed and detected. If a chemical was not detected or its concentration was not measured at a particular location it is not shown on the tag maps.

If a COPC was selected for surface soil, it was also plotted as if it was detected in subsurface soil, whether or not it was actually a COPC in subsurface soil. This was done to show any relationships for the affected analytes in the two media.

Flags such as "ECO" and "R9TAP" are incorporated into the tags to show where an analyte concentration exceeds one or more risk-based criteria that were used as the bases for COPC selection criteria. Because the COPC selection criterion is one-tenth the risk-based criterion from noncarcinogens, it is possible for noncarcinogenic COPCs to appear on a tag map with no flag next to it. In those cases, the observed chemical concentration is understood to fall between the risk-based criterion and one-tenth the risk-based criterion. The U.S. EPA Region 9 PRGs for carcinogens were not divided by 10 when selecting COPCs so this situation does not exist for carcinogens. Risk-based criteria are presented in the COPC Section 4.0, Tables 4-8 through 4-13, 4-15, and 4-16.

When selecting ecological COPCs a chemical was selected as a COPC if no ecological risk-based criterion was available, however tag maps do not display any criteria exceedance flags for the affected chemicals for lack of risk-based criteria. If a particular chemical did not have human health-based screening criterion, it was not automatically selected as COPCs for human health risk assessment. Few chemicals are affected this way. For chemicals without human health screening criteria the chemical is typically an essential nutrient, or the observed concentrations did not exceed background concentrations, or the chemical is detected infrequently. Such chemicals were not evaluated quantitatively in the human health risk assessment but they were discussed in the risk uncertainty analysis.

The MGBG QAPP (TtNUS, 2001) indicates that the extent of contamination would be delineated by the perimeter encompassing both an HI of 1.0 and an ILCR of 10E-4 for a future potential resident. This was not feasible for many contaminants, especially in soil, sediment, and surface water, because of the few and widely scattered detectable chemical concentrations. Instead of plotting the HI and ILCR contours, the extent of contamination was described in terms of concentrations in a more qualitative manner. Contaminant concentrations and the bounding of contaminants are discussed relative to COPC screening levels used to select COPCs. References to extent of contamination refer to spatial contaminant patterns

that exhibit concentrations in excess of COPC screening levels toward the center (or upgradient) of an area, and concentrations that are less than COPC screening levels in a direction away from the center (or downgradient) of the contaminated area. Table 4-17 presents a summary of human health and ecological COPCs.

5.1 SURFACE SOIL, ROUND 1

Twenty surface soil grab samples (0- to 2-foot depth) were collected across the MGBG during Round 1 field activities. One surface soil sample was also collected at a local background spot approximately 700 feet southeast of the MGBG. Composite surface soil samples were collected from the two anomaly excavation pits - one composite from the small pit (01TPS04) and three composites from the large pit (01TPL01, 01TPL02, and 01TPL03). Each composite comprised three grab samples collected from across the bottom of the pit (See Figure 1-11).

Each surface soil grab sample was analyzed for the same chemicals with the exception of the background location sample, 01SS210002 (See Table 2-2). That sample was analyzed for thorium radioisotopes, pH and CEC only. Table 4-1 presents a summary of the results reported for compounds detected in the surface soil samples collected from MGBG. Tables 4-8, 4-9, and 4-15 present summaries of descriptive statistics for detected surface soil chemicals, including concentration ranges, frequencies of detection, locations of maximum concentrations, comparisons to background concentrations, and COPC screening criteria. Appendix E contains a copy of the entire analytical database for MGBG surface soil.

Figure 5-1 presents concentrations of organic COPCs detected in surface soil and subsurface soil samples (excluding rejected data). Figure 5-2 presents concentrations of inorganic COPCs detected in surface soil samples (excluding rejected data).

No radionuclides exhibited surface soil concentrations in excess of background concentrations; therefore, no maps of radionuclide surface soil concentrations were generated. Although the lists of organic COPCs for surface and subsurface soil differ, the union of the two sets of COPCs is presented on Figure 5-1 to reveal potential relationships between surface and subsurface soil contamination. A similar strategy was used for inorganic COPCs (Figure 5-2), although the lists of COPCs was too large to allow surface and subsurface data to be presented on the same figure.

VOCs

Although every surface soil sample was analyzed for VOCs, few VOCs were detected in surface soil. Acetone, 2-butanone, carbon disulfide, methylene chloride, and toluene were the only VOCs detected. Acetone was detected in samples 01SS070002, 01SS180002, 01SS190002, and 01SS200002 at concentrations ranging from 21 µg/kg to 180 µg/kg. These concentrations are likely to be biased low (Table 3-9). Methylene chloride was detected in samples 01SS060002, 01SS070002, 01SS100002, 01SS130002, 01SS140002, and 01SS160002 through 01SS200002, at concentrations ranging from 2 µg/kg to 61 µg/kg. Although not attributed to blank contamination during data validation, acetone and methylene chloride are common laboratory contaminants and may not be site-related. Acetone concentrations were well below COPC screening levels for surface soil, so that chemical is not discussed further.

Section 3.4.3 presents a more detailed evaluation of methylene chloride concentrations with the conclusion that methylene chloride can not be ruled out as a site contaminant on the basis of the data quality review. Methylene chloride is a reductive dechlorination breakdown product of chloroform, and chloroform was also detected at the site in about one-third of the ground water samples (Rounds 1 and 2) and in two subsurface soil samples (sampled only in Round 1). Chloroform and methylene chloride are also common laboratory and industrial solvents but can not be ruled out as having been released at the MGBG.

Carbon disulfide and toluene were detected in samples 01SS130002 and 01SS180002 at concentrations of 6 µg/kg and 2 µg/kg, respectively. These concentrations are within a factor of two of their detection limit (both 3 µg/kg), which suggests that the reported concentrations are not known with a high degree of confidence although the presence of the compounds is not in question. 2-Butanone was detected in samples 01SS060002 and 01SS130002 at concentrations of 38 µg/kg and 71 µg/kg, respectively.

There is no apparent pattern of VOC contamination that suggests the presence of one or more VOC sources in surface soils. This is further evident when viewing surface and subsurface soil contamination together (See Section 5.2). For example, methylene chloride was detected in half of the surface soil samples, but no spatial concentration trend existed with high source concentrations decreasing, for example, in a downgradient direction. The methylene chloride contamination was detected in several MGBG perimeter sample locations and is not bounded in the lateral direction relative to COPC screening levels.

2-butanone, carbon disulfide, and toluene were not selected as COPCs because their maximum detected concentrations were less than the risk-based screening concentrations, and these constituents are not addressed further in the report (not that carbon disulfide and toluene were detected at concentrations close to their respective detection limits). Methylene chloride was the only VOC selected as a COPC in surface soil, and its extent is unbounded. This chemical is a common laboratory contaminant.

SVOCs

Bis(2-ethylhexyl)phthalate, isosafrole, and 10 PAHs, were detected in several soil samples as identified below. Bis(2-ethylhexyl)phthalate was detected in samples 01SS090002, 01SS110002, and 01SS180002 at concentrations of 420, 89, and 83 µg/kg, respectively. Isosafrole was detected in samples 01SS050002, 01SS060002, 01SS110002, 01SS180002, 01SS20002, and 01TPS04, at concentrations ranging from 150 to 46,000 µg/kg.

Isosafrole occurs naturally in sassafras and is used in the food and fragrance industries. The concentration of this chemical exceeds the ecological screening level (9940 µg/kg) in soil boring 01SB05 (sample 01SB050002). The measured concentrations of this chemical did not exceed the HH risk-based screening level of 611,000 µg/kg derived by TtNUS based on toxicity studies and explained in Section 7.6.1 of the HHRA. Consequently, isosafrole was not selected as a human health COPC but it was retained as a COPC for ecological risk evaluation. Sassafras plants grow at NSWC Crane and are present at the MGBG, so these plants could be the source of the isosafrole. Otherwise, the presence of this compound is unexplainable and its source is not known. This chemical was detected in widely separated surface soil locations across the MGBG where sassafras roots would be found. It was not detected in any of the subsurface soils. Although this chemical was retained as a COPC, it is unlikely to be a site contaminant. The extent of isosafrole contamination is unbounded relative to the ecological COPC screening level.

Select PAHs, including halogenated and alkylated PAHs, were detected in samples 01SS040002, 01SS050002, 01SS060002, 01SS080002, 01SS090002, 01SS110002, 01SS150002, and 01SS170002, 01SS200002, and 01TPL01 (Figure 5-1). The PAH concentrations in those samples ranged from 3.98 to 260 µg/kg, with all concentrations except two being less than 16 µg/kg. A source of these chemicals at the MGBG is not known. Most of the detections were in the northern half of the MGBG where equipment associated with past exhumations and well installation has been used. This could explain the presence of these chemicals. Sample 01SS170002, which had 260 µg/kg of 7,12-dimethylebenz(a)anthracene, is located along a path leading from the eastern edge of the MGBG toward the PBA. This pathway was traversed by heavy equipment associated with past exhumations. Burning, which is a common source of

PAHs, is not known to have occurred at the MGBG, although any local fires could have contributed PAHs through aerial deposition. Another common source of PAHs is waste oil, although the site history does not have recorded releases of oil. None of the PAHs was present at a concentration great enough to classify it as a surface soil COPC so these chemicals are not discussed further.

Energetics

Energetic compounds were not detected in MGBG surface soils and are not discussed further in this section.

Pesticide and PCBs

Gamma-chlordane and heptachlor were detected in several surface soil samples. Gamma-chlordane was detected in samples 01SB040002, 01SB120002, 01SB130002, 01SB140002, 01SB170002, 01SB180002, and 01SB190002. The concentration range is narrow, extending from 0.55 µg/kg to 1.1 µg/kg. Heptachlor was detected in 11 samples, also within a narrow concentration range of 1.2 µg/kg to 2.4 µg/kg (Figure 5-1). No PCBs were detected in MGBG surface soils.

The concentrations and locations of pesticides appear to be consistent with topical spot applications or general use in agriculture rather than disposal by dumping at MGBG. This is discussed further in Section 5.2. Because the observed concentrations did not exceed HH or ecological screening levels, no pesticides were retained as COPCs for surface soil samples and this class of compounds is not discussed further in this section.

Herbicides

Silvex was detected in samples 01SB110002 and 01SB150002 at concentrations of 15 µg/kg and 5.9 µg/kg, respectively. Silvex concentrations did not exceed COPC screening levels, and this chemical was not selected as a HH or ecological COPC. Therefore, it is not discussed further.

Out of 20 samples, 2,4-D was detected in four samples, 01SS020002, 01SB030002, 01SB170002, and 01SB180002, at concentrations ranging from 35 µg/kg to 210 µg/kg. These concentrations exceed the 27.3 µg/kg ecological screening level. These four samples are well separated across the MGBG. This wide spatial spread, the observed concentrations, and the fact that herbicides are not typical laboratory chemicals that are likely to have been disposed at the MGBG, suggest that topical spot applications rather than disposal by dumping may be the source of these compounds. Nevertheless, 2,4-D was retained as an ecological COPC for further evaluation, and the extent of this chemical contaminant is not

bounded. The concentrations of this chemical are not bounded toward the southwest of the MGBG and directly north of the PBA.

Metals

Twenty-five metals were detected in surface soil samples. Of the 25 detected metals, aluminum, arsenic, barium, chromium, cobalt, copper, iron, lead, manganese, nickel, strontium, vanadium, and zinc were detected in all 24 MGBG samples (background soil boring 01SB21 not included). Four of the detected metals (calcium, magnesium, potassium, and sodium) are considered to be essential nutrients and are not discussed any further. Otherwise, the measured concentration ranges are provided in Table 5-1.

After comparing the measured concentrations to background concentrations and conducting additional evaluations as described in Section 3.4, aluminum, copper, iron, selenium, vanadium, and zinc exceeded background concentrations and risk-based screening levels. The aluminum, copper, iron, vanadium, and zinc concentrations in surface soil are rather evenly distributed across the sampled locations of the MGBG suggesting that these metals are not operationally related contaminants. As presented in Section 3.4.4 for arsenic, the observed metal concentrations could reflect a slightly elevated subset of NSWC Crane background concentrations. Nevertheless, aluminum, iron and selenium were retained as HH COPCs, and all six metals were retained as ecological COPCs. The concentrations of these six metals in samples collected from the site perimeter exceeded COPC screening levels presented in the applicable Section 4.0 tables, hence the metals contamination in surface soil is not bounded. The degree of risk associated with these metals is evaluated in Sections 7.0 and 8.0.

Radionuclides

All radionuclide concentrations in surface soils were within background concentrations, and no radionuclides were selected as COPCs. However, because of the general concern of the public with radiation, the one radionuclide (thorium-230) that required additional evaluation to determine whether its MGBG concentrations exceeded background concentrations is discussed here. Thorium-230 was detected in 18 of 25 samples at concentrations ranging from 0.0178 pCi/g to 0.621 pCi/g. One fourth (seven of 25) of the sampling locations had thorium-230 concentrations greater than the single background sample collected at soil boring 01SB21 located approximately 700 feet southeast of the MGBG. Based on chance alone, this percentage would be expected to be 50 percent in the absence of contamination. The thorium-230 concentrations were also rather evenly distributed across the MGBG surface soils (data not plotted). The uniformity of Thorium-230 concentrations across the MGBG are not indicative of Thorium-230 contamination. This is consistent with past exhumations in which the MGBG

had been declared suitable for unrestricted used from a radiation perspective (Table 1-1 of the MGBG QAPP). In summary, the data indicate a lack of radionuclide contamination in MGBG surface soils, though background levels of radionuclides were detected.

Mustard Gas and Mustard Gas Degradates

While the study area for this investigation is a former mustard gas bomb burial site, the site history is clear that past exhumations have removed any threat associated with mustard gas bombs. Furthermore, no surface samples exhibited detectable concentrations of mustard gas or its degradates. Therefore, these chemicals are not discussed further for surface soils.

Miscellaneous Parameters, Round 1

The miscellaneous parameters, CEC, pH and TOC, are not potential contaminants; however, these parameters are useful in evaluating the fate and transport of contaminants as presented in Section 6.0, so they are discussed briefly here. These parameters were measured in select Round 1 surface soil samples with the following results:

- CEC: 11.2 meq/100 g to 24.4 meq/100 g (six samples)
- pH: 5 to 7.8 standard units (six samples)
- TOC: 619 mg/kg (one sample)

These results appear to be consistent with NSWC Crane soils and are discussed in more detail in Section 6.0.

5.2 SUBSURFACE SOIL, ROUND 1

Figure 1-11 displays the locations where subsurface soil samples were collected during Round 1 field activities. Table 2-2 identifies the parameters measured in each sample. Table 4-2 presents a summary of the results reported for compounds detected in the subsurface soil samples collected from MGBG. Tables 4-10 and 4-11 present summaries of descriptive statistics for detected subsurface soil chemicals, including concentration ranges, frequencies of detection, locations of maximum concentrations, comparison to background concentrations, and COPC screening criteria. Appendix E contains a copy of the entire analytical database for MGBG subsurface soil.

Figure 5-1 presents concentrations of organic COPCs detected in surface soil and subsurface soil (excluding rejected data). Figure 5-3 presents concentrations of inorganic COPCs detected in subsurface soil (excluding rejected data).

Although the lists of organic COPCs for surface and subsurface soil differed, the union of the two sets is presented on Figure 5-1 to reveal potential relationships between surface and subsurface soil contamination. A similar strategy was used for inorganic COPCs (Figure 5-3), although the lists of COPCs was too large to allow surface and subsurface soil data to be presented on the same figure.

VOCs,

Four VOCs (1,1,2,2-PCA, acetone, chloroform, and methylene chloride) were detected sporadically throughout subsurface soil samples. Methylene chloride, the most frequently detected VOC and also a common laboratory contaminant, was detected in 27 of 35 samples at concentrations ranging from 3 to 86 µg/kg. This range of concentrations is consistent with the range of concentrations measured in surface soils. Acetone, also a common laboratory contaminant, was detected the next most frequently in 12 samples at concentrations ranging from 6 to 42 µg/kg. 1,1,2,2-PCA was detected in only sample 01SB090206 at a concentration of 2 µg/kg. Chloroform was detected in the same sample, 01SB090206, at a concentration of 4 µg/kg. Sample 01SB0900206 was collected from the PBA where, based on site history, any release of VOCs to soils is most likely to have occurred.

As in surface soils, no concentration trend for methylene chloride exists across the site to suggest a source for this contaminant. The consistency of concentrations between surface and subsurface soil also suggests that this chemical is not site-related. Approximately the same percentage of subsurface (30 percent) and surface samples (27 percent) exhibited methylene chloride concentrations greater than 20 µg/kg. Although it may not be related to site operations, this chemical could not be ruled out as site-related contaminant, and it was retained as a HH COPC. This chemical was detected in most of the sampling locations along the MGBG perimeter, and many of the concentrations exceed the 1 µg/kg (0.001 mg/kg) COPC screening level presented in Table 4-9; therefore, it is not bounded laterally. Of the 15 soil borings where methylene chloride was detected, the concentrations increased with sampling depth in just two borings. Thus, the methylene chloride is vertically well bounded at all but two locations. Methylene chloride was detect in 01SB07 samples at 41 µg/kg (0 to 2 feet bgs) and 41 µg/kg (2 to 5 feet bgs). In 01SB10, it was detected at 13 µg/kg (0 to 2 feet bgs) and 50 µg/kg (2 to 6 feet bgs). Bedrock was encountered at 5 feet bgs and 7 feet bgs, respectively, in these two borings.

1,1,2,2-PCA was not detected in surface soil and was detected in just one subsurface soil sample, 01SB090206, at 2 µg/kg. This concentration is an order of magnitude greater than the COPC screening level presented in Table 4-11 and, therefore, 1,1,2,2-PCA was selected as a HH COPC for subsurface soil. Furthermore, this chemical was detected at high concentrations in ground water, as discussed in Section 5.3. Because the one sample showing detectable concentrations of this COPC sits atop bedrock, the 1,1,2,2-PCA is not bounded in soil. The bedrock at the three borings (01SB03, 10SB05, 01SB09) that are located in the western half of the PBA is within 7 feet of ground surface. This would facilitate transfer of chemicals released in the shallow subsurface soil directly into the shallow bedrock.

In summary, only four VOCs were detected in subsurface soils. Of those, methylene chloride was detected most frequently and at the greatest concentrations and was selected as a HH COPC. Only one subsurface soil sample showed detectable concentrations of 1,1,2,2-PCA, but the 2 µg/kg concentrations exceeded the COPC screening level and this chemical was also retained as a HH COPC. There is no indication that further sampling would better define the extent of a methylene chloride-contaminated area. The 1,1,2,2-PCA contamination is bounded laterally but the sample exhibiting detectable concentrations of this chemical sits atop bedrock, so it is not bounded in the vertical direction. Moreover, it appears that the shallow depth to bedrock within the PBA could have facilitated the transfer of soil contaminants directly to the bedrock.

SVOCs

Bis(2-ethylhexyl)phthalate and 13 PAHs were detected infrequently in subsurface soil samples. Bis(2-ethylhexyl)phthalate was detected in samples 01SB050610, 01SB090206, and 01SB160610 at concentrations ranging from 97 to 5,600 µg/kg. Samples 01SB050610 and 01SB090206 were collected from the PBA where most of the burial and exhumation activities took place. The greatest concentration of this chemical was detected in sample 01SB090206 at the western edge of the PBA where past exhumations have occurred. Despite the detection of this compound in a few samples, it was not selected to be a human health or ecological COPC and is not discussed further for subsurface soil.

PAHs were detected in the following samples: 01SB020206, 01SB030610, FD08260101, 01SB060206, 01SB060610, 01SB090206, 01SB140206, and 01SB200610. The PAH concentrations across all samples ranged from 4.34 µg/kg to 540 µg/kg.

The majority of PAH detections and the greatest concentrations were generally observed in the samples from soil boring 01SB20, located at the southeast corner of the MGBG near one of the debris piles. Benzo(a)pyrene, benzo(a)anthracene, and benzo(b)fluoranthene concentrations exceed subsurface soil

COPC screening levels in sample 01SB200610 and have been retained as a HH COPCs. The surface and mid-level soil samples for boring 01SB20 did not have any detections of PAHs; therefore, the PAH contamination is not bounded vertically because the 6- to 8-foot soil interval sits atop bedrock. However, the lack of PAHs in the mid-depth soil sample raises questions concerning how the deepest soil interval could be contaminated with PAHs from site activities in an area where intrusive activities are not known or suspected to have occurred. Soil boring 01SB20 is located in the southeast corner along the site perimeter; therefore, this contamination is not bounded laterally (Figure 5-1). The observed PAH concentrations may be related to the debris piles at the southeastern corner of the MGBG or even to the proximity of soil boring locations to Highway 251. Leaching from asphalt and perhaps other materials in the piles would direct PAHs deeper into soils, and they would spread outward as the distance below ground surface increases. This could explain the existence of deep subsurface contamination where surface or shallow subsurface contamination is not evident. Aerial deposition from the road or runoff from the debris piles could be transported into drainage ditches rather than accumulating in surface soil, again explaining why surface soils show limited PAH concentrations with greater concentrations in subsurface soil.

In summary, few SVOCs were detected in subsurface soils and most detections were of PAHs. Of these, the maximum concentrations of benzo(a)pyrene, benzo(a)anthracene, and benzo(b)fluoranthene exceed HH COPC screening levels and these three chemicals were retained as COPCs. The PAH contamination is not bounded laterally or vertically in the strictest sense, but the few detections of PAHs are viewed to render these chemicals relatively insignificant as site contaminants.

Energetics

HMX was detected in sample 01SB080206 at a concentration of 70.6 mg/kg. HMX was not detected in the surface or deep soil sample at location 01SB08 and is therefore bounded vertically. Soil boring 01SB08 is located in the northeast corner along the site perimeter and therefore is not bounded laterally. However, HMX does not exceed subsurface soil COPC screening levels and it was not retained as a COPC. It is noteworthy that HMX and other energetic compounds were not detected in PBA soils where past exhumations of bombs took place. This is the location where energetic compounds might be expected if they were site-related contaminants. This single detection of HMX at the MGBG northeastern corner 150 feet away from the PBA is interpreted as potential aerial deposition from other NSWC Crane activities that migrated to deeper soils, rather than a site-related release. The MGBG is downwind of the Pyrotechnics Test Area (SWMU 19) located approximately 2 miles to the west-southwest. Explosives magazines are also located along Highway 251 which runs along the southern boundary of the MGBG.

Pesticide and PCBs

Gamma-chlordane and heptachlor were detected in several subsurface soil samples. Gamma-chlordane was detected in six of 20 samples at concentrations ranging from 0.64 to 3 µg/kg. Heptachlor was detected in 13 of 20 samples at concentrations ranging from 0.94 to 2 µg/kg. No PCBs were detected in MGBG subsurface soils.

In most cases, subsurface soil detection of these chemicals occurs in the same soil boring as a surface soil detection. However, the subsurface soil concentrations are generally of equal magnitude or less than surface concentrations in the same boring. Because subsurface soil pesticide concentrations are less than or equal to surface soil concentrations, these chemicals are vertically bounded. Based on the expected deposition mechanism of surface applications to the ground, herbicides and pesticides were not sampled in the 6- to 10-foot bgs sampling interval. The concentrations and locations of pesticides are consistent with topical spot applications rather than disposal at the MGBG. No pesticides were retained as COPCs for subsurface soil samples, and these chemicals are not discussed further for subsurface soils. Furthermore, pesticide contamination is not viewed to be related to site operations (i.e., burials and exhumations of bombs, laboratory chemicals, and flare development chemicals).

Herbicides

Herbicides were not detected in subsurface samples and therefore no herbicides were retained as COPCs. The absence of herbicides in the subsurface soils has vertically bounded the five detections for herbicides in the surface soils. No herbicides were selected as subsurface soil COPCs, and these chemicals are not discussed further for subsurface soil

Metals

Twenty-four metals were detected in subsurface soil samples. Four of the detected metals (calcium, magnesium, potassium, and sodium) are considered to be essential nutrients and are not discussed further. Of the 24 detected metals, aluminum, barium, chromium, copper, lead, iron, manganese, nickel, strontium, vanadium, and zinc were detected in all 35 samples. Arsenic, beryllium, cobalt, mercury, thallium, thorium (thorium-calc), and tin concentrations were determined to be statistically indistinguishable from background concentrations and are not discussed further.

Aluminum, barium, cadmium, chromium, selenium, iron, manganese, and nickel exceeded background concentrations and subsurface soil COPC screening levels and were retained as HH COPCs. Aluminum, barium, chromium, iron, manganese, and nickel were detected in 35 of 35 samples at concentrations

ranging from 1,420 to 18,100 mg/kg, 11.3 to 300 mg/kg, 6.4 to 24 mg/kg, 4,940 to 71,500 mg/kg, 8.6 to 408 mg/kg, and 1.6 to 39.3 mg/kg, respectively. Cadmium was detected in 17 of 35 samples at concentrations ranging from 0.04 to 1.1 mg/kg. Selenium was detected in 16 of 35 samples at concentrations ranging from 0.12 to 1.7 mg/kg. Concentrations of aluminum, copper, selenium, vanadium, and zinc in samples collected from the site perimeter exceeded the COPC screening levels, hence those contaminants are not bounded laterally. The aluminum, barium, chromium, iron, manganese, and nickel concentrations in subsurface soil are rather evenly distributed, both laterally and vertically, across the sampled locations of the MGBG. This suggests that these six metals are not operationally related contaminants, even though the concentrations exceed COPC screening levels. Each of these six metals is evaluated for its contribution to HH risk in Section 7.

Radionuclides, Round 1

All radionuclide concentrations in subsurface soils were statistically indistinguishable from background concentrations, and no radionuclides were selected as COPCs. However, because of the general concern of the public with radiation, the one radionuclide (thorium-230) that required additional evaluation to determine whether its MGBG concentrations exceeded background concentrations is discussed here. Thorium-230 was detected in 25 of 37 (72 percent) of subsurface soil samples at concentrations ranging from 0.0332 to 0.637 pCi/g. This percentage of detections is very similar to the 68 percent frequency of detection across surface soil samples. One-third (12 of 37) of the subsurface samples had thorium-230 concentrations greater than the single background sample collected at soil boring 01SB21, which is located approximately 700 feet southeast of the MGBG. Based on chance alone, this ratio would be expected to be approximately 50 percent in the absence of contamination. The thorium-230 concentrations were also rather evenly distributed across the MGBG subsurface soils (data not plotted). The uniformity of thorium-230 concentrations across the MGBG are not indicative of thorium-230 contamination. This is consistent with past exhumations in which the MGBG had been declared suitable for unrestricted use from a radiation perspective (Table 1-1 of the MGBG QAPP). In summary, the data indicate a lack of radiological contamination in MGBG subsurface soils, though background levels of radionuclides were detected.

Mustard Gas and Mustard Gas Degradates

Although the study area for this investigation is a former mustard gas bomb burial site, the site history is clear that past exhumations have removed any threat associated with mustard gas bombs. Furthermore, no subsurface samples exhibited detectable concentrations of mustard gas or its degradates. Therefore, these chemicals are not discussed further for subsurface soils.

Miscellaneous Parameters, Round 1 Only

The miscellaneous parameters, CEC, pH and TOC, are not potential contaminants; however, these parameters are useful in evaluating the fate and transport of contaminants as presented in Section 6.0, so they are discussed briefly here. These parameters were measured in select Round 1 subsurface soil samples with the following results:

- CEC: 11 meq/100 g to 20.1 meq/100 g (nine samples)
- pH: 4.4 to 7.1 standard units (two samples)
- TOC: 589 mg/kg to 608 mg/kg (two samples)

These results appear to be consistent with NSWC Crane soils and are discussed in more detail in Section 6.0.

5.3 GROUND WATER, ROUNDS 1 AND 2

In 2001 (Round 1), one new well (01T02) and 26 of 27 existing ground water monitoring wells were sampled across the approximately 20-acre area surrounding the MGBG. The sampled wells are located in and around a VOC plume identified in the 1980s. Well 01-16 was dry and did not yield a sample.

The VOC data collected in 2001 verified the existence of a VOC plume reported in the 1980s. After discussing the Round 1 data with the U.S. EPA Region 5, a second round of sampling was planned and executed in 2002. That Round 2 sampling event included the sampling of three new wells (two deep, 01T03 and 01T04 and one shallow, 01T05) located along the longitudinal axis of the VOC plume, plus 17 of the existing wells. Figure 1-11 displays the locations where these samples were collected and Table 2-2 identifies the analyte fractions for which each sample was analyzed. Table 4-3 presents a summary of the results reported for the ground water samples collected from the MGBG. Table 4-14 presents a summary of descriptive statistics for ground water detections, including ranges of detection, frequencies of detection, locations of maximum concentrations, comparisons to background concentrations, and HHRA screening criteria. Appendix E contains a copy of the entire analytical database for MGBG ground water samples.

Figure 5-4 presents concentrations of detected organic COPCs and associated degradation products in ground water (excluding rejected data). Figure 5-5 presents concentrations of detected inorganic COPCs in ground water (excluding rejected data).

Concentrations of radiological parameters were either less than detection limits or less than COPC screening levels. Furthermore, the observed concentrations appeared to be within normal background concentrations. The concentrations of all parameters, including radiological parameters, are tabulated in Appendix E.

VOCs, Rounds 1 and 2

Twenty-two VOCs were detected in ground water samples; however, most VOCs were detected infrequently and at such low concentrations as to not cause the detected VOCs to be selected as COPCs. The sample collected from the most contaminated well, 01-02 (Sample 01GW0201), in 2001 was diluted in the laboratory 1,000 fold, which resulted in elevated detection limits (MDLs are typically increased by the amount equal to the dilution factor). Such dilutions were not necessary in 2002. The dilutions were implemented to render the most significant VOC contaminants, e.g., 1,1,2,2-PCA and TCE, measurable because their concentrations would have otherwise exceeded their calibration ranges. Dilutions were made for similar reasons on samples from wells 01-15 (25-times dilution) and 01-25 (five-times dilution), although the effect on MDLs was not nearly as severe as for sample 01GW0201. Despite the dilutions, little consequence was observed on the selection of VOCs because many chemicals exhibiting elevated MDLs were selected as COPCs and certainly any VOC of significance was selected as a COPC. Furthermore, chemical concentrations in 2001 and 2002 are consistent with those reported in the 1980s, both with and without dilutions.

Maximum VOC concentrations were measured in ground water samples 01GW0201, 01GW0701, 01GW1102, 01GW1502, 01GW1901, and 01GWT0203 (see Table 4-12). The two VOCs detected the most frequently and at the greatest concentrations were 1,1,2,2-PCA and TCE. In 2001, the maximum concentrations observed for these two compounds were 38,000 µg/L (1,1,2,2-PCA) and 16,000 µg/L (TCE) in well 01-02. These concentrations are consistent with historical data from the 1980s, although significant fluctuations in the measured concentrations have been observed as described below. The prevalence of these two compounds renders them the most significant of all detected VOCs in 2001 and 2002 for defining the extent of the ground water VOC plume. Although most of the discussion below centers on 1,1,2,2-PCA and TCE, Figure 5-4 shows that all detectable VOC COPCs and related compounds are located in the same general area, with 1,1,2,2-PCA and TCE having the greatest extent.

Because VOCs were determined to be the primary MGBG contaminants in ground water, isoconcentration plots were generated for the two most widely detected VOCs, 1,1,2,2-PCA and TCE. The isoconcentration contours were generated using Environmental Visualization System software (PRO

Version EVS/MVS Version 5.11 8/14/2001 C Tech Development Corporation) to krig the ground water concentration data from 2001 and 2002, as appropriate. Isoconcentration contour plots for 1,1,2,2-PCA and TCE data from 2001 are displayed in Figures 5-6 and 5-7. Isoconcentration contour plots for the same chemicals are presented in Figures 5-8 and 5-9 for 2002.

For wells not sampled in 2002, the 2001 data were used in the kriging. VOC concentrations in those wells appear to be reasonably constant in space or are so close to detection limits as not to yield the possibility for significantly different concentrations between 2001 and 2002. Thus, it was not necessary to resample all wells in 2002. The krig was based on an anisotropic variogram because the ground water contamination pattern has a northwesterly orientation, in contrast to the radial ground water flow with steepest hydraulic gradients oriented toward the north and northeast. The contours thus generated were compared to contours generated using manual triangulation and interpretation. The dashed contour lines in Figures 5-6 through 5-9 represent extrapolations of data or manual adjustments implemented to reflect the understanding of ground water flow that is based on water level data presented in Figures 1-15 and 1-16 and the local topography. For example, the increasing topographical elevations to the west of explosives Magazine 1410 and the local ground water elevations decreasing toward the northeast away from that magazine indicate that the ground water flow is most likely northward, away from Highway 251 in that area. The kriged contours were manually extended to reflect this. Manual adjustments were used only where the kriging software was unable to account for local topography/hydrology and where the kriging appeared to introduce unjustifiable complexities into the contours. While this approach to generating isopleths is subjective, it was necessary because the hydrogeology of the site is heterogeneous. Apparent fracture flow patterns render the use of purely mathematical interpolation techniques such as triangulation or kriging unsuitable as the only means of generating contours.

One of the most noticeable features in Figures 5-6 through 5-9 is that the 1,1,2,2-PCA and TCE concentrations along the perimeter of the plume have not changed very much between 2001 and 2002. The static nature of the plume is even more evident if historical data are considered. Figure 1-20 shows TOX concentrations from the early and mid 1980s. The center of mass of the 1980s data appears to be in the same general location as the 2001 and 2002 centers of mass. The plume extends from an apparent contaminant source area near well 01-02 toward the west and northwest. This suggests slow movement of the plume to the west and northwest in the direction of ground water flow. The fate and transport of MGBG contaminants are discussed in more detail in Section 6.0.

Another apparent feature of the TCE ground water plume is that, while the center of mass appears to be static, the boundary of the ground water contaminant plume undulates. Concentrations of chemicals in wells along the perimeter of the plume fluctuate over time, with little apparent overall movement in the

horizontal direction. This was the reason why several perimeter wells were not sampled in 2002. Select interior wells were also not sampled because they were not needed to define the extent of contamination or to estimate HH risk. With one exception, the 2002 TCE plume is bounded in essentially all directions relative to the 1.6 µg/L COPC screening level. The exception is boundary well 01-08, where the TCE concentration is 7 µg/L in 2002. Nevertheless, this 7 µg/L is within a factor of four of the 1.6 µg/L COPC screening level, and the plume boundary undulations could render this concentration less than 1.6 µg/L in a subsequent sampling event because of experimental uncertainty. Furthermore, complete lateral bounding of this chemical contaminant is satisfied relative to the commonly used cleanup goal of 5 µg/L.

Bounding of 1,1,2,2-PCA relative to its COPC screening level (0.055 µg/L) is not as complete as for TCE. The nominal detection limit achieved for this compound was 0.5 µg/L, which is an order of magnitude greater than the screening level. The 1,1,2,2-PCA concentration contours as low as 1 µg/L (just two times the detection limit) are shown on Figures 5-7 and 5-9. While most perimeter wells showed non-detectable concentrations of 1,1,2,2-PCA, wells 01-08 (3 µg/L) and 01T05 (2 µg/L) were the only perimeter wells in 2002 (Round 2) to show detectable concentrations of 1,1,2,2-PCA. Well 01T05 did not exist prior to 2002. The next closest upgradient well, 01-25, showed a concentration decrease between 2001 (32 µg/L) and 2002 (24 µg/L), although such a small decrease is within experimental uncertainty so the two concentrations should be considered to be equal.

A third and striking feature of the plume is that, relative to 2001, the 2002 data show a marked decrease in 1,1,2,2-PCA and TCE concentrations near well 01-02. Both of these contaminants have decreased by an almost identical ratio (38,000 to 30 µg/L for 1,1,2,2-PCA and 16,000 to 20 µg/L for TCE) between 2001 and 2002. The vicinity of well 01-02 is the approximate center of mass of the plume, which suggests that the VOC source is located nearby. Based on soil concentrations of VOCs and site history, the source is most likely in the bedrock beneath the PBA. Based on the 2001 and historical ground water concentrations, dense non-aqueous phase liquid (DNAPL) could be present in the bedrock. A commonly used rule of thumb is that ground water chlorinated organic chemical concentrations in excess of 1% (10,000 µg/L) of a chemical's solubility indicate the presence or potential presence of non-aqueous phase liquid. Solubilities and other physical characteristics of individual chemicals are presented and discussed in Section 6.0.

The observed decrease in TCE concentrations between 2001 and 2002 was verified to be real (See Section 3.4.8) and is consistent with historical concentration changes. That is, there appears to be a net overall decrease in the mass of the plume with large concentration fluctuations in the interior of the plume at select wells, most notably wells 01-02, 01-05, and 01-11. The consistency with past concentration fluctuations suggests that the drop in concentration between 2001 and 2002 is not a sample collection

error. It suggests that, while the measured concentrations at well 01-02 reflect actual sample concentrations, the decreases in 1,1,2,2-PCA (and TCE) concentration from 38,000 (16,000) µg/L in 2001 to 30 (20) µg/L in 2002 should not be taken too literally. Future samples are likely to show a concentration rebound to thousands of µg/L TCE. An example of a large temporal concentration increase within the plume interior is the change from 550 µg/L TCE in 2001 to 840 µg/L TCE in 2002 in Well 01-05. This sort of data scatter is suggestive of bedrock fracturing that could support tortuous flow patterns of non-aqueous phase chemicals, resulting in high concentrations in one sampling event and much lower concentrations in another. Overall, the concentrations of 1,1,2,2-PCA and TCE since the 1980s have been greater than 10,000 µg/L. It is believed that the interior of the plume near well 01-02 still exhibits such concentrations although the 2002 data suggest otherwise.

It was thought that rainfall might play a role in the dramatic concentration changes observed in some wells. A review of rainfall data for 2001 and 2002 showed that the cumulative rainfall in the three months leading up to the 2001 sampling round was approximately 14.7 inches. The rainfall for a similar period in 2002 was 23.1 inches. This is a significant difference, and it might explain the observed differences in VOC concentrations between the two years. The rainfall data are summarized in Table 1-1.

The vertical extent of VOC contamination is well bounded based on the fact that three of four deep wells (01-06, 01C01, and 01T04) exhibited non-detectable concentrations of VOCs and that the TCE concentration in 2002 was 1 µg/L in well 01T03. This 1 µg/L concentration is less than the 1.6 µg/L COPC screening level and the commonly used 5 µg/L cleanup level.

The discussions above focused on two COPCs, TCE and 1,1,2,2-PCA. Concentrations of other VOCs in ground water follow the same spatial distribution patterns.

In summary, dramatic concentration fluctuations are observed periodically in select wells located within the plume. The perimeter plume concentrations undulate, but there seems to have been little expansion of the plume since the 1980s. There is a slow creep toward the northwest, discussed further in Section 6.0. When allowance is made for the undulating perimeter, the VOC plume is well bounded in all directions relative to COPC screening levels. Local topography and ground water elevations indicate that the VOC plume hooks northward near explosives Magazine 1410. If this interpretation is incorrect and, for example, the plume migrates in a more westerly direction in that area, then the plume would be considered to be unbounded in that direction. However, the immediate consequences of such a condition would be mitigated greatly by the fact that such migration is toward the interior of NSWC Crane. Moreover, further delineation of the plume in that direction would have little consequence on the selection

of a remedial course of action for this site. With these considerations in mind, the extent of ground water VOC contamination is viewed to be satisfactorily delineated.

SVOCs

Eight SVOCs were detected in ground water samples from Round 1 at concentrations ranging from 0.06 to 15 µg/L, including:

- 4-Nitrophenol (detected in sample 01GW0501)
- Acenaphthene (detected in samples 01GW0401, 01GW1101, and 01GWC0101)
- Acenaphthylene (detected in sample 01GW0201)
- Bis(2-ethylhexyl)phthalate (detected in samples 01GW0101, 01GW1101,and 01GW1701)
- Butylbenzylphthalate (detected in sample 01GW1101)
- Fluorene (detected in sample 01GW0201)
- Hexachloroethane (detected in sample 01GW0201)
- Napthalene (detected in samples 01GW0201, 01GW0601, and 01GW1101)

Ground water samples were not analyzed for SVOCs in Round 2.

Of the detectable SVOCs, only bis(2-ethylhexyl)phthalate and hexachloroethane concentrations exceeded risk-based COPC screening levels. However, it is noteworthy that wells 01-02 and 01-11 had detectable concentrations of four of these eight compounds and are among the same wells that historically exhibit the greatest VOC concentrations.

Based on Round 1 data, Figure 5-4 shows that SVOCs are well bounded in all directions relative to COPC screening levels and are not discussed further in this section.

Energetics

Four energetic compounds were detected in ground water:

- 2,4,6-Trinitrotoluene in sample 01GW1701 (0.127 µg/L).
- 2-Nitrotoluene in sample 01GW0201 (0.202 µg/L).
- 4-Amino-2,6-dinitrotoluene in samples 01GW0501 (0.263 µg/L) and 01GWT0201 (0.275 µg/L).
- HMX in sample 01GW0101 (0.201 µg/L).

Of these chemicals, only the 4-amino-2,6-dinitrotoluene was selected as a COPC. Figure 5-4 shows that this chemical contaminant is well bounded in all directions except to the southeast where there is no sample downgradient of sample 01GWT0201. However, it is not believed that this chemical or other energetic chemicals are site-related contaminants because of the very infrequent detections and the fact that the energetic compounds, when detected, have concentrations very near detection limits. Furthermore, there is no detection of 4-amino-2,6-dinitrotoluene upgradient of 01GWT0201 and sample 01GWT0201 was collected well outside of the MGBG. Finally, the parent compound (2,4,6-trinitrotoluene) for this chemical was not detected in soil, it was detected in just one ground water sample (01GW1701) at 0.127 µg/L, which is close to the nominal 0.09 µg/L detection limit, and it was not detected in the field duplicate of that sample (01GW1701-D). This raises questions concerning the source of this compound or the likelihood that any residual traces of 4-amino-2,6-dinitrotoluene will remain in the environment very long because of its tendency to degrade over time. Energetic compounds are not discussed further for ground water.

Pesticides, PCBs, and Herbicides

Thirteen ground water samples were analyzed for pesticides, herbicides, and PCBs in Round 1 only. None of these analyses were conducted on Round 2 ground water samples. Pentachlorophenol, though normally analyzed as a SVOC, was included in the herbicide fraction because of the significantly lower detection limit achieved under those conditions.

No herbicides or PCBs were detected in any of the ground water samples and are not discussed further. Gamma chlordane, a pesticide, was detected in samples 01GW0101 and 01GW0301 at 0.025 µg/L and 0.075 µg/L, respectively. The pesticide, heptachlor, was detected in samples 01GW1101 and 01GWC0101 at 0.023 µg/L and 0.017 µg/L, respectively. Both of these pesticides were also detected in surface and subsurface soils and in sediments. Only heptachlor was retained as a HH COPC because the measured maximum concentration exceeded the COPC screening level of 0.015 µg/L.

Both wells in which heptachlor was detected are within about 200 feet of each other and are bounded laterally by wells in which pesticides were analyzed but in which this compound was not detected (wells 01-01, 01-02, 01-03, 01-04, 01-05, 01-06, 01-18, and 01-25). The heptachlor shows a decreasing concentration trend toward the deeper well 01C01 whose heptachlor concentration (0.017 µg/L) approximates the COPC screening level. The heptachlor contamination is reasonably bounded in all directions in ground water relative to its human health COPC screening level. However, pesticide contamination is not viewed to be related to site operations (i.e., burials and exhumations of bombs, laboratory chemicals, and flare development chemicals).

Metals

Twenty-four of the 25 metals analyzed in ground water samples were detected at least once in Round 1, although beryllium, cadmium and lead were detected in just two samples, three samples, and two samples, respectively. Selenium was not detected in Round 1 or Round 2 and is not discussed further. In Round 2, only the following 12 metals were detected in the eight wells sampled and analyzed for metals:

- Aluminum
- Barium
- Calcium
- Cobalt
- Iron
- Magnesium
- Manganese
- Nickel
- Potassium
- Sodium
- Strontium
- Zinc

Calcium, magnesium, potassium, and sodium are essential nutrients and are not discussed further. Thallium was detected in nine Round 1 samples when analyzed using ICP, but a re-analysis of select ground water samples by GFAA indicated that the reported values were false detections (See Section 3.4.5). The analyses for Round 2, also by GFAA, yielded no detectable thallium, thus corroborating this conclusion.

Of the metals detected in Round 1 and Round 2 ground water samples, aluminum, antimony, arsenic, iron, manganese, nickel, and strontium were retained as HH COPCs (Figure 5-5).

The concentrations of these metals that exceed COPC screening levels are not bounded in any direction, but some interesting observations are made for three of these metals. The greatest aluminum concentration observed was in well 01T02. This well is the furthest well from the MGBG. Although this well is downgradient of the MGBG, the water levels indicate that there is little driving force for ground water (and ground water contaminants) to flow in that direction. This is borne out in that the

concentrations of VOCs (the primary site contaminants) at well 01T02 are at or less than detectable concentrations. A similar situation exists for strontium and nickel. The only strontium concentrations (3820 to 3990 µg/L, Rounds 1 and 2) that were greater than the 2,200 µg/L COPC screening level were measured in well 01T02. The second greatest strontium concentration in any other well was less than half of this COPC screening level, and half of the wells had strontium concentrations that were an order of magnitude less than this level. The greatest nickel concentrations (115 to 273 µg/L Rounds 1 and 2) were also measured in well 01T02. These concentrations exceeded the 73.0 µg/L COPC screening level, but only one other nickel concentration (75.1 in sample 01T0501) exceeded this level. Otherwise, all nickel concentrations are less than 65 µg/L and nearly all (20 of 29) are less than 20 µg/L.

Of the four remaining COPCs, antimony was infrequently detected at low concentrations approximating the HH COPC screening level (1.5 µg/L). Arsenic concentrations, averaging 1.2 µg/L (with non-detect values represented by MDL/2), were well above the COPC screening level of 0.045 µg/L. The maximum arsenic concentration detected was in sample 01GW0301 at 7.9 µg/L. Iron and manganese concentrations varied greatly in ground water across the site. Iron concentrations ranged from 22.1 to 44,600 µg/L and manganese concentrations ranged from 1.5 to 9,600 µg/L. The COPC screening levels for these metals are 300 µg/L (iron) and 50 µg/L (manganese).

In summary, well 01T02 was originally not considered to be part of the MGBG study area (it was selected to be the upgradient well until water levels indicated it was downgradient). This is significant because samples from this particular well display chemical characteristics that differ from the rest of the site. For example, the maximum metal concentrations for ten of the 25 metals (including three of the six ground water metal COPCs) were observed in this single well, **even though no readily identifiable sources of metals contamination are evident in this area**. The elevated metals concentrations may reflect the natural heterogeneity of the Pennsylvanian aquifer with regard to naturally occurring metals. While no source of metals contamination is readily identifiable, it is notable that this well is located adjacent to Highway 251. Some elevated metals concentrations observed in samples from well 01T02 are related to industrial metals (e.g., aluminum, iron, manganese, and nickel) that may have originated from vehicular traffic along this highway. Furthermore, while it is separated from the rest of the MGBG by at least one well that exhibits no detectable concentrations of VOCs, this well has VOC concentrations that are approximately equal to or less than the detection limits (Figure 5-4). One of the VOCs detected in well 01T02, toluene, is not a COPC and is not a significant site contaminant. Toluene is a component of gasoline, indicating that the roadway may be the source of this chemical. This chemical was detected in only three other widely separated wells at concentrations less than or equal to 2 µg/L, much less than its COPC screening level. In conclusion, samples collected from well 01T02 were not used to establish

background (i.e., upgradient) concentrations because of the significantly different chemistry and the fact that this well is downgradient of the MGBG.

Excluding well 01T02, the metal COPC concentrations are not bounded relative to COPC screening levels in the lateral direction for aluminum (all directions), antimony (to the northeast and south), arsenic (all directions), iron (all directions), manganese (all directions). The impact of this on the risk assessment is addressed in Section 7.0.

Mustard Gas and Mustard Gas Degradates, Round 1 Only

Several samples were analyzed for mustard gas as shown in Table 2-2. Neither mustard gas nor its degradation products were detected in Round 1 samples; therefore, these chemicals are not discussed further in this section.

Miscellaneous Parameters

Miscellaneous parameters, nitrate and nitrite, were measured using field test kits during Round 2 so that the potential for natural attenuation of organic chemicals could be evaluated. Nitrate was detected in seven of the eight ground water samples at concentrations ranging from 0.08 to 1.28 mg/L. Nitrite was detected in three of the eight samples at concentrations ranging from 0.008 mg/L to 0.008 mg/L.. These results are typical for ground water and do not represent contamination. Further discussion of well stabilization parameters and natural attenuation parameters is presented in the context of contaminant fate and transport in Section 6.0.

5.4 SEDIMENT, ROUNDS 1 AND 2

In 2001 (Round 1) eight sediment samples were analyzed for the parameters identified in Table 2-2. In 2002 (Round 2), additional sediment samples were collected to supplement the original sediment data set or to verify concentrations measured in Round 1. The analyses of the Round 2 sediment samples, also shown in Table 2-2, included significantly fewer analytical parameters than in Round 1 because few sediment contaminants were identified in Round 1. Sediment location 01SD01 was designated to be the upgradient location against which chemical concentrations measured downstream would be compared.

Figure 1-11 displays the locations where sediment samples were collected, and Figure 5-10 is a tag map of COPC concentrations in sediments. Tables 4-13 and 4-15 present summaries of descriptive statistics for sediment detections, including ranges of detection, frequencies of detection, locations of maximum

concentrations, comparisons to upgradient concentrations, and COPC screening criteria. Appendix E contains a copy of the entire analytical database for MGBG sediment samples.

VOCs

Five VOCs (1,1,2,2-PCA, acetone, carbon disulfide, dichlorodifluoromethane, and toluene) were detected in sediment samples. No VOCs were selected as HH COPCs for sediment; acetone and dichlorodifluoromethane were selected as ecological COPCs. Nevertheless, all of the detected compounds are discussed here because of their potential for being related to site activities and for acting as markers for contaminant transport.

The 1,1,2,2-PCA (not a sediment COPC) was detected only at location 01SD03 at 7 µg/kg in Round 1 and at 9 µg/kg in Round 2. These concentrations, measured almost a year apart, are consistent, indicating that ground water contamination may be contaminating sediment downgradient of the MGBG in the drainage channel from which these two samples were collected. The drainage channel is an intermittently flowing channel that is flowing only during rain events. The extent of 1,1,2,2-PCA contamination is bounded because downstream sediment samples, 01SD02, 01SD10, and 01SD11, did not show evidence of this contaminant. Furthermore, all surface water samples including sample 01SW02, which was collected downstream of sediment location 01SD03, were free of detectable VOCs.

Acetone (ecological COPC only) was detected in seven sediment samples across the site, including the upgradient sampling location (290 µg/L) at concentrations ranging from 12 to 630 µg/kg. The duplicate field sample (01SD0102-D) collected from the upgradient location had an acetone concentration of 420 µg/L. These concentrations suggest that the acetone is not related to MGBG activities because they are upgradient to MGBG sediments.

The most downgradient samples to the northwest (01SD1102) and the southeast (01SD1202) of the MGBG exhibit the greatest acetone concentrations, thus the acetone contamination is unbounded relative to its 453 µg/L ecological COPC screening level. This chemical, being a common laboratory contaminant, could have been disposed at the MGBG with other laboratory chemicals. It could also be evidence of laboratory contamination during analysis of the MGBG samples. One indication that supports the latter hypothesis is that acetone was detected in Round 2 but not in Round 1 at the locations that were sampled in both rounds. However, there is insufficient data to discern definitively whether the observed acetone concentrations reflect actual site conditions. Therefore, this contaminant was carried forward as an ecological COPC to the risk assessment described in Section 8.0.

Carbon disulfide was detected in samples 01SD0102, 01SD0302, and 01SD1102 at 2 µg/kg in each of the samples. This chemical was not selected as a COPC because the observed concentrations are well below any COPC screening levels; therefore, carbon disulfide is not discussed further.

Dichlorodifluoromethane was detected in four samples at concentrations ranging from 2 to 8 µg/kg and this chemical was selected as an ecological COPC. The dichlorodifluoromethane concentrations are bounded in the northern drainage channels relative to ecological COPC screening levels because sediment sample 01SD1102, collected downstream of location sample 01SD1002, did not exhibit a detectable dichlorodifluoromethane concentration. This chemical was detected in only one sample to the south of the MBGB, in sample 01SD0801. Thus bounding of this ecological COPC is also achieved in the southern drainage channels.

Toluene, though not selected as a COPC, is potentially related to site activities based on the detection of this compound in ground water. Well 01-07, in particular, is situated near sediment sampling location 01SD03. The presence of this chemical could be evidence of ground water contaminating sediment at this location, especially when viewed in conjunction with the 1,1,2,2-PCA data. Toluene was detected only in the Round 2 sample (01SD0302).

SVOCs, Round 1

The following SVOCs were detected in sediment samples, all of which are PAHs, except isosafrole:

- Acenaphthene (139 µg/kg).
- Benzo(a)anthracene (14.4 µg/kg).
- Benzo(a)pyrene (4.97 µg/kg to 27.5 µg/kg).
- Benzo(b)fluoranthene (7.7 µg/kg to 120 µg/kg).
- Benzo(g,h,i)perylene (21.8 µg/kg).
- Benzo(k)fluoranthene (6.26 µg/kg to 14.6 µg/kg).
- Bis(2-ethylhexyl)phthalate (98 µg/kg).
- Chrysene (17.3 µg/kg).
- Fluoranthene (4.93 µg/kg to 18.4 µg/kg).
- Indeno(1,2,3-cd)pyrene (12.8 µg/kg).
- Isosafrole (7600 µg/kg).
- Pyrene (5.31 µg/kg to 24 µg/kg).

Of the detectable SVOCs, only two were found at concentrations exceeding COPC screening levels: acenaphthene and isosafrole. The PAH, acenaphthene, was detected in just one sample (01SD0701) at 139 µg/kg. This concentration was great enough to cause this chemical to be selected as an ecological COPC, despite its limited spatial distribution. The reported acenaphthene concentrations exhibit negative bias (Section 3.3.4). This chemical is not bounded in the downgradient direction because sediments were not analyzed for PAHs in downgradient sediments. The sample exhibiting the greatest concentrations of PAHs, 01SD0701, is located adjacent to Highway 251, and downgradient of the debris piles at the southeast corner of the MGBG. These debris piles were observed to contain construction debris, including asphalt, which is a source of PAHs. Vehicular traffic is another known source of PAHs, which originate from the combustion of fossil fuels such as gasoline and diesel fuel. Sediment sample 01SD0701 had 10 detectable PAHs. The sample with the next greatest number of detectable PAHs was sample 01SD08 (six PAHs). This sample is also located near the debris piles and Highway-251. The number of PAHs detected per sample and the concentrations of the PAHs consistently decrease with distance from the area near sample 01SD0701 and the debris piles. This indicates that the debris piles and/or Highway 251 traffic are likely sources of these chemicals. It is noteworthy that the subsurface soil sample with the greatest number of PAH detections (01SB200610) was also located near Highway-251.

Isosafrole was detected in just one sediment sample (01SD0601) at 7,600 µg/kg. The presence of this chemical is unexplained other than to speculate that it originates with sassafras plants that are known to grow at NSWC Crane (See Sections 1.2.8 and 5.1). Nevertheless it was retained as an ecological COPC. Its concentrations relative to COPC screening levels are bounded in the downgradient direction.

Energetics, Round 1

Of the 14 energetic compounds analyzed in sediment, only HMX was detected. It was detected in four samples at concentrations ranging from 54.2 (sample 01SD0201) to 134 µg/kg (sample 01SD0501). There are no ecological COPC screening levels for this chemical so it was retained for further evaluation as an ecological COPC. The lowest detectable concentration of this compound to the north of the MGBG was in the most downgradient sample (01SD0201) (Figure 5-10). Hence this chemical contaminant is bounded in the downgradient direction. All HMX concentrations are much less than the HH COPC screening criterion of 3,100,000 µg/kg. This chemical is evaluated further in Section 8.0.

Pesticide and PCBs, Round 1

Few pesticide or PCB detections were noted in sediment samples. Aroclor 1260 was detected in sediment sample 01SD0701 only at 19 µg/kg. This concentration is less than COPC screening levels and

this contaminant is bounded in the downgradient direction, so it is not discussed further. Heptachlor was selected as an ecological COPC because six of eight samples exhibited detectable concentrations that exceeded the 0.6 µg/kg ecological COPC screening level. This chemical, which was also detected in several soil samples and two ground water samples, was detected in sediment at concentrations ranging from 0.95 µg/kg (sample 01SD0101) to 2.5 µg/kg (sample 01SD0601). The concentrations of this chemical exceeding COPC screening levels are not bounded in the downgradient direction to the north or south of the MGBG. However, pesticide contamination is not viewed to be related to site operations (i.e., burials and exhumations of bombs, laboratory chemicals, and flare development chemicals).

Herbicides, Round 1

Herbicides were detected in all eight sediment samples at concentrations ranging from 3 µg/kg to 16 µg/kg including the upgradient location, 01SD01, which had the 16 µg/kg result. These concentrations are well below COPC screening levels and no herbicides were selected as COPCs in sediment. Therefore, they are not discussed further.

Metals

No metals concentrations from Rounds 1 or 2 exceeded the upgradient metals concentrations. Therefore, no metals were selected as COPCs in sediment and are not discussed further in this section.

Mustard Gas and Mustard Gas Degradates, Round 1

No sediment samples exhibited detectable concentrations of mustard gas, or its degradation products; therefore, these chemicals are not discussed further.

Radionuclides

All radionuclide concentrations in MGBG sediments were statistically indistinguishable from upgradient radionuclide concentrations. Therefore, no radionuclides were selected as COPCs ,and these analytes are not discussed further.

Miscellaneous Parameters, Round 1

The miscellaneous parameters, CEC, pH and TOC, are not potential contaminants. However, these parameters are useful in evaluating the fate and transport of contaminants as presented in Section 6.0, so

they are discussed briefly here. These parameters were measured in all Round 1 sediment samples with the following results:

- CEC: 11.1 meq/100 g to 58.1 meq/100 g
- pH: 5.5 to 7.3 standard units
- TOC: 5580 mg/kg to 49600 mg/kg

These results appear to be consistent with NSWC Crane sediments and are discussed in more detail in Section 6.0.

5.5 SURFACE WATER, ROUND 2

As shown in Table 2-2, four surface water samples were collected and analyzed for the analyte fractions listed in the table. Surface water was not available in Round 1, so the only available surface water data comes from Round 2. Figure 1-11 displays the locations where surface water samples were collected. Because few chemicals were detected in other media during Round 1, Round 2 surface water samples were analyzed only for VOCs, which are the primary site contaminants. No VOCs were detected in surface water, so there are no chemicals to be evaluated with regard to the nature and extent of contamination.

5.6 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

Although several chemicals were detected in various environmental media (except surface water), few chemicals were selected as COPCs and even fewer were detected consistently from one medium to another. In particular, select VOCs, PAHs, and metals were the most frequently detected contaminants. The COPC summary of Section 4.4 and Table 4-17 identifies which chemicals were retained as COPCs. Of those, it is questionable whether any of the following COPCs are actual site contaminants for reasons explained above:

- Metals in ground water [although in excess of COPC screening levels, generally appear to fall within normal ground water concentrations observed nationwide with few exceptions (Dragun, 1988)].

- 4-amino-2,6-dinitrotoluene (although in excess of COPC screening levels, there does not appear to be a source for this infrequently detected chemical).

- Acetone and methylene chloride in sediment, soil, and ground water (although selected as a COPCs, concentrations and spatial distribution patterns suggest that these contaminants are laboratory contamination).

- HMX in sediment, subsurface soil, and ground water (although selected as a COPC, the spatial distribution suggests that this chemical is not related to MGBG activities).

- 2,4-D in surface soil (although in excess of COPC screening levels, this contaminant was probably used legally for its intended purpose as a herbicide rather than being released as waste at the MGBG).

- Isosafrole in surface soil and sediment (the presence of this uncommon chemical contaminant is unexplained but may be related to the presence of sassafras plants, which are a source of this chemical).

- PAHs in soil and sediment located away from the debris piles (the infrequent detections of these chemicals at low concentrations suggest they may have entered soils during past exhumations or from non site-related aerial deposition).

- Gamma chlordane and heptachlor in ground water, sediment, and soil (these contaminants are most likely anthropogenic background associated with widespread intended use of pesticides and windblown deposition from other areas, rather than site related burials.)

Of the detected chemicals, the following are believed to be site-related contaminants:

- Chlorinated VOCs and toluene in ground water, sediment, and possibly in soil
- Bis(2-ethylhexyl)phthalate in surface soil, sediment, and ground water
- PAHs in sediment near Highway 251 and the debris piles located outside the MGBG perimeter

It is not cost-effective to establish definitively whether all of the questionable chemicals are actually site-related contaminants because many of the chemicals have little effect on the overall risk to human or ecological receptors, as is explained in Sections 7.0 and 8.0. Therefore, all COPCs regardless of the plausibility as site-related contaminants, were carried forward to the HH and ecological risk evaluations.

The extent of these chemicals is generally well bounded relative to COPC screening levels with the following exceptions:

- Acetone in sediment
- Aluminum, copper, iron, selenium, vanadium, zinc, methylene chloride, isosafrole, and 2,4-D in surface soil
- Aluminum, selenium, methyene chloride, and select PAHs in subsurface soil
- Aluminum, antimony, arsenic, iron, and manganese in ground water
- Acenaphthene, and heptachlor in sediment

The effect of not having completely defined the extent these chemicals is evaluated further in Sections 6.0, 7.0, and 8.0.

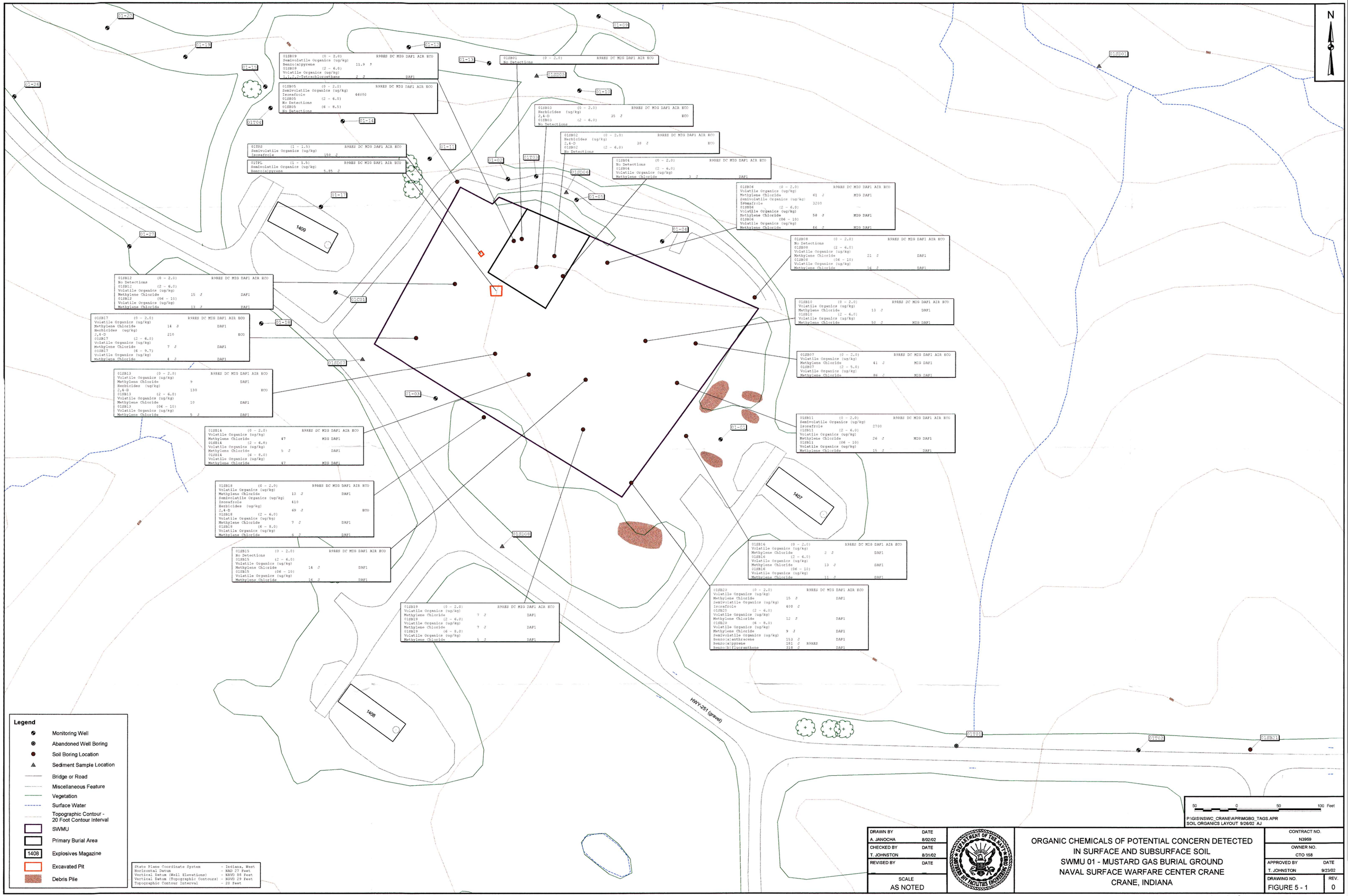
VOCs in ground water merit special attention because the concentrations of select VOCs, especially TCE and 1,1,2,2-PCA, are indicative of a significant release of VOCs in or near the MGBG. The PBA, located within the MGBG proper, is the most likely area of release, based on the site history and observed contamination patterns, although a source was not found in soils. It is not known whether the VOCs were released to surface soil or subsurface soil. The soils in the PBA exhibited very little VOC contamination (two VOCs detected at low concentrations in soil boring 01SB09), but the bedrock is shallow in this region and any VOCs released to surface or subsurface soil could have migrated swiftly to bedrock. If released to surface soil, some VOCs would have volatilized to the atmosphere. The greatest observed TCE and 1,1,2,2-PCA concentrations in ground water are suggestive of the presence of DNAPLs, although there is currently no proof that DNAPLs exist. DNAPLs were neither detected visually nor through the use of vapor monitoring instruments during soil boring and well installations. Fracturing in the bedrock could facilitate migration of DNAPLs, if present, from the surface soils deeper into the bedrock. However, lateral and vertical bounding of ground water VOC contamination relative to COPC screening levels is good with a minor indication that 1,1,2,2-PCA is not completely bounded in the downgradient directions relative to its COPC screening level. Select VOCs appear to have contaminated drainage channel sediments at sampling location 01SD03. Sediment and surface water samples downstream of that location did not exhibit detectable concentrations of VOCs. Large changes in ground water VOC concentrations have been observed over the past two decades, including the last two rounds of sampling. These large fluctuations confound the ability to estimate representative VOC concentrations to be used in risk assessments. Sections 6.0, 7.0, and 8.0 address the topics of VOC fate and transport, concentration fluctuations, and representative risk exposure point concentrations.

Based on the above observations and conclusions, contamination at the MGBG is limited and sparsely distributed with the exception of VOCs. Therefore, it is not believed that further investigation of any chemicals other than VOCs in ground water would be warranted to establish or to periodically re-establish the extent of MGBG contaminants. The VOCs are currently well bounded with very minor exceptions. The exceptions (described above) do not prevent the evaluation of human or ecological risks or the generation of cost estimates for a CMS. PAHs in soil and sediment could be a minor concern if the debris piles are left in place, although acenaphthene is the only sediment PAH with a concentration greater than COPC screening levels (ecological only). Risks to human and ecological receptors are evaluated fully in Sections 7.0 and 8.0, respectively.

TABLE 5-1

CONCENTRATIONS OF METALS IN SURFACE SOILS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Metal	No. of Samples with Detectable Concentrations	Concentration Range, mg/kg
Aluminum	24	9,400 - 19,400
Antimony	1	1.7
Arsenic	24	6-10.9
Barium	24	42.9-169
Beryllium	23	0.21 - 1
Cadmium	14	0.05 - 1.3
Chromium	24	11.5-24.3
Cobalt	24	3.2-22.3
Copper	24	7.4 - 18.5
Iron	24	14,600 - 25,500
Lead	24	11-21.6
Manganese	24	114-2010
Mercury	16	0.03 - 0.07
Nickel	24	6.9-16
Selenium	16	0.49 - 1.3
Strontium	24	5-33.5
Thallium	20	0.69 - 2.8
Thorium (natural)	24	1.90-6.44
Tin	7	2.5 - 3.9
Vanadium	24	22.8 - 44.5
Zinc	24	25.1 - 67.8



Legend

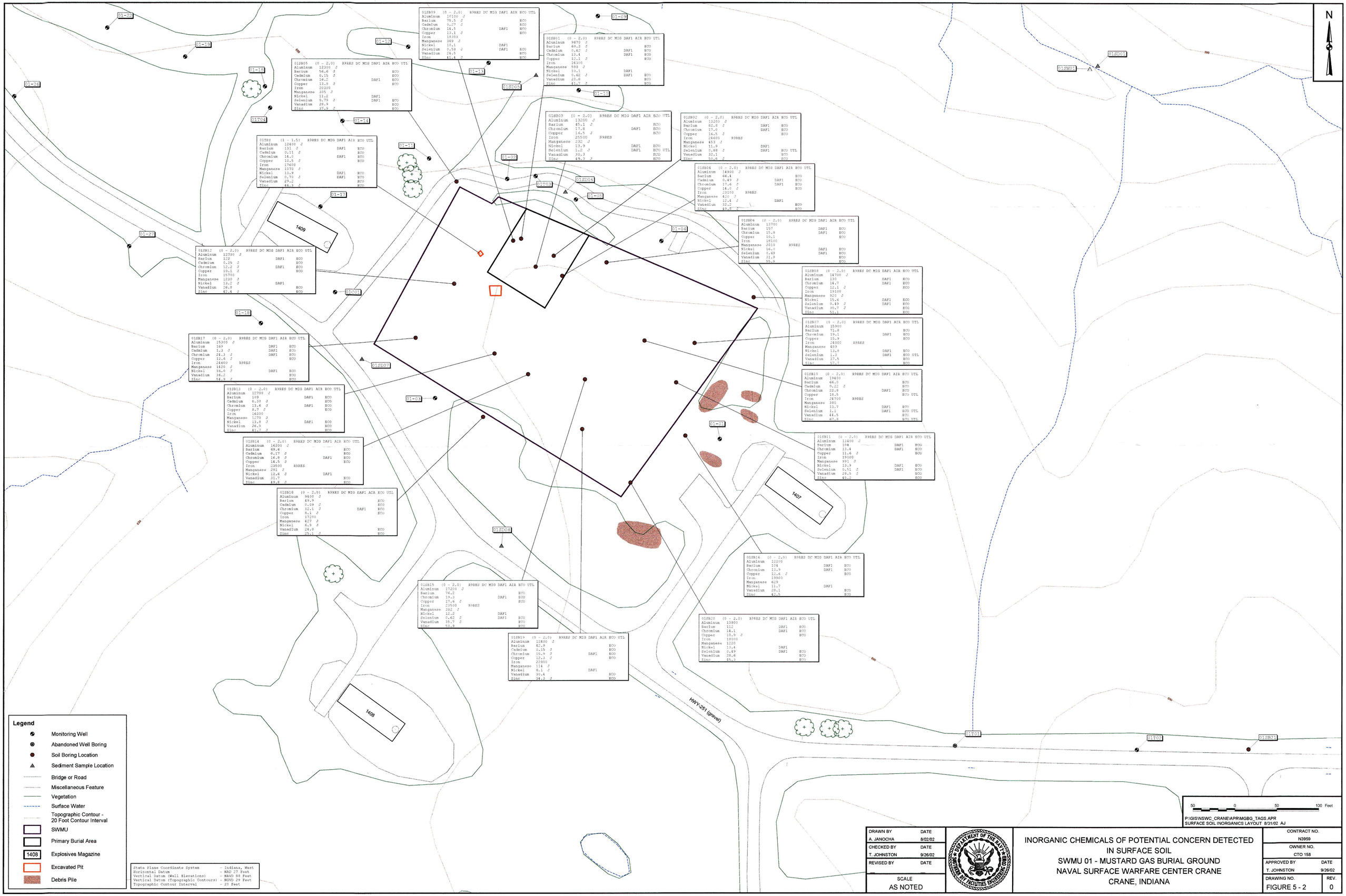
- Monitoring Well
- Abandoned Well Boring
- Soil Boring Location
- Sediment Sample Location
- Bridge or Road
- Miscellaneous Feature
- Vegetation
- Surface Water
- Topographic Contour - 20 Foot Contour Interval
- SWMU
- Primary Burial Area
- 1408 Explosives Magazine
- Excavated Pit
- Debris Pile

State Plane Coordinate System	- Indiana, West
Horizontal Datum	- NAD 27 Feet
Vertical Datum (Well Elevations)	- NAVD 88 Feet
Vertical Datum (Topographic Contours)	- NGVD 29 Feet
Topographic Contour Interval	- 20 Feet

DRAWN BY	DATE
A. JANOCHA	8/02/02
CHECKED BY	DATE
T. JOHNSTON	8/31/02
REVISED BY	DATE
SCALE	
AS NOTED	

ORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED
IN SURFACE AND SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO.	N3959
OWNER NO.	CTO 158
APPROVED BY	DATE
T. JOHNSTON	9/23/02
DRAWING NO.	REV.
FIGURE 5 - 1	0



01SB09 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	10100 J				
Barium	75.5 J				ECO
Cadmium	0.27 J				ECO
Chromium	14.5			DAF1	ECO
Copper	13.1 J				ECO
Iron	18300				
Manganese	369 J				
Nickel	10.1			DAF1	
Selenium	0.58 J			DAF1	ECO
Vanadium	24.5				ECO
Zinc	41.4 J				ECO

01SB01 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	9670 J				
Barium	69.2 J				ECO
Cadmium	0.42 J			DAF1	ECO
Chromium	13.4			DAF1	ECO
Copper	12.1 J				ECO
Iron	16300				
Manganese	598 J				
Nickel	10.1			DAF1	
Selenium	0.62 J			DAF1	ECO
Vanadium	21.6				ECO
Zinc	41.7 J				ECO

01SB05 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12300 J				
Barium	56.6 J				ECO
Cadmium	0.15 J				ECO
Chromium	16.2			DAF1	ECO
Copper	13.9 J				ECO
Iron	20300				
Manganese	305 J				
Nickel	11.2			DAF1	
Selenium	0.79 J			DAF1	ECO
Vanadium	28.9				ECO
Zinc	37.9 J				ECO

01SB03 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	13200 J				
Barium	45.1 J				ECO
Chromium	17.8			DAF1	ECO
Copper	16.5 J				ECO
Iron	25500	R9RES			
Manganese	232 J				
Nickel	13.9			DAF1	ECO
Selenium	1.2 J			DAF1	ECO UTL
Vanadium	30.3				ECO
Zinc	49.3 J				ECO

01SB02 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	13200 J				
Barium	82.8 J			DAF1	ECO
Chromium	17.6			DAF1	ECO
Copper	16.5 J				ECO
Iron	24400	R9RES			
Manganese	453 J				
Nickel	11.9			DAF1	
Selenium	0.88 J			DAF1	ECO UTL
Vanadium	32.1				ECO
Zinc	50.6 J				ECO

01TP2 (1 - 1.5) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12400 J				
Barium	131 J			DAF1	ECO
Cadmium	0.11 J				ECO
Chromium	14.0			DAF1	ECO
Copper	10.5 J				ECO
Iron	17600				
Manganese	1070 J				
Nickel	13.9			DAF1	ECO
Selenium	0.70 J			DAF1	ECO
Vanadium	29.2				ECO
Zinc	46.3 J				ECO

01SB04 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	14900 J				
Barium	66.4				ECO
Cadmium	0.49 J			DAF1	ECO
Chromium	17.6 J			DAF1	ECO
Copper	14.0 J				ECO
Iron	23100	R9RES			
Manganese	420 J				
Nickel	12.4 J			DAF1	
Vanadium	32.2				ECO
Zinc	49.5 J				ECO

01SB06 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	13700				
Barium	157			DAF1	ECO
Chromium	15.8			DAF1	ECO
Copper	10.1				ECO
Iron	19100				
Manganese	2010	R9RES			
Nickel	16.0			DAF1	ECO
Selenium	0.69			DAF1	ECO
Vanadium	21.9				ECO
Zinc	55.2				ECO

01SB12 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12700 J				
Barium	122			DAF1	ECO
Cadmium	0.25 J				ECO
Chromium	12.2 J			DAF1	ECO
Copper	19.1 J				ECO
Iron	15700				
Manganese	1230 J				
Nickel	13.2 J			DAF1	
Vanadium	26.8				ECO
Zinc	42.4 J				ECO

01SB08 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	14700 J				
Barium	130			DAF1	ECO
Chromium	14.7			DAF1	ECO
Copper	12.1 J				ECO
Iron	19100				
Manganese	920 J				
Nickel	15.6			DAF1	ECO
Selenium	0.49 J			DAF1	ECO
Vanadium	30.7 J				ECO
Zinc	51.1				ECO

01SB07 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	15900				
Barium	71.8				ECO
Chromium	19.1			DAF1	ECO
Copper	15.9				ECO
Iron	24000	R9RES			
Manganese	489				
Nickel	13.8			DAF1	ECO
Selenium	1.3			DAF1	ECO UTL
Vanadium	37.5				ECO
Zinc	57.7				ECO

01SB17 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	15300 J				
Barium	169			DAF1	ECO
Cadmium	1.3 J			DAF1	ECO
Chromium	24.3 J			DAF1	ECO
Copper	12.6 J				ECO
Iron	24600	R9RES			
Manganese	1420 J				
Nickel	16.6 J			DAF1	ECO
Vanadium	36.2				ECO
Zinc	54.9 J				ECO

01SB10 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	19400				
Barium	66.0				ECO
Cadmium	0.22 J				ECO
Chromium	22.8			DAF1	ECO
Copper	18.5				ECO UTL
Iron	24700	R9RES			
Manganese	380				
Nickel	13.7			DAF1	ECO
Selenium	1.1			DAF1	ECO UTL
Vanadium	44.5				ECO
Zinc	67.8				ECO UTL

01SB13 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12700 J				
Barium	109			DAF1	ECO
Cadmium	0.30 J				ECO
Chromium	13.6 J			DAF1	ECO
Copper	8.7 J				ECO
Iron	16300				
Manganese	1270 J				
Nickel	13.8 J			DAF1	ECO
Vanadium	26.9				ECO
Zinc	41.7 J				ECO

01SB11 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	13400 J				
Barium	104			DAF1	ECO
Chromium	13.4			DAF1	ECO
Copper	11.6 J				ECO
Iron	19000				
Manganese	991 J				
Nickel	13.9			DAF1	ECO
Selenium	0.51 J			DAF1	ECO
Vanadium	28.5 J				ECO
Zinc	45.2				ECO

01SB14 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	16200 J				
Barium	69.6				ECO
Cadmium	0.17 J				ECO
Chromium	16.8 J			DAF1	ECO
Copper	14.5 J				ECO
Iron	23500	R9RES			
Manganese	281 J				
Nickel	12.6 J			DAF1	
Vanadium	31.7				ECO
Zinc	49.8 J				ECO

01SB18 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	9400 J				
Barium	49.9				ECO
Cadmium	0.09 J				ECO
Chromium	12.1 J			DAF1	ECO
Copper	8.1 J				ECO
Iron	17200				
Manganese	427 J				
Nickel	6.9 J				
Vanadium	24.8				ECO
Zinc	25.1 J				ECO

01SB16 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12200				
Barium	104			DAF1	ECO
Chromium	11.9			DAF1	ECO
Copper	12.6 J				ECO
Iron	19900				
Manganese	629				
Nickel	11.7			DAF1	
Vanadium	28.1				ECO
Zinc	42.5				ECO

01SB15 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	17200 J				
Barium	76.2				ECO
Chromium	19.2			DAF1	ECO
Copper	17.6 J				ECO
Iron	23500	R9RES			
Manganese	282 J				
Nickel	12.2			DAF1	
Selenium	0.62 J			DAF1	ECO
Vanadium	35.7 J				ECO
Zinc	50.9				ECO

01SB20 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	13800				
Barium	112			DAF1	ECO
Chromium	14.1			DAF1	ECO
Copper	15.9 J				ECO
Iron	18000				
Manganese	1220				
Nickel	13.4			DAF1	
Selenium	0.49			DAF1	ECO
Vanadium	28.6				ECO
Zinc	45.3				ECO

01SB19 (0 - 2.0) R9RES DC MIG DAF1 AIR ECO UTL

Aluminum	12400 J				
Barium	42.9				ECO
Cadmium	0.15 J				ECO
Chromium	15.9 J			DAF1	ECO
Copper	12.3 J				ECO
Iron	22800				
Manganese	114 J				
Nickel	8.1 J			DAF1	
Vanadium	30.4				ECO
Zinc	34.3 J				ECO

Legend

- Monitoring Well
- Abandoned Well Boring
- Soil Boring Location
- Sediment Sample Location
- Bridge or Road
- Miscellaneous Feature
- Vegetation
- Surface Water
- Topographic Contour - 20 Foot Contour Interval
- SWMU
- Primary Burial Area
- 1408 Explosives Magazine
- Excavated Pit
- Debris Pile

State Plane Coordinate System	- Indiana, West
Horizontal Datum	- NAD 27 Feet
Vertical Datum (Well Elevations)	- NAVD 88 Feet
Vertical Datum (Topographic Contours)	- NGVD 29 Feet
Topographic Contour Interval	- 20 Feet

50 0 50 100 Feet

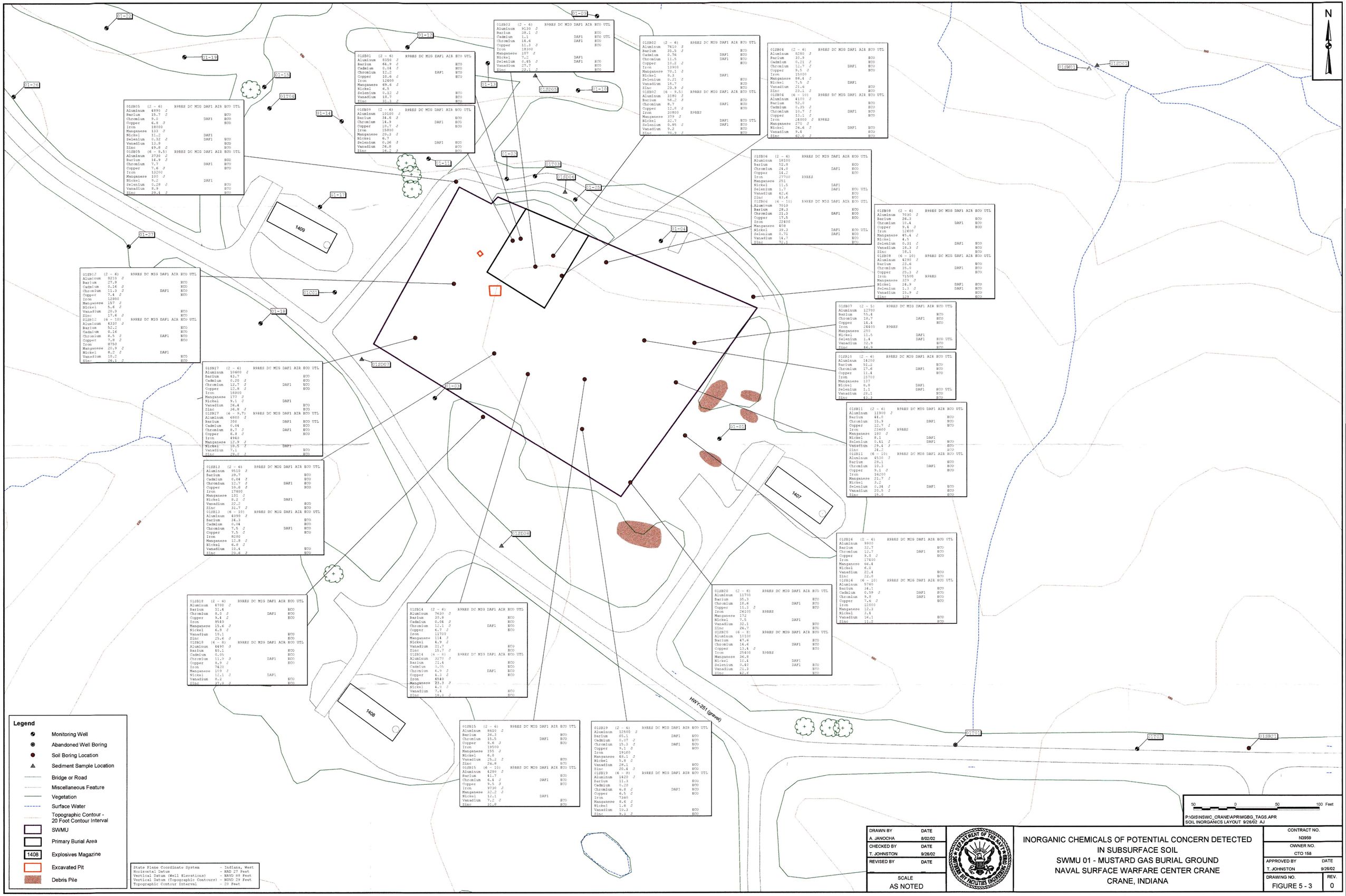
P:\GIS\NSWC_CRANE\APR\MGBG_TAGS.APR
SURFACE SOIL INORGANICS LAYOUT 8/31/02 AJ

DRAWN BY A. JANOCHA	DATE 8/02/02
CHECKED BY T. JOHNSTON	DATE 9/26/02
REVISED BY	DATE
SCALE AS NOTED	

DEPARTMENT OF THE NAVY - NAVAL FACILITIES ENGINEERING COMMAND

INORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED IN SURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO.	N3959
OWNER NO.	CTO 158
APPROVED BY T. JOHNSTON	DATE 9/26/02
DRAWING NO.	FIGURE 5 - 2
REV.	0



01SB03 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 9130 J
Barium 38.1 J ECO
Cadmium 1.1 DAF1 ECO UTL
Chromium 14.6 DAF1 ECO
Copper 11.3 J ECO
Iron 18300
Manganese 107 J
Nickel 7.2 DAF1
Selenium 0.45 J DAF1 ECO
Vanadium 27.7 ECO
Zinc 22.1 J ECO

01SB01 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 8350 J
Barium 64.9 J ECO
Cadmium 0.04 J ECO
Chromium 12.2 DAF1 ECO
Copper 10.6 J ECO
Iron 12400
Manganese 69.6 J
Nickel 6.5
Selenium 0.12 J ECO
Vanadium 18.7 ECO
Zinc 31.3 J ECO

01SB09 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 10100 J
Barium 34.6 J ECO
Chromium 14.9 DAF1 ECO
Copper 10.7 J ECO
Iron 15800
Manganese 29.3 J
Nickel 6.7
Selenium 0.36 J DAF1 ECO
Vanadium 26.8 ECO
Zinc 14.2 J ECO

01SB02 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 7610 J
Barium 35.5 J ECO
Cadmium 0.76 DAF1 ECO
Chromium 11.5 DAF1 ECO
Copper 10.2 J ECO
Iron 13900
Manganese 70.1 J
Nickel 9.3 DAF1
Selenium 0.21 J ECO
Vanadium 18.7 ECO
Zinc 23.9 J ECO
01SB02 (6 - 9.5) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 3180 J
Barium 56.2 J ECO
Chromium 8.7 DAF1 ECO
Copper 12.8 J ECO
Iron 30800 R9RES
Manganese 379 J
Nickel 32.7 DAF1 ECO UTL
Selenium 0.85 J DAF1 ECO
Vanadium 9.2 ECO
Zinc 70.9 J ECO

01SB04 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 8280 J
Barium 30.9 ECO
Cadmium 0.21 J ECO
Chromium 12.7 J DAF1 ECO
Copper 9.5 J ECO
Iron 15000
Manganese 86.4 J
Nickel 7.5 J DAF1
Vanadium 21.6 ECO
Zinc 23.1 J ECO
01SB04 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4100 J
Barium 52.0 ECO
Cadmium 0.35 J ECO
Chromium 10.7 J DAF1 ECO
Copper 13.1 J ECO
Iron 24800 J R9RES
Manganese 270 J
Nickel 26.6 J DAF1 ECO
Vanadium 9.4 ECO
Zinc 62.0 J ECO

01SB06 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 18100
Barium 52.8 ECO
Chromium 24.0 DAF1 ECO
Copper 14.2 ECO
Iron 27700 R9RES
Manganese 251
Nickel 11.5 DAF1
Selenium 1.7 DAF1 ECO UTL
Vanadium 42.6 ECO
Zinc 43.6 ECO
01SB06 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 7010
Barium 28.3 ECO
Chromium 21.3 DAF1 ECO
Copper 17.5 ECO
Iron 22400
Manganese 408
Nickel 39.3 DAF1 ECO UTL
Selenium 0.71 DAF1 ECO
Vanadium 14.7 ECO
Zinc 72.1 ECO

01SB08 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 7030 J
Barium 26.2 ECO
Chromium 10.4 DAF1 ECO
Copper 9.4 J ECO
Iron 12600
Manganese 45.4 J
Nickel 4.5
Selenium 0.31 J DAF1 ECO
Vanadium 18.3 J ECO
Zinc 18.1 ECO
01SB08 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4290 J
Barium 23.6 ECO
Chromium 15.0 DAF1 ECO
Copper 25.3 J ECO
Iron 71500 R9RES
Manganese 329 J
Nickel 24.9 DAF1 ECO
Selenium 1.1 J DAF1 ECO
Vanadium 15.9 J ECO
Zinc 129 ECO

01SB07 (2 - 5) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 12700
Barium 55.4 ECO
Chromium 18.7 DAF1 ECO
Copper 14.4 ECO
Iron 24400 R9RES
Manganese 250
Nickel 11.5 DAF1
Selenium 1.4 DAF1 ECO UTL
Vanadium 32.9 ECO
Zinc 46.9 ECO

01SB10 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 14200
Barium 51.2 ECO
Chromium 17.6 DAF1 ECO
Copper 11.4 ECO
Iron 15700
Manganese 137
Nickel 8.8 DAF1
Selenium 1.1 DAF1 ECO UTL
Vanadium 26.1 ECO
Zinc 41.3 ECO

01SB11 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 11900 J
Barium 44.0 ECO
Chromium 15.9 DAF1 ECO
Copper 12.7 J ECO
Iron 23600 R9RES
Manganese 180 J
Nickel 8.1 DAF1
Selenium 0.41 J DAF1 ECO
Vanadium 29.4 J ECO
Zinc 34.2 ECO
01SB11 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4530 J
Barium 28.1 ECO
Chromium 10.3 DAF1 ECO
Copper 9.1 J ECO
Iron 16200
Manganese 21.7 J
Nickel 3.2
Selenium 0.34 J DAF1 ECO
Vanadium 20.5 J ECO
Zinc 15.0 ECO

01SB16 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 9900
Barium 32.7 ECO
Chromium 12.7 DAF1 ECO
Copper 9.8 J ECO
Iron 17400
Manganese 66.4
Nickel 6.9
Vanadium 22.4 ECO
Zinc 22.6 ECO
01SB16 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 5760
Barium 34.1 ECO
Cadmium 0.59 J DAF1 ECO
Chromium 9.8 DAF1 ECO
Copper 7.6 J ECO
Iron 12600
Manganese 12.3
Nickel 3.4
Vanadium 16.1 ECO
Zinc 11.2 ECO

01SB20 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 11700
Barium 35.3 ECO
Chromium 18.6 DAF1 ECO
Copper 11.3 J ECO
Iron 26100 R9RES
Manganese 172
Nickel 7.5 DAF1
Vanadium 32.1 ECO
Zinc 26.7 ECO
01SB20 (6 - 8) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 10100
Barium 47.6 ECO
Chromium 14.6 DAF1 ECO
Copper 13.4 J ECO
Iron 25400 R9RES
Manganese 26.8
Nickel 10.4 DAF1
Selenium 0.40 DAF1 ECO
Vanadium 21.3 ECO
Zinc 42.6 ECO

01SB17 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 10600 J
Barium 43.7 ECO
Cadmium 0.20 J ECO
Chromium 12.7 J DAF1 ECO
Copper 12.8 J ECO
Iron 18800
Manganese 177 J
Nickel 9.1 J DAF1
Vanadium 26.4 ECO
Zinc 36.8 J ECO
01SB17 (6 - 9.7) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 6800 J
Barium 350 DAF1 ECO UTL
Cadmium 0.04 ECO
Chromium 8.7 J DAF1 ECO
Copper 6.8 J ECO
Iron 4940
Manganese 12.9 J
Nickel 10.5 J DAF1
Vanadium 7.1 ECO
Zinc 29.0 J ECO

01SB13 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 9510 J
Barium 39.7 ECO
Cadmium 0.04 J ECO
Chromium 12.7 J DAF1 ECO
Copper 10.8 J ECO
Iron 17800
Manganese 131 J
Nickel 8.2 J DAF1
Vanadium 22.2 ECO
Zinc 31.7 J ECO
01SB13 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4090 J
Barium 34.3 ECO
Cadmium 0.04 ECO
Chromium 7.5 J DAF1 ECO
Copper 7.5 J ECO
Iron 8200
Manganese 12.8 J
Nickel 6.0 J
Vanadium 10.4 ECO
Zinc 20.6 J ECO

01SB18 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4700 J
Barium 31.4 ECO
Chromium 8.0 J DAF1 ECO
Copper 9.4 J ECO
Iron 9540
Manganese 15.6 J
Nickel 6.8 J
Vanadium 19.1 ECO
Zinc 25.6 J ECO
01SB18 (6 - 8) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4490 J
Barium 40.1 ECO
Cadmium 0.05 ECO
Chromium 11.0 J DAF1 ECO
Copper 8.9 J ECO
Iron 7420
Manganese 109 J
Nickel 12.1 J DAF1
Vanadium 8.2 ECO
Zinc 27.0 J ECO

01SB12 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 8210 J
Barium 27.9 ECO
Cadmium 0.16 J ECO
Chromium 11.3 J DAF1 ECO
Copper 7.4 J ECO
Iron 12800
Manganese 157 J
Nickel 5.6 J
Vanadium 20.9 ECO
Zinc 17.6 J ECO
01SB12 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4320 J
Barium 52.2 ECO
Cadmium 0.16 ECO
Chromium 8.5 J DAF1 ECO
Copper 7.8 J ECO
Iron 8750
Manganese 20.9 J
Nickel 8.2 J DAF1
Vanadium 10.2 ECO
Zinc 28.1 J ECO

01SB14 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 7630 J
Barium 30.8 ECO
Cadmium 0.04 J ECO
Chromium 12.1 J DAF1 ECO
Copper 6.7 J ECO
Iron 11700
Manganese 114 J
Nickel 4.9 J
Vanadium 21.7 ECO
Zinc 15.7 J ECO
01SB14 (6 - 8) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 3270 J
Barium 21.4 ECO
Cadmium 0.05 ECO
Chromium 6.9 J DAF1 ECO
Copper 4.3 J ECO
Iron 6540
Manganese 23.3 J
Nickel 4.0 J
Vanadium 7.4 ECO
Zinc 18.0 J ECO

01SB15 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 8610 J
Barium 36.3 ECO
Chromium 15.5 DAF1 ECO
Copper 9.6 J ECO
Iron 19500
Manganese 155 J
Nickel 6.8
Vanadium 25.2 J ECO
Zinc 26.8 ECO
01SB15 (6 - 10) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 4280 J
Barium 41.7 ECO
Chromium 6.4 J DAF1 ECO
Copper 9.5 J ECO
Iron 9730 J
Manganese 32.2 J
Nickel 12.1 DAF1
Vanadium 7.2 J ECO
Zinc 31.8 ECO

01SB19 (2 - 6) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 12500 J
Barium 65.1 DAF1 ECO
Cadmium 0.07 J ECO
Chromium 15.3 J DAF1 ECO
Copper 9.1 J ECO
Iron 19100
Manganese 48.1 J
Nickel 5.8 J
Vanadium 28.1 ECO
Zinc 20.4 J ECO
01SB19 (6 - 8) R9RES DC MIG DAF1 AIR ECO UTL
Aluminum 1420 J
Barium 11.3 ECO
Cadmium 0.20 ECO
Chromium 6.8 J DAF1 ECO
Copper 6.5 J ECO
Iron 7360
Manganese 8.6 J
Nickel 1.6 J
Vanadium 10.3 ECO
Zinc 9.3 J ECO

Legend

- Monitoring Well
- Abandoned Well Boring
- Soil Boring Location
- Sediment Sample Location
- Bridge or Road
- Miscellaneous Feature
- Vegetation
- Surface Water
- Topographic Contour - 20 Foot Contour Interval
- SWMU
- Primary Burial Area
- 1408 Explosives Magazine
- Excavated Pit
- Debris Pile

State Plane Coordinate System	- Indiana, West
Horizontal Datum	- NAD 27 Feet
Vertical Datum (Well Elevations)	- NAVD 88 Feet
Vertical Datum (Topographic Contours)	- NGVD 29 Feet
Topographic Contour Interval	- 20 Feet

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A. JANOCHA	8/02/02
CHECKED BY	DATE
T. JOHNSTON	9/26/02
REVISED BY	DATE
SCALE	
AS NOTED	

DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND

INORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED
IN SUBSURFACE SOIL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

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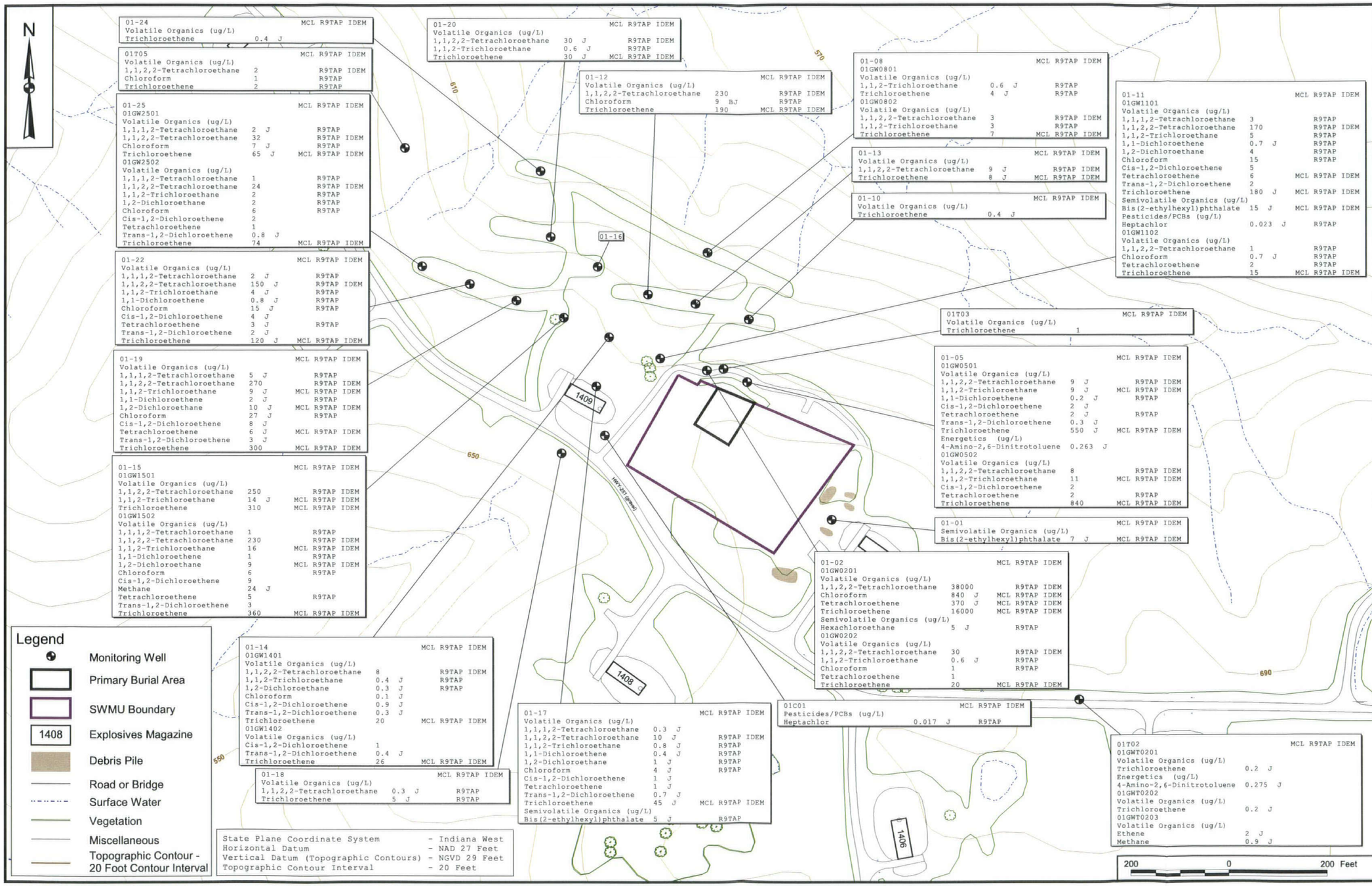
FIGURE 5 - 3	0



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DRAWING NO. — FIGURE 5 - 4 — REV 0

ORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED IN GROUND WATER, 2001 AND 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA

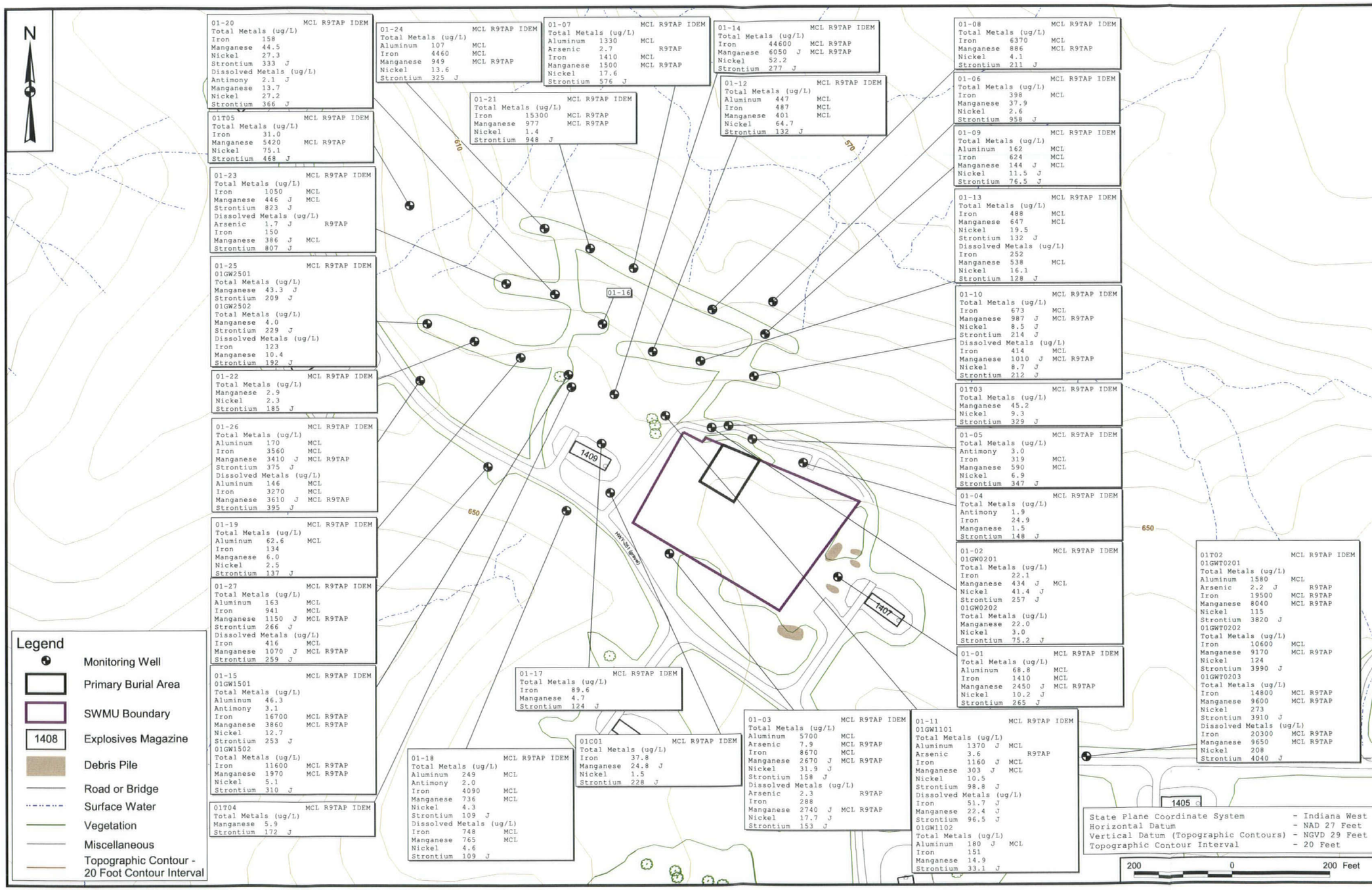
DRAWN BY A. JANOCHA — DATE 8/28/02

CHECKED BY T. JOHNSTON — DATE 9/26/02

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/MGBG_TAGS.APR GROUND WATER ORGANIC TAG LAYOUT 9/26/02 AJ



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APPROVED BY ____ — DATE ____

DRAWING NO. FIGURE 5 - 5

REV 0

INORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED IN GROUND WATER, 2001 AND 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA

DRAWN BY A. JANOCHA — DATE 8/28/02

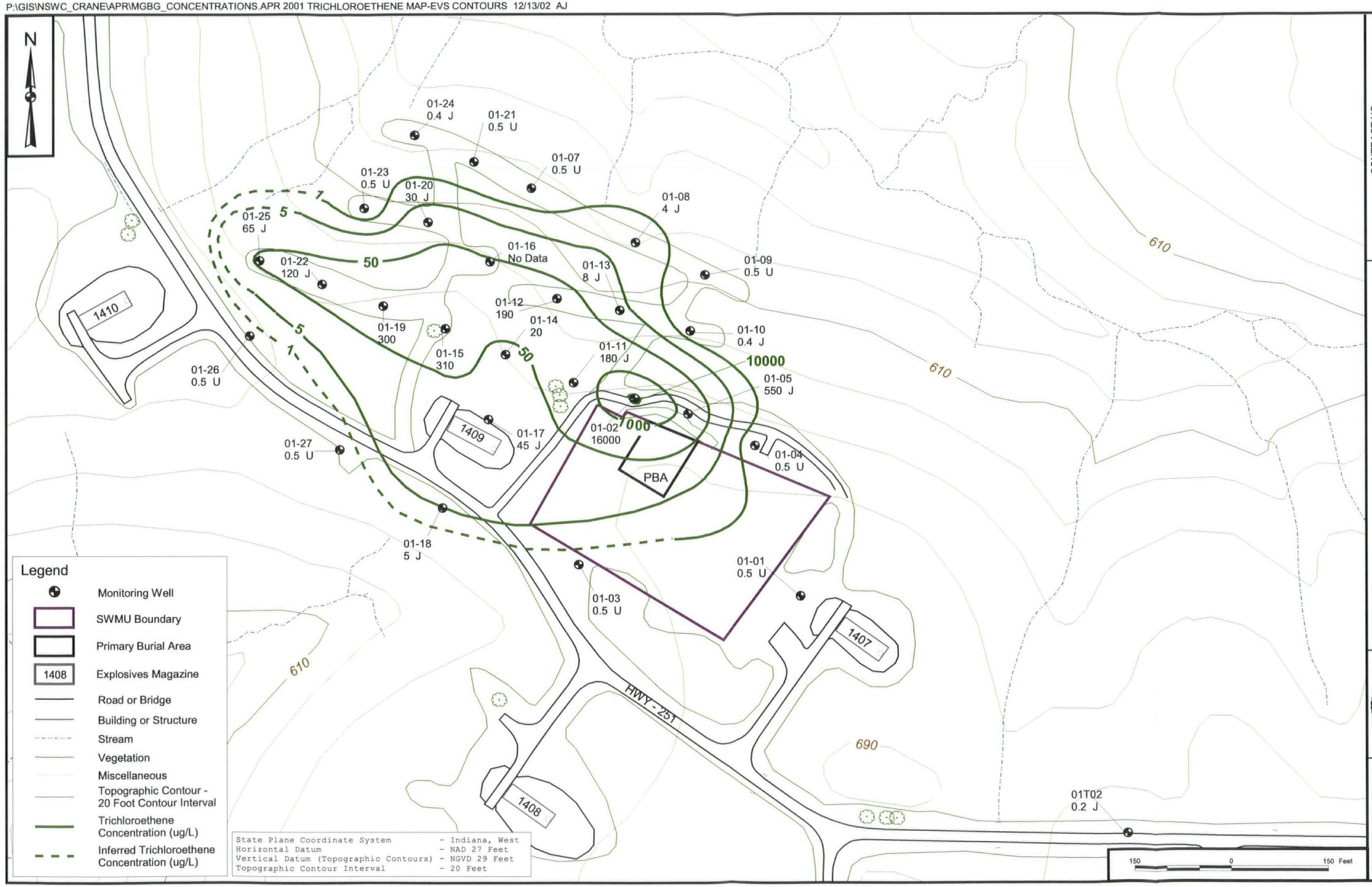
CHECKED BY T. JOHNSTON — DATE 9/26/02

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/MGBG_TAGS.APR GROUND WATER INORGANIC TAG LAYOUT 9/26/02 AJ

P:\GIS\NSWC_CRANE\APR\MGBG_CONCENTRATIONS.APR 2001 TRICHLOROETHENE MAP-EVS CONTOURS 12/13/02 AJ



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APPROVED BY T. JOHNSTON — DATE 12/13/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 5-6

REV 0

TRICHLOROETHENE CONCENTRATIONS (UG/L) IN SHALLOW WELLS, 2001
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER - CRANE
CRANE, INDIANA

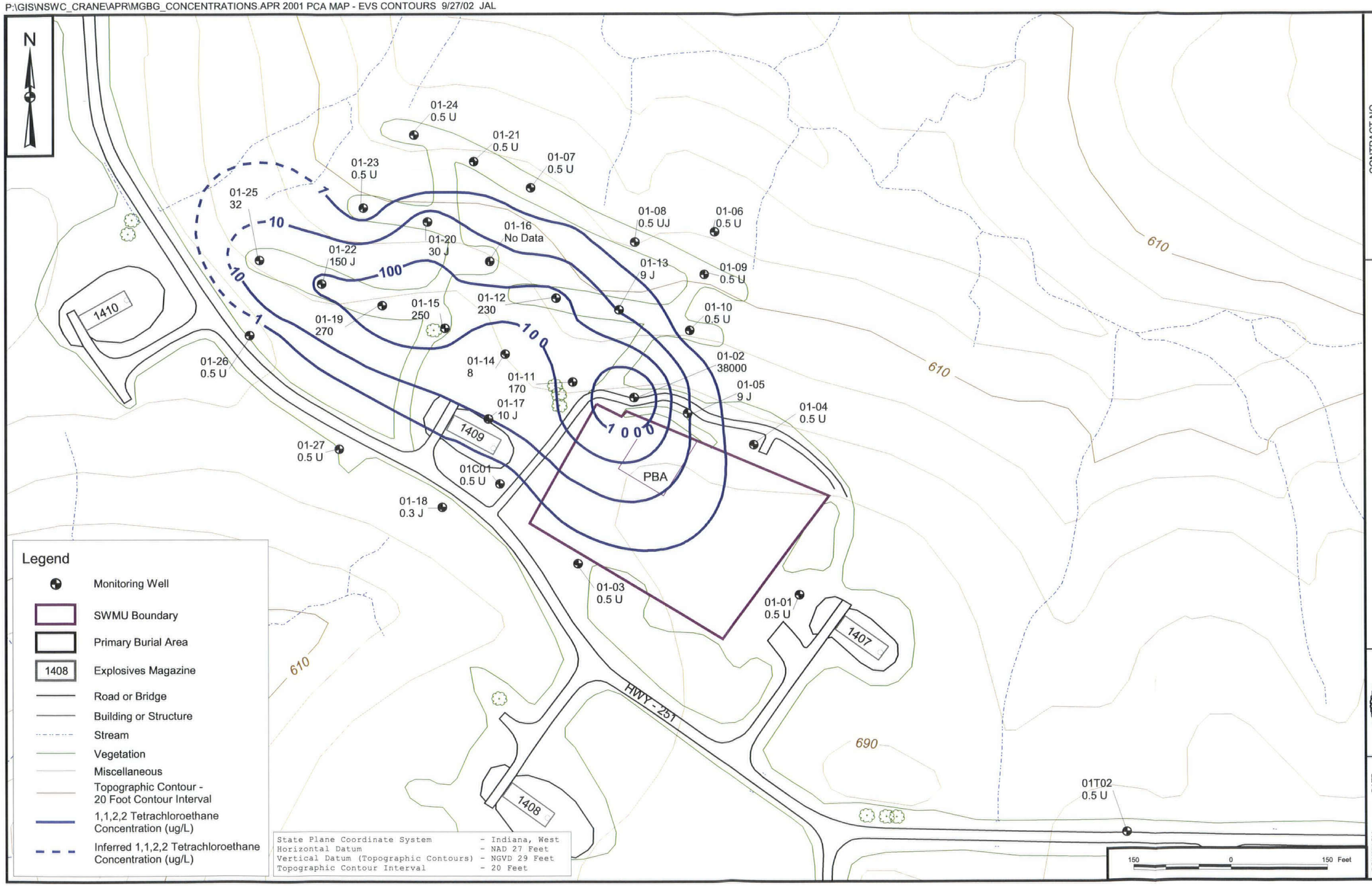
DRAWN BY J. LAMEY — DATE 8/20/02

CHECKED BY T. JOHNSTON — DATE 12/13/02

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\MGBG_CONCENTRATIONS.APR 2001 PCA MAP - EVS CONTOURS 9/27/02 JAL



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APPROVED BY T. JOHNSTON — DATE 9/27/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 5-7 — REV 0

1,1,2,2 TETRACHLOROETHANE CONCENTRATIONS (UG/L) IN SHALLOW WELLS, 2001
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

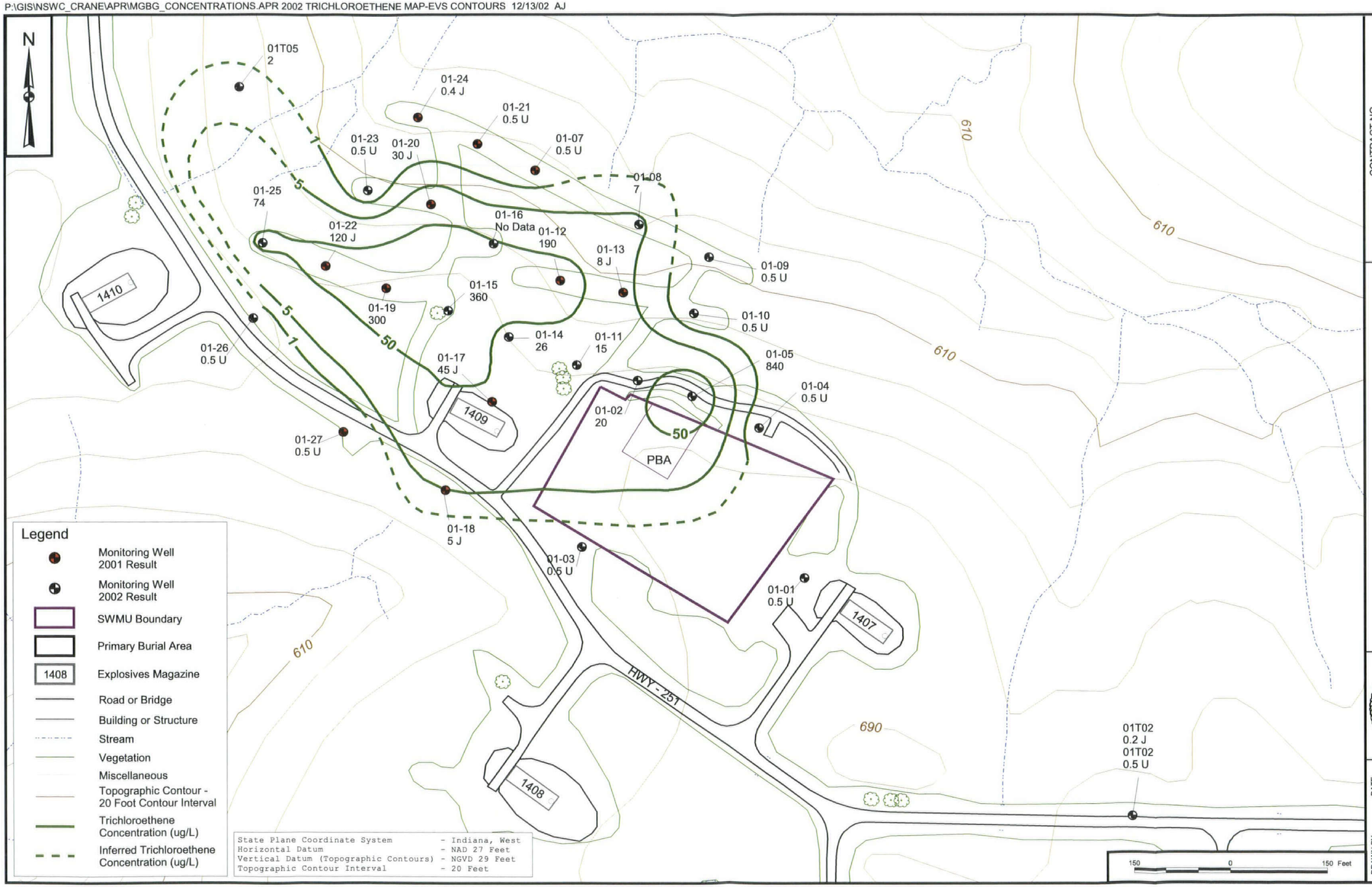
DRAWN BY J. LAMEY — DATE 8/20/02

CHECKED BY T. JOHNSTON — DATE 9/27/02

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\MGBG_CONCENTRATIONS.APR 2002 TRICHLOROETHENE MAP-EVS CONTOURS 12/13/02 AJ



CONTRACT NO. 3959

APPROVED BY T. JOHNSTON DATE 12/13/02

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DRAWING NO. FIGURE 5-8

REV 0

TRICHLOROETHENE CONCENTRATIONS (UG/L)
IN SHALLOW WELLS, 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ SOUTHERN DIV. FACILITIES ENGINEERING COMD ★

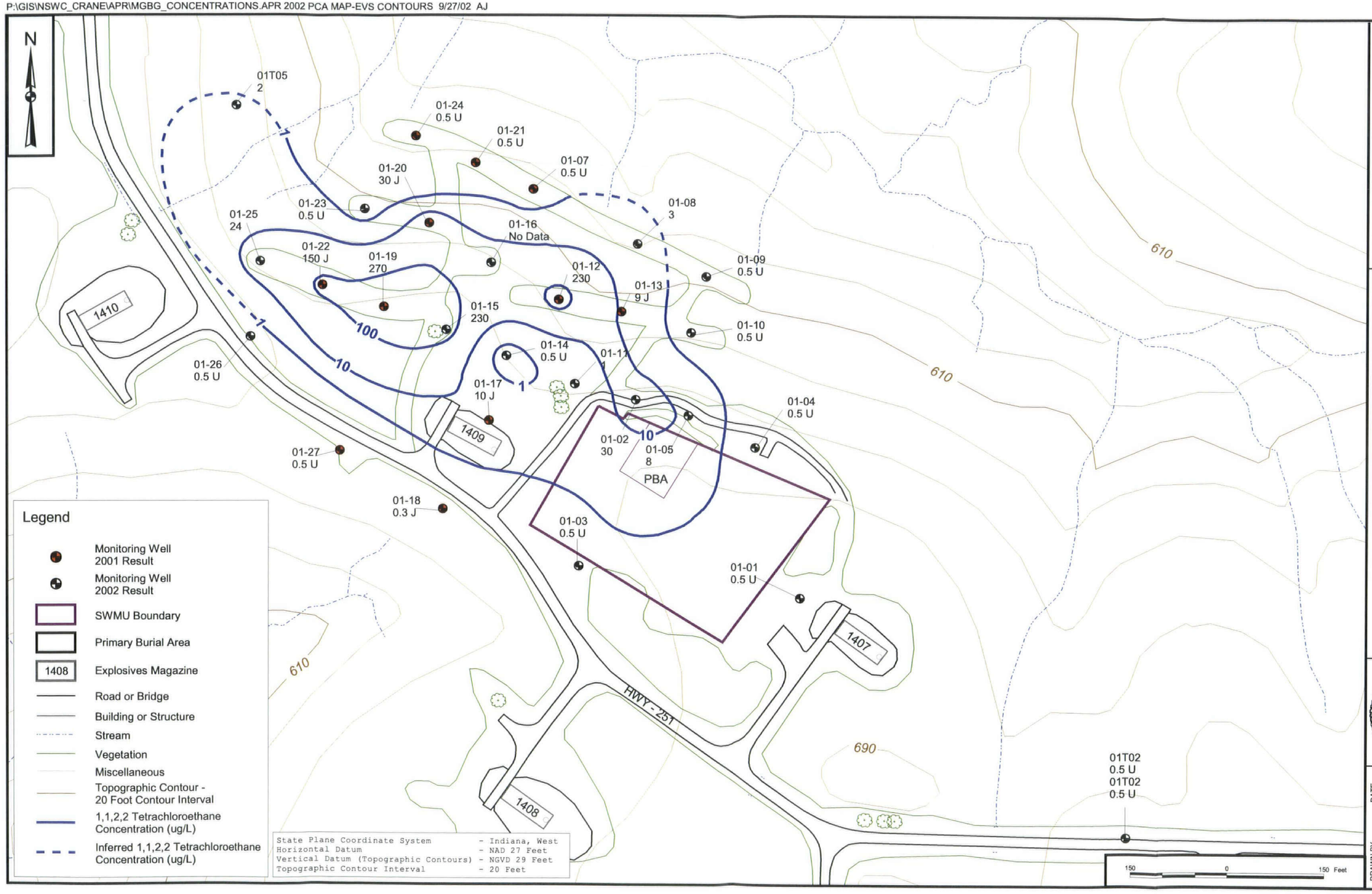
DRAWN BY J. LAMEY DATE 8/20/02

CHECKED BY T. JOHNSTON DATE 12/13/02

COST/SCHED-AREA

SCALE AS NOTED

P:\GIS\NSWC_CRANE\APR\MGBG_CONCENTRATIONS.APR 2002 PCA MAP-EVS CONTOURS 9/27/02 AJ



CONTRACT NO. N3959

APPROVED BY T. JOHNSTON DATE 9/27/02

APPROVED BY ___ DATE ___

DRAWING NO. FIGURE 5-9

REV 0

1,1,2,2 TETRACHLOROETHANE CONCENTRATIONS (UG/L) IN SHALLOW WELLS, 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

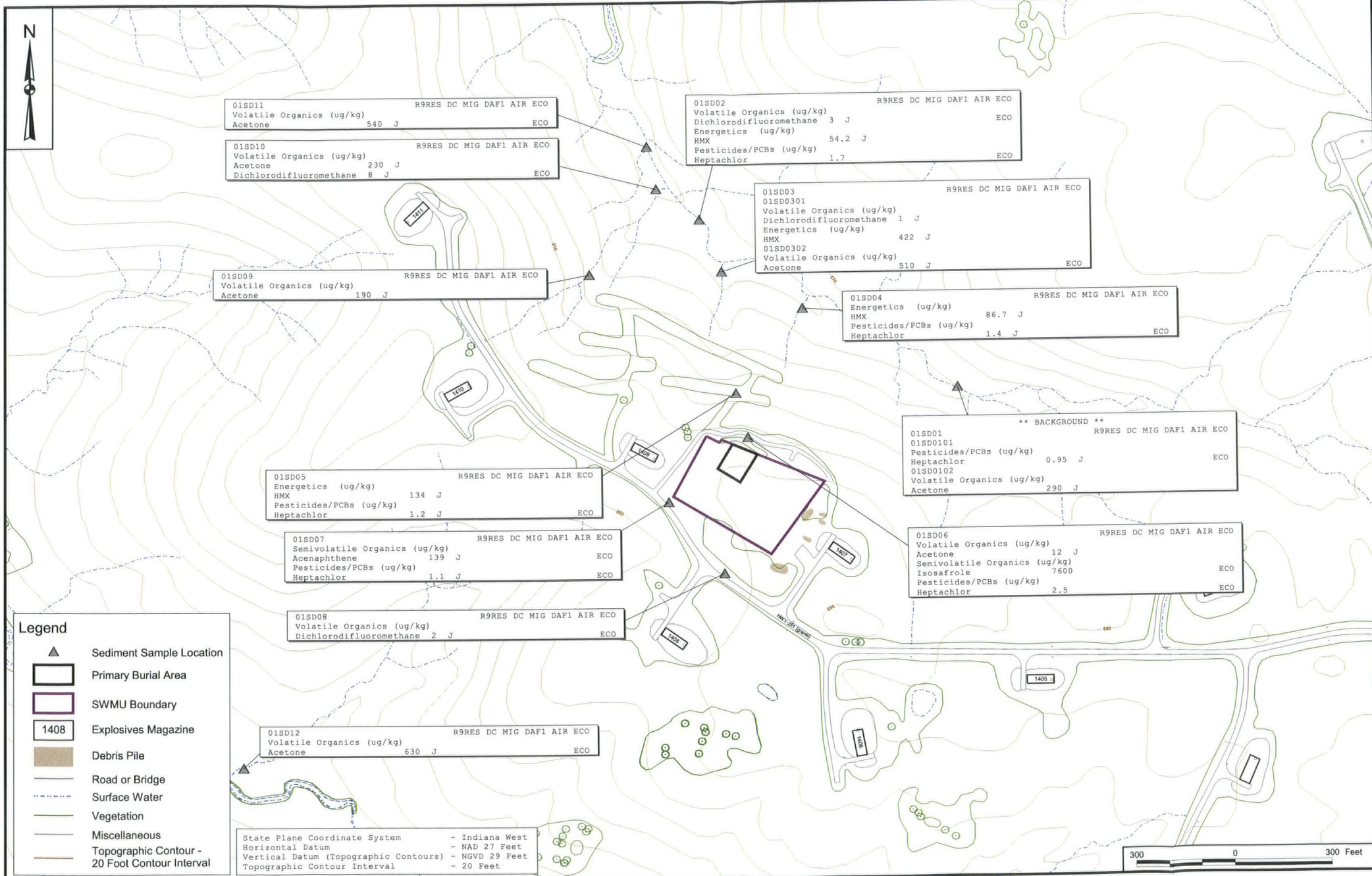
DEPARTMENT OF THE NAVY ★ SOUTHERN DIV FACILITIES ENGINEERING COMD ★

DRAWN BY J. LAMEY DATE 8/20/02

CHECKED BY T. JOHNSTON DATE 9/27/02

COST/SCHED-AREA

SCALE AS NOTED



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APPROVED BY T. JOHNSTON — DATE 9/26/02

APPROVED BY ___ — DATE ___

DRAWING NO. FIGURE 5 - 10

REV 0

ORGANIC AND INORGANIC CHEMICALS OF POTENTIAL CONCERN DETECTED IN SEDIMENT, 2001 AND 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

DRAWN BY A. JANOCHA — DATE 8/28/02

CHECKED BY T. JOHNSTON — DATE 9/26/02

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/MGBG_TAGS.APR SEDIMENT TAG LAYOUT 8/29/02 AJ

6.0 CHEMICAL FATE AND TRANSPORT ANALYSIS

Knowledge of a contaminant's potential to migrate and persist in an environmental medium is important when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. This section contains information on chemical properties and degradation potential of the COPCs, and the environmental conditions of the site and hydrological considerations that are likely affecting contaminant fate and transport in the MGBG and surrounding area. Section 6.1 contains a general discussion of the various chemical and physical properties of COPCs detected at the MGBG site. Section 6.2 reviews the potential for chemical compounds to biodegrade or undergo other transformations. Section 6.3 presents a discussion of transport pathways where migration and attenuation might be occurring and how spatial and temporal variations in hydrologic conditions might be affecting transport. Section 6.4 presents an overall summary of contaminant migration in the MGBG watershed.

In Section 4.0, a total of 37 different chemicals were identified as COPCs in the five different environmental media-surface soil, subsurface soil, ground water, surface water, and sediment (Table 4-17). Many of these chemicals were only detected in a few samples in one medium at concentrations exceeding the COPC screening level. For example, only one sediment sample had a concentration of acenaphthene greater than the screening level and acenaphthene was not detected at concentrations greater than screening levels in any other environmental medium. In general, the detections of SVOCs (including PAHs), herbicides, pesticides, and energetic compounds at concentrations exceeding COPC screening levels were very limited. The emphasis of this section is to describe the fate and transport of the COPCs selected in Section 4.0 with an emphasis on those that are the most important site contaminants. It is expected that minor site contaminants would exhibit the same fate and transport as the major site contaminants of similar chemical and physical characteristics.

6.1 CHEMICAL AND PHYSICAL PROPERTIES AFFECTING COPC MOBILITY

Table 6-1 presents physical and chemical properties of the organic COPCs identified in Table 4-17. These properties can be used to estimate the environmental mobility and fate of site contaminants. The properties that are discussed include the following:

- Specific gravity
- Vapor pressure
- Water solubility -Henry's Law Constant
- Octanol/water partition coefficient (K_{ow})

- Organic carbon partition coefficient (K_{oc})
- Soil-water distribution coefficient (K_d)
- Bioconcentration factor (BCF)
- Mobility index (MI)

Literature values of the water solubility, K_{ow}, K_{oc}, vapor pressure, Henry's Law constant, BCF, MI, and specific gravity are presented for each organic COPC, when available in Table 6-1. Calculated values, which were obtained using approximation methods, are presented when literature values are not available and the values could be computed. A discussion of the environmental significance of each of these parameters follows.

6.1.1 Specific Gravity

Specific gravity is the ratio of the density of a given volume of pure chemical at a specified temperature (usually 20°C) to the density of the same volume of water at a given temperature (usually 4°C). Its primary use is to determine whether a chemical will have a tendency to float or sink in water if it is present as a pure chemical or at very high concentrations. Chemicals with a specific gravity greater than 1, including halogenated aliphatic compounds, PAHs, and pesticides, will tend to sink if present as a pure liquid. Chemicals with a specific gravity less than 1 (e.g., ketones) will tend to float. This physical characteristic becomes important only when the chemicals are at very high concentrations and are liquid when they are in pure phase. Only two compounds (1,1,2,2-PCA and TCE) were detected in sufficiently high concentrations to speculate that they may currently be present, or may have been present in the past, in the soils or ground water as DNAPLs. The greatest concentration of 1,1,2,2-PCA detected in ground water was 38,000 µg/L (38 mg/L), which is approximately 14 percent of its solubility limit in water (277 mg/L, Table 6-1). The greatest concentration of TCE detected in ground water was 16,000 µg/L (16 mg/L), which is approximately 1.5 percent of its solubility limit in water (1,100 mg/L, Table 6-1). Historical data indicate that concentrations of these chemicals in the 1980s were even greater, suggesting that DNAPLs may have been present in soils or ground water at the site.

6.1.2 Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It is of primary importance at environmental interfaces such as surface soil/air and surface water/air. Volatilization from stream sediments could also be significant under low flow conditions (i.e., during summer months and drought conditions) when the sediments are exposed to the atmosphere in a dry creek bed. Volatilization is not as important when evaluating contaminated ground water and subsurface

soils that are not exposed to the atmosphere. Vapor pressures for ketones and halogenated aliphatics are generally many times greater than vapor pressures for PAHs, herbicides, pesticides, energetic compounds, and phthalate esters. Chemicals with greater vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is a significant loss process for VOCs in surface water, surface soil, and sediment. Volatilization is not significant for most inorganics. Surface soils and surface waters in the MGBG area do not contain significant concentrations of VOCs; therefore, volatilization from soil is not currently an important loss mechanism at this site. However, volatilization in the past may account for the lack of VOCs in the surface soil samples collected during the RFI.

6.1.3 Water Solubility

The rate at which a chemical is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. The water solubilities presented in Table 6-1 indicate that the VOC COPCs (ketones and halogenated aliphatics) are usually several orders of magnitude more water soluble than pesticides, herbicides, and some of the PAHs.

6.1.4 Henry's Law Constant

Both vapor pressure and water solubility are of use in determining volatilization rates from surface water bodies and ground water.. The ratio of these two parameters (the Henry's Law constant) is used to calculate the equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant of less than 1×10^{-5} atm-m^3/mole, such as pesticides and PAHs, should volatilize very little and should be present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's Law constant greater than 5×10^{-3} atm-m^3/mole, such as many of the halogenated aliphatics, volatilization and diffusion in soil gas could be significant.

6.1.5 Octanol/Water Partition Coefficient (K_{ow})

K_{ow} is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors, or the bioconcentration factor (BCF), has been established (Lyman et al., 1990). The K_{ow} is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available. Pesticides and aromatic compounds, lacking functional groups that enhance water solubility, are several

orders of magnitude more likely to partition to fatty tissues than the more soluble VOCs. K_{ow} values are also used to estimate BCFs in aquatic organisms.

6.1.6 Organic Carbon-Water Partition Coefficient (K_{oc})

K_{oc} indicates the tendency of a chemical to adhere to organic matter contained in soils. Many VOCs have relatively low K_{oc} values and tend to be fairly mobile in the environment. Chemicals with high K_{oc} values generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which the more mobile chemicals (e.g., ketones and halogenated aliphatics) are transported in ground water. Chemicals such as most pesticides and PAHs are relatively immobile in the soil and are preferentially bound to the soil. These compounds are not subject to ground water transport to the same extent as compounds with higher water solubilities. However, these immobile chemicals can be transported by erosional processes when they occur in surface soils. Several factors affect the measured value of K_{oc}. Values of K_{oc} usually decrease with increasing temperature. The fine silt and clay fraction of soil and sediments may have a greater tendency to absorb chemicals because they often have a higher concentration of organic matter (hence, a higher number of adsorption sites per unit volume).

6.1.7 Soil-Water Distribution Coefficient (K_d)

K_d is a measure of the equilibrium distribution of a chemical in soil/water systems. The K_d of organic chemicals is a function of both the K_{oc} and the fraction of organic carbon in the soil (f_{oc}):

$$K_d = K_{oc} * f_{oc}$$

The degree to which organic chemicals sorb to soils is very important when assessing migration potential. If a chemical tends to sorb strongly to soil, there is much less probability that the chemical will reach ground water and affect ground water quality.

For the MGBG site, 18 different SVOCs were detected in surface and subsurface soils (Tables 4-17), but only eight were detected in ground water samples (Table 4-17). The chemicals, such as SVOCs, that migrate slowly through soil and the upper unsaturated rock units have a relatively long time period where they are subjected to biodegradation processes before they reach the first water-bearing rock unit. As a consequence of low migration potential, there is a very low probability that chemicals with very high K_d values (i.e., SVOCs) will reach surface water bodies via ground water flow. However, if SVOCs, pesticides, or herbicides are present at the ground surface, eroded, and transported in surface runoff with soil particles (as a sorbed phase), then there is potential for these compounds to reach the adjacent

stream channels. One energetic, several SVOC, two pesticide, and two herbicide COPCs were detected in channel sediments collected during the RFI (Table 4-17). However, it is not clear whether the MGBG is the source of these contaminants because upgradient samples also contained concentrations of some of these compounds that exceed COPC screening levels.

A total of seven sediment samples collected from the gullies and channels adjacent to the MGBG were analyzed for TOC. Values of TOC ranged from 5,580 to 49,600 mg/kg. TOC is also expressed as (f_{oc}) in sediment. For the MGBG sediments, f_{oc} values ranged from 0.5 to 4.9 percent (average = 2.4 percent). This amount of organic carbon in the sediments is providing a relatively large capacity for sorption of organic compounds. This capacity favors retention of the COPCs on soil particles rather than dissolution into the surface water.

6.1.8 Bioconcentration Factor

BCF represents the ratio of aquatic-animal-tissue concentration to water concentration. The ratio is both contaminant- and species-specific. When site-specific values are not measured, literature values are used or the BCF is derived from the K_{ow}. Many of the pesticides and PAHs will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in the water, but VOCs and energetic compounds are not as readily bioconcentrated.

6.1.9 Mobility Index

The MI is a quantitative assessment of mobility that uses water solubility (S), vapor pressure (VP), and the K_{oc} (Laskowski, 1983). It is defined as

$$MI = \log ((S^{*}VP)/K_{oc})$$

A scale to evaluate MI, as presented by Ford and Gurba (1984), is:

Relative MI	Mobility Description
> 5	extremely mobile
0 to 5	very mobile
-5 to 0	slightly mobile
-10 to –5	immobile
< -10	very immobile

Of the organic chemicals detected at MGBG, chlorinated solvents and ketones generally have MIs greater than 5 and are considered extremely mobile. Lighter molecular weight PAHs, such as naphthalene, have MIs ranging from -5 to 0 and are considered slightly mobile. Heavier molecular weight PAHs [e.g., benzo(a)pyrene] and heptachlor are classified as very immobile, having MIs less than -10. The MIs for organic COPCs detected at MGBG are presented in Table 6-1.

6.1.10 Inorganic COPCs

The solubility and mobility of inorganics are strongly influenced by their valence state(s) and mineral forms present in soils (e.g., silicates, hydroxides, oxides, carbonates, etc.). The solubility of a metal also depends on pH, redox potential (Eh), temperature, and other ionic species in solution (the Debye-Huckel theory). Nearly all metals are more soluble at lower water pH values (e.g., < 5.0). Iron, manganese, and chromium are metals that have more than one valence state and are more soluble in the reduced valence states. As a result, these metals are more soluble under reducing conditions. The solubility products reported in the literature vary with the type of chemical complex formed, but generally for example, cadmium and copper complexes are more soluble than lead and nickel complexes.

The K_d for inorganic constituents is the ratio of the concentration adsorbed on soil surfaces to the concentration in water. K_ds for metals vary over several orders of magnitude because the K_d is dependent on the size and charge of the ion and the soil properties governing exchange sites on soil surfaces. Approximate K_d values for the inorganic COPCs are presented in Table 6-2. The average pH in the near-surface soils (average = 5.5) is slightly less than the average pH measured in ground water samples (average = 6.2). As shown in Table 6-2, the K_d values increase slightly when the pH value increases from 5.5 to 6.2. Overall, iron, strontium, barium, and antimony have lower K_d values and hence have greater mobilities. Aluminum, chromium, vanadium, and selenium generally have much higher K_d values and lesser mobilities.

6.2 CHEMICAL PERSISTENCE AND DEGRADATION PROCESSES

Degradation and other transformation processes that affect the COPCs are discussed in this section, including hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. Biodegradation rates for various organic COPCs in soil and ground water are summarized in Table 6-3.

6.2.1 Ketones

Hydrolysis is generally not a significant fate process for this class of chemicals. Acetone has a high vapor pressure and, once released to the atmosphere, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days (Howard, 1990).

6.2.2 Halogenated Aliphatics

Photolysis and oxidation reactions are not considered to be significant degradation mechanisms for this class of compounds (Mabey et al., 1982). Limited hydrolysis of saturated aliphatics (i.e., alkanes) may occur, but it does not appear to be a significant degradation mechanism for unsaturated species (i.e., alkenes) (Mabey et al., 1982).

Four of the chlorinated VOCs detected in soil and ground water samples are chlorinated ethene compounds: tetrachloroethene (PCE), TCE, and two dichloroethene (DCE) isomers (1,1-DCE and cis-1,2-DCE). Generally, PCE and TCE are used as cleaning solvents, and the DCE compounds and vinyl chloride are generally considered to be biodegradation products of PCE and TCE. TCE can also be a biodegradation product of PCE. In general, soil microbes strip off chlorine atoms from the ethene chain via reductive dechlorination, one chlorine atom at a time:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{vinyl chloride}$$

The dechlorination of TCE typically produces much more cis-1,2-DCE than either 1,1-DCE or trans-1,2-DCE (Aziz et al., 2000).

At the MGBG, none of the chlorinated ethene compounds were detected in the surface or subsurface soil samples (Tables 4-1 and 4-2). In ground water, TCE was the most frequently detected (27 out of 49 ground water samples) and detected at the greatest concentration (16,000 µg/L, well 01-02 in 2001) of all the chlorinated ethenes (Table 4-12). These data suggest that TCE was the primary ethene compound disposed at the MGBG. Cis-1,2-DCE was detected in 10 samples, with concentrations ranging from 0.9 to 9.0 µg/L. 1,1-DCE was detected in six well samples, with concentrations ranging from only 0.2 to 2.0 µg/L. The presence of cis-1,2-DCE and 1,1-DCE in ground water suggests that biodegradation of TCE is occurring around well 01-02 and farther downgradient toward well 01-15.

There was only one chlorinated ethane compound (1,1,2,2-PCA) detected and it was detected in only one MGBG soil sample at 2 µg/kg (Table 4-1). 1,1,2,2-PCA was detected in 7 out of 49 ground water

samples (Table 4-12), and the maximum concentration detected was 38,000 µg/L (well 01-02 in 2001). Also detected in ground water were 1,1,2-trichloroethane (1,1,2-TCA), and 1,2-dichloroethane (1,2-DCA). Presumably, the 1,1,2,2-PCA is being sequentially biodegraded to 1,1,2-TCA and 1,2-DCA. This pathway for biodegradation is described by Lorah et al. (1997).

Thus, the original chlorinated VOCs released at the MGBG were apparently 1,1,2,2-PCA, TCE, and to a lesser extent PCE. Biodegradation of these compounds by soil microbes has apparently resulted in the reduction in overall chlorinated VOC mass at the site and the formation of six or more chlorinated daughter products.

Tag maps of the organic compounds are presented in Figures 5-1, 5-4, and 5-10. The concentrations presented in these figures represent an overall decrease in VOC concentrations over the last two decades when compared to Figure 1-20.

6.2.3 Polycyclic Aromatic Hydrocarbons

PAHs in soil are much more likely to bind to soil and to be transported via erosion and surface water runoff than to be solubilized. PAHs are subject to slow degradation *via* aerobic bacterial metabolism, but may be relatively persistent in the absence of microbial populations or macronutrients such as phosphorus and nitrogen.

Landspreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. The rate of degradation is influenced by temperature, pH, oxygen concentrations, initial chemical concentrations, and moisture. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil [Agency for Toxic Substances and Disease Registry (ATSDR), 1997].

The most important fates of PAHs in water are photo-oxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action, and hydrolysis is considered to be an insignificant degradation mechanism. The rate of photodegradation is influenced by water depth, turbidity, and temperature. Benzo(a)pyrene is reported to be resistant to photodegradation. PAHs may also be metabolized by microbes under oxygenated conditions (ATSDR, 1997).

6.2.4 Energetic Compounds

Four different nitrogen-containing explosives (i.e., energetic compounds) were detected in soil, ground water, surface water, and sediment samples collected from the MGBG area. Two of these compounds

[HMX, 4-amino-2,6-dinitrotoluene (4ADNT)] have been identified as COPCs for the MGBG area (Table 4-17).

Numerous laboratory studies and past site investigations at DOD facilities have yielded information on the biodegradation of energetic compounds. 2,4,6-trinitrotoluene (TNT) in soils, ground water, and surface water can degrade biotically or abiotically, and can degrade under a fairly wide range of pH and Eh conditions (Brannon et al., 1998). The two most common degradation products found in soils and ground water have been 2-amino-4,6-dinitrotoluene (2ADNT) and 4ADNT (Pennington et al., 1999a,b,c). These compounds subsequently degrade to diaminonitrotoluene compounds and other less reactive compounds. The degradation process involves consecutive reduction of nitro groups (NO_2) to amino groups (NH_2). 2ADNT and 4ADNT have been found in surface and subsurface soils collected at the NSWC Crane Ammunition Burning Ground (ABG) (Albertson et al., 1998), surface and subsurface soils collected at the NSWC Crane Old Jeep Trail (OJT) area (TtNUS, 2002c), ground water samples collected at the ABG area, particularly wells 03C08P2 and 03C20 (TtNUS, 2001c), and ground water samples collected from the NSWC Crane OJT area (TtNUS, 2002c). Thus, there is ample evidence that biodegradation of TNT, 2ADNT, and 4ADNT is occurring in soils and ground water systems at NSWC Crane. Recent research by the USACE (May et al., 2002) suggests that plant uptake and phytoremediation may also be removing and degrading TNT, 2ADNT, and 4ADNT from the soils at the ABG.

6.2.5 Field Measurements and Natural Attenuation

Field readings of pH, DO, ORP, temperature, specific conductance, and turbidity are presented in Figure 6-1. Shallow ground water in the Lower Pennsylvanian sandstones and shales at MGBG is slightly acidic (ranges from 4.41 to 7.45), and has a wide range of DO and ORP measurements. In wells 01-02 and 01-11 near the source of the VOC plume, the DO readings ranged from 1.01 to 7.57 mg/L, and the ORP readings ranged from 445 to 562 mV (slightly oxidizing conditions). Further downgradient at wells 01-14 and 01-15, however, the DO values (0.08 to 2.41 mg/L) and the ORP readings (-156 to 75.2) indicated that much more reducing conditions. This is where the greater concentrations of 1,1,2,2-PCA and TCE breakdown products appear. Because microbes degrade these compounds most efficiently via reductive dechlorination processes, the appearance of breakdown products in the area of reducing conditions is further evidence that biodegradation is actively occurring at the site downgradient of the source area.

Measurements of other chemical parameters were conducted in order to help evaluate the potential for biodegradation at the site. Measurements of those natural attenuation parameters are displayed on Figure 6-2. Chloride, ferrous iron, manganese, and sulfide levels are low and the nitrate concentration is

moderately high in wells 01-02 and 01-11. By the time the shallow ground water has reached the downgradient well 01-15, the concentration of nitrate decreases to 0.01 mg/L, and the concentrations of chloride, ferrous iron, manganese, and sulfide increase sharply. The rise in ferrous iron, manganese, and sulfide indicate progressively reducing conditions in the downgradient direction, which is conducive to the biodegradation of chlorinated aliphatics. The biotic dechlorination of the aliphatic compounds may be responsible for the progressive rise in chloride concentrations in wells 01-15, 01-25, and 01T05.

6.2.6 Inorganics

Metals are highly persistent environmental contaminants because they do not biodegrade. However, their valence states and ionic forms can readily change based on pH and Eh conditions, biotic uptake and assimilation into living organisms, and decay and decomposition of dead plant matter. The major fate mechanisms for metals are adsorption to the soil matrix or precipitation as a mineral coating, uptake and bioaccumulation in plants, or transport through the hydrologic system.

6.3 CONTAMINANT TRANSPORT PATHWAYS

A contaminant transport pathway represents the physical path or the mechanism by which a contaminant moves or might move from one location (i.e., the source area) to another. A transport pathway may also involve a phase change for the contaminant (e.g., a contaminant is absorbed to soil, volatilizes to soil gas in the vadose zone, and then migrates into a basement as a gas). In addition, contaminant transport pathways provide mechanisms and conduits for contaminants to migrate to a new location where they may contribute to a human health or ecological risk. The determination of whether a pathway is currently causing a risk or could potentially cause a future risk depends on the combination of chemical characteristics, the existence of a potential pathway, the physical site conditions, and the potential for exposure to occur now or in the future.

This section presents a brief overview of contaminant fate and transport pathways that exist at the MGBG. Based on the evaluation of existing conditions, the following potential contaminant transport pathways may exist at the site:

- Leaching of soil contaminants to ground water
- Migration of ground water contaminants within the Pennsylvanian strata
- Mixing of ground water (i.e., spring discharges and creekbed seepage) with surface water in the adjacent stream channels during storm events
- Erosion and runoff of contaminated particles from soil and deposition in surface water bodies

- Leaching of contaminants from creek sediment to surface water during storm events
- Migration of contaminants in surface water as dissolved or sorbed phases during storm events
- Volatilization from soil, ground water, or surface water

6.3.1 Leaching of Soil Contaminants to Ground Water

Contaminants that adhere to soil particles or have accumulated in soil pore spaces at the MGBG can leach and migrate vertically to the ground water as a result of infiltration of precipitation. The rate and extent of this leaching is influenced by the amount of precipitation, rate of infiltration, the physical and chemical properties of the soil, the physical and chemical properties of the contaminant, and the depth of the water table.

During the selection of COPCs in soil (Section 4.2), the maximum detected concentrations of individual soil contaminants were compared against SSLs. The SSLs for protection of ground water are derived from assumptions regarding aquifer hydraulic conductivity, hydraulic gradient, infiltration rate, mixing zone height, aquifer thickness, source length, and chemical-specific soil-water K_ds. These SSLs for protection of ground water are used to conservatively estimate whether a chemical could potentially leach from soil, migrate to ground water, and raise the ground water concentration above the pertinent RBTL for ground water.

Based on the results of the soil analyses, there were two VOCs, two SVOCs, and five metals whose concentrations exceeded the soil-to-ground water SSLs and were identified as COPCs in soil (Tables 4-9 and 4-11). However, only two of these nine chemicals (1,1,2,2-PCA and nickel) were detected in ground water samples at concentrations that caused them to become ground water COPCs. Hence, leaching of the other seven chemicals from soil to ground water is not considered to be a problem. Because disposal activities at the MGBG ceased in the 1960s, the likelihood of these seven compounds appearing in the ground water in the future is very low. If a chemical did not have an SSL (e.g., aluminum, iron, and manganese), it was not evaluated in this regard.

The contaminants in ground water at present (e.g., the chlorinated aliphatic compounds) are not present in the soils, except a very minor detection of chloroform and 1,1,2,2-PCA at soil boring 01SB09 (sample 01SB090206). Evidently, the majority of the contaminant mass leached or volatilized out of the soils prior to the recent soil sampling activities.

6.3.2 Migration of Ground Water Contaminants

At the MGBG, the detected ground water contaminants may be affected by one or more mechanisms during transport in ground water. Volatilization of VOCs or precipitation as a mineral phase (for metals) may physically transform contaminants. Contaminants may be chemically transformed through hydrolysis, oxidation/reduction, or biodegradation.

There are two primary groups of contaminants detected in the ground water within the MGBG area. VOCs comprise the first group. These were detected at concentrations greater than HH screening levels in 15 of the 31 wells sampled at the site (Figure 5-4). The wells with the greatest concentrations of chlorinated aliphatics (01-02, 01-11, 01-15, 01-19, 01-22, and 01-25) are shallow wells aligned from southeast to the northwest. The greatest concentrations detected during this investigation were observed in well 01-02 in 2001 (close proximity to the MGBG), and concentrations decreased to the northwest. Shallow ground water is mounded near the MGBG and is flowing primarily north and northeast, with minor flow components to the northwest and southwest (Figure 1-15). The distributions of the two most significant ground water contaminants, 1,1,2,2-PCA and TCE, are presented in Figures 5-6 through 5-9. The long axis of the VOC plume is oriented obliquely to the direction one would expect based on the hydraulic gradient. It is assumed that the source of the VOCs was originally located near well 01-02, which displayed the greatest VOC concentrations recently and historically. By the time the ground water reaches 01-25 about 625 feet to the northwest, the concentrations of 1,1,2,2-PCA and TCE decrease approximately two to three orders of magnitude. None of the 1,1,2,2-PCA and TCE biodegradation products were observed in well 01-02. Because of the high concentrations of 1,1,2,2-PCA and TCE in the samples from this well, the VOC samples had to be significantly diluted in order to complete the analysis. Hence, the lack of detections of degradation products is not surprising. However, degradation products (e.g., 1,1,2-TCA, 1,2-DCA, 1,1-DCE, 1,2-DCE) are found in wells along the plume centerline to the northwest of well 01-02 (Figure 5-4). The maximum concentrations of 1,1,2-TCA and cis-1,2-DCE were detected near the midpoint of the plume long axis (in well 01-15, about 300 feet northwest of well 01-02). The lateral ground water velocity in the plume area is slow based on the relatively low hydraulic conductivities measured for the site, as presented in Section 1.0. As the contaminants migrate, the 1,1,2,2-PCA and TCE are degrading until the maximum concentrations of the degradation products occur near well 01-15. As the ground water migrates farther to the northwest, the degradation products are presumably degrading as fast or faster than they are being formed because their concentrations, in addition to the concentrations of 1,1,2,2-PCA and TCE, decline between wells 01-15 and 01-25. Besides biodegradation, dilution from surface recharge is also a factor that causes the concentrations to decline in a northwesterly direction. Based on historical data, the plume is not expanding. The size has remained

relatively stable since the 1980s, based on the 5 µg/L isoconcentration contour. However, the maximum concentrations and total mass with the plume boundary have been declining.

Concentrations versus time plots have been generated for four compounds in four different wells located along the centerline of the VOC plume. Concentrations for well 01-02 near the plume's source, at well 01-05 at the southeast edge of the plume, at well 01-15 near the center of the plume, and 01-25 near the front of the plume are shown in Figures 6-3 through 6-6, respectively. These figures are presented in order to show general temporal trends in concentrations. In well 01-02, the concentrations of 1,1,2,2-PCA, TCE, and PCE have decreased more than an order of magnitude between 1982 and 2002 (20 years). Chloroform concentrations have not shown a stable trend over time, but do not appear to be increasing in well 01-02. In well 01-05 (Figure 6-4), the concentration of 1,1,2,2-PCA appears to be decreasing over time, while the other three compounds appear to be relatively stable. In well 01-15 (Figure 6-5), concentrations of all four compounds vary, but each compound appears to be relatively stable. Near the leading edge of the plume at well 01-25, the concentration of 1,1,2,2-PCA appears to be declining, whereas the concentration of TCE appears to be increasing slightly (59 to 74 µg/L) over 20 years time (Figure 6-6). The concentrations of PCE and chloroform are low in this well and do not appear to change over time.

The plume of organic contaminants in the shallow ground water at MGBG is slowly migrating northwestward. Well 01T05 was installed in 2002 in order to define the edge of the plume. Very low concentrations (1 to 2 µg/L) of 1,1,2,2-PCA, TCE, and chloroform were detected in this well. As such, the lateral boundaries of the plume are well defined. It does not appear that the plume is reaching or will reach a surface water body. Hence, there is no reason to believe that a ground water to surface water pathway exists.

Wells 01-06, 01C01, 01T03, and 01T04 are all screened in an upper Mississippian (possibly Glen Dean Formation) limestone bed. Only a trace (1.0 µg/L) of TCE was detected in one of the wells (01T03), indicating that virtually none of the organic contamination has migrated vertically downward.

Two sediment samples (01SD0301 and 01SD0302) had detections of 1,1,2,2-PCA of 7 µg/kg and 9 µg/kg, respectively. This may indicate that ground water has transported contaminants to a seep in the hillside, thereby contaminating surface sediments. No seeps were identified during either the 2001 or the 2002 sampling events, even though a search for seeps was made. It is common for seeps of low flow rates to go undetected and ground water seepage is assumed to be occurring.

The second primary group of COPCs detected in ground water at the MGBG are metals. The COPC screening levels for aluminum, iron, and manganese were exceeded the most frequently (Figure 5-5). The greatest concentrations of these metals occurred in wells 01-03, 01-14, and 01T02. The COPC screening level for arsenic was exceeded in a few wells, with the greatest concentration (7.9 µg/L) occurring in well 01-03. The distribution of concentrations of these metals is generally random and distinct patterns could not be discerned. Thus, no contamination source can be, or is likely to be, identified. It is believed that the metals are not related to SWMU activities and that they likely reflect background concentrations. The elevated concentrations could be related to small quantities of laboratory chemicals once discarded at the MGBG. However, the few ounces of chemicals that were reportedly disposed are not expected to pose a significant contaminant source and could be nearly impossible to find. Transport of metals would follow ground water flow patterns. The metals may migrate in soluble form or bound to colloidal particles. Migration of soluble metals would be retarded by ion exchange with bedrock and the rate of colloidal flow through the bedrock would depend on particle size with smaller particles moving more quickly than larger particles.

6.3.3 Migration of Contaminants from Surface Soil to Surface Water

Rainfall, snowmelt, and surface water runoff that comes in direct contact with surface soils can leach contaminants from the soils and transport them to the unnamed tributary channels via runoff during storm events. Soil particles containing sorbed contaminants can also be dislodged from the soil surface and be physically transported to the creek via overland runoff. The MGBG area is located on a ridge that has relatively steep slopes on the north and southwest sides. However, the topography in the immediate area of the MGBG is relatively flat, and the area is also heavily vegetated with trees, bushes, and weeds (Figure 1-3). Hence, the amount of overland runoff from this site should be very small.

Four surface water samples (two upgradient and two downgradient) were collected during one storm event in 2002 at sampling locations shown on Figure 1-11. Those samples were analyzed only for VOCs and no VOCs were detected. Six different organic contaminants in sediment samples exceeded ecological screening levels, but did not exceed HH screening levels (Table 4-17). These COPCs include acetone, dichlorodifluoromethane, acenaphthene, isosafrole, heptachlor, and HMX. It is believed that HMX is not a site related contaminant that is transported from the site. Rather, it is believed that the HMX reflects a general NSWC Crane-wide aerial deposition.

6.4 SUMMARY OF CONTAMINANT MIGRATION

The chlorinated VOC concentrations detected in soils at the MGBG area were very minor; it appears that the chlorinated solvents have leached out of or have volatilized from the soils in the past and only a small mass of these contaminants still resides in the soils. There were small residual quantities of other VOCs and SVOCs (e.g., PAHs) detected in the surface and near-surface soils. Because the SVOCs, herbicides, and pesticides have relatively low solubilities and very high K_d values, their mobility in subsurface soils and bedrock is very limited. In the case of the MGBG area, these compounds were detected in a few shallow ground water samples, but only in low concentrations. Small debris piles which contained asphalt and other materials were detected along the southern and eastern boundaries of the MGBG (see Section 1.3.2 and Figure 1-18). These debris piles might be a source of PAHs. One PAH compound, acenaphthene, was detected in one out of seven sediment samples (01SD0701) at a concentration that exceeded the ecological screening level (see Table 4-16). Sample 01SD0701 was collected from a road ditch on the west-southwest side of the MGBG. This road ditch collects surface runoff from the southern half of the MGBG site, including the area containing the debris piles. Thus, the sediment sample in the ditch may include some contaminated sediment from the debris piles, which was transported via surface runoff.

There is a distinct plume in the shallow ground water flow system that contains chlorinated VOCs. This elongated plume includes eight wells (between wells 01-02 and 01T05, inclusive) that lie along the southeast-northwest axis of the plume. Well 01-02 contained the greatest concentrations of chlorinated VOCs during this investigation, as well as during a previous sampling event in the 1980s. The source of the TCE, 1,1,2,2-PCA, and some of the other VOCs is believed to have been located close to well 01-02 because the greatest concentrations were detected in this well. Some of the other chlorinated VOCs (e.g., *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE, 1,1,2-TCA) are the degradation products of the primary COPC contaminants. Hence, degradation of 1,1,2,2-PCA and TCE is actively occurring in the shallow ground water system.

The outline of the plume is accurately defined relative to COPC screening levels, based on the locations of numerous well samples surrounding the plume that had low or no detections of the primary contaminants. A new well (01T05) was installed near the leading edge of the plume to define the farthest extent where ground water contamination is present.

Analyses of samples from four relatively deep wells screened in an Upper Mississippian limestone formation directly beneath the Pennsylvanian strata have shown that virtually none of the ground water contamination has reached the aquifer immediately below the shallow contaminated zone in at least 20 years since VOCs were first released at the MGBG.

An unnamed tributary channel receives drainage from the MGBG site during storm events. However, surface water and sediment samples have shown almost no effect from the chlorinated aliphatic compounds that were detected in ground water. Sediment samples did show detectable concentrations of six organic compounds that were designated as ecological COPCs (acetone, dichlorodifluoromethane, acenaphthene, isosafrole, heptachlor, and HMX). However, these chemicals are minor site contaminants and some of them (e.g., acetone, HMX and isosafrole) may not be related to MGBG operations or may be related to intended use of pesticides/herbicides (e.g., heptachlor).

As discussed in Section 1.0, all contaminated ground water near the MGBG site flows northwestward. However, the plume is stationary or near stationary and is not discharging into any surface water body or ephemeral channel.

TABLE 6-1

PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC COPCs
SWMU 01 -- MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	Specific Gravity[1] (@ 20/4°C)[2]	Vapor Pressure (mm Hg @ 20°C)[1]	Water Solubility (mg/L @ 20°C)[1]	Octanol/Water Partition Coefficient[3]	Organic Carbon Partition Coefficient[2]	Henry's Law Constant (atm-m3/mole)[3]	Bioconcentration Factor (mg/kg/mg/L)[2]	Mobility Index log((solubility*VP)/K_{oc})
KETONES								
Acetone	0.7899	2.66E+02 (25°C)	Miscible	5.75E-01	7.08E+03 (3)	4.276E-5 (25°C)	3.81E-1[6]	NA
HALOGENATED ALIPHATICS								
1,1,1,2-Tetrachloroethane	1.54	1.00E+01	2.00E+02	1.10E+03	NA	1.10E-02	NA	NA
1,1,2,2-Tetrachloroethane	1.60 (15/4°C)	4.00E+00	2.90E+03	2.45E+02	9.33E+01	3.80E-04	3.90E+01	2.09E+00
1,1,2-Trichloroethane	1.4397	2.50E+01	4.50E+03	1.48E+02	5.01E+01	9.60E-04	1.90E+01	3.35E+00
1,1-Dichloroethene	1.218	5.91E+2 (25°C)	2.1E+02 (25°C)	3.02E+01	5.89E+01[4]	2.286E-2 (25°C)	5.30E+01	3.32E+00
1,2-Dichloroethane	1.235	7.9E+01 (25°C)	8.69E+03	2.82E+01		1.178E+03 (25°C)	NA	NA
Chloroform	1.4832	1.60E+02	9.3E+03 (25°C)	9.33E+01	3.98E+01[4]	3.39E-3 (25°C)	2.60E+01	4.57E+00
cis-1,2-Dichloroethene	1.2837	2.02E+2 (25°C)	8.00E+02	1.58E+02	3.55E+01[4]	4.08E-3 (24.8°C)	1.4E+1(4)	3.66E+00
Dichlorodifluoromethane	1.405	4.25E+03	2.8E+02 (25°C)	1.45E+02	1.06E+03	3.9E-01 (25°C)	3.50E+01	NA
Methylene chloride	1.3266	4.29E+2 (25°C)	1.67E+04 (25°C)	1.78E+01	1.17E+01[4]	3.19E-3 (25°C)	6.00E+00	5.79E+00
Tetrachloroethene	1.6227	1.9E+1 (25°C)	1.5E+02 (25°C)	3.39E+02	1.55E+02[4]	2.685E-2 (25°C)	2.52E+02	1.26E+00
Trichloroethene	1.4642	7.70E+1 (25°C)	1.10E+03 (25°C)	3.39E+02	1.66E+02	1.17E-02 (25°C)	9.70E+01	2.67E+00
PAHs								
Acenaphthene	1.07	5.00E-03	4.24E+02	8.32E+03	7.08E+03	2.41E-04 (25°C)	1.10E+03	-3.52E+00
Benzo(a)anthracene	1.274	5.00E-09	1.0E-02 (24°C)	4.07E+05	3.98E+05[4]	6.60E-07	5.30E+04	-1.59E+01
Benzo(a)pyrene	1.351	5.00E-09	3.8E-03 (25°C)	9.55E+05	1.02E+06[4]	4.9E-7 (25°C)	1.40E+05	-1.67E+01
Benzo(b)fluoranthene	NA	5.00E-07	1.2E-03 (25°C)	3.72E+06	1.23E+06[4]	1.20E-05	1.40E+05	-1.53E+01
PHTHALATE ESTERS								
bis(2-Ethylhexyl) phthalate	0.99 (20/20°C)	1.2E+0 (200°C)	4.0E-01 (25°C)	2.00E+05	1.51E+07[4]	3.00E-07 (20°C)	2.30E+08	-7.50E+00
MISCELLANEOUS SVOCs								
Hexachloroethane	2.091	4.00E-01	5.0E+01 (22°C)	1.38E+04	NA	2.24E-02 (25°C)	NA	NA
Isosafrole	1.122	1.60E-08	1.09E+03	4.57E+02	NA	3.25E-12	NA	NA
PESTICIDES								
Heptachlor	1.57 (9°C)	3E-04 (25°C)	5.6E-2 (25°C)	2.51E+04	1.41E+06[4]	1.48E-03	4.40E+03	-1.09E+01
HERBICIDES								
2,4-D	NA	8.25E-05[6]	6.77E+2 (25°C)[6]	2.81E+00[6]	1.09E+02[7]	3.54E-8 (25°C)	NA	-3.29E+00
EXPLOSIVES								
4-Amino-2,6-dinitrotoluene	NA	NA	NA	NA	NA	NA	NA	NA
HMX	NA	NA	NA	3.89E+00[8]	3.8E+00[8]	NA	1.7E+00[8]	NA

NA = Not available.

1 U.S. EPA, 1992c.
2 (20/4°C) indicates that density of the chemical was measured at 20°C; whereas, density of water was measured at 4°C. Numbers in parentheses below indicate densities were measured at given temperatures.
3 Mabey et al, 1982.
4 U.S. EPA, 1996. Soil Screening Guidance.
5 Lyman et al., 1990, Equation 5-3. Handbook of Chemical Property Estimation Methods.
6 Syracuse Research Corporation. Online Database: Interactive Physical Properties Database Demo. www.esc.syrres.com/efdb.htm. Web site last updated October 17, 2001.
7 Howard, 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume 1.
8 Lyman et al., 1990. Eq. 5-2

TABLE 6-2

SOIL-WATER PARTITION COEFFICIENTS FOR INORGANIC COPCs
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Inorganic Element	K_d at pH = 5.5[1] (L/kg)	K_d at pH = 6.2[2] (L/kg)	K_d[3] (L/kg)
Aluminum	NA	NA	1,500
Antimony	NA	NA	45
Arsenic	26	28	200
Barium	21	33	41
Cadmium	27	42	75
Chromium (as Cr^{+3})	2,100	420,000	1,800,000
Copper	NA	NA	428
Iron	NA	NA	25
Manganese	NA	NA	65
Nickel	28	42	65
Selenium	12	75	300
Strontium	NA	NA	35
Vanadium	NA	NA	1,000
Zinc	26	42	62

1 Values from Illinois EPA Tiered Approach to Corrective Action Objectives (TACO) Program; pH of 5.5 is the average soil pH at MGBG.

2 Values from Illinois EPA TACO Program; pH of 6.2 is the average ground water pH at MGBG.

3 Values from the U.S EPA-sponsored Risk Assessment Information System (RAIS) Internet site: "http://risk.lsd.ornl.gov/rap_hp.html"

NA = Not applicable.

K_d = Soil-water distribution coefficient.

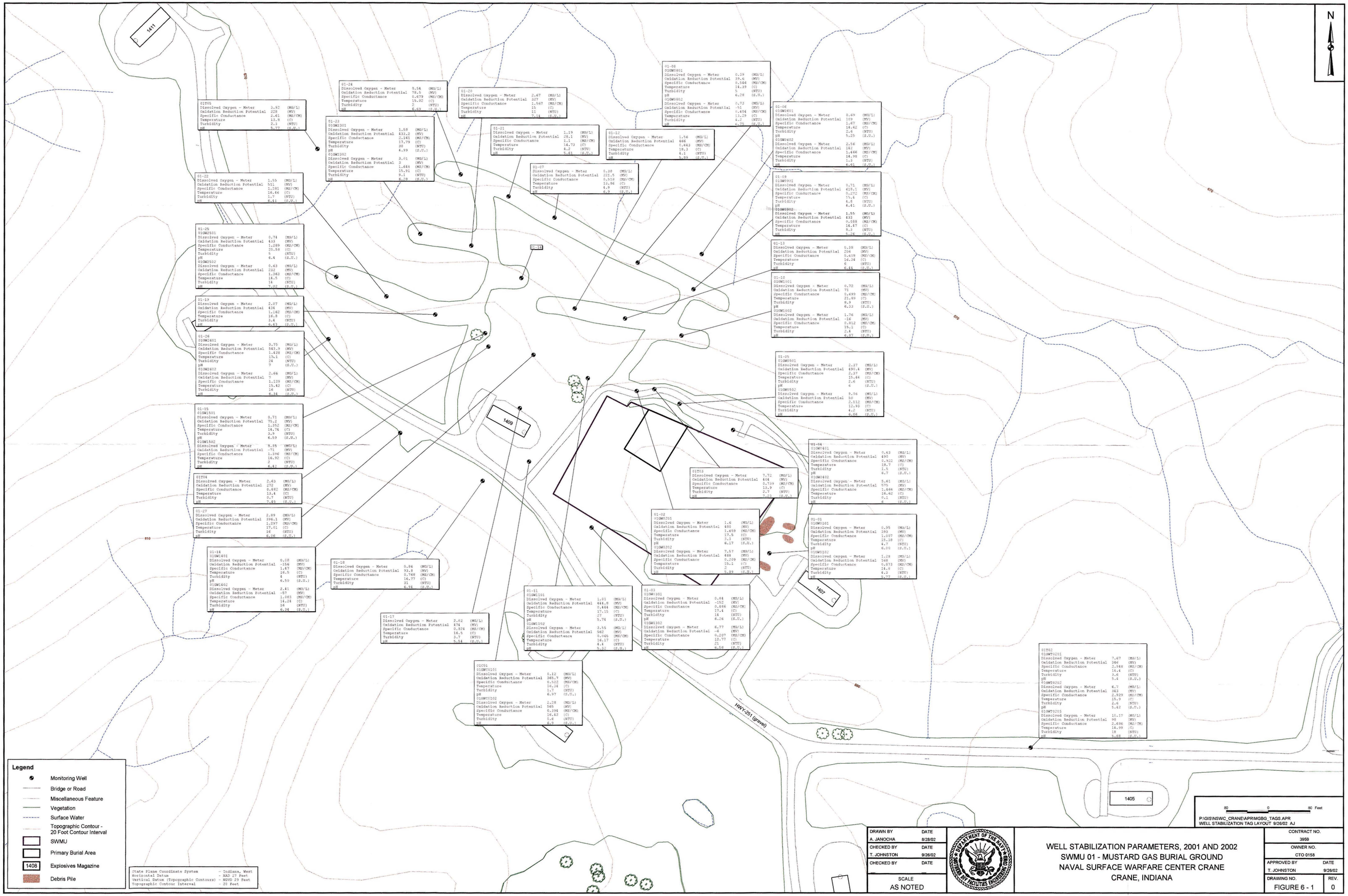
TABLE 6-3

RANGES OF BIODEGRADATION RATES FOR ORGANIC COPCs
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	SOIL		GROUND WATER	
	Small Half-Life (days)	Large Half-Life (days)	Small Half-Life (days)	Large Half-Life (days)
VOCs				
1,1,1,2-Tetrachloroethane	0.66	66.8	0.66	66.8
1,1,2,2-Tetrachloroethane	0.45	44	0.45	44
1,1,2-Trichloroethane	136	365	136	730
1,1-Dichloroethene	28	180	56	132
1,2-Dichloroethane	100	180	100	360
Acetone	1	7	2	14
Chloroform	28	180	56	1800
cis-1,2-Dichloroethene	28	180	56	2875
Dichlorodifluoromethane	28	180	56	360
Methylene Chloride	0	0	0	0
Tetrachloroethene	180	360	360	720
Trichloroethene	180	360	321	1653
SVOCs				
Acenaphthene	12.3	102	24.6	204
Benzo(a)anthracene	102	680	204	1360
Benzo(a)pyrene	57	530	114	1060
Benzo(b)fluoranthene	360	610	720	1220
bis(2-Ethylhexyl) phthalate	5	23	10	389
Hexachloroethane	28	180	56	360
Isosafrole	7	28	14	56
Herbicides				
2,4-D	NA	NA	NA	NA
Pesticides				
Heptachlor	1.0	5.4	1.0	5.4
Energetics				
4-Amino-2,6-Dinitrotoluene	NA	NA	NA	NA
HMX	NA	NA	NA	NA

Range of biodegradation half-life values from Howard et al., 1991.

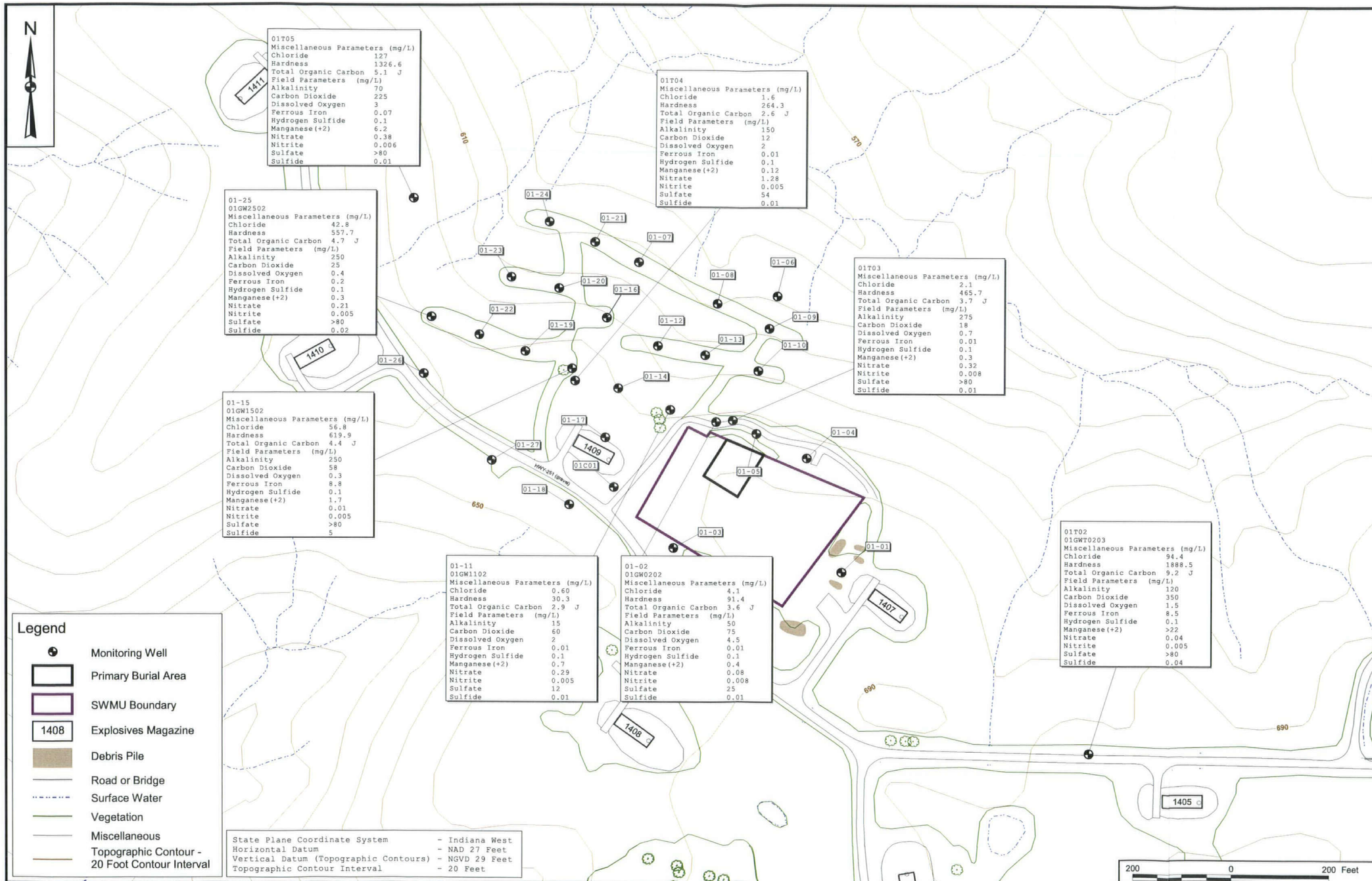
NA = Not available.



DRAWN BY A. JANOCHA	DATE 8/28/02
CHECKED BY T. JOHNSTON	DATE 9/26/02
CHECKED BY	DATE
SCALE AS NOTED	

WELL STABILIZATION PARAMETERS, 2001 AND 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. 3959	
OWNER NO. CTO 0158	
APPROVED BY T. JOHNSTON	DATE 9/26/02
DRAWING NO. FIGURE 6 - 1	REV. 0



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APPROVED BY T. JOHNSTON — DATE 9/26/02

APPROVED BY — DATE

DRAWING NO. FIGURE 6 - 2 — REV 0

NATURAL ATTENUATION PARAMENTERS, 2002
SWMU 01 - MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

DEPARTMENT OF THE NAVY ★ NAVAL FACILITIES ENGINEERING COMMAND ★ SOUTHERN DIVISION

DRAWN BY A. JANOCHA — DATE 8/28/02

CHECKED BY T. JOHNSTON — DATE 9/26/02

COST/SCHED-AREA

SCALE AS NOTED

P:/GIS/NSWC_CRANE/APR/MGBG_TAGS.APR MNA TAG LAYOUT 9/26/02 AJ

FIGURE 6-3. CONCENTRATIONS OF MAJOR VOCs VS TIME, WELL 01-02

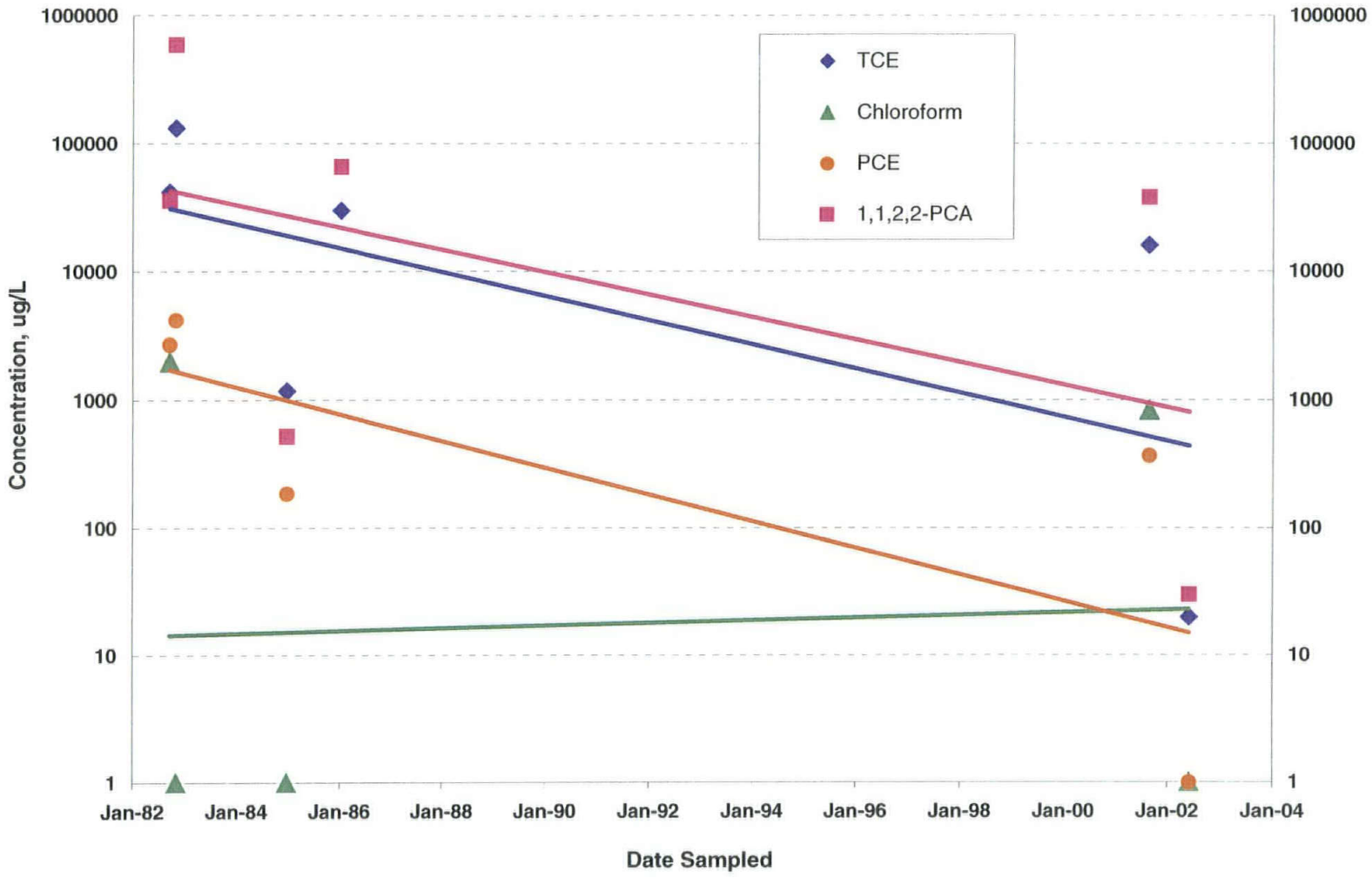


FIGURE 6-4. CONCENTRATIONS OF MAJOR VOCs VS TIME, WELL 01-05

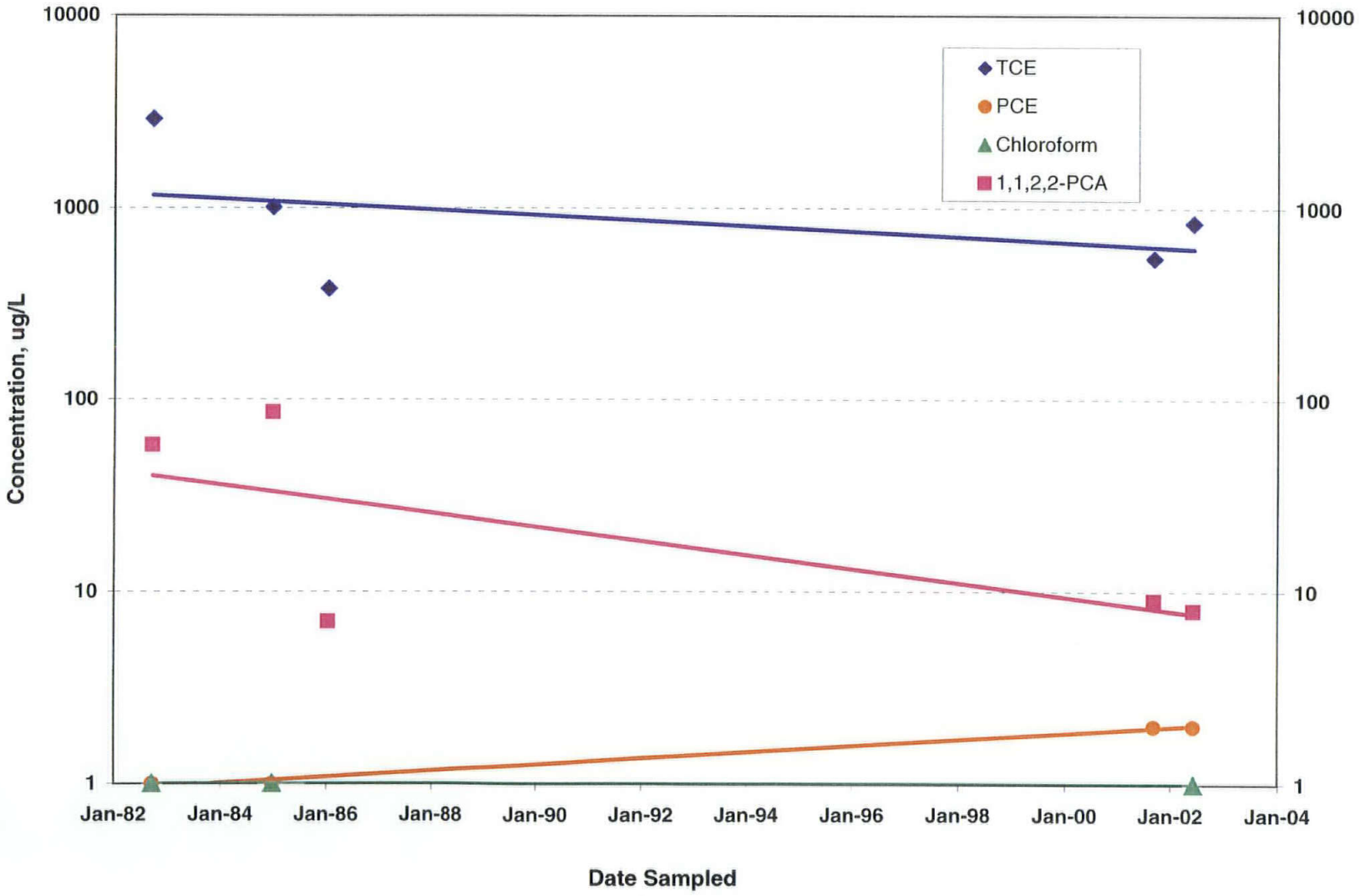


FIGURE 6-5. CONCENTRATIONS OF MAJOR VOCs VS TIME, WELL 01-15

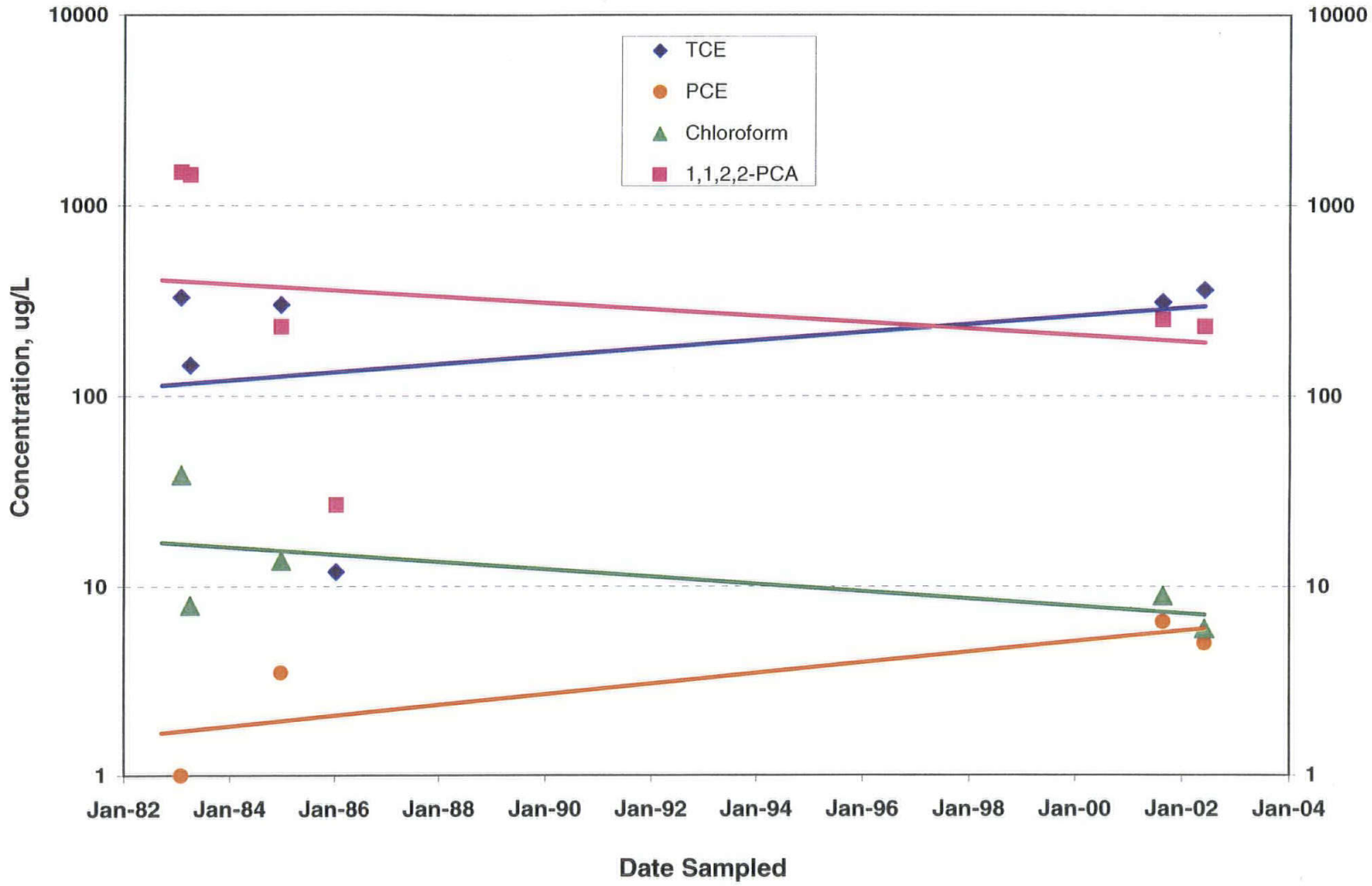
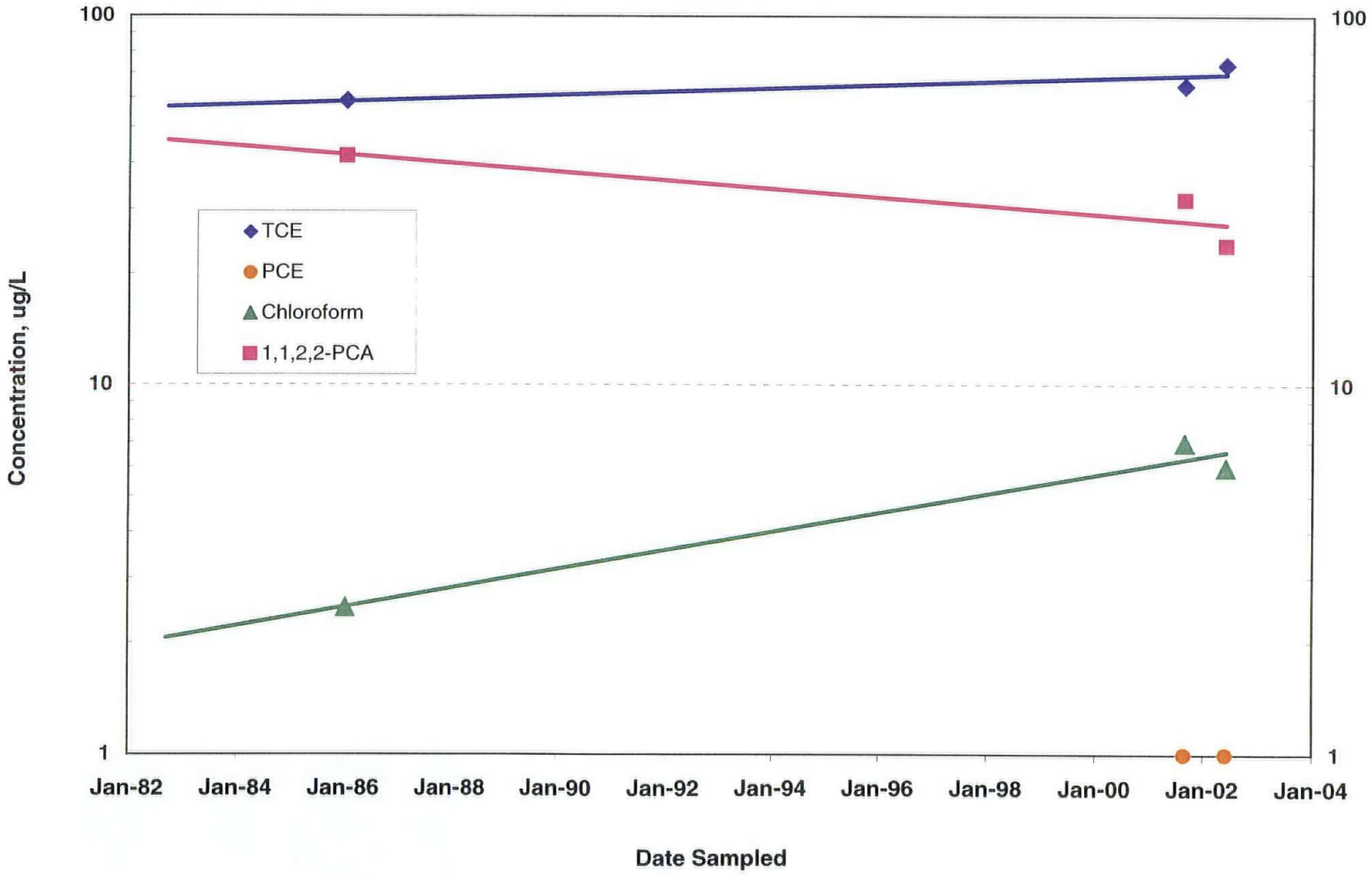


FIGURE 6-6. CONCENTRATIONS OF MAJOR VOCs VS TIME, WELL 01-25



7.0 HUMAN HEALTH RISK ASSESSMENT

This section presents the HHRA for the MGBG at NSWC Crane. The objective of the risk assessment was to determine whether detected concentrations of chemicals within the study area pose a significant threat to potential human receptors under current and/or future land use. The potential risks to human receptors were estimated based on the assumption that no actions were or will be taken to control contaminant releases.

7.1 INTRODUCTION

The following current U.S. EPA and the IDEM risk assessment guidance documents were used to develop the framework for the HHRA:

- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A). (U.S. EPA, 1989).
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Washington, D.C. Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03 (U.S. EPA, 1991).
- Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication No. 9285.7-081 (U.S. EPA, 1992b).
- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. OSWER (U.S. EPA, 1993a).
- Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response. EPA/540/R-95/128 (U.S. EPA, 1996).
- Exposure Factors Handbook. Office of Health and Environmental Assessment. EPA/600/P-95/002Fa (U.S. EPA, 1997c).
- RISC (Risk-Integrated System of Cleanups). Technical Resource Guidance Document. Indiana Department of Environmental Management, Office of Environmental Response (IDEM, 2001).

- Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (U.S. EPA, 1998a).

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim, EPA/540/R/99/005, Office of Emergency and Remedial Response. (U.S. EPA, 2001b).

This HHRA also followed the methodology and decision rules presented in the MGBG QAPP (TtNUS, 2001b).

An HHRA consists of five components: data evaluation, exposure assessment, toxicity assessment, risk characterization, and uncertainty analysis. Sections 7.2 through 7.6 contain detailed discussions of the five components of the HHRA. A schematic diagram of the general risk assessment process is provided as Figure 7-1.

Three major aspects of chemical contamination and environmental fate and transport were considered to evaluate potential risks: (1) Contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or by human action; (2) potential exposure points must exist; (3) human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of the factors listed above were absent, and risks are not quantitatively evaluated for that exposure pathway.

7.2 DATA EVALUATION

Data evaluation, the first component of an HHRA, is a medium-specific task involving the compilation and evaluation of analytical data. The main objective of the data evaluation is to develop a medium-specific list of COPCs, that are used to quantitatively determine potential HH risks for site media.

7.2.1 Data Usability

Data collected from this investigation were used to assess risks to potential human receptors. All analytical data used in the quantitative estimation of potential risks was subject to a data quality evaluation. A discussion of the data validation protocol is provided in Section 3.1 of this report. A data quality report is included in Section 3.0 that provides information on precision, accuracy, representativeness, completeness, and comparability of the analytical data.

Fixed-based laboratory analytical results only for the targeted analytes for the investigation were used in the quantitative risk evaluation. Typically, unfiltered results for ground water and surface water were used to assess risks associated with those media. Field measurements and data regarded as unreliable (i.e., qualified as "R" during the data validation process) were not used in the quantitative risk assessment. The uncertainty associated with the rejection of analytical results discussed in Section 7.6.1.

7.2.2 Selection of Chemicals of Potential Concern

Chemicals that were retained as COPCs and evaluated in this HHRA are identified in Section 4.2 and summarized in Table 4-17. The following constituents wee selected as COPCs for the MGBG.

- Surface soil – methylene chloride, aluminum, iron, selenium
- Subsurface soil – 1,1,2,2-tetrachloroethane, methylene chloride, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, aluminum, barium, cadmium, chromium, iron, manganese, nickel, selenium
- Ground water – 1,1,1,2-Tetrachloroethane, 1,1,2,2-Tetrachloroethane 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, chloroform, cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, bis(2-ethylhexyl)phthalate, hexachloroethane, 2-amino-4,6-dinitrotoluene, heptachlor, aluminum, antimony, arsenic, iron, manganese, nickel, strontium.

7.3 EXPOSURE ASSESSMENT

This portion of the risk assessment defined and evaluated, quantitatively or qualitatively, the type and magnitude of human exposure to the chemicals present at or migrating from the MGBG. The exposure assessment was designed to depict the physical setting of the site, identify potentially exposed populations and applicable exposure pathways, calculate concentrations of COPCs to which receptors might be exposed, and estimate chemical intakes under the identified exposure scenarios.

Actual or potential exposures at MGBG are determined based on the most likely pathways of contaminant release and transport, as well as human activity patterns. A complete exposure pathway has three components: a source of chemicals that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure or contact point for a human receptor.

7.3.1 Conceptual Site Model

This section discusses the conceptual site model (CSM) for the MGBG. A CSM facilitates consistent and comprehensive evaluation of the potential risks to human health by creating a framework for identifying the pathways by which human receptors may come in contact with contaminated media resulting from the source area. A CSM depicts the relationships among the following elements, which are necessary for defining complete exposure pathways:

- Site sources of contamination
- Contaminant release mechanisms and transport/migration pathways
- Exposure routes
- Potential receptors

Physical site characteristics, results of previous site investigations, hazard identification (detected chemicals of interest based on the previous investigations), and current and future land use scenarios also were considered during the development of the site-specific CSM. Details on the site background, physical setting, previous investigations, and hazard identification were presented in Section 1.0. The site-specific CSM for the MGBG is presented in Figure 7-2 in this section.

The elements of the CSM establish the manner and degree to which a potential receptor may be exposed to chemicals present at the site. The degree of risk incurred by a potential receptor varies according to the means of exposure, the duration of exposure, and the specific chemical to which the receptor is exposed. An exposure, however long in duration, does not necessarily result in an "unacceptable" health or environmental risk, although risks generally increase with increased frequency and/or duration of exposure.

The elements of the CSM, including how they pertain to the MGBG, are presented in Sections 7.3.1.1 through 7.3.1.3.

7.3.1.1 Site Sources of Contamination

As stated in Section 1.3.2, the MGBG is an inactive waste burial site approximately 2 acres in size. The MGBG was used between the end of World War II and 1956 for disposal of materials such as mustard munitions and other select items. Disposal was in the form of shallow burials, typically within 6 feet of the surface. Three types of hazards or potential hazards were identified at the site:

- Aerial mustard bombs (without the explosives).
- Thorium nitrate powder (in pyrotechnic flares).
- Unspecified laboratory chemical wastes.

The thorium nitrate and illuminant material containing thorium or thorium compounds was buried as waste from a research and development effort related to pyrotechnic devices. Also buried were some small amounts (a few ounces each) of unspecified chemical wastes documented to have comprised some 90 small quantities of aged laboratory chemicals. This latter disposal was designed to encourage decomposition of the small amounts of chemical wastes effecting close contact with soil and moisture.

A few debris piles comprising asphalt, concrete, and earth are visible among the trees on the eastern and southeastern sides of the MGBG. A drainage ditch immediately north of and parallel to HWY-251 lies between the road and the southern border of the MGBG. At least one culvert transports site runoff via the drainage ditch, under the road, and into an intermittent drainage channel located about 400 feet south-southwest of the MGBG.

Exhumations conducted in 1974 and 1980 uncovered aerial bombs (three of which contained chemical agent), seven 55-gallon-drums-worth of thorium nitrate-contaminated soil, illumination devices (i.e., flares), bomb casings, one mustard gas identification kit, an unspecified quantity of thorium nitrate, illumination candle debris, and other debris.

Based on historical site sampling data, the following parameters are among the site-related chemical/ radiological contaminants known to be present or potentially present in environmental media within the study area:

- Mustard gas and its degradation products (1,4-thioxane; 1,4-dithiane; and thiodiglycol).
- Thorium nitrate, small amounts of other metal salts, and of laboratory metals.
- Explosives such as HMX, TNT, and dinitrotoluenes.
- VOCs such as 1,1,2,2-TCA, 1,2-dichloroethane, TCE, and PCE.

7.3.1.2 Potential Contaminant Release Mechanisms and Transport Pathways

Past activities at the MGBG appear to have resulted in contaminant releases to the surrounding environment. Based on historical information available for the study area and a review of the existing ground water data for the site, a release of hazardous constituents to environmental media has occurred as a result of historical site operations. As discussed in Section 6.4, the ground water data indicates the

presence of a distinct plume in the shallow ground water system containing chlorinated VOCs. The source of the TCE, 1,1,2,2-PCA, and other VOCs is believed to have been located close to well 01-02 because the greatest concentrations were detected in this well. Some of the other chlorinated VOCs (e.g., cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, 1,1,2-TCA) are the degradation products of the primary COPC contaminants indicating that degradation of 1,1,2,2-PCA and TCE is actively occurring in the shallow ground water system. Because the shallow water table aquifer is in communication with the shallow bedrock aquifer system, transport of contaminants is possible along this pathway. However, analyses of samples from four wells screened in an Upper Mississippian limestone formation directly beneath the Pennsylvanian strata have shown that virtually none of the ground water contamination has reached the aquifer immediately below the shallow contaminated zone in at least 20 years since VOCs were first released at the MGBG. Depth to ground water ranges from 5 to 40 feet bgs across the MGBG. The shallower water depths may facilitate transport of chemicals from soils to ground water. The study area is a ground water recharge area.

Based on the elevation of the study area versus the surrounding area, ground water may flow radially from the study area. However, surface water and surface sediment sample data indicate that these media have not been impacted by the chlorinated aliphatic compounds that were detected in ground water. Also, soil data indicates that the chlorinated VOC concentrations detected in soils at the MGBG were minor and it appears that the VOCs have leached out of or have volatilized from the soils in the past and only a small mass of these contaminants still resides in the soils.

The MGBG area is located on a ridge that has relatively steep slopes on the north and southwest sides. Therefore, there is some potential for overland runoff in these directions, especially toward the road ditch in the southern half of the MGBG which includes the area containing the debris piles. However, the topography in the immediate area of the MGBG is relatively flat, and the area is also heavily vegetated with trees, bushes, and weeds. Hence, the amount of overland runoff from the site is likely to be minimal.

Based on the evaluation of existing conditions, the following potential contaminant transport pathways may exist at the site:

- Leaching of soil contaminants to ground water
- Migration of ground water contaminants within the Pennsylvanian strata
- Mixing of ground water (i.e., spring discharges and creekbed seepage) with surface water in the adjacent stream channels during storm events

- Erosion and runoff of contaminated particles from soil and deposition in surface water bodies (i.e., Little Sulphur Creek)

- Leaching of contaminants from creek sediment to surface water during storm events

- Migration of contaminants in surface water as dissolved or sorbed phases during storm events

- Volatilization from soil, ground water, or surface water

- Migration of fugitive dusts and volatile organic chemicals from surface soils (and subsurface soils if construction/excavation activities occur).

A discussion of potential contaminant transport pathways is presented in Section 6.0.

7.3.1.3 Potential Current and Future Receptors of Concern and Exposure Pathways

NSWC Crane is currently an active naval base and will remain an active base for the foreseeable future. There are currently no plans to disestablish NSWC Crane. The MGBG is no longer used as a disposal area and is likely to be used for military or recreational purposes in the future. However, for purposes of completeness, the HHRA considered receptor exposure under residential, industrial, and recreational land use scenarios. Based on current and potential future land use, the following potential receptors may be exposed to contaminated environmental media at the site:

- Trespasser – A plausible receptor under current and future land use. Although access to the Base is controlled, once inside the Base, access to the site is not limited by any physical constraints (the fence at the MGBG has been removed). In addition, hunting activities are permitted at the Base. Because the site is remote and surrounded by forested areas, hunters (particularly adolescents) may trespass onto the site. These receptors may be exposed to potentially contaminated surface soil (0 to 2 feet bgs) (incidental ingestion; dermal contact), air (inhalation), and surface water (dermal contact) and sediment (incidental ingestion; dermal contact) in the intermittent streams. However, because of the intermittent nature of the streams, exposure to surface waters is likely to be very limited. Direct contact with ground water or subsurface soils is not anticipated for this receptor.

- Maintenance Worker - A likely receptor under future land use. This includes adult military or civilian personnel assigned duties within the MGBG (e.g., groundskeeping activities). This receptor could be

exposed to surface soils (incidental ingestion; dermal contact) and air (inhalation). Direct contact with ground water or subsurface soils or exposure to surface water or sediment is not anticipated for this receptor.

- Construction Worker - A plausible receptor under future land use. No construction activities are currently planned at the site. Additionally, the shallow depth to ground water in some sections of the MGBG area would likely preclude excavation/construction. However, excavation/construction is plausible in other sections of the MGBG area. Consequently, this receptor would potentially be exposed to surface and subsurface soil (to an estimated maximum depth of 10 feet bgs) (incidental ingestion; dermal contact), ground water (dermal contact), and air (inhalation). Exposure to surface water and sediment is not expected for the construction worker.

- Occupational Worker - A plausible receptor under future land use. Includes adult military or civilian personnel assigned to work at the former MGBG. This receptor could potentially be exposed to surface soil (incidental ingestion; dermal contact) and air (inhalation). It is anticipated that this receptor would not be exposed to subsurface soil, ground water, surface water, or sediment. This receptor is expected to be exposed on a more frequent basis than the maintenance worker.

- Recreational User - A plausible receptor under future land use. If the NSWC Crane were to close, the most likely scenario is that the property would be converted to a state park. A recreational user may be exposed to potentially contaminated surface soil (0 to 2 feet bgs) (incidental ingestion; dermal contact), air (inhalation), and surface water (dermal contact) and sediment (incidental ingestion; dermal contact) in the intermittent streams. However, because of the intermittent nature of the streams, exposure to surface water is likely to be very limited. Direct contact with ground water or subsurface soil is not anticipated for this receptor. It is unlikely that NSWC Crane would close because principal Base operations, the demilitarization of munitions, are critical to the support of the U.S. Naval Fleet.

- Resident - Although this scenario is highly unlikely, a future residential scenario is typically evaluated in a risk assessment for decision-making purposes. For example, the need for deed restrictions at a site may be eliminated, prior to site closure, if minimal risks are estimated for residential receptors. It is assumed that a hypothetical resident may be exposed to surface soil (incidental ingestion; dermal contract), ground water (ingestion, dermal contact), surface water (dermal contact), air (inhalation), and sediment (incidental ingestion; dermal contact).

Table 7-1 provides a site-specific listing of all exposure pathways considered and the basis for inclusion or exclusion of each exposure pathway for each receptor. Table 7-2 provides a site-specific summary of the potential receptors and exposure routes that are addressed quantitatively in the HHRA.

7.3.2 Central Tendency Exposure vs. Reasonable Maximum Exposure

Traditionally, exposures evaluated in the HHRA were based on the concept of a reasonable maximum exposure (RME) only, which is defined as "the maximum exposure that is reasonably expected to occur at a site" (U.S. EPA, 1989). However, recent risk assessment guidance (U.S. EPA, 1992a) indicates the need to address an average case or central tendency exposure (CTE).

To provide a full characterization of potential exposure, both RME and CTE were evaluated in the HHRA for the MGBG at NSWC Crane. The available guidance (U.S. EPA, 1993a) concerning the evaluation of CTE is limited; therefore, professional judgment was used when defining CTE conditions for a particular receptor at a site.

7.3.3 Exposure Point Concentrations

The exposure point concentration (EPC), which was calculated for COPCs only, is a reasonable maximum estimate of the chemical concentration that is likely to be contacted over time by a receptor and is used to calculate estimated exposure intakes. The 95 percent upper confidence limit (UCL) on the arithmetic mean, which is based on the distribution of a data set, is considered to be the best estimate of the exposure concentration for data sets with 10 or more samples (U.S. EPA, 1992a). The 95 percent UCL was used as the exposure concentration to assess RME and CTE risks at the MGBG (U.S. EPA, 1993a). For data sets with fewer than 10 samples, the UCL is considered to be a poor estimate of the mean, and the exposure concentration was defined as the maximum detected concentration. For soils, the EPC is affected significantly by the spatial distribution of contaminants and the potential for a receptor to be exposed to the measured chemical concentrations in various locations. Accordingly, the two areas of the MGBG that could have represented different levels of contamination. Consequently, the PBA and the remainder of the MGBG were compared to assess their relative levels of contamination. The two areas were indistinguishable in this regard (Section 3.4.9). For ground water, it was assumed that receptors access the ground water via wells that are fixed in their location in the study area.

Conventional statistical methods (i.e., the Shapiro-Wilk W-Test) were used to determine the distribution and UCL of a particular data set (Gilbert, 1987; U.S. EPA, 1992a). If the results of the Shapiro-Wilk W-Test were inconclusive, the data were assumed to be lognormally distributed. Nondetected data

points were utilized; in general, one-half the sample-specific detection limit represented these analytical results in the statistical analysis. If the calculated 95 percent UCL exceeded the maximum detected concentration, then the maximum detected concentration was selected as the EPC. Example calculations for the distribution of the data sets and UCLs are provided in Appendix G-3.

The following paragraphs discuss the exposure units to be evaluated and the guidelines used to calculate the media-specific EPCs for MGBG.

The MGBG SWMU boundary plus an additional 20 feet in all directions (approximately 2 acres) was considered the exposure unit for soils. For purposes of risk assessment, surface soil extended to a depth of 2 feet, and subsurface soil included all soil from a depth of 2 to 10 feet or bedrock, whichever was shallower. A 2-acre exposure unit area was considered a reasonable exposure unit size based on the current/anticipated land use for the study area (i.e., military/industrial) and the rural nature of the area surrounding the Base (i.e., farmland). The 20-foot extension of the MGBG area facilitated assessing contamination that extends beyond the former MGBG fence line, but does not extend so far into expected uncontaminated regions that the exposure unit concentrations were artificially reduced. Additional discussion of the exposure unit size is presented in Section 3.4.9.

The EPCs for a receptor hypothetically using/exposed to the ground water underlying the MGBG study area are the COPC concentrations in the most highly contaminated well underlying the study area (01GW02). The greater of the Round 1 and Round 2 concentrations from this well were selected as the EPCs (The higher concentrations were generally observed during Round 1). A number of constituents selected as COPCs for ground water (1,1,2,2-PCA, 1,1-DCA, 1,2-DCA, cis-1,2-DCE, BEHP, 4-amino-2,6-dinitrotoluene, heptachlor, antimony, and arsenic) were not detected in sample 01GW0201, in part because of the elevated detection limits required for VOC analysis of the Round 1 sample. For these COPCs, ½ the MDLs were used as the EPCs. See Section 3.4.8 for a discussion of the temporal fluctuations in ground water samples.

The following guidelines were used to calculate the EPCs:

- If a soil dataset contained fewer than 10 samples, the EPC for the RME and CTE cases were defined as the maximum detected concentration.

- If a soil dataset for an exposure unit contained 10 or more samples, the 95 percent UCL on the arithmetic mean, which is based on the distribution of the dataset, was selected as the EPCs for the RME and CTE cases. As noted previously, conventional statistical methods (e.g., the Shapiro-Wilk

W-Test the T and H-statistic based UCL calculation) were used to determine the distribution and UCL. [The "best fit" distribution (normal or lognormal) was assumed if the dataset distribution was undefined.] If the calculated 95 percent UCL exceeded the maximum detected concentration, the maximum was used as the EPC.

- The EPCs for ground water were the maximum of the Round 1 and Round 2 concentrations in the most highly contaminated well underlying the study area (01GW02). If a COPC was not positively detected in sample 01GW0201, ½ the MDL for the COPC in this sample was used as the EPC.

EPCs for COPCs for surface soil, surface/subsurface soil, and ground water are summarized in Table 7-3. RAGS Part D tables for the EPCs are presented in Appendix G.

7.3.4 Chemical Intake Estimation

The methodologies and techniques used to estimate exposure intakes are presented in this section. Intakes for the identified potential receptor groups were calculated using current U.S. EPA risk assessment guidance (U.S. EPA, 1989; U.S. EPA, 2001b) and are presented in the risk assessment spreadsheets (Appendix G).

Noncarcinogenic intakes were estimated using the concept of an average daily exposure. Carcinogenic intakes were calculated as an incremental lifetime average daily exposure, which assumed a life expectancy of 70 years. Equations used to calculate estimated intakes are provided below. Exposure factors and assumptions regarding exposure are presented in Table 7-4. Overall the exposure assumptions presented in this section are the same as those presented in the MGBG QAPP except that some values have been updated to reflect current U.S. EPA guidance (e.g., U.S. EPA, 2001b).

7.3.4.1 Inhalation of Air and Fugitive Dust/Volatile Emissions

As mentioned previously in Section 4.2, a qualitative evaluation of exposure (i.e., comparison of maximum site soil concentrations to U.S. EPA generic SSLs for chemical transfers from soil to air) was used to identify whether a quantitative analysis of the inhalation exposure pathway was warranted. As shown in Tables 4-9 and 4-11, the concentrations of all chemicals detected in soil at the MGBG are less than the inhalation SSLs. Therefore, a quantitative evaluation of inhalation risks from soil was not required and was not performed. The potential risks associated with the inhalation pathway are regarded as minimal.

7.3.4.2 Dermal Contact with Soil

Direct physical contact with soil may result in the dermal absorption of chemicals. Exposures associated with the dermal route were estimated in the following manner (U.S. EPA, 2001b):

$$\text{Intake}_{si} = \frac{(C_{si})(SA)(AF)(ABS)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

Intake_{si}	=	amount of chemical "i" absorbed during contact with soil (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (dimensionless)
CF	=	conversion factor (1×10^{-6} kg/mg)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

Exposed surface areas of body available for dermal contact were determined on a receptor-specific basis because they correspond with assumed human activities and clothing worn during exposure events. Note that the skin surface areas (and other dermal exposure factors) used in the risk assessment represent recent changes in U.S. EPA dermal guidance and may differ from the values specified in the QAPP (Tetra Tech NUS, Inc., 2001b). Current guidance (U.S. EPA, 2001b; U.S. EPA, 1997b) was used to develop the default assumptions concerning the amount of skin surface area available for contact for a receptor. To maintain consistency from project to project, input parameters previously used for other NSWC Crane risk assessments (e.g., B&R Environmental, 1997) were also reviewed when developing the exposed surface areas. The rationales used to select the skin areas are as follows:

- For construction workers exposed to surface and subsurface soil, the surface areas for the RME (5,800 cm^2) and CTE (5,000 cm^2) are the values recommended for soil contact by the U.S. EPA in the Exposure Factors Handbook (U.S. EPA, 1997b). These values represent 25 percent of the total body surface area of an adult male.

- For maintenance workers and occupational workers exposed to soil, the surface area available for soil contact is assumed to be the head, hands, and forearms. The skin surface area is 3,300 cm^2 for the CTE and the RME. These values represent the 50th percentile areas for the head, hands, and forearms (U.S. EPA, 2001b).

- For adolescent trespassers, 25 percent of the total body surface area for an adolescent (aged 6 to 17) was assumed to be available for surface soil contact. The RME value (3,280 cm^2) was derived from the 95th percentile surface area data, and the CTE value (3,100 cm^2) was derived from the 50th percentile data as provided in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997b).

- For adult recreational users assumed to be exposed to surface soil, the exposed surface area available for contact was the sum of the feet, lower, legs, hands, and arms of an adult male. This skin surface area is 7,770 cm^2 for the CTE and 9,190 cm^2 for the RME. These values represent the 50th and 95th percentile areas for the feet, lower legs, hands and forearms, respectively (U.S. EPA, 1997b).

- For adult residents exposed to surface soil, the exposed surface area available for contact was the U.S. EPA recommended value of 5,700 cm^2 for the RME and CTE scenarios (U.S. EPA, 2001b). This value assumes that the adult resident is wearing a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface is limited to the head, hands, forearms, and lower legs. For a child resident, the recommended value of 2,800 cm^2 was used as the exposed skin surface area for the RME and CTE scenarios (U.S. EPA, 2001b). This value assumes that the child resident is wearing a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface area is limited to the head, hands, forearms, lower legs, and feet.

The following values of soil adherence factors provided in RAGS Part E (U.S. EPA, 2001b) were used to evaluate risks from dermal exposure to soil.

- Construction workers - 0.3 mg/cm^2 for the RME and 0.1 mg/cm^2 for the CTE
- Maintenance workers and occupational workers - 0.2 mg/cm^2 for the RME and 0.02 mg/cm^2 for the CTE
- Adolescent trespassers - 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE
- Child recreational users and child residents - 0.2 mg/cm^2 for the RME and 0.04 mg/cm^2 for the CTE
- Adult recreational users and adult residents - 0.07 mg/cm^2 for the RME and 0.01 mg/cm^2 for the CTE

For the constituents identified as COPCs in soil, the following dermal absorption factors were used (U.S. EPA, 2001b):

- PAHs - 0.13
- Cadmium - 0.001
- SVOCs - 0.1

As indicated in RAGS Part E, dermal absorption factors for metals other than arsenic and cadmium and VOCs have not been developed because of insufficient data to support a default value. Therefore, risks from dermal absorption of metals (other than cadmium) and VOCs from soil were not quantified in this risk assessment. The uncertainty associated with the omission of these constituents is discussed in the uncertainty analysis.

7.3.4.3 Incidental Ingestion of Soil

Incidental ingestion of soil by potential receptors coincides with dermal exposure. Exposures associated with incidental ingestion were estimated in the following manner (U.S. EPA, 1989):

$$Intake_{si} = \frac{(C_{si})(IR_s)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

$Intake_{si}$	=	intake of contaminant "i" from soil (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil (mg/kg)
IR_s	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (dimensionless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (year)
CF	=	conversion factor (1×10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

For the RME scenario, the ingestion rate is set at 480 mg/day for construction workers, 200 mg/day for the future child resident, and 100 mg/day for the other potential receptors (U.S. EPA, 1991 and 1993a). For the CTE scenario, the ingestion rate is set at 240 mg/day for construction workers, 100 mg/day for the future child resident, and 50 mg/day for the other potential receptors. The same exposure frequencies

and durations used in the estimation of dermal intakes were used to estimate exposure via incidental ingestion. Default values of 1.0 (RME) and 0.5 (CTE) were used for the fraction of soil ingested from the source.

7.3.4.4 Dermal Contact with Ground Water

Direct contact with ground water at the MGBG is limited to exposure that would occur under residential and construction worker scenarios. Hypothetical future on-base residential receptors were assumed to use ground water for domestic purposes (i.e., bathing, showering, washing dishes), that can result in a dermal exposure. Short-term dermal exposure was assumed to occur for the construction worker.

The following equation was used to assess exposures resulting from dermal contact with water (U.S. EPA, 2001b):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event)
EV	=	event frequency (events/day)
ED	=	exposure duration (year)
EF	=	exposure frequency (days/year)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

Ground water exposure for hypothetical future residential receptors using the ground water as a domestic water supply was assumed to occur on a daily basis. Exposure to ground water for construction workers was assumed to occur each day the receptor visits the study area. Dermal intakes for residents assumed total body exposure. For construction workers, the exposed surface area of the body available for contact was based on assumed work activities and was similar to the assumptions outlined for dermal contact with soil. Table 7-4 summarizes the exposure parameters that were used in this HHRA.

The absorbed dose per event (DA_{event}) was estimated using a nonsteady-state approach for organic compounds and a traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2)(FA)(K_p)(C_{wi})(CF)\left[\sqrt{\frac{6\,\tau\, t_{event}}{\pi}}\right]$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (FA)(K_p)(C_{wi})(CF)\left[\frac{t_{event}}{1+B} + 2\,\tau\left[\frac{1+3B+3B^2}{(1+B)^2}\right]\right]$$

where:

t_{event}	=	duration of event (hour/event)
t^*	=	time it takes to reach steady-state conditions (hour)
K_p	=	permeability coefficient from water through skin (cm/hour)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hour)
π	=	constant (dimensionless; equal to 3.1416)
CF	=	conversion factor (0.001 L/cm^3)
B	=	Dimensionless ratio of the permeability of the stratum corneum relative to the permeability across the viable epidermis
FA	=	Chemical specific fraction absorbed (dimensionless)

Values for the chemical-specific parameters (t^*, K_p, τ, FA, and B) were obtained from RAGS Part E, the current dermal guidance (U.S. EPA, 2001b), and are presented in Table 7-5. If no published values were available for a particular compound, they were calculated using equations provided in the cited guidance.

The following steady-state equation was used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)(C_{wi})(t_{event})$$

In general, the recommended default value of 0.001 was used for the dermal permeability of inorganic constituents. For most metals, dermal absorption is not a significant pathway because penetration through the skin is minimal.

7.3.4.5 Ingestion of Ground Water

Residents may be exposed to ground water via direct ingestion. Intakes associated with ingestion of water were evaluated using the following equations (U.S..EPA, 1989):

$$Intake_{wi} = \frac{(C_{wi})(IR_w)(EF)(ED)}{(BW)(AT)}$$

where: $Intake_{wi}$ = intake of chemical "i" from water (mg/kg/day)

C_{wi} = concentration of chemical "i" in water (mg/L)

IR_w = ingestion rate for ground water (L/day)

EF = exposure frequency (days/year)

ED = exposure duration (year)

BW = body weight (kg)

AT = averaging time (days);
for noncarcinogens, AT = ED x 365 days/year;
for carcinogens, AT = 70 years x 365 days/year

The same exposure frequencies and durations used to assess dermal exposure to water were used to estimate intakes for ingestion of water.

7.3.4.6 Inhalation of Volatiles in Ground Water

Ground water exposure may also result in an inhalation exposure if the water resource is used as a domestic water supply and volatile chemicals are present in ground water. This exposure route was evaluated for residential receptors only who may be exposed while showering, bathing, washing dishes, etc. Inhalation exposures were estimated using a mass transfer model, developed specifically for this exposure route, in combination with an air intake estimation model. The mass transfer model accounts for inhalation that occurs during a shower and after a shower while the receptor remains in the closed bathroom. The method employed was as follows (U.S. EPA, 1989; Foster and Chrostowski, 1987):

$$Intake_{si} = (S)(IR_{sh})(K)(EF)(ED) \ / \ (BW)(AT)(R_a)(CF)$$

$$K = D_s + \frac{\exp(-R_a \ x \ D_t)}{R_a} - \frac{\exp[R_a \ x \ (D_s - D_t)]}{R_a}$$

where: $Intake_{wi}$ = intake of chemical "i" from water via inhalation (mg/kg/day)

S = volatile chemical generation rate (µg/m^3-min-shower)

IR_{sh} = inhalation rate (L/min)

K = mass transfer coefficient (min)

EF = exposure frequency (showers/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time or period of exposure (days)

R_a = air exchange rate (min^{-1})

CF = conversion factor ($1 \times 10^{+6}$ µg-L/mg-m^3)

D_s = shower duration (min)

D_t = total time in bathroom (min)

The volatile chemical generation rates were estimated using the Foster and Chrostowski mass transfer model, which is based on two-phase film theory. The model employs contaminant-specific mass transfer coefficients, Henry's Law constants, droplet diameter, drop time, viscosity, temperature, etc. For SVOCs, pesticides, energetics, and metals, volatilization is not a significant pathway because these substances do not vaporize readily at room temperature.

Exposure of Workers to Volatiles in a Construction/Utility Trench

There are no well-established models available for estimating migration of volatiles from ground water into a construction/utility trench. This risk assessment used an approach suggested by the Virginia Department of Environmental Quality (VDEQ, 2002) that is based on a combination of a vadose zone model to estimate volatilization of gases from contaminated ground water into a trench and a box model to estimate dispersion of the contaminants from the air inside the trench into the above-ground atmosphere to estimate the EPC for air in a construction trench. The VDEQ methodology is described in the following sections. A copy of the Foster and Chrostowski model is provided in Appendix G-5.

Airborne concentrations of a contaminant in a trench were estimated using the following equation:

$$C_{trench} = C_{GW} \times VF$$

where: C_{trench} = air concentration of contaminant in the trench ($\mu g/m^3$)
C_{GW} = concentration of contaminant in ground water ($\mu g/L$)
VF = volatilization factor (L/m^3)

The model used in this risk assessment assumed that a construction project could result in an excavation 15 feet bgs or less. If the depth to ground water at a site was less than 15 feet, the VDEQ model assumed that a worker would encounter ground water when digging an excavation or a trench. The worker would then have direct exposure to the ground water. The worker would also be exposed to contaminants in the air inside the trench that would result from volatilization from the ground water pooling at the bottom of the trench.

The following equation was used to calculate VF for a trench less than 15 feet deep.

$$VF = (Ki \times A \times F \times 10^{-3} \times 10^{4} \times 3{,}600) / (ACH \times V)$$

where: K_i = overall mass transfer coefficient of contaminant (cm/s)
A = area of the trench (m^2)
F = fraction of floor through which contaminant can enter (unitless)
ACH = air changes per hour (h^{-1} = 360 h^{-1})
V = volume of trench (m^3)
10^{-3} = conversion factor (L/cm^3)
10^4 = conversion factor (cm^2/m^2)
3,600 = conversion factor (seconds/hour)

Studies of urban canyons suggest that if the ratio of trench width relative to wind direction to trench depth is less than or equal to 1, a circulation cell or cells will be set up within the trench that limits the degree of gas exchange with the atmosphere and the ACHs are assumed to be of 2 based upon measured ventilation rates of buildings. If the ratio of trench width to trench depth is greater than one, air exchange between the trench and above-ground atmosphere is not restricted, thus ACHs are assumed to be 360 based on the ratio of trench depth to the average wind speed. This risk assessment assumed that the width to trench depth ratio was greater than 1. Therefore, ACH were assumed to be 360.

$$K_i = 1 / \{(1/k_iL) + [(RT) / (H_i\, k_iG)]\}$$

where: k_iL = liquid-phase mass transfer coefficient of i (cm/s)

R = ideal gas constant (atm-m^3/mole-°K = 8.2×10^{-5})

T = average system absolute temperature °K (Default = 298°K)

H_i = Henry's Law constant of i (atm-m^3/mol)

K_iG = gas-phase mass transfer coefficient of i (cm/s)

$$kiL = (MWO_2/MWi)^{0.5} \times (T/298) \times kL,O_2$$

where: k_iL = liquid-phase mass transfer coefficient of component i (cm/s)

MWO_2 = molecular weight of O_2 (g/mol)

MW_i = molecular weight of component i (g/mol)

kL, O_2 = liquid-phase mass transfer coefficient of oxygen at 25°C (cm/s)

The value of kL, O_2 is 0.002 cm/s.

$$k_iG = (MWH_2O/MW_i)^{0.335} \times (T/298)^{1.005} \times kG, H_2O$$

where: kiG = gas-phase mass transfer coefficient of component i (cm/s)

MWH_2O = molecular weight of water (g/mol)

kG,H_2O = gas-phase mass transfer coefficient of water vapor at 25°C (cm/s)

The value of kG, H_2O is 0.833 (cm/s) (U. S. EPA, April 1988)

Exposures associated with the inhalation route for construction workers were estimated in the following manner (U.S. EPA, 1989):

$$Intake_{ai} = \frac{(C_{ai})(IR_a)(ET)(EF)(ED)}{(BW)(AT)}$$

where: $Intake_{ai}$ = intake of chemical "i" from air via inhalation (mg/kg/day)

C_{ai} = concentration of chemical "i" in air (mg/m^3)

IR_a = inhalation rate (m^3/hr) = 2.5 m^3/hr (U.S. EPA, August 1997b)

ET = exposure time (hours/day)

EF = exposure frequency (days/year)

ED = exposure duration (year)

BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT = ED x 365 days/year;
		for carcinogens, AT = 70 years x 365 days/year

Input assumptions for the volatilization from ground water to outdoor air model are presented in Appendix G. Site-specific values were used whenever possible. Model default values were used when they were believed to be representative of site conditions. Chemical properties were obtained from the Soil Screening Guidance: User's Guide (U.S. EPA, 1996) and are presented in model calculations in Appendix G.

7.3.4.7 Summary of Exposure Parameters

A summary of the exposure input parameters for all exposure pathways is presented in Table 7-4 for the identified potential receptor groups at the MGBG. In general, standard default parameters (e.g., U.S. EPA, 1991; U.S. EPA, 1997b; U.S. EPA, 2001b), which combine mid-range and upper-end exposure factors, were used to assess RME conditions. CTE scenarios were assessed primarily by the use of mid-range exposure factors presented in current risk assessment guidance (e.g., U.S. EPA, 1989; U.S. EPA, 1993a).

7.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment was to identify the potential health hazards and adverse effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects were defined for the identified COPCs. Quantitative toxicity values determined during this component of the risk assessment were integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The toxicity value used to evaluate noncarcinogenic health effects was the reference dose (RfD). Carcinogenic effects were quantified using the cancer slope factor (CSF).

7.4.1 Toxicity Criteria

Oral and inhalation RfDs and CSFs used in the HHRA for the MGBG were obtained from the following primary literature sources:

- Integrated Risk Information System (IRIS) (U.S. EPA, online September 2002)
- Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1997b)
- National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center

Although RfDs and CSFs can be found in several toxicological sources, U.S. EPA's IRIS on-line database was the preferred source of toxicity values. This database is continuously updated and values presented have been verified by U.S. EPA RfD and Carcinogenic Risk Assessment Verification Endeavor (CRAVE) work groups. The U.S. EPA Region 9 PRG tables and Region 3 (RBC) tables were also used as a source of toxicity criteria. The RfDs and CSFs for the constituents selected as COPCs for MGBG are presented in Tables 7-5 through 7-8.

7.4.1.1 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature may be expressed as administered doses; therefore, these values are considered to be inappropriate for estimating the risks associated with dermal routes of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made.

The adjustment to an absorbed dose was made using chemical-specific gastrointestinal absorption efficiencies published in RAGS Part E (U.S. EPA, 2001b) and the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) / (ABS_{GI})$$

where: ABS_{GI} = absorption efficiency in the gastrointestinal tract

7.4.1.2 Toxicity Criteria for Carcinogenic Effects of PAHs

Limited toxicity values are available to evaluate the carcinogenic effects from exposure to PAHs. The most extensively studied PAH is benzo(a)pyrene, which is classified by the U.S. EPA as a probable human carcinogen. Although CSFs are available for benzo(a)pyrene, insufficient data are available to calculate CSFs for other carcinogenic PAHs. Toxic effects for these chemicals were evaluated using the concept of estimated orders of potential potency, as presented in current U.S. EPA guidance (U.S. EPA, 1993b). These parameters are based on the carcinogenicity of benzo(a)pyrene and are available for select carcinogenic PAHs. The equivalent oral CSF for these chemicals were derived by multiplying the

CSF for benzo(a)pyrene by the order of potential potency. The orders of potential potency used in this HHRA are as follows:

Compound	TEF
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

7.4.1.3 Toxicity Criteria for Chromium

Toxicity criteria are available for different forms of chromium, which is considered to be more toxic in the hexavalent state. Because there is no evidence to suggest that hexavalent chromium is present at the MGBG as a contaminant, speciation analyses were not performed for the MGBG. However, risks associated with this chemical were assessed by conservatively assuming that 100 percent of the reported total chromium result was attributable to hexavalent chromium.

7.4.2 Toxicity Profiles

Toxicological profiles for each COPC are presented in Appendix G. These brief profiles present a summary of the current available literature on the carcinogenic and noncarcinogenic health effects associated with human exposure to COPCs.

7.5 RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the potential exposures to COPCs at the MGBG. Section 7.5.1 outlines the methods used to quantitatively estimate the type and magnitude of potential risks for human receptors. A summary of the risk characterization for the MGBG is provided in Section 7.5.2.

7.5.1 Quantitative Analysis

Quantitative estimates of risk were calculated according to risk assessment methods outlined in U.S. EPA guidance (U.S. EPA, 1989). Lifetime cancer risks are expressed in the form of dimensionless

probabilities, referred to as ILCRs, based on CSFs. Noncarcinogenic risk estimates are presented in the form of HQs that are determined through a comparison of intakes with published RfDs.

ILCR estimates were generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$ILCR = (\text{Estimated Exposure Intake})(CSF)$$

If the above equation resulted in an ILCR greater than 0.01, the following equation was used:

$$ILCR = 1-[\exp(-\text{Estimated Exposure Intake})(CSF)]$$

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, noncarcinogenic risks were assessed using the concept of HQs and HIs. The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows:

$$HQ = (\text{Estimated Exposure Intake})/(RfD)$$

An HI was generated by summing the individual HQs for all COPCs. The HI is not a mathematical prediction of the severity of toxic effects and therefore is not a true risk; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects.

7.5.1.1 Comparison of Quantitative Risk Estimates to Benchmarks

To interpret the quantitative risks and to aid risk managers in determining the need for remediation at a site, quantitative risk estimates were compared to typical benchmarks. Calculated ILCRs were interpreted using the U.S. EPA's target range (10^{-4} to 10^{-6}), and HIs were evaluated using a value of 1.0.

U.S. EPA has defined the range of 10^{-4} to 10^{-6} as the ILCR target range for hazardous waste facilities addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and RCRA. Individual or cumulative ILCRs greater than 1×10^{-4} are generally considered to be "unacceptable" by the U.S. EPA. Risk management decisions are necessary when the ILCR is within 1×10^{-4} to 1×10^{-6}.

An HI exceeding unity (1.0) indicates that there may be noncarcinogenic health risks associated with exposure. If an HI exceeds unity, target organ effects associated with exposure to COPCs are considered. Only those HQs for chemicals that affect the same target organ(s) or exhibit similar critical effect(s) are regarded as truly additive. Consequently, it may be possible for a cumulative HI to exceed 1.0, but no adverse health effects are anticipated if the COPCs do not affect the same target organ or exhibit the same critical effect. The target organ analysis for each receptor is presented in the RAGS Part D tables (Tables 9.1 through 9.7) presented in Appendix G.

7.5.2 Results of the Risk Characterization

This section contains a summary of the results of the risk characterization for the MGBG. Quantitative risk estimates for potential human receptors were developed for those chemicals identified as COPCs. Uncertainties associated with the risk estimates are discussed in Section 7.6. The methodology used to calculate the risks presented in this section is provided in Sections 7.3 and 7.4. Potential cancer risks and HIs were calculated for current adolescent trespassers and future construction workers, maintenance workers, occupational workers, child recreational users, adult recreational users, and future on-site residents under the RME and CTE scenarios and are summarized in Tables 7-9 and 7-10, respectively. Sample calculations are presented in Appendix G, and the results of the risk assessment in RAGS Part D format are included in Appendix G.

7.5.2.1 Noncarcinogenic Risks – RME

Cumulative HIs for the occupational worker, maintenance worker, adult recreational user, and adolescent trespasser under the RME scenario were less than unity (1.0), indicating that no toxic effects are anticipated for these receptors under the defined exposure conditions. Cumulative HIs for the construction worker, future adult, and child resident exceeded unity.

The cumulative HI for the future construction worker was 78. The major contributors to this HI were TCE (HI = 68) by dermal contact with ground water and chloroform (HI = 9.6) by inhalation of vapors in a trench.

Cumulative HIs for future adult and child residents were 1,700 and 6,100, respectively. 1,1,2,2-PCA, 1,1-dichloroethene, chloroform, cis-1,2-dichloroethene, PCE, TCE, and manganese in ground water were the major contributors to the total HIs for these receptors. HIs for exposure to soil were less than unity for all receptors, on a target organ basis.

The HIs calculated for exposure to ground water at MGBG are subject to the following sources of uncertainty:

- The HIs for ground water were based on exposure to concentrations of COPCs in the most highly contaminated well (01GW0201). The greater of the Round 1 and Round 2 concentrations from this well were selected as the EPCs. Therefore, potential receptors were assumed to be exposed to the maximum detected concentrations of 1,1,2,2-PCA, PCE, TCE, and chloroform. As discussed previously, there were considerable differences in the concentrations reported from Rounds 1 and 2 for this well. For example, the Round 1 concentration of 1,1,2,2-PCA (collected in September 2001) was 38,000 µg/L and the concentration detected in Round 2 (June 2002) was 30 µg/L. Likewise, the Round 1 concentration of TCE was 16,000 µg/L and the concentration detected in Round 2 was 20 µg/L. There were also considerable differences in the COPC concentrations from well to well. The ground water VOC plume is most concentrated near well 01-02 and concentrations decrease in an outward direction from this well. Therefore, the location of a drinking water well would play a significant role in the level of risk incurred.

- A number of constituents selected as COPCs for ground water were not detected in well 01GW0201, in part because of the elevated detection limits reported for VOC analysis of the Round 1 sample. These COPCs include: 1,1,1,2-PCA, 1,1-DCE, 1,2-DCA, cis-1,2-DCE, BEHP, 4-amino-2,6-dinitrotoluene, heptachlor, aluminum, antimony, and arsenic. For these COPCs, ½ the sample MDLs were used as the EPCs. Using ½ the MDLs as EPCs for these constituents can either overestimate or underestimate potential risks. Because MDLs were elevated for VOCs, risks based on ½ the MDLs of VOCs are likely to be overestimated. For example, ½ the MDL for cis-1,2-DCE in Round 1 is 500 µg/L but the highest concentration of cis-1,2-DCE detected in ground water at MGBG was 9 µg/L. Therefore, the HIs calculated for cis-1,2-DCE may be overestimated by one to two orders of magnitude. On the other hand, ½ the MDL for aluminum was 20.1 µg/L but the maximum concentration in ground water at the site was 5,700 µg/L. Therefore, the HIs estimated for aluminum may be underestimated by more than two orders of magnitude.

- Risks for inorganic COPCs in ground water were also based on concentrations detected in well 01GW0201. However, the concentrations of inorganics in this well were considerably less than maximum concentrations detected in other wells at the site, as indicated below:

  - the concentration of iron detected in well 01GW0201 was 22.1 µg/L but the maximum concentration of iron detected at MGBG was 44,600 µg/L

- the concentration of manganese detected in well 01GW0201 was 434 µg/L, the maximum detected concentration was 9,600 µg/L

- the concentration of nickel detected in well 01GW0201 was 41.4 µg/L, the maximum detected concentration was 273 µg/L

- the concentration of strontium detected in well 01GW0201 was 257 µg/L, the maximum detected concentration was 3,990 µg/L

Therefore, the HIs quantitated for these COPCs may be underestimated. If the maximum concentrations for iron, manganese, nickel, and strontium were use to quantitate risks, HIs for iron and nickel would also exceed unity for the future child resident (Iron HI = 14, nickel HI = 1.3). Based on this discussion and the discussion in the previous bullet, there is considerable uncertainty in the ground water EPCs used in the quantitative risk assessment.

- No chemicals were eliminated as COPCs for ground water on the basis of background because background concentrations or upgradient well data are currently not available for the site. Therefore, risks from exposure to metals in ground water (e.g., manganese) may be overestimated. A comparison of well 01T02 data to other site ground water data corroborates this. Well 01T02 which is approximately 800 feet to the southwest of the MGBG had the greatest metal concentrations for 10 metals, even though ground water flow is predominantly to the northwest.

- Inhalation risks for construction workers were based on the VDEQ model described in Section 7.2.4.6. A number of the inputs to this model, such as trench size and air exchange rates, are based on professional judgement and may overestimate or underestimate the calculated risks.

7.5.2.2 Carcinogenic Risks – RME

Cumulative ILCRs for the occupational worker, maintenance worker, adult recreational user, and adolescent trespasser are less than the U.S. EPA target risk range, $1x10^{-6}$ to $1x10^{-4}$. The ILCR for the construction worker (ILCR = $3.8x10^{-4}$) and total residential ILCR (adult + child = $3.2x10^{-1}$) exceed the target risk range.

The elevated carcinogenic risks for construction workers and future residents are primarily a result of exposure to 1,1,1,2-PCA, 1,1,2,2-PCA, 1,2-DCA, PCE, TCE, chloroform, and arsenic in ground water.

1,1,2,2-PCA and TCE (total residential ground water ILCR = 3.2×10^{-1}) accounted for more than 99 percent of the total carcinogenic risk for hypothetical residents. These estimates assume that the drinking water well is situated near well 01-02. Siting a well elsewhere, especially in areas of relatively low VOC concentrations or outside the VOC plume, would result in less risk which would be proportional to the VOC concentrations in the respective wells.

The uncertainties associated with the carcinogenic risks are similar to the uncertainties discussed for noncarcinogens in Section 7.5.2.1. An additional uncertainty for carcinogenic risks is the fact that the USEPA has recently withdrawn the CSFs for 1,1-DCE, pending further study. Therefore, risks for 1,1-DCE were not calculated in the quantitative risk assessment and the carcinogenic risks for ground water may have been underestimated. However, given the magnitude of the risks calculated for ground water, the omission of 1,1-DCE is likely to have a minimal effect on the results and conclusions of the risk assessment. In addition, even though risks for future residents from exposure to arsenic in ground water were greater than 1.0×10^{-6}, the maximum detected concentration of arsenic (7.9 µg/L) is less than the proposed MCL (10 µg/L) and background was not used in the selection of COPCs for ground water.

7.5.2.3 Noncarcinogenic Risks – CTE

Cumulative HIs for the occupational worker, maintenance worker, adult recreational user, and adolescent trespasser under the RME scenario are less than unity (1.0), indicating that no toxic effects are anticipated for these receptors under the defined exposure conditions. Cumulative HIs for the construction worker, future adult, and child resident exceeded unity.

The cumulative HI for the future construction worker is 58. The major contributors to this HI are TCE (HI = 49) by dermal contact with ground water and chloroform (HI = 7.2) by inhalation of vapors in a trench.

Cumulative HIs for the future adult and child residents are 1,200 and 2,800, respectively. 1,1,2,2-PCA, PCE, TCE, chloroform, and cis-1,2-DCE in ground water were the major contributors to the total CTE HIs for these receptors. CTE HIs for exposure to soil were less than unity for all receptors.

7.5.2.4 Carcinogenic Risks - CTE

Cumulative ILCRs for the occupational worker, maintenance worker, adult recreational user, and adolescent trespasser were less the U.S. EPA target risk range of 1×10^{-6} to 1×10^{-4}. The ILCR for the

construction worker (ILCR = 2.8×10^{-4}) and total residential ILCR (adult + child = 8.1×10^{-2}) exceeded the target risk range.

The elevated carcinogenic risks for construction workers and future residents were primarily a result of exposure to 1,1,2,2-PCA, 1,2-DCA, PCE, TCE, chloroform, in ground water. 1,1,2,2-PCA and TCE (total residential ground water ILCR = 8.0×10^{-2}) accounted for more than 99 percent of the total residential carcinogenic risk.

7.5.2.5 Qualitative Evaluation of Chemicals Eliminated as COPCs on the Basis of Background Comparisons

Aluminum, arsenic, chromium, iron, manganese, and thallium were detected in soils and/or sediments at concentrations exceeding the conservative screening levels established for COPC selection but were not selected as COPCs because study area concentrations did not exceed background concentrations. The following table provides a qualitative evaluation of the metals by comparing maximum detected concentrations to the U.S. EPA Region 9 PRGs for residential and industrial exposures.

Parameter	Maximum Surface Concentration (mg/kg)	Maximum Subsurface Concentration (mg/kg)	Maximum Sediment Concentration (mg/kg)	Region 9 Residential PRG (mg/kg)	Region 9 Industrial PRG (mg/kg)	Literature Background (mg/kg)
Aluminum	NA	NA	13,700	76,000	100,000	10,000 – 300,000(1)
Arsenic	10.9	20.2	31.1	0.39	1.6	0.1 – 97(2)
Chromium	NA	NA	45.1	210(3)	450(3)	1 – 2,000(2)
Iron	NA	NA	76,900	24,000	100,000	700 – 550,000(1)
Manganese	114	NA	1,640	1,800	20,000	100 – 4,000(1)
Thallium	0.69	0.75	7.1	5.2	68	0.1 -- 12

1 – Dragun, 1988. The Soil Chemistry of Hazardous Materials. Hazardous Material Control Research Institute, Silver Spring, Maryland.
2 – U.S. EPA Region 9 Preliminary Remedial Goal Table, October, 2002.
3 – The PRG presented for chromium assumes a 1:6 ratio of hexavalent chromium to trivalent chromium. The PRG for hexavalent chromium was used in the selection of COPCs.
NA - Not Applicable

The PRGs presented for aluminum, iron, manganese, and thallium are based on the potential for non-carcinogenic health effects (the values are 10 times the COPC screening levels used in this HHRA). The maximum detected concentrations of aluminum and manganese are less than their respective residential

and industrial PRGs. The maximum detected concentration of aluminum is one-fifth of the residential PRG and one-seventh of the industrial PRG. The maximum detected concentration of manganese is 90 percent of the residential PRG and one-twelve of the industrial PRG. The maximum detected concentrations of iron and thallium exceed their residential PRGs but are less than their industrial PRGs. The maximum detected concentration of iron is approximately 3 times its residential PRG and 75 percent of its industrial PRG. The PRG for iron is actually based on a recommended daily intake for iron. Consequently, an exceedance of the PRG for iron is not a definitive indication of the potential for adverse non-cancer health effects. The maximum detected concentration of thallium slightly exceeds its residential PRG and is one-ninth of the industrial PRG. The PRGs presented for arsenic and chromium are based on the potential for cancer effects and represent the 1×10^{-6} (one-in-one-million) cancer risk level (these values are the COPC screening levels used in this HHRA). PRGs representing the 1×10^{-5} and 1×10^{-4} cancer risk levels would be 10 and 100 times the values, respectively, presented for the 1×10^{-6} cancer risk level. Consequently, the maximum detected concentrations of chromium and arsenic do not exceed the 1×10^{-6} and 1×10^{-4} cancer risk levels, respectively. Additionally, the concentrations of metals in soil and sediment are within the background ranges reported in literature.

Cesium-137, lead-210, potassium-40, radium-226, and thorium-228 were detected in soils and/or sediments at concentrations exceeding the conservative screening levels established for COPC selection but were not selected as COPCs because study area concentrations did not exceed background concentrations. The following table provides a qualitative evaluation of the radionuclides by comparing maximum detected concentrations to the U.S. EPA SSLs for radionuclides in soil:

Parameter	Maximum Surface Concentration (pCi/g)	Maximum Subsurface Concentration (pCi/g)	Maximum Sediment Concentration (pCi/g)	SSL (pCi/g)	Literature Background (pCi/g)(1)	
					Surface Soil	Subsurface Soil
Cesium-137	0.09	NA	NA	0.061	0.49	0.28
Lead-210	0.52	0.65	NA	0.063	NA	NA
Potassium-40	9.94	9.23	NA	0.14	16	16
Radium-226	1.68	1.9	NA	0.013	1.5	1.5
Thorium-228	0.73	0.781	1.49	0.16	1.6	1.6

1 – Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Risk Assessment Information System Internet site. http://risk.lsd.ornl.gov/rap_hp.shtml.

NA - Not Applicable

The PRGs presented for radionuclides are based on the potential for cancer effects and represent the 1 x 10^{-6} (one-in-one-million) cancer risk level (the values are the COPC screening levels used in this HHRA). PRGs representing the 1 x 10^{-5} and 1 x 10^{-4} cancer risk levels would be 10 and 100 times the values, respectively presented, for the 1 x 10^{-6} cancer risk level. The maximum detected concentrations of cesium-137 and thorium-228 do not exceed the 1 x 10^{-5} cancer risk level, and the maximum detected concentrations of lead-210 and potassium-40 do not exceed the 1 x 10^{-4} cancer risk level. The maximum detected concentrations of radium-226 slightly exceed the 1 x 10^{-4} cancer risk level. Additionally, with the exception of radium-226, the concentrations of radionuclides in soil and sediment are within the background ranges reported in literature. The maximum MGBG radium-226 concentration exceeds the literature background concentration by less than 7 percent; the literature background would also exceed the cancer risk level of 1 x 10^{-4}.

Thallium was originally detected in ground water at concentrations exceeding the screening levels established for COPC selection. Those results are provided here:

Parameter	Ground Water Concentration (µg/L)	Region 9 PRG (µg/L)	Federal MCL (µg/L)
Thallium (Total)	5.1	2.4	2
Thallium (Dissolved)	7.7	2.4	2

However, those analyses were suspect because the thallium results were unusually uniform and the analytical technique used for analysis is known to suffer occasionally from interferences. Therefore, the thallium was re-analyzed in select samples representing the ranges of concentrations and matrices of the original thallium analyses (see Section 3.4.5). The re-analyses indicated that the original thallium results were false positives and that thallium was not detectable in ground water. Thus, thallium was not selected as a COPC.

7.6 UNCERTAINTY ANALYSIS

This section presents a brief summary of uncertainties inherent in the risk assessment and includes a discussion of how they may affect the quantitative risk estimates and conclusions of the risk analysis. The baseline HHRA for the MGBG was performed in accordance with current U.S. EPA guidance. However, there are varying degrees of uncertainty associated with the baseline HHRA. The following sections discuss general uncertainties in risk assessment and uncertainties specific to the risk assessment for the MGBG.

Uncertainty in the selection of COPCs was related to the current status of the predictive databases, the grouping of samples, the numbers, types and distributions of samples, data quality, and the procedures used to include or exclude constituents as COPCs. Uncertainty associated with the exposure assessment included the values used as input variables for a given intake route or scenario, the assumptions made to determine EPCs, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment included the quality of the existing toxicity data needed to support dose-response relationships and the weight-of-evidence used to determine the carcinogenicity of COPCs. Uncertainty in risk characterization was associated with exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier steps of the risk assessment process.

Whereas there were various sources of random uncertainty and bias, the magnitude of bias and uncertainty and the direction of bias was influenced by the assumptions made throughout the risk assessment including selection of COPCs and selection of values for dose-response relationships. Throughout the entire risk assessment, assumptions, that considered safety factors were made so that the final calculated risks were overestimated.

Generally, risk assessments carry two types of uncertainty: measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflected the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

Once the risk assessment was complete, the results were reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates were made to ensure that the particular assumptions were protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward overpredicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk

assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point of departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are less than an acceptable risk level (i.e., 10^{-6}), the interpretation of no significant risk is typically straightforward. However, when risks calculated using a high degree of uncertainty exceed an acceptable risk level (i.e., 10^{-4}), a conclusion can be difficult unless uncertainty is considered.

7.6.1 Uncertainty in Selection of COPCs

The most significant issues related to uncertainty in COPC selection were the usability of existing databases (i.e., the use of validated and unvalidated sample results (only validated data were used in this risk assessment) and the completeness, precision, and accuracy of the data set), the inclusion of chemicals potentially attributable to background, the screening levels used, and the absence of screening levels for a few chemicals detected in the site media. A brief discussion of each of these issues is provided in the remainder of this section.

Usability of Existing Databases

All data used in the risk assessment for the MGBG were obtained from samples collected in August 2001 and June 2002 (and reported in Appendix E of this report). All the data were validated as described in Section 3.0. An overall review of data quality is also provided in that section. The qualification of data during the formal data validation process did not compromise the results of the baseline HHRA. Analytical data qualified as estimated were utilized, even though the reported positive concentrations or sample-specific quantitation limits may have been somewhat biased or imprecise. The use of estimated data added to the uncertainty associated with the risk assessment; however, the associated uncertainty was expected to be negligible compared to the other uncertainties inherent in the risk evaluation process (i.e., uncertainties with land uses, exposure scenarios, toxicological criteria, etc.). Analytical data qualified for blank contamination were used in the baseline risk assessment. When determining exposure concentrations via statistical procedures, chemicals not detected were conservatively assumed to be present at a concentration equal to one-half the sample-specific quantitation limit. This includes those chemicals for which the detection limits were elevated relative to the target limits. Analytical results for some chemicals were qualified "R," unreliable, and were not used in the risk assessment. The sporadic rejection of a few chemicals (e.g., acetone, 2-butanone, HMX, RDX, gamma-chlordane, and several PAHs) in a few samples was not considered to be problematic because there were enough usable

analytical data for these parameters to identify whether these chemicals were actually present at the site and to estimate the necessary data distribution parameters. In addition, based on historical knowledge of the site, most of the chemicals with rejected results (e.g., acrolein, 1,4-dioxane, isobutanol, propionitrile, 4-nitroquinoline-1-oxide, methacrylonitrile, methapyrilene, pronamide) were not expected to be present and were not expected to have been related to site activities. Because only results of the most recent sampling events were used and because all data were validated, the uncertainty in the calculated risks associated with the data was minimal. This was especially true because the COPCs used in the quantitative risk calculations were minimally affected by data quality problems.

As discussed in Section 3.3.4, spiked sample recoveries for the following analytes exhibited moderate to very low recoveries in soil, sediment, and/or ground water samples resulting in concentrations or detection limits having a low bias (a low bias denotes that the reported concentration or detection limit is less than the true value): dinoseb, acenaphthene, acenaphthylene, naphthalene, dibenzo(a,h)anthracene, 2,6-dichlorophenol, aniline, 4-chloroaniline, pyridine, hexcholocyclopentadiene, diphenylamine, endosulfan I, endosulfan II, acetone, 1,4-dioxane, methyl methacrylate, and antimony. Of these, only acetone, acenaphthene, naphthalene, dibenzo(a,h)anthracene, and antimony were positively detected in any samples. Naphthalene exhibited the lowest recovery with a MS recovery of two percent in one sample. However, the maximum concentration of naphthalene in soil was approximately 500 times less than the risk-based screening level and 5,000 times less than the Region 9 PRG. Therefore, the elimination of naphthalene as a COPC and risk assessment results are not likely to be affected by the low bias. A similar case can be made for the other positively detected constituents listed above. None of the other above listed constituents (dinoseb, acenaphthylene, 2,6-dichlorophenol, aniline, 4-chloroaniline, pyridine, hexcholocyclopentadiene, diphenylamine, endosulfan I, endosulfan II, 1,4-dioxane, and methyl methacrylate) were positively detected in any media at the site. It is possible that the low biases may have resulted in these analytes not being detected. However, this is unlikely because the recoveries for these chemicals were generally only slightly low (e.g., 40 to 70 percent) and they were not detected in other samples which were not affected by the low recoveries. In addition, based on historical information, these compounds are not site-related contaminants and would not be expected to be found at the site. Consequently, the results and conclusions of the risk assessment are not likely to be affected by the low spiked sample recoveries.

Tables 3-5, 3-6, 3-7, and 3-8 present a comparison minimum and maximum detection limits with risk-based target levels (RBTLs) for soil, sediment, ground water and surface water, respectively. The target levels presented in these tables represent the lowest of all screening criteria used in this report (i.e., the lowest of human health risk-based criteria, SSLs ,and ecological criteria). Two types of detection limits are presented in the tables, the minimum and maximum observed non-detected values reported by the

laboratory for MGBG analytical data and detection limits computed by the laboratory (labeled as Nominal MDLs). The minimum and maximum non-detect values generally represent ½ the typical laboratory reporting limits which are greater than the nominal MDLs. The following discussion focuses only on the human health aspects of these comparisons.

- A comparison of soil detection limits with the human health component of the RBTLs for residential exposure to soil presented in Table 3-5 (i.e., Region 9 PRGs for residential land use and U.S. EPA SSLs) indicates that the observed non-detect values exceeded the human health RBTLs for a number of constituents. However, approximately 80 percent of these were due to exceedances of SSLs and the non-detect values of only eight compounds (3,3'-dimethylbenzidine, kepone, five n-nitrosoamines, and 1,2,3-trichloropropene) exceeded the risk-based PRGs. The exceedance of SSLs indicates the potential for a chemical to impact ground water quality but does not indicate a potential for human health risks. The reported concentrations of all but these eight chemicals were less than the screening levels for direct contact with soil and U.S. EPA generic SSLs for inhalation. In addition, the eight chemicals which exceeded the risk-based criteria were not detected in any other samples in any media at the site and appear not to be site-related contaminants. Therefore, the uncertainty associated with these exceedances and their effect on the total risks calculated for exposure to soil are likely to be minimal. Because the reported non-detect values are reported when the measured concentration does not exceed the nominal MDL, there is a high degree of confidence that the actual concentration, if any of these chemicals is actually present, would be one-fifth or less of the reported non-detected value.

- The comparison of sediment detection limits with the human health component of the RBTLs presented in Table 3-6 (i.e., Region 9 PRGs for residential land use) indicates that the observed non-detect values exceeded the human health RBTLs for 3,3'-dimethylbenzidine, bis(2-chloroethyl)ether, hexachlorophene, kepone, five n-nitrosoamines, 1,2,3-trichloropropane, and trans-1,4-dichloro-2-butene. However, the nominal MDLs (the values that could actually be detected by the laboratory) for all the above listed compounds, except the n-nitrosoamines, were less than or similar to the risk-based PRGs. In addition, none of the chemicals that exceeded the risk-based criteria were detected in any other samples in any media at the site and appear not to be site-related contaminants. Consequently, the uncertainty from the exceedances of risk-based criteria by these few observed non-detect values is likely to be minimal.

- The comparison of ground water detection limits with the human health risk-based component of the RBTLs presented in Table 3-7 (i.e., Region 9 PRGs for tap water) indicates that the observed non-detect values exceeded the risk-based RBTLs for RDX, arsenic, thallium, a number of

pesticides/PCBs and SVOCs, and most VOCs. The laboratory only reported a non-detected value when the measured analyte concentration was less than the nominal MDL. As shown in the table, the nominal MDLs (the values that could actually be detected by the laboratory) for many of these analytes were less than or similar to the risk-based PRGs. As indicated in Section 7.5.2, ½ the maximum non-detect values for a number of SVOCs and VOCs were used to estimate risks for ground water. The use of these elevated detection limits for quantifying risks, results in an overestimation of the calculated risks, as shown in Section 7.5.2.1. Even though the nominal MDL and minimum and maximum non-detect values for arsenic were greater than the RBTLs, the MDL and non-detect values were less than the proposed MCL for arsenic. Arsenic was also eliminated as a COPC in soil which would be the expected source for any arsenic ground water contamination. To summarize, minimum and maximum observed non-detect values exceeded the risk-based RBTLs for some chemicals but the nominal MDLs for many of these were less than criteria. ½ The maximum non-detect values were used in risk assessment calculations and risks for exposure to ground water are likely overestimated by using the elevated values as EPCs.

- As stated previously, no VOCs were detected in surface water samples. The comparison of surface water detection limits with the human health component of the RBTLs presented in Table 3-8 (i.e., Region 9 PRGs for tap water) indicates that the observed non-detect values exceeded the human health RBTLs for 19 of the VOCs listed in the Table. Only six of these (1,1,1,2-PCA, 1,1,2,2-PCA, 1,1,2-TCA, 1,1-DCE, 1,2-DCA, and chloroform) have been detected in ground water samples collected at the site and the non-detect values for most of these only slightly exceed the RBTLs. The use of the Region 9 tap water PRGs for surface water is very conservative because exposure to surface water is expected to be considerably less than exposure to domestic tap water (e.g., the intakes calculated for residential exposure to surface water are typically 1 to 2 orders of magnitude less than that for ground water). Consequently, even though there were some non-detect exceedances of PRGs which might have resulted in some compounds not being selected as COPCs, the effect of the total site risks is expected to be negligible.

As discussed in Section 2.0, not all of the surface and subsurface soil samples were analyzed for the same parameters. As discussed in Section 4.4.1 of the QAPP, herbicides, pesticides, and PCBs were not expected to be present at the site. Therefore, only the upper two soil intervals were tested for these analytes. The subsurface soil concentrations of pesticides and herbicides were generally of equal magnitude or less than surface concentrations in the same boring (Section 5.2). Because subsurface soil pesticide and herbicide concentrations were less than surface soil concentrations, these chemicals were considered to be vertically bounded. PCBs were not detected in any soil samples collected at MGBG. Consequently, the uncertainty associated with the fact that not all samples were analyzed for these

parameters was expected to be minimal. In addition, the soil overburden was adequately represented by the sampling and analysis that were conducted.

As discussed in Section 5.5, four surface water samples were collected at the site and analyzed for VOCs only. Because VOCs are the primary site contaminant and no VOCs were detected in any of the surface water samples, the uncertainty associated with the limited analyses of surface water was expected to be minimal.

Chemicals Potentially Attributable to Background

COPCs for the MGBG were selected using available background concentrations for soil and sediment. Metal concentrations in soil were compared to background concentrations provided in the NSWC Crane Basewide Background Soil Investigation (TtNUS, 2001a) using the WRS Test at the 95 percent confidence level. The background data sets used for these comparisons were the representative soil types described in the Basewide Background Soil Investigation that most closely matched the site soil samples in terms of depositional environment, depth, and grain size. The use of matching soil types reduced the uncertainty in the background comparisons for soils.

As discussed in Section 4.2.2, the maximum concentrations of arsenic and thallium exceeded screening criteria and background concentrations. However, these metals were not identified as COPCs because reanalysis of surface soil samples for thallium by GFAA and an additional review of arsenic data indicated that the concentrations of arsenic and thallium were within background levels. These issues are further discussed in Sections 3.4.4 and 3.4.5.

Arsenic in subsurface soil (Section 3.4.4 and Tables 4-10 and 4-11) was also eliminated from the quantitative risk assessment on the basis of background comparisons. Because the background and site data sets for subsurface soil are relatively small, especially for Soil Group 9 samples, there is more uncertainty associated with the elimination of arsenic as a COPC in subsurface soil than in surface soil. To more fully characterize the effects of omitting arsenic from the quantitative risk assessment, risks for the only receptor evaluated for exposure to combined surface/subsurface soil, the construction worker, were recalculated with arsenic included. The results of the recalculations were as follows: the total HI for the construction worker (RME) increased from 0.28 to 0.37 and the ILCR increased form 4.2×10^{-9} to 5.8×10^{-7}. The HI and ILCR are less than U.S. EPA benchmarks and therefore, the effects of omitting arsenic in subsurface soil from the quantitative risk assessment are likely to be minimal. Even if the maximum detected concentration in subsurface soil (20.2 mg/kg) was used to calculate risks, the total ILCR (1.4 x

10^{-6}) would only slightly exceed the lower limit of the U.S. EPA's risk management range, 1.0 x 10^{-6}. Therefore, eliminating arsenic as a COPC was justifiable.

As indicated in Section 4.2.2, the maximum concentration of thorium-230 exceeded its soil screening level for migration to ground water and background levels. However, thorium-230 was not selected as a COPC based on the spatial distribution of thorium-230 and site history and additional evaluations presented in Section 3.4.7.

Background data are not available for ground water and no constituents were eliminated as COPCs in ground water on the basis of background. However, the ground water metal concentrations observed at the MGBG generally fall within concentration ranges observed in the U.S. Therefore, site-related risks for inorganics in ground water may be overestimated.

COPC Screening Levels

The use of risk-based screening values based on conservative land use scenarios (i.e., residential land use for soil and sediment and ingestion of tap water for ground water and surface water) corresponding to an ILCR of 10^{-6} and HI of 0.1 ensured that all the significant contributors to risk from a site were evaluated. The elimination of chemicals present at concentrations that correspond to an ILCR less than 10^{-6} and an HI less than 0.1 should not have affected the final conclusions of the risk assessment because those chemicals were not expected to cause a potential health concern at the detected concentrations.

Some constituents identified as COPCs in soil were conservatively selected as COPCs because maximum concentrations exceeded U.S. EPA and IDEM SSLs for migration from soil to ground water using a dilution attenuation factor (DAF) of 1. However, U.S. EPA's Soil Screening Guidance (U.S. EPA, 1996) states "The EPA has selected a default DAF of 20 to account for contaminant dilution and attenuation during transport through the saturated zone to a compliance point (i.e., receptor well). At most sites, this adjustment will more accurately reflect a contaminant's threat to ground water resources than assuming a DAF of 1 (i.e., no dilution or attenuation)." The guidance further states, "A DAF of 20 is protective for sources up to 0.5 acres in size" and "can be protective of larger sources as well." If a DAF of 20 had been used in the COPC selection process, some compounds, for example, 1,1,2,2-PCA, benzo(a)anthracene, benzo(b)fluoranthene, and selenium would not have been selected as COPCs. However, use of a DAF of 1 for screening was not expected to significantly affect the results of the risk assessment because the risks calculated for COPCs selected by a DAF of 1 were minimal.

Chemicals without Established Screening Levels

RBSLs are currently not available for some constituents [e.g., acenaphthylene, benzo(g,h,i)perylene, 2-methylnaphthalene, and phenanthrene]. Therefore, surrogates were selected for these chemicals based on similar chemical structures. In the COPC screening, acenaphthene was used as a surrogate for acenaphthylene, naphthalene was used as a surrogate for 2-methylnaphthene, and pyrene was selected as a surrogate for benzo(g,h,i)perylene and phenanthrene. Applying toxicity values of one compound to another added to the uncertainty in the risk assessment both in regard to the selection of COPCs and the subsequently calculated risks.

7.6.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arose because of the methods used to calculate exposure point concentrations, the determination of land use conditions, the selection of receptors and scenarios, the estimation of EPCs, and the selection of exposure parameters. Each of these is discussed below.

Land Use

The current land use patterns at NSWC Crane are well established, thereby limiting the uncertainty associated with land use assumptions. Land use at the MGBG is currently limited and is expected to be limited in the future, as long as NSWC remains open (potential and infrequent trespassers are the only current and likely future receptors). To be conservative, risks to potential and future construction workers, maintenance workers, occupational workers, recreational users, and on-site residents were estimated for the site.

Exposure Point Concentrations

Uncertainty was associated with the use of the 95 percent UCL on the mean concentration as the EPC. As a result of using the 95 percent UCL, the estimations of potential risk for the RME scenario were most likely overstated because this is a representation of the upper limit that potential receptors would be exposed to over the entire exposure period. In some cases (because datasets contained fewer than 10 samples or because the UCL was greater than the maximum concentration), the maximum concentration was used as the EPC. Use of the maximum concentration tended to overestimate potential risks because receptors were assumed to be exposed continuously to the maximum concentration for the entire exposure period. Uncertainty was also introduced when the nondetects results were assigned a value of one-half the nondetect quantitation limit in the calculation of the EPC. This may have either overstated or understated the risks to the receptors.

As discussed in Section 7.5.2.1, risks for ground water were based on the assumption that EPCs for ground water were the concentrations in the most highly contaminated well (01GW0201). The greater of the Round 1 and Round 2 concentrations from this well were selected as the EPCs. This approach tended to overestimate risks for VOCs and underestimate risks from other constituents such as metals. Potential receptors were assumed to be exposed to the maximum detected concentrations of 1,1,2,2-PCA, PCE, TCE, and chloroform and to elevated detection limits of several other VOCs. In addition, there was considerable uncertainty regarding the concentrations in well 01GW0201 because of the fluctuations in concentrations between Rounds 1 and 2 and historical fluctuations (See Section 3.4.8 for a detailed discussion). For example, the Round 1 concentration of 1,1,2,2-PCA was 38,000 µg/L and the concentration detected in Round 2 was 30 µg/L. Likewise, the Round 1 concentration of TCE was 16,000 µg/L and the concentration detected in Round 2 was 20 µg/L. Based on the above discussion it is possible that risks estimated for exposure to ground water were greatly overestimated. T he fact that chemical concentrations vary from well to well also leads to uncertainty because, depending on the location of a potential drinking water wells, the magnitude in the estimated EPCs could vary significantly.

There was also uncertainty in assuming that current ground water concentrations will not change in the future, and this introduced additional uncertainty in the EPC and risks for any ground water or surface water COPC. Concentrations in ground water may diminish over time due to natural attenuation processes involving source depletion and dilution.

Exposure Routes and Receptor Identification

The determination of various receptor groups and exposure routes of potential concern was based on current land use observed at the site and the anticipated future land use. Therefore, the uncertainty associated with the selection of exposure routes and potential receptors was minimal because they were considered to be well defined. Although residential use of ground water was evaluated as an exposure scenario, ground water is not currently used at the site nor is it expected to be used in the future. Therefore, the evaluation of direct exposure to ground water that was performed in this baseline HHRA was included primarily to aid in risk management decision making.

Exposure Parameters

Each exposure factor (for RME and CTE scenarios) selected for use in the risk assessment had some associated uncertainty. Generally, exposure factors were based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally had a

broad distribution. To avoid underestimation of exposure, in most cases, the U.S. EPA guidelines (U.S. EPA, 1991) on the RME receptor were used, which generally specify the use of the 95th percentile value for most parameters. Therefore, the selected values for the RME receptor represented an upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for many assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often, the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty.

For many parameters for which limited information exists (i.e., dermal absorption of chemicals from soil), greater uncertainty exists. For example, current U.S. EPA guidance (U.S. EPA, 2001b) does not provide dermal absorption factors for exposure to most metals (except arsenic and cadmium) in soil. Therefore, risks for dermal contact from soil were not evaluated for most metals in this risk assessment. Consequently, risks from exposure to soil may have been underestimated.

Many of the exposure parameters used to calculate exposures and risks in this report were selected from a distribution of possible values including U.S. EPA guidance (U.S. EPA, 1991; U.S. EPA, 1993a) and dermal guidance (U.S. EPA, 1997c; U.S. EPA, 2001b). For the RME scenario, the value representing the 95th percentile was generally selected for each parameter to ensure that the assessment bounds the majority of actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

To address these issues, U.S. EPA (1992a) has suggested the use of the CTE receptor, whose intake variables are often set at approximately the 50th percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. Some of the parameters presented in this risk assessment were estimated using professional judgment, although U.S. EPA does provide limited guidance for the CTE evaluation (U.S. EPA, 1993a).

EPCs of VOCs in air were estimated by the Foster and Chrostowski Shower Model and the VDEQ model for exposure of construction workers to vapors in a trench to evaluate potential risks from exposure to air. Site-specific parameters, such as ground water concentrations were used in the model, if possible. However, it was necessary to use model default values for most of the input parameters. The use of model default values tended to increase the uncertainty in the calculated risks. The direction of the

uncertainty was not known, although the model default values were generally conservative and tended to overestimate air concentrations.

7.6.3 Uncertainty in the Toxicological Evaluation

Uncertainties associated with the toxicity assessment (determination of RfDs and CSFs and use of available criteria) are presented in this section.

Derivation of Toxicity Criteria

Uncertainty associated with the toxicity assessment was associated with hazard assessment and dose-response evaluations for the COPCs. The hazard assessment dealt with characterizing the nature and strength of the evidence of causation or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity was evaluated as a weight-of-evidence determination using U.S. EPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data often suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arose from the nature and quality of the animal and human data. Uncertainty was reduced when similar effects were observed across species, strain, sex, and exposure route; when the magnitude of the response was clearly dose related; when pharmacokinetic data indicated a similar fate in humans and animals; when postulated mechanisms of toxicity were similar for humans and animals; and when the chemical of concern was structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation included the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the noncarcinogenic assessment. Uncertainty was introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also resulted from intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype, so intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity, including unusual sensitivity or tolerance to the COPC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not

unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate was derived and the database used. For cancer effects, the uncertainty associated with dose-response factors was mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. Evidence suggests, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic. Therefore, the use of the linearized multistage model was conservative for chemicals that exhibited a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may have been applied in the derivation of the RfD to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arose from the use of an effect level in the estimation of an RfD, because this estimation was predicated on the assumption of a threshold less than which adverse effects were not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arose in estimation of an RfD for chronic exposure from subchronic data. Unless empirical data indicated that effects did not worsen with increasing duration of exposure, an additional uncertainty factor was applied to the no-effect level in the subchronic study. Uncertainty in the derivation of RfDs was mitigated by the use of uncertainty and modifying factors that normally ranged between 3 and 10. The resulting combination of uncertainty and modifying factors may have reached 1,000 or more.

The derivation of dermal RfDs and CSFs from oral values may have caused uncertainty. This was particularly the case when no gastrointestinal absorption rates were available in the literature or when only qualitative statements regarding absorption were available.

Uncertainty Associated with Evaluation of the Dermal Exposure Pathway

According to RAGS Part E (U.S. EPA, 2001b), risks for dermal absorption of chemicals in soil were quantitatively evaluated for arsenic, cadmium, chlordane, 2,4-dichlorophenoxyacetic acid, DDT, TCDD (and other dioxins), PAHs, PCBs, pentachlorophenol, and SVOCs only because of the limited information guidance available to evaluate dermal exposure to other constituents. Therefore, risks from dermal exposure to aluminum, barium, chromium, iron, manganese, nickel, and selenium (the only metal COPCs found in the MGBG solid media aside from cadmium) were not quantified in the risk assessment. Consequently, potential risks may have been underestimated by excluding these constituents from the dermal risk assessment calculations.

The model for dermal exposure to soil assumes that only a very thin, constant thickness layer of soil is available for contaminant transfer to the stratum corneum and that a constant amount of contaminant, proportional to the soil concentration, will be absorbed per unit area of skin and per exposure event. However, adherence to skin varies with such factors as particle size, soil type, and organic carbon content. As estimated by U.S. EPA (U.S. EPA, 2001b), the absorbed dermal dose could vary by as much as a factor of 50 from the model estimates, even assuming that activity patterns lead to the exposure duration applied in the experimental trials used to develop absorption factors.

Experimental determination of absorption rates indicates that interspecies differences are considerable, which, along with other variabilities related to condition and age of skin, differences in lag time, and site of application effects, yielded appreciable uncertainty in estimated dermal exposures using published chemical-specific permeation functions. In addition, literature data indicate a variation by as much as a factor of 300 in chemical absorption rates for skin in different anatomical areas of the body. In addition, children generally have greater absorption rates than adults.

Use of Aluminum and Iron Toxicity Criteria

NCEA provisional RfDs were used to evaluate noncarcinogenic effects from exposure to aluminum and iron. The provisional RfDs for these chemicals are based on allowable intakes rather than adverse effect levels. Therefore, there was some degree of uncertainty associated with the use of the RfDs. Note that some U.S. EPA regions (e.g., Region 1) consider the use of the oral RfD for aluminum and iron inappropriate and recommend that these metals not be evaluated quantitatively in risk assessments.

Alternate RfD for Iron

As previously discussed there is uncertainty associated with the toxicity data for iron. The RfD for iron is based on the RDA for adult human nutrition. Children and adolescents require more iron in their diets than adults do, consequently, using an RfD based on the adult RDA for iron to evaluate exposures to children results in an overestimation of the risks for children. When the HI for exposures to iron by children exceed unity U.S. EPA Region 3 recommends recalculating the HI using an RfD 1.1 mg/kg/day (instead of the 0.3 mg/kg/day provided in IRIS). If this value were used to estimate risks for children, the HQs calculated for iron would decrease by a factor of 1.1/0.3. Therefore, the risk estimates calculated for iron may be overestimated. However, since the risks for exposure to iron for the child resident are less than unity, the overestimation is not considered to be significant.

Alternate RfD for Manganese

The oral RfD for manganese listed in the Region 9 PRG table (0.024 mg/kg/day) was used to calculate risks for ingestion of ground water. This value includes a modification factor of 3 which is applied to the non-dietary reference dose (0.14 mg/kg/day) presented in IRIS. An RfD of 0.07 mg/kg/day for manganese was used to estimate risks for soil, based on discussions in IRIS. The oral reference dose for manganese presented in IRIS (0.14 mg/kg/day) represents an allowable level for the total oral intake. IRIS indicates that an adjustment for the dietary contribution should be subtracted from this allowable intake. The resulting nondietary reference dose is 0.07 mg/kg/day. This value is recommended by U.S. EPA Region 1 for Superfund risk evaluations involving soil exposure.

Uncertainty in the Toxicity of 1,1-Dichloroethene

The U.S. EPA has recently downgraded 1,1-DCE from a Group C carcinogen to the "suggestive" evidence category under the new cancer guidelines. Therefore, 1,1-DCE is no longer quantitatively assessed as a carcinogen and carcinogenic risks for 1,1-DCE were not calculated in the quantitative risk assessment. Consequently, the carcinogenic risks for exposure to ground water may have been underestimated. However, given the magnitude of the risks calculated for ground water, the omission of 1,1-DCE was likely to have had a minimal effect on the results and conclusions of the risk assessment.

7.6.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization resulted from assumptions made regarding additivity of effects from exposure to multiple COPCs from various exposure routes. High uncertainty existed when summing noncancer risks for several substances across different exposure pathways. This assumed that each substance has a similar effect and/or mode of action. Even when compounds affect the same target organs, they may have different mechanisms of action or differ in their fate in the body, so additivity may not have been an appropriate assumption. However, the assumption of additivity was considered because in most cases it represented a conservative estimate of risk.

Risks to any individual may also have been overestimated by summing multiple assumed exposure pathway risks for any single receptor. Although every effort was made to develop reasonable scenarios, not all individual receptors may have been exposed via all pathways considered.

Finally, the risk characterization did not consider antagonistic or synergistic effects. Little or no information was available to determine the potential for antagonism or synergism for the COPCs. Because chemical-specific interactions could not be predicted, the likelihood for risks to be overpredicted

or underpredicted could not be defined, but the methodology used was based on current U.S. EPA guidance.

7.7 SUMMARY AND CONCLUSIONS

This section briefly summarizes the results of the HHRA performed for the MGBG. Table 7-11 contains a summary of conclusions and recommendations.

The baseline HHRA for the MGBG was performed to characterize the potential risks to likely human receptors under current and potential future land use. Potential receptors under current land use are adolescent trespassers. Potential receptors under future land use are construction workers, maintenance workers, occupational workers, recreational users, and hypothetical residents (children and adults). Although future land use is likely to be the same as current land use, the potential future receptors were evaluated in the baseline HHRA, primarily for decision-making purposes.

Potential risks associated with inhalation exposures were considered to be minimal for soil, sediment, and surface water. Inhalation of volatile emissions and fugitive dust was evaluated qualitatively via a comparison of site data with U.S. EPA generic SSLs for transfers from soil to air. Inhalation exposure was considered to be relatively insignificant because all detected soil concentrations were less than the SSLs. Inhalation of volatiles from surface water and sediment was considered to yield insignificant exposures compared to ingestion and dermal exposures. In addition, no VOCs were detected in surface water samples. The inhalation of volatiles from ground water, which could occur during showering, bathing, and other routine household activities and during future excavation/construction projects, were evaluated for the MGBG because volatile organics were identified as COPCs in ground water.

The list of COPCs for the MGBG included the following:

- Surface soil - methylene chloride, aluminum, iron, and selenium

- Subsurface soil - 1,1,2,2-PCA, methylene chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, aluminum, barium, cadmium, chromium, iron, manganese, nickel, and selenium.

- Ground water - 1,1,1,2-PCA, 1,1,2,2-PCA, 1,1,2-TCA, 1,1-DCE, 1,2-DCA chloroform, cis-1,2-DCE, PCE, TCE, BEHP, hexachloroethane, 4-amino-2,6-dinitrotoluene, heptachlor, aluminum, antimony, arsenic, iron, manganese, nickel, and strontium

No sediment or surface water COPCs were identified.

Quantitative estimates of noncarcinogenic and carcinogenic risks (HIs and ILCRs, respectively) were developed for potential human receptors and are summarized below.

Exposure to Soil

Cumulative HIs for all current and future receptors exposed to surface and/or subsurface soil under the RME and CTE scenarios were less than unity (1.0) on a target organ basis, indicating that adverse non-carcinogenic effects are not anticipated for these receptors under the defined exposure conditions.

Cumulative soil ILCRs for all receptors were less than the U.S. EPA's target risk range of 10^{-4} to 10^{-6} for the RME and CTE scenarios.

Exposure to Ground Water

Maintenance workers, occupational workers, recreational users, and adolescent trespassers were not evaluated for exposure to ground water.

HIs for the future construction worker and future on-site child and adult residents exposed to ground water exceeded unity. 1,1,2,2-PCA, 1,1-DCE, chloroform, cis-1,2-DCE, PCE, TCE, and manganese in ground water were the major contributors to the total HIs for these receptors.

Cumulative ILCRs for future construction workers and future on-site child and adult residents exposed to ground water exceeded the U.S. EPA target risk range. 1,1,1,2-PCA, 1,1,2,2-PCA, 1,2-DCA, PCE, TCE, and chloroform were the major contributors (ILCRs > 1.0×10^{-4}) to the ILCRs for ground water.

In summary for the MGBG, no significant potential human health risks are expected for exposures to soil under current or future land use. Under current land use, no significant potential human health risks are anticipated for exposures to ground water because there are no exposures to ground water under current land use. Under future land use, noncarcinogenic and carcinogenic risks exceeding U.S. EPA benchmarks were estimated for construction workers and future on-site child and adult residents assuming that ground water is used as a potable water source. There is a great deal of uncertainty in the EPCs on which the risks are based. The elevated HIs and ILCRs for ground water were based on exposure to concentrations of COPCs in the most highly contaminated well (01GW0201), and potential

receptors were assumed to be exposed to the maximum detected concentrations of 1,1,2,2-PCA, PCE, TCE, and chloroform. The greater of the Round 1 and Round 2 concentrations from this well were selected as the EPCs. However, the concentrations of the primary risk drivers in the Round 2 samples were several orders of magnitude less than concentrations in the Round 1 samples. For example, the total residential ILCR for exposure to 1,1,2,2-PCA was 1.6×10^{-1}, based on the Round 1 concentration (38,000 µg/L). If the Round 2 concentration (30 µg/L) in well 01BW02 were used for risk estimation, the ILCR for exposure to 1,1,2,2-PCA would be 1.3×10^{-4}. It is important to note that these risks are based on the assumption that a drinking water well is installed at location 01GW02. However, VOC concentrations in a number of other wells within the plume (e.g., wells 01GW05 and 01GW15 in both sampling rounds) also exceeded screening levels and exposure to VOCs in these wells would result in cancer risk estimates greater than 1×10^{-3}. Therefore, the risks posed by COPC concentrations in other wells also exceed U.S. EPA benchmarks by more than an order of magnitude and there can be no doubt that a human receptor using ground water a MGBG would incur unacceptable levels of health risks. A summary of the major contributors to risks at MGBG is provided in Table 7-11.

TABLE 7-1

SELECTION OF EXPOSURE PATHWAYS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Current/Future	Surface Soil[1]	Surface Soil	Entire Site	Trespassers	Adolescent	Ingestion	On-site	Quant[2]	Although access to the Base is controlled, once inside the Base, access to the study areas is not limited by any physical constraints.
						Dermal	On-site	Quant	
					Adult	Ingestion	On-site	None	Potential risks were assumed to be similar to adolescent trespassers. Risks for this receptor were inferred using the calculated risks for the adolescent trespasser.
						Dermal	On-site	None	
		Air	Vapors and Particulates in Air - Entire Site	Trespassers	Adult and Adolescent	Inhalation	On-site	Qual[3]	Exposure was evaluated qualitatively by a comparison of site data to U.S. EPA Generic SSLs[4] for transfers from soil to air.
	Ground Water	Ground Water/Air	Surficial Aquifer	Trespassers	Adult and Adolescent	Ingestion	On-site	None	Direct contact with ground water does not occur under current land use. Shallow ground water is not expected to be used as a domestic water supply.
						Dermal	On-site	None	
						Inhalation	On-site	None	
	Surface Water	Surface Water	On-site Intermittent Drainge Channels	Trespassers	Adolescent	Ingestion	On-site	Quant	Although access to the Base is controlled, once inside the Base, access to the study areas is not limited by any physical constraints.
						Dermal	On-site	Quant	
					Adult	Ingestion	On-site	None	Potential risks were assumed to be similar to adolescent trespassers. Risks for this receptor were inferred using the calculated risks for the adolescent trespasser.
						Dermal	On-site	None	
		Air	On-site Intermittent Drainge Channels	Trespassers	Adult and Adolescent	Inhalation	On-site	None	Minimal exposure to vapors emitted from surface water is anticipated (i.e., so low such that it is not worth quantifying).
	Sediment	Sediment	On-site Intermittent Drainge Channels	Trespassers	Adolescent	Ingestion	On-site	Quant	Although access to the Base is controlled, once inside the Base, access to the study areas is not limited by any physical constraints.
						Dermal	On-site	Quant	
					Adult	Ingestion	On-site	None	Potential risks were assumed to be similar to adolescent trespassers. Risks for this receptor were inferred using the calculated risks for the adolescent trespasser.
						Dermal	On-site	None	
		Air	Vapors and Particulates in Air - Entire Site	Trespassers	Adult and Adolescent	Inhalation	On-site	None	Minimal exposure is anticipated (i.e., so low such that it is not worth quantifying).
Future	Surface/ Subsurface Soil[5]	Surface/ Subsurface Soil	Entire Site	Excavation/Construction Workers	Adult	Ingestion	On-site	Quant	Excavation/construction activities may occur at the site in the future.
						Dermal	On-site	Quant	
		Air	Vapors and Particulates in Air - Entire Site	Excavation/Construction Workers	Adult	Inhalation	On-site	Qual	Exposure was evaluated qualitatively by a comparison of site data to U.S. EPA Generic SSLs for transfers from soil to air.
	Surface Soil	Surface Soil	Entire Site	Maintenance Workers	Adult	Ingestion	On-site	Quant	Although maintenance activities are not currently performed on the site, activities, such as groundkeeping, may occur in the future.
						Dermal	On-site	Quant	
				Occupational Workers	Adult	Ingestion	On-site	Quant	Although the site is currently not in use, it could be used in the future for industrial purposes.
						Dermal	On-site	Quant	
				Recreational Users	Adult	Ingestion	On-site	Quant	This scenario was evaluated on the assumption that the Facility would close and be turned into a state park in the future.
						Dermal	On-site	Quant	
				Residents	Child and Adult	Ingestion	On-site	Quant	Although the scenario is unlikely, a residential scenario was included to aid in future risk management decisions.
						Dermal	On-site	Quant	
		Air	Vapors and Particulates in Air - Entire Site	Maintenance/Occupational Workers, Recreational Users, and Residents	Child and Adult	Inhalation	On-site	Qual	Exposure was evaluated qualitatively by a comparison of site data to U.S. EPA Generic SSLs for transfers from soil to air.

TABLE 7-1

SELECTION OF EXPOSURE PATHWAYS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future (continued)	Ground Water	Ground Water	Surficial Aquifer	Excavation/Construction and Maintenance Workers	Adult	Ingestion	On-site	None	Minimal exposure is anticipated (i.e., so low such that it is not worth quantifying).
						Dermal	On-site	Quant	Excavation/construction activities may occur at the site and workers may be exposed by direct contact with ground water.
				Occupational Workers	Adult	Ingestion	On-site	None	Occupational workers are not expected to be exposed to ground water.
						Dermal	On-site	None	
				Recreational Users	Adult	Ingestion	On-site	None	Direct contact with ground water is not expected to occur for future recreational users.
						Dermal	On-site	None	
				Residents	Child and Adult	Ingestion	On-site	Quant	Although it is unlikely that shallow ground water at the site would be used as a domestic water supply, this scenario was included to aid in future risk management decisions.
						Dermal	On-site	Quant	
		Air	Vapors	Maintenance/Occupational Workers and Recreational Users	Adult	Inhalation	On-site	None	Minimal exposure is anticipated (i.e., so low such that it is not worth quantifying).
				Excavation/Construction Workers	Adult	Inhalation	On-site	Quant	Construction workers may be exposed to COPCs that have volatilized from ground water when excavation exposes the shallow water table.
				Residents	Child and Adult	Inhalation	On-site	Quant	Although it is unlikely that shallow ground water at the site would be used as a domestic water supply, this scenario was included to aid in future risk management decisions.
	Surface Water	Surface Water	On-site Intermittent Drainge Channels	Excavation/Construction and Maintenance Workers	Adult	Ingestion	On-site	None	Minimal exposure is anticipated (i.e., so low such that it is not worth quantifying).
						Dermal	On-site	None	
				Occupational Workers	Adult	Ingestion	On-site	None	Occupational workers are not expected to be exposed to surface water.
						Dermal	On-site	None	
				Recreational Users	Adult	Ingestion	On-site	Quant	This scenario was evaluated on the assumption that the Facility would close and be turned into a state park in the future.
						Dermal	On-site	Quant	
				Residents	Child and Adult	Ingestion	On-site	Quant	Although the scenario is unlikely, a residential scenario was included to aid in future risk management decisions.
						Dermal	On-site	Quant	
		Air	On-site Intermittent Drainge Channels	Excavation/Constuction/ Maintenance/Occupational Workers, Recreational Users, and Residents	Child and Adult	Inhalation	On-site	None	Minimal exposure to vapors emitted from surface water is anticipated (i.e., so low such that it is not worth quantifying).

TABLE 7-1

SELECTION OF EXPOSURE PATHWAYS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Population	Receptor Age	Exposure Route	On-Site/ Off-Site	Type of Analysis	Rationale for Selection or Exclusion of Exposure Pathway
Future	Sediment	Sediment	On-site Intermittent Drainge Channels	Excavation/Construction and Maintenance Workers	Adult	Ingestion Dermal	On-site On-site	None None	Minimal exposure is anticipated (i.e., so low such that it is not worth quantifying).
				Occupational Workers	Adult	Ingestion Dermal	On-site On-site	None None	Occupational workers are not expected to be exposed to sediment.
				Recreational Users	Adult	Ingestion Dermal	On-site On-site	Quant Quant	This scenario is evaluated on the assumption that the Facility would close and be turned into a state park in the future.
				Residents	Adult and Child	Ingestion Dermal	On-site On-site	Quant Quant	Although the scenario is unlikely, a residential scenario is included to aid in future risk management decisions.
		Air	On-site Intermittent Drainge Channels	Excavation/Constuction/ Maintenance/Occupational Workers, Recreational Users, and Residents	Child and Adult	Inhalation	On-site	None	Minimal exposure to vapors emitted from surface water is anticipated (i.e., so low such that it is not worth quantifying).

Footnotes:
1 Surface soil is defined as soil collected from 0 to 2 feet bgs.
2 Quantitative.
3 Qualitative.
4 Soil Screening Levels (U.S. EPA, 1996).
5 Surface/subsurface soil is defined as soil collected from 0 to 10 feet bgs; no exposure to soil at depths below 10 feet bgs is anticipated.

TABLE 7-2

EXPOSURE ROUTES FOR QUANTITATIVE EVALUATION
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Receptors	Exposure Routes
Adolescent Trespassers (6 to 17 Years) (current/future land use)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface)
Maintenance/Occupational Workers (future land use)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface)
Construction Workers (future land use)	• Soil dermal contact (surface and subsurface) • Soil ingestion (surface and subsurface) • Inhalation of air/dust/emissions (surface and subsurface) • Ground water dermal contact (during excavation) • Ground water inhalation (in a trench during excavation)
Adult Recreational Users (future land use)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface) • Surface water/sediment dermal contact • Sediment ingestion
Residents (Adult/Children)□(future land use)	• Soil dermal contact (surface) • Soil ingestion (surface) • Inhalation of air/dust/emissions (surface) • Direct ingestion of ground water • Ground water dermal contact (showering/bathing) • Inhalation of volatiles in ground water (showering/bathing)

TABLE 7-3

EXPOSURE POINT CONCENTRATIONS (EPCs) FOR COPCs
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Exposure Point Concentration		
	Surface Soil[1] (mg/kg)	Surface/ Subsurface Soil[1] (mg/kg)	Ground Water[2] (mg/L)
1,1,1,2-Tetrachloroethane	-	-	0.25[3]
1,1,2,2-Tetrachloroethane	-	0.00159	38
1,1,2-Trichloroethane	-	-	0.0006
1,1-Dichloroethene	-	-	0.5[3]
1,2-Dichloroethane	-	-	0.25[3]
Chloroform	-	-	0.84
cis-1,2-Dichloroethene	-	-	0.5[3]
Methylene Chloride	0.0216	0.0217	-
Tetrachloroethene	-	-	0.37
Trichloroethene	-	-	16
Benzo(a)anthracene	-	0.0077	-
Benzo(a)pyrene	-	0.008	-
Benzo(b)fluoranthene	-	0.0084	-
Bis(2-Ethylhexyl)Phthalate	-	-	0.0025[3]
Hexachloroethane	-	-	0.005
4-Amino-2,6-Dinitrotoluene	-	-	0.000325[3]
Heptachlor	-	-	0.00002[3]
Aluminum	14,088	10,772	0.0201[3]
Antimony	-	-	0.00255[3]
Arsenic	-	-	0.0011[3]
Barium	-	77.1	-
Cadmium	-	0.282	-
Chromium	-	14.8	-
Iron	21,267	20,654	0.0221
Manganese	-	-	0.434
Nickel	-	12.8	0.0414
Selenium	0.796	0.634	-
Strontium	-	-	0.257

1 The exposure concentration is the 95 percent UCL based on distribution of the data set (best fit of normal or lognormal), unless otherwise noted.
2 Maximum detected concentration from Well 01GW02 (greater of Rounds 1 and 2).
3 1/2 the SQL for COPCs not detected in Well 01GW02.
- = Not a chemical of potential concern for this medium.

TABLE 7-4

SUMMARY OF EXPOSURE ASSUMPTIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Adolescent Trespasser (6 to 17 Years)	EF (days/year)	26	13	Professional judgement; 1 day/week in warm weather months for the RME and 1 day/every other week in warm weather months for the CTE.
	ED (years)	11	11	Adolescents from age 6 to 17 evaluated.
	BW (kg)	43	43	Average age-specific value (U.S EPA, May 1989).
	SA (cm^2/day) and A (cm^2)	3,820	3,100	25 percent of the total body surface area was assumed to be available for soil, sediment, and surface water contact. CTE and RME areas represented the mean of 50th and 95th percentile values for ages 6 to 17, respectively, as provided in Table 6-6 of the Exposure Factors Handbook (U.S. EPA, 1997c).
	IR_S (mg/day)	100	50	Assumed similar to adult exposure (U.S. EPA, 1993a).
Maintenance/ Occupational Worker	EF (days/year)	24 (maintenance) 250 (occupational)	12 (maintenance) 219 (occupational)	Professional judgement for maintenance worker; 2 days/month for the RME and 1 day/month for the CTE. Convention for the occupational worker (U.S. EPA, 1993a).
	ED (years)	25	9	Convention for RME (U.S. EPA, 1991) and CTE (U.S. EPA, 1993a).
	BW (kg)	70	70	U.S. EPA, 1993a.
	SA (cm^2/day)	3,330	3,300	Surface area available for soil contact was assumed to be the head, hands, and forearms. This value represented the 50th percentile areas for the head, hands, and forearms (U.S. EPA, 2001).
	IR_S (mg/day)	100	50	U.S. EPA, 1993a.
Construction Worker	EF (days/year)	150	150	Professional judgement. Ground assumed to be frozen or snow-covered for 22 weeks/year.
	ED (years)	1	1	Estimated length of construction project (professional judgement).
	ET (hours)	2 (ground water)	1.5 (ground water)	For air, standard default (U.S. EPA, 1991). Professional judgement for dermal exposure to ground water.
	BW (kg)	70	70	U.S. EPA, 1993a.

TABLE 7-4

SUMMARY OF EXPOSURE ASSUMPTIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Construction Worker (continued)	SA (cm^2/day)	5,800	5,000	Recommended values for adult skin surface area assumed to be available for soil contact (U.S. EPA, 1997c; Table 6-16).
	IR_S (mg/day)	480	240	Convention for the RME (U.S. EPA, 1991). CTE was assumed to be one-half the RME value.
	IR_a (m^3/hour)	2.5	2.5	Recommended short-term heavy activities rate for outdoor workers (U.S. EPA, 1997c; Table 5-23).
	EV (events/day)	1	1	Professional judgement.
Adult Recreational User	EF (days/year)	52	26	Professional judgement; 2 day/week for the RME in warm weather months and 1 day/every other week in warm weather months for the CTE.
	ED (years)	30	9	U.S. EPA, 1993a. Assumed length of residence for an adult living near the Facility.
	BW (kg)	70	70	U.S. EPA, 1993a.
	SA (cm^2/day)	9,190	7,770	Feet, lower legs, hands, and arms of adult male assumed to be available for sediment contact. The RME and CTE values represented the 95th and 50th percentile areas of the feet, lower legs, hands and arms (U.S. EPA, 1997c, Table 6-2).
	IR_S (mg/day)	100	50	Based on U.S. EPA, 1993a.

TABLE 7-4

SUMMARY OF EXPOSURE ASSUMPTIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Receptor	Exposure Assumptions			Rationale/Reference
	Input Parameter	RME	CTE	
Resident (Adult/Child)	EF (days/year or showers/year)	350	234	U.S. EPA, 1993a. One shower assumed to be taken per day.
	ED (years)	24(1) 6(2)	7(1) 2(2)	U.S. EPA, 1993a.
	t_{event} (hr/event)	0.25	0.167	15 min/event for RME and 10 min/event for CTE (U.S. EPA, January 1992).
	BW (kg)	70(1) 15(3)	70(1) 15(3)	U.S. EPA, 1993a.
	SA (cm^2/day)	5,700(1) 2,800(2)	5,700(1) 2,800(2)	The value for the adult assumed that the adult resident was wearing a short-sleeved shirt, shorts, and shoes; therefore, the exposed skin surface was limited to the head, hands, forearms, and lower legs. The value for the child assumed that the child resident was wearing a short-sleeved shirt, shorts, and no shoes; therefore, the exposed skin surface area was limited to the head, hands, forearms, lower legs, and feet. (U.S. EPA, 2001)
	IR_S (mg/day)	100(1) 200(2)	50(1) 100(2)	U.S. EPA, 1993a.
	IR_a (m^3/hr) (showering)	0.6	0.6	For all age groups while showering (U.S. EPA, 1989).
	IR_W (L/day)	2(1) 1.5(2)	1.4(1) 0.66(2)	U.S. EPA, 1993A for adult exposure. U.S. EPA, 1997c, Table 3-30 for child exposure.
	EV (events/day)	1	1	Professional judgement.

EF = Exposure Frequency
ED = Exposure Duration
ET = Exposure Time
BW = Body Weight
SA = Body Surface Area Exposed
IRs = Ingestion Rate - Soil
IRa = Inhalation Rate
EV = Exposure Events
CTE = Central Tendency Exposure
RME = Reasonable Maximum Exposure
A = Area
t = Time

1 Exposure assumption for adult receptor.
2 Exposure assumption for small children (0 to 6 years of age).

TABLE 7-5

CANCER TOXICITY DATA FOR CHEMICALS OF CONCERN - ORAL/DERMAL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD (mg/kg/day)	Oral to Dermal Adjustment Factor[1]	Adjusted Dermal RfD[2] (mg/kg/day)	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ[3]
1,1,1,2-Tetrachloroethane	chronic	3.0E-02	1	3.00E-02	Liver, Kidney	3,000	IRIS	09/05/02
1,1,2,2-Tetrachloroethane	chronic	6.0E-02	1	6.00E-02	Liver	NA	NCEA	04/02/02
1,1,2-Trichloroethane	chronic	4.0E-03	1	4.00E-03	Liver	1,000	IRIS	09/05/02
1,1-Dichloroethene	chronic	5.0E-02	1	5.00E-02	Liver	100	IRIS	09/05/02
1,2-Dichloroethane	chronic	3.0E-02	1	3.00E-02	NOAEL	NA	NCEA	04/02/02
Chloroform	chronic	1.0E-02	1	1.00E-02	Liver	1,000	IRIS	09/05/02
cis-1,2-Dichloroethene	chronic	1.0E-02	1	1.00E-02	Blood	NA	HEAST	07/97
Methylene Chloride	chronic	6.0E-02	1	6.00E-02	Liver	100	IRIS	09/05/02
Tetrachloroethene	chronic	1.0E-02	1	1.00E-02	Liver	1,000	IRIS	09/05/02
Trichloroethene	chronic	6.0E-03	1	6.00E-03	CNS	NA	NCEA	04/02/02
bis(2-Ethylhexyl) phthalate	chronic	2.0E-02	1	2.00E-02	Liver	1,000	IRIS	09/05/02
Hexachloroethane	chronic	1.0E-03	1	1.00E-03	Kidney	1,000	IRIS	09/05/02
Heptachlor	chronic	5.0E-04	1	5.00E-04	Liver	300	IRIS	09/05/02
4-Amino-2,6-dinitrotoluene	chronic	6.0E-05	1	6.00E-05	Liver	NA	IRIS	09/05/02
Aluminum	chronic	1.0E+00	1	1.00E+00	Immunological, Nails	300	NCEA	04/02/02
Antimony	chronic	4.0E-04	0.15	6.00E-05	Lifespan	1,000	IRIS	09/05/02
Arsenic	chronic	3.0E-04	1	3.00E-04	Skin, Vascular	3	IRIS	09/05/02
Barium	chronic	7.0E-02	0.07	4.90E-03	Blood	1,000	IRIS	09/05/02
Cadmium	chronic	5.0E-04	0.05	2.50E-05	Kidney	10	IRIS	09/05/02
Chromium	chronic	3.0E-03	0.025	7.50E-05	NOAEL	1,000	IRIS	09/05/02
Iron	chronic	3.0E-01	1	3.00E-01	Liver/Blood/GI Tract	NA	NCEA	04/02/02
Manganese (soil)	chronic	7.0E-02	0.04	2.80E-03	CNS	1	IRIS	09/05/02
Manganese (water)	chronic	2.4E-02	0.04	9.60E-04	CNS	1	IRIS	09/05/02
Nickel	chronic	2.0E-02	0.04	8.00E-04	Decreased body / organ weights	300	IRIS	09/05/02
Selenium	chronic	5.0E-03	1	5.00E-03	Blood/Skin/CNS	3	IRIS	09/05/02
Strontiium	chronic	6.0E-01	0.04	2.40E-02	Bone	300	IRIS	09/05/02

1 - U.S. EPA, 2001.
2 - RfD dermal = RfD oral x (Oral to Dermal Adjustment Factor).
3 - Dates of IRIS, HEAST, or NCEA.

Notes: RfD = Reference dose.
CNS = Central nervous system.
IRIS = Integrated Risk Information System, on-line database search (U.S. EPA, September 2002).
HEAST = Health Effects Assessment Summary Tables (U.S. EPA, 1997b).
NCEA = U.S. EPA National Center for Environmental Assessment (U.S. EPA Region 3 RBC Table, April 2002).
NA = Not applicable/Not available.
NOAEL = No-observed-adverse-effect-level .

TABLE 7-6

NON-CANCER TOXICITY DATA FOR CHEMICALS OF CONCERN - INHALATION
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Chronic/ Subchronic	Value Inhalation RfC (mg/m^3)	Adjusted Inhalation RfD (mg/kg/day)	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Date[1]
1,1-Dichloroethene	Chronic	2.1E-01	5.7E-02	Liver	30	IRIS	9/5/2002
1,2-Dichloroethane	Chronic	4.9E-03	1.4E-03	NOAEL	NA	NCEA	4/2/2002
Chloroform	Chronic	3.0E-04	8.6E-05	Liver	NA	NCEA	4/2/2002
Tetrachloroethene	Chronic	4.9E-01	1.4E-01	Liver	NA	NCEA	4/2/2002
Trichloroethene	Chronic	3.5E-02	1.0E-02	CNS	NA	NCEA	4/2/2002

1 - Dates of IRIS and NCEA

Notes:

RfC = Reference concentration.
RfD = Reference dose.
IRIS = Integrated Risk Information System, on-line database search (U.S. EPA, 2002).
NCEA = U.S. EPA National Center for Environmental Assessment
(U.S. EPA Region III RBC Table, April 2002).
NA = Not applicable/not available.
NOAEL = No-observed-adverse-effect-level

TABLE 7-7

CANCER TOXICITY DATA FOR CHEMICALS OF CONCERN - - ORAL/DERMAL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Oral CSF	Oral to Dermal Adjustment Factor[1]	Adjusted Dermal Cancer Slope Factor[2] $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/ Cancer Guideline Description	Source	Date[3]
1,1,1,2-Tetrachloroethane	2.6E-02	1	2.60E-02	C	IRIS	09/05/02
1,1,2,2-Tetrachloroethane	2.0E-01	1	2.00E-01	C	IRIS	09/05/02
1,1,2-Trichloroethane	5.7E-02	1	5.70E-02	C	IRIS	09/05/02
1,1-Dichloroethene	NA	1	NA	NA	IRIS	09/05/02
1,2-Dichloroethane	9.1E-02	1	9.10E-02	B2	IRIS	09/05/02
Chloroform	6.1E-03	1	6.10E-03	B2	IRIS	09/05/02
Methylene Chloride	7.5E-03	1	7.50E-03	B2	IRIS	09/05/02
Tetrachloroethene	5.2E-02	1	5.20E-02	B2	NCEA	4/2/2002
Trichloroethene	4.0E-01	1	4.00E-01	B2	NCEA	4/2/2002
Benzo(a)anthracene	7.3E-01	1	7.30E-01	B2	IRIS	09/05/02
Benzo(a)pyrene	7.3E+00	1	7.30E+00	B2	IRIS	09/05/02
Benzo(b)fluoranthene	7.3E-01	1	7.30E-01	B2	IRIS	09/05/02
bis(2-Ethylhexyl) phthalate	1.4E-02	1	1.40E-02	B2	IRIS	09/05/02
Hexachloroethane	1.4E-02	1	1.20E-01	C	IRIS	09/05/02
Heptachlor	4.5E+00	1	4.50E+00	B2	IRIS	09/05/02
Arsenic	1.5E+00	1	1.50E+00	A	IRIS	09/05/02

1 - U.S. EPA, 2001.
2 - CSFdermal = CSForal/(Oral to Dermal Adjustment Factor).
3 - Dates of IRIS, HEAST, or NCEA.

Notes:
CSF = Cancer Slope Factor.
IRIS = Integrated Risk Information System, on-line database search (U.S. EPA, September 2002).
NCEA = U.S. EPA National Center for Environmental Assessment (U.S. EPA Region III RBC Table, April 2002).

EPA Group:
A - Human carcinogen.
B1 - Probable human carcinogen - indicates that limited humar data are available.
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans.
C - Possible human carcinogen.
D - Not classifiable as a human carcinogen.
E - Evidence of noncarcinogenicity.

TABLE 7-8

CANCER TOXICITY DATA FOR CHEMICALS OF CONCERN - - INHALATION
SWMU 01 - MUSTARD GAS BURIAL ROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Potential Concern	Unit Risk	Units	Adjustment(1)	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	Weight of Evidence/ Cancer Guideline Description	Source	Date(2)
1,1,1,2-Tetrachloroethane	7.4E-03	$(mg/m^3)^{-1}$	3.5E+00	2.60E-02	C	IRIS	9/5/2002
1,1,2,2-Tetrachloroethane	5.8E-02	$(mg/m^3)^{-1}$	3.5E+00	2.00E-01	C	IRIS	9/5/2002
1,1,2-Trichloroethane	1.6E-02	$(mg/m^3)^{-1}$	3.5E+00	5.60E-02	C	IRIS	9/5/2002
1,1-Dichloroethene	NA	$(mg/m^3)^{-1}$	NA	NA	NA	IRIS	9/5/2002
1,2-Dichloroethane	2.6E-02	$(mg/m^3)^{-1}$	3.5E+00	9.10E-02	B2	IRIS	9/5/2002
Chloroform	2.3E-02	$(mg/m^3)^{-1}$	3.5E+00	8.10E-02	B2	IRIS	9/5/2002
Methylene Chloride	4.7E-07	$(mg/m^3)^{-1}$	3.5E+00	1.60E+00	B2	IRIS	9/5/2002
Tetrachloroethylene (PCE)	2.9E-03	$(mg/m^3)^{-1}$	3.5E+00	1.00E-02	B2	NCEA	4/2/2002
Trichloroethylene (TCE)	1.1E-01	$(mg/m^3)^{-1}$	3.5E+00	4.00E-01	B2	NCEA	4/2/2002

IRIS = Integrated Risk Information System (U.S.EPA, Spetember 2002).
HEAST= Health Effects Assessment Summary Tables.
NCEA = U.S. EPA National Center for Environmental Assessment (U.S. EPA Region III RBC Table, April 2002).

EPA Group:
B2 - Probable human carcinogen - indicates sufficient evidence in animals inadequate or no evidence in humans.
C - Possible human carcinogen.

1 - Unit risk is converted to an inhalation CSF by multiplying by 70 kg/20m^3/day.
2 - Dates of IRIS and NCEA.

TABLE 7-9

CUMULATIVE RISK SUMMARY - REASONABLE MAXIMUM EXPOSURE
SWMU 01 - MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $\geq 10^{-6}$ and $\leq 10^{-5}$	Hazard Index (HI)	Chemicals with HI ≥ 1
Construction Worker	Surface/Subsurface Soil	Ingestion	2.9E-09	- -	- -	- -	2.8E-01	- -
		Dermal Contact	1.3E-09	- -	- -	- -	1.2E-04	- -
		Total	4.2E-09	- -	- -	- -	2.8E-01	- -
	Ground Water	Dermal Contact	2.1E-04	Trichloroethene	1,1,2,2-Tetrachloroethane	Tetrachloroethene	6.7E+01	Trichloroethene
		Inhalation	1.7E-04	- -	1,1,2,2-Tetrachloroethane, Trichloroethene	- -	1.1E+01	Chloroform, Trichloroethene
		Total	3.8E-04	1,1,2,2-Tetrachloroethane, Trichloroethene	- -	Tetrachloroethene, Chloroform	7.8E+01	Chloroform, Trichloroethene
		Total All Media	3.8E-04				7.8E+01	
Maintenance Workers	Surface Soil	Ingestion	5.4E-12	- -	- -	- -	8.0E-03	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	5.4E-12	- -	- -	- -	8.0E-03	- -
Occupational Workers	Surface Soil	Ingestion	5.7E-11	- -	- -	- -	8.3E-02	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	5.7E-11	- -	- -	- -	8.3E-02	- -
Adult Recreational Users	Surface Soil	Ingestion	1.4E-11	- -	- -	- -	1.7E-02	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	1.4E-11	- -	- -	- -	1.7E-02	- -
Adolescent Trespasser	Surface Soil	Ingestion	4.2E-12	- -	- -	- -	1.4E-02	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	4.2E-12	- -	- -	- -	1.4E-02	- -

TABLE 7-9

CUMULATIVE RISK SUMMARY - REASONABLE MAXIMUM EXPOSURE
SWMU 01 - MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $\geq 10^{-6}$ and $\leq 10^{-5}$	Hazard Index (HI)	Chemicals with HI ≥ 1
Adult Resident	Surface Soil	Ingestion	7.6E-11	- -	- -	- -	1.2E-01	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	7.6E-11	- -	- -	- -	1.2E-01	- -
	Ground Water	Ingestion	1.3E-01	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Tetrachloroethene, Trichloroethene	1,1,1,2-Tetrachloroethane, Chloroform, Arsenic	- -	1.5E+03	1,1,2,2-Tetrachloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene
		Dermal Contact	1.3E-02	1,1,2,2-Trichloroethane, Trichloroethene	Tetrachloroethene	1,1,1,2-Tetrachloroethene, 1,2-Dichloroethane, Chloroform	1.6E+02	1,1,2,2-Tetrachloroethene, Trichloroethene
		Inhalation	2.7E-02	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene	1,1,1,2-Tetrachloroethane, 1,2-Dichloroethane	Tetrachloroethene	8.2E+01	1,2-Dichloroethane, Chloroform, Trichloroethene
		Total	1.7E-01	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, Tetrachloroethene, Trichloroethene	1,1,1,2-Tetrachloroethane, Arsenic	Hexachloroethane, Heptachlor	1.7E+03	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene
		Total All Media	1.7E-01				1.7E+03	
Child Resident	Surface Soil	Ingestion	1.8E-10	- -	- -	- -	1.1E+00	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	1.8E-10	- -	- -	- -	1.1E+00	- -
	Ground Water	Ingestion	1.1E-01	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Tetrachloroethene, Trichloroethene	1,1,1,2-Trichloroethane, Chloroform, Arsenic	- -	5.2E+03	1,1,2,2-Tetrachloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, Manganese
		Dermal Contact	1.1E-02	1,1,2,2-Tetrachloroethane, Trichloroethene	Tetrachloroethene	1,1,1,2-Trichloroethane, 1,2-Dichloroethane, Chloroform	5.6E+02	1,1,2,2-Tetrachloroethene, Tetrachloroethane, Trichloroethene
		Inhalation	3.1E-02	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene	1,1,1,2-Trichloroethane, 1,2-Dichloroethane	Tetrachloroethene	3.8E+02	1,2-Dichloroethane, Chloroform, Trichloroethene
		Total	1.5E-01	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, Tetrachloroethene, Trichloroethene	1,1,1,2-Tetrachloroethane, Arsenic	Heptachlor	6.1E+03	1,1,2,2-Tetrachloroethane, 1,1-Dichloroethene, 1,2-Dichloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene, Manganese
		Total All Media	1.5E-01				6.1E+03	

TABLE 7-9

CUMULATIVE RISK SUMMARY - REASONABLE MAXIMUM EXPOSURE
SWMU 01 - MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $\geq 10^{-6}$ and $\leq 10^{-5}$	Hazard Index (HI)	Chemicals with HI ≥ 1
Lifelong Resident	Surface Soil	Ingestion	2.5E-10	- -	- -	- -	NA	- -
		Dermal Contact	- -	- -	- -	- -	NA	- -
		Total	2.5E-10	- -	- -	- -	NA	- -
	Ground water	Ingestion	2.4E-01	1,1,1,2-Tetrachloroethane, 1,1,2,2-Trichloroethane, 1,2-Dichloroethane, Tetrachloroethene, Trichloroethene	Chloroform, Arsenic	Hexachloroethane, Heptachlor	NA	- -
		Dermal Contact	2.3E-02	1,1,2,2-Tetrachloroethane, Tetrachloroethene, Trichloroethene	1,2-Dichloroethane	1,1,1,2-Trichloroethane, Chloroform	NA	- -
		Inhalation	5.8E-02	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, Trichloroethene	1,1,1,2-Trichloroethane, Tetrachloroethene	- -	NA	- -
		Total	3.2E-01	1,1,1,2-Tetrachloroethane, 1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, Tetrachloroethene, Trichloroethene	Arsenic	Bis(2-ethylhexyl)phthalate, Hexachloroethane, Heptachlor	NA	- -
		Total All Media	3.2E-01				NA	

Notes:
NA - Not applicable.
Total HIs are summarized in this Table; HIs determined on a target organ basis are presented in Appendix G.

TABLE 7-10

CUMULATIVE RISK SUMMARY - CENTRAL TENDENCY EXPOSURE
SWMU 01 - MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-6}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $\geq 10^{-6}$ and $\leq 10^{-6}$	Hazard Index (HI)	Chemicals with HI ≥ 1
Construction Worker	Surface/Subsurface Soil	Ingestion	1.4E-09	- -	- -	- -	1.4E-01	- -
		Dermal Contact	3.8E-10	- -	- -	- -	3.3E-05	- -
		Total	1.8E-09	- -	- -	- -	1.4E-01	- -
	Groundwater	Dermal Contact	1.6E-04	- -	1,1,2,2-Tetrachloroethane, Trichloroethene	- -	4.9E+01	Trichloroethene
		Inhalation	1.3E-04	- -	1,1,2,2-Tetrachloroethane, Trichloroethene	- -	8.5E+00	Chloroform, Trichloroethene
		Total	2.8E-04	1,1,2,2-Tetrachloroethane, Trichloroethene	- -	- -	5.7E+01	Chloroform, Trichloroethene
		Total All Media	2.8E-04				5.8E+01	
Maintenance Workers	Surface Soil	Ingestion	4.9E-13	- -	- -	- -	2.0E-03	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	4.9E-13	- -	- -	- -	2.0E-03	- -
Occupational Workers	Surface Soil	Ingestion	8.9E-12	- -	- -	- -	3.6E-02	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	8.9E-12	- -	- -	- -	3.6E-02	- -
Adult Recreational Users	Surface Soil	Ingestion	1.1E-12	- -	- -	- -	4.3E-03	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	1.1E-12	- -	- -	- -	4.3E-03	- -
Adolescent Trespasser	Surface Soil	Ingestion	1.1E-12	- -	- -	- -	3.5E-03	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	1.1E-12	- -	- -	- -	3.5E-03	- -
Adult Resident	Surface Soil	Ingestion	1.1E-11	- -	- -	- -	5.8E-02	- -
		Dermal Contact	- -	- -	- -	- -	- -	- -
		Total	1.1E-11	- -	- -	- -	5.8E-02	- -
	Groundwater	Ingestion	2.7E-02	1,1,2,2-Tetrachloroethane, Trichloroethene	1,1,1,2-Tetrachloroethane, 1,2-Dichloroethane, Tetrachloroethene	Chloroform, Arsenic	1.0E+03	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene
		Dermal Contact	3.0E-03	1,1,2,2-Trichloroethane, Trichloroethene	Tetrachloroethene	1,1,1,2-Tetrachloroethene, 1,2-Dichloroethane	1.3E+02	1,1,2,2-Tetrachloroethene, Trichloroethene
		Inhalation	1.5E-02	1,1,2,2-Trichloroethane, Trichloroethene	1,2-Dichloroethane, Chloroform	1,1,1,2-Tetrachloroethene, Tetrachloroethene	4.5E+01	Chloroform, Trichloroethene
		Total	4.5E-02	1,1,2,2-Trichloroethane, Chloroform, Trichloroethene	1,1,1,2-Tetrachloroethane, 1,2-Dichloroethane, Tetrachloroethene	Arsenic	1.2E+03	1,1,2,2-Tetrachloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene
		Total All Media	4.5E-02				1.2E+03	

TABLE 7-10

CUMULATIVE RISK SUMMARY - CENTRAL TENDENCY EXPOSURE
SWMU 01 - MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

Receptor	Media	Exposure Route	Cancer Risk	Chemicals with Cancer Risks $> 10^{-4}$	Chemicals with Cancer Risks $> 10^{-5}$ and $\leq 10^{-4}$	Chemicals with Cancer Risks $\geq 10^{-6}$ and $\leq 10^{-5}$	Hazard Index (HI)	Chemicals with HI ≥ 1
Child Resident	Surface Soil	Ingestion	3.0E-11	- -	- -	- -	5.4E-01	- -
		Dermal Contact	- - -	- -	- -	- -	- -	- -
		Total	3.0E-11	- -	- -	- -	5.4E-01	- -
	Ground Water	Ingestion	1.7E-02	1,1,2,2-Tetrachloroethane, Trichloroethene	1,2-Dichloroethane, Tetrachloroethene	1,1,1,2-Trichloroethane, Chloroform, Arsenic	2.3E+03	1,1,2,2-Tetrachloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene
		Dermal Contact	2.1E-03	1,1,2,2-Tetrachloroethane, Trichloroethene	Tetrachloroethene	1,2-Dichloroethane	3.2E+02	1,1,2,2-Tetrachloroethene, Trichloroethene
		Inhalation	1.7E-02	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene	1,2-Dichloroethane	1,1,1,2-Tetrahcloroethene, Tetrachloroethene	2.1E+02	1,2-Dichloroethane, Chloroform, Trichloroethene
		Total	3.6E-02	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene	1,1,1,2-Tetrachloroethane, 1,2-Dichloroethane, Tetrachloroethene	Arsenic	2.8E+03	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, cis-1,2-Dichloroethene, Tetrachloroethene, Trichloroethene
		Total All Media	3.6E-02				2.8E+03	
Lifelong Resident	Surface Soil	Ingestion	4.1E-11	- -	- -	- -	NA	- -
		Dermal Contact	- -	- -	- -	- -	NA	- -
		Total	4.1E-11	- -	- -	- -	NA	- -
	Ground Water	Ingestion	4.4E-02	1,1,2,2-Tetrachloroethane, Trichloroethene	1,1,1,2-Trichloroethane, 1,2-Dichloroethane, Chloroform, Tetrachloroethene	Arsenic	NA	- -
		Dermal Contact	5.1E-03	1,1,2,2-Tetrachloroethane, Trichloroethene	Tetrachloroethene	1,1,1,2-Trichloroethene, 1,2-Dichloroethane, Chloroform	NA	- -
		Inhalation	3.2E-02	1,1,2,2-Tetrachloroethane, Chloroform, Trichloroethene	1,1,1,2-Tetrahcloroethene, 1,2-Dichloroethane	Tetrachloroethene	NA	- -
		Total	8.1E-02	1,1,2,2-Tetrachloroethane, 1,2-Dichloroethane, Chloroform, Trichloroethene	1,1,1,2-Tetrachloroethane, Trichloroethene	Arsenic	NA	- -
		Total All Media	8.1E-02				NA	

Notes:
NA - Not applicable.

TABLE 7-11

SUMMARY OF CONCLUSIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

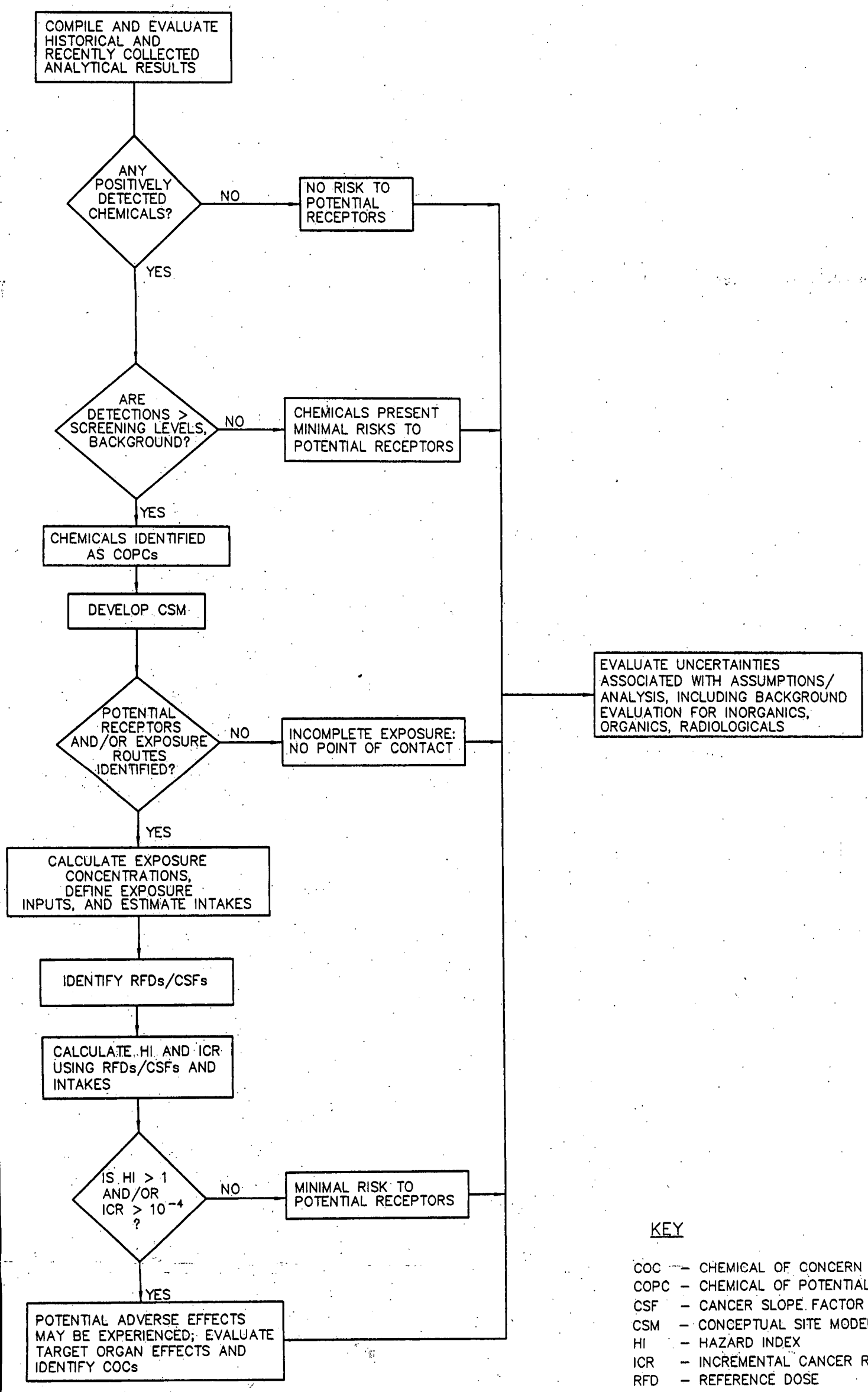
Chemical of Concern[1]	Impact on Human Receptors	Comments
GROUND WATER		
1,1,1,2-Tetrachloroethane	Child Resident: ILCR = 7.3E-5 Adult Resident: ILCR = 8.0E-05 Total Lifelong Resident: ILCR = 1.5E-04	Risks for ground water are based on hypothetical exposure to ground water in future excavation projects of in future use of ground water as a domestic water supply. Ground water is not currently used at the site. Estimated risks for VOCs were based on exposure to concentrations in the most highly contaminated well (01GW02). There is considrable uncertainty in the exposure point concentrations. Concentrations in this well varied by several orders of magnitude between Rounds 1 and 2. Risks based on VOC concentrations in Well 01GW02 may be overestimated by more than 2 orders of magnitude compared to other contaminated wells at the site. However, total ILCRs for these other wells would be greater than 1.0E-03. The U.S. EPA has recently withdrawn the CSF for 1,1-DCE. Therefore, carcinogenic risk estimates were not calculated for 1,1-DCE.
1,1,2,2-Tetrachloroethane	Construction Worker: ILCR = 1.8E-4 Child Resident: ILCR = 7.8E-2 HQ = 66 Adult Resident: ILCR = 8.6E-2 HQ = 19 Total Lifelong Resident: ILCR = 1.6E-1	
1,1-Dichloroethene	Child Resident: HQ = 1.4	
1,2-Dichloroethane	Child Resident: ILCR = 2.5E-4 HQ = 6.4 Adult Resident: ILCR = 2.7E-4 HQ = 1.4 Total Lifelong Resident: ILCR = 5.2E-4	
Chloroform	Construction Worker: ILCR = 1.0E-6 HQ = 9.6 Child Resident: ILCR = 2.4E-4 HQ = 330 Adult Resident: ILCR = 2.2E-4 HQ = 72 Total Lifelong Resident: ILCR = 4.6E-4	
cis-1,2-Dichloroethene	Child Resident: HQ = 5.1 Adult Resident: HQ = 1.5	
Tetrachloroethene	Construction Worker: ILCR = 1.2E-6 Child Resident: ILCR = 2.3E-4 HQ = 5 Adult Resident: ILCR = 2.6E-4 HQ = 1.4 Total Lifelong Resident: ILCR = 4.9E-4	
Trichloroethene	Construction Worker: ILCR = 2.0E-4 HQ = 68 Child Resident: ILCR = 7.5E-2 HQ = 5700 Adult Resident: ILCR = 8.1E-2 HQ = 1600 Total Lifelong Resident: ILCR = 1.6E-1	

TABLE 7-11

SUMMARY OF CONCLUSIONS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical of Concern[1]	Impact on Human Receptors	Comments
GROUND WATER (Continued)		
Bis(2-ethylhexyl)phthalate	Total Lifelong Resident: ILCR = 1.2E-6	Risks for groundwater are based on hypothetical future use as a domestic water supply. Groundwater is not currently used at the site. BEHP is a common laboratory contaminant and the total residential ILCR for BEHP is well within the U.S. EPA's risk management range.
Hexachloroethane	Adult Resident: ILCR = 1.0E-6 Total Lifelong Resident: ILCR = 1.9E-6	Risks for groundwater are based on hypothetical future use as a domestic water supply. Groundwater is not currently used at the site. Hexachloroethane was only detected in one Round 1 sample and the total residential ILCR for hexachloroethane is within the U.S. EPA's risk management range.
Heptachlor	Child Resident: ILCR = 1.0E-6 Adult Resident: ILCR = 1.2E-6 Total Lifelong Resident: ILCR = 2.2E-6	Risks for groundwater are based on hypothetical future use as a domestic water supply. Groundwater is not currently used at the site. Heptachlor was detected in two samples at estimated concentrations (below the SQL) and the total residential ILCR for heptachlor is within the U.S. EPA's risk management range.
Arsenic	Child Resident: ILCR = 1.4E-5 Adult Resident: ILCR = 1.6E-5 Total Lifelong Resident: ILCR = 3.0E-5	Risks for groundwater are based on hypothetical future use as a domestic water supply. Groundwater is not currently used at the site. Total residential ILCR for arsenic is within the U.S. EPA's risk management range. Concentrations of arsenic in all wells at the site are less than the proposed MCL (10 µg/L). Background was not used in the COPC selection of for groundwater.
Manganese	Child Resident: HQ = 1.9	Risks for groundwater are based on hypothetical future use as a domestic water supply. Groundwater is not currently used at the site. Risks for manganese are based on the concentration in Well 01GW02 and may be underestimated by as much as an order of magnitude compared to concentrations in other wells. However, as shown in previous HHRAs performed for NSWC Crane, high concentrations of manganese are common in soil and groundwater and may be naturally occurring at Crane. Background was not used in the COPC selection for groundwater.

HQ = Hazard Quotient.
ILCR = Incremental Lifetime Cancer Risk.
1 - Any carcinogenic chemical with an ILCR greater than 1.0E-6 or a noncarcinogenic chemical contributing to target organ hazard indices (HI) greater than 1.0.



KEY

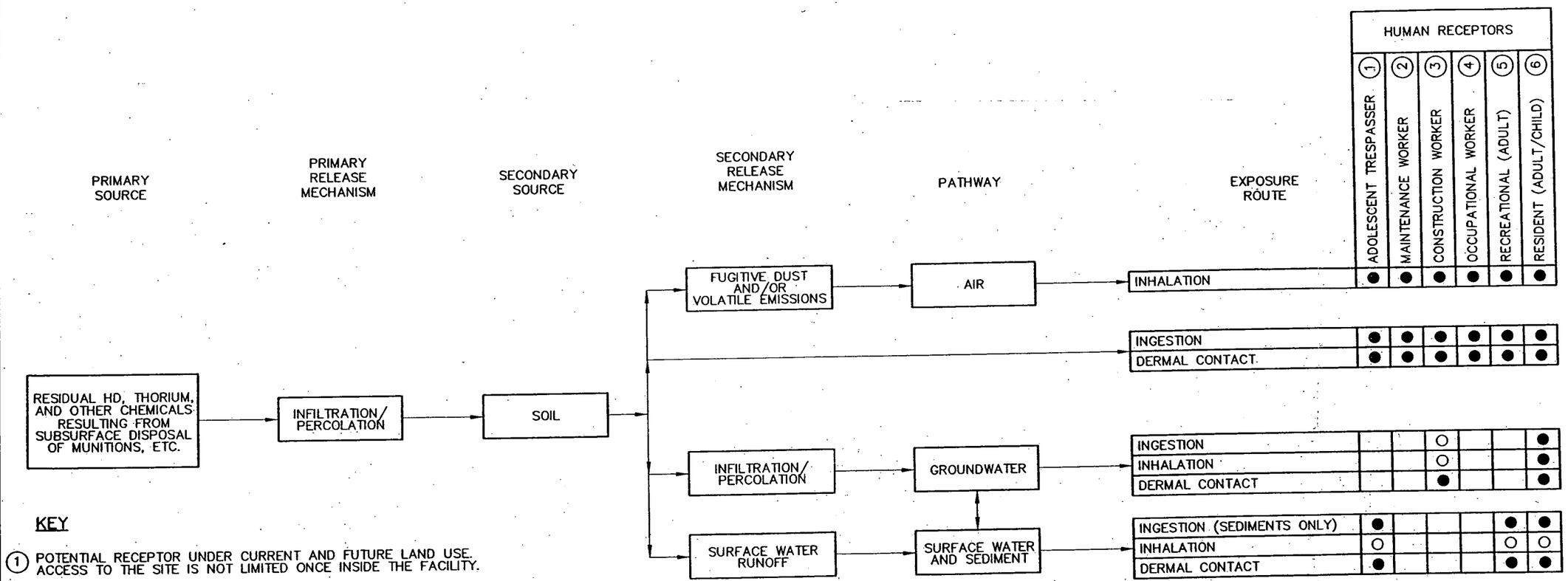
COC – CHEMICAL OF CONCERN
COPC – CHEMICAL OF POTENTIAL CONCERN
CSF – CANCER SLOPE FACTOR
CSM – CONCEPTUAL SITE MODEL
HI – HAZARD INDEX
ICR – INCREMENTAL CANCER RISK
RFD – REFERENCE DOSE

ACAD: 0504KF02.dwg 05/07/01 HJP

DRAWN BY HJP DATE 5/7/01	SUMMARY OF HUMAN HEALTH RISK ASSESSMENT PROCESS SWMU 01 – MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	CONTRACT NO. 0504	
CHECKED BY DATE		APPROVED BY DATE	
COST/SCHED–AREA		APPROVED BY DATE	
SCALE NOT TO SCALE		DRAWING NO. FIGURE 7–1	REV. 0

FORM CADD NO. SDIV_BV.DWG – REV 0 – 1/20/98

ACAD:0504kf01.dwg 12/26/02 MF PIT



KEY

(1) POTENTIAL RECEPTOR UNDER CURRENT AND FUTURE LAND USE. ACCESS TO THE SITE IS NOT LIMITED ONCE INSIDE THE FACILITY.

(2) POTENTIAL RECEPTOR UNDER FUTURE LAND USE.

(3) POTENTIAL RECEPTOR UNDER FUTURE LAND USE. A SHORT-TERM PROJECT (I.E. UTILITY INSTALLATION) MAY OCCUR.

(4) PLAUSIBLE FUTURE RECEPTOR. HOWEVER, SITE IS NOT LIKELY TO BE DEVELOPED.

(5) POTENTIAL RECEPTOR UNDER FUTURE LAND USE. BASE COULD CLOSE AND BE TURNED INTO A STATE PARK.

(6) POTENTIAL RECEPTOR UNDER FUTURE LAND USE. EVALUATED FOR DECISION-MAKING PURPOSES.

● EXPOSURE PATHWAY TO BE EVALUATED IN RISK ASSESSMENT.

○ RELATIVELY INSIGNIFICANT POTENTIAL EXPOSURE PATHWAY COMPARED TO OTHER PATHWAYS EVALUATED IN THE RISK ASSESSMENT. RISKS NOT EVALUATED QUANTITATIVELY.

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 5/7/01
CHECKED BY DATE
COST/SCHED-AREA
SCALE NOT TO SCALE

CONCEPTUAL SITE MODEL
SWMU 01 – MUSTARD GAS BURIAL GROUND
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. 0504
APPROVED BY DATE
APPROVED BY DATE
DRAWING NO. FIGURE 7-2
REV. 0

FORM CADD NO. SDV_BH12.DGN – REV 0 – 1/20/98

8.0 ECOLOGICAL RISK ASSESSMENT

The goal of the SERA is to evaluate the potential for adverse ecological impacts of site-related contamination. The SERA is used to determine the need for further investigation and/or remedial action at MGBG, NSWC Crane.

8.1 INTRODUCTION

The SERA for MGBG at NSWC Crane was conducted in accordance with the following guidance documents:

- Department of Navy Environmental Policy Memorandum 97-04: Use of Ecological Risk Assessments (DON, 1997)
- Chief of Naval Operations Letter 5090 Ser N453E/9U 59 5335 (April 5, 1999).
- Navy Policy for Conducting Ecological Risk Assessment (DON, 1999).
- Final Guidelines for Ecological Risk Assessment (U.S. EPA, 1998b).
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (U.S. EPA, 1997a).

This ERA consists of Steps 1, 2, and 3a of the eight steps required by U.S. EPA guidance (U.S. EPA, 1997a; U.S. EPA, 1998b) and the Navy Policy for Conducting Ecological Risk Assessments (DON, 1999). The first two steps are the screening level risk assessment. Step 3a is the first step of the baseline ecological risk assessment (BERA) and consists of refining the list of COPCs that were retained following Steps 1 and 2. Steps 3b through 7 were not required as part of this investigation but are conducted if additional evaluations or investigations are necessary. Finally, Step 8, risk management, is incorporated throughout the ERA process, in cooperation with the U.S. EPA Region 5 Biological Technical Assistance Group (BTAG). Figure 8-1 presents the Navy's Ecological Risk Assessment Tiered Approach.

Due to the potential complexity, ecological risk assessments are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs consist of meetings involving the risk managers and risk assessment team and are conducted to evaluate the work up to that

point and to ensure that the ecological risk assessment is proceeding in an efficient manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met. The results are then used to identify the data required for the next tier, if necessary. U.S. EPA guidance for conducting ERAs suggests an SMDP at the end of Step 2 of the ERA process. As mentioned above, this ERA includes Steps 1, 2, and 3a of the ERA process. Step 3a was conducted without an official post-Step 2 SMDP to expedite the ERA process. The SMDP is presented between Step 2 and Step 3a and provides the rationale for conducting the Step 3a evaluation.

8.2 PROBLEM FORMULATION

Problem formulation, the first step of a SERA, results in three products (U.S. EPA, 1998b):

- Assessment endpoints that adequately reflect management goals and the ecosystems they represent.
- Conceptual models that describe the key relationships between a stressor and assessment endpoint or among several stressors and assessment endpoints.
- An analysis plan.

Problem formulation includes identification of the following:

- Ecosystems potentially at risk
- Source and stressor characteristics
- Exposure characteristics
- Ecological effects

The problem formulation process enables the risk assessor to identify the ecological resources to be protected (known as assessment endpoints), the measurements used to evaluate risks to those resources (known as measures of effects), and the chemicals, geographic areas, and environmental media relevant to the risk assessment.

8.2.1 Environmental Setting

Descriptions of the habitat and potential ecological receptors at the site are presented in this section of the ERA. The problem formulation phase of the ERA also describes likely chemical sources, release

mechanisms, migration pathways, and the fate of chemicals resulting from site-related activities, as well as ecological resources that could be adversely affected by chemicals.

The following paragraphs briefly summarize the base-wide and site-specific environmental setting.

8.2.1.1 Basewide Environmental Setting

A biological characterization of NSWC Crane Facility, including a listing of plants and animals found at the Facility, is presented in the Installation Assessment (IA) (U.S. Army, 1978) and the Initial Assessment Study (IAS) (NEESA, 1983), and is summarized in the Environmental Monitoring Reports (EMR) (Halliburton NUS, 1992a,b). A list of the species that may inhabit NSWC Crane and are protected under the U.S. Endangered Species Act, Indiana Department of Natural Resources Heritage Data Center, or the U.S. Fish and Wildlife Service is included in the RCRA Facility Permit (U.S. EPA, 1995). The following paragraphs briefly summarize the environmental setting at the base.

Terrestrial Habitats:

Eighty percent of NSWC Crane's 63,000 acres are classified as Central Hardwoods Forest of the United States (NEESA, 1983). In addition, some agricultural fields are in various stages of succession. Openings on dry upland sites contain almost pure stands of grasses with some clumps of woody plants such as persimmon, sassafras, and sumac. Areas that are typically more wet have river birch, willow, sycamore, and cottonwood. Hillside communities have mostly hickory, white and black oak, red maple, sugar maple, tulip poplar, ash, and beech (NEESA, 1983).

The great variety of habitats at NSWC Crane (i.e., many stages of forest succession, streams, ponds, Lake Greenwood, grassy open spaces) lead to a high diversity of animal species (NEESA, 1983). Some of these species include (but are not limited to) white-tailed deer, beaver, coyote, hawk, red fox, rabbit, raccoon, mice; birds such as ducks, geese, wild turkey, bobwhite quail, red-tailed hawk, and American robin; and various amphibians, reptiles, fish, and invertebrates.

The bird population includes a number of state or federal threatened, endangered, or species of special concern whose home ranges could include the site. These species include the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and the worm-eating warbler (B&R Environmental, 1997). Also, the Indiana bat, a federally endangered species, is known to forage at NSWC Crane. During a mist net and radiotelemetry survey conducted for NSWC Crane, a male Indiana bat was captured along Furst Creek. Because of the bat and its potential

habitat, the cutting of trees is restricted to certain times during the year, and the cutting of shagbark hickory trees is prohibited.

Aquatic Habitats:

Six main creeks receive drainage in five separate drainage basins at NSWC Crane: Furst Creek, Sulphur Creek, Little Sulphur Creek, Boggs Creek, Turkey Creek, and Seed Tick Creek. There also are many smaller streams, creeks, and drainage ditches located at the Facility, along with several small man-made ponds and one large lake (Greenwood Lake). Greenwood Lake is the source of potable water for NSWC Crane. Surface water from the Facility eventually discharges to the east fork of the White River, which is located south of the Facility.

Previous studies conducted at NSWC Crane (Nelson et al., 1987) identified 21 amphibian species and 22 reptile species (including skinks, lizards, snakes, and turtles).

A total of 46 distinct fish species were collected from the Facility during a 1987 inventory of the fish fauna at NSWC Crane. Other than Greenwood Lake, the 1987 study observed that the greatest number of individual fish species were recorded from the largest stream (Boggs Creek) and the smallest number of species were recorded from Turkey Creek. Boggs Creek contained 29 species including eight species of fish characteristic of large river type systems. This included long-nose gar, paddlefish, bowfin, gizzard shad, ribbon shiner, bigmouth buffalo, channel catfish, and flathead catfish. By contrast, the Turkey Creek survey yielded 16 species of fish, none of which were unusual.

8.2.1.2 Site-Specific Environmental Setting

The MGBG lies on a gently rolling northwest-southeast ridge crest. Elevations at the site range from approximately 660 to 680 feet amsl, and the highest elevations at the MGBG are only 5 to 10 feet greater than Hwy 251, immediately south of the site. A deeply incised drainage channel lies about 450 feet north of the MGBG. The elevation along this channel is approximately 530 to 580 amsl. Another deeply-incised channel lies about 1,200 feet south-southwest of the MGBG and its elevation is about 510 to 560 feet amsl as it passes south of the MGBG. The steepest slopes near the MGBG occur on the north side and are about 30 percent.

Runoff from the MGBG drains into the two drainage channels/unnamed tributaries of Goldsberry Hollow, which drains west-southwest about 1.2 miles before entering Boggs Creek (see Figure 1-2). Boggs Creek then flows southward into a large reservoir located at the southern boundary of NWSC Crane. From the

reservoir, Boggs Creek continues to flow south about 6 miles where it joins the East Fork of the White River. The Boggs Creek basin drains roughly 70 percent of NWSC Crane. The Boggs Creek-Goldsberry Hollow waterbody segment designated state water uses are aquatic life support, fish consumption, and primary contact. This waterbody segment was not assessed as part of the 2004 Indiana Integrated Water Quality Monitoring and Assessment Report to determine if the waterbody was supporting those uses (IDEM, 2004). However, the Boggs Creek-Buzzard Run waterbody segment, located downstream of the Boggs Creek-Goldsberry Hollow waterbody segment, is fully supporting the aquatic life support and primary contact water uses; it was not assessed for the fish consumption water use (IDEM, 2004).

A site reconnaissance was conducted at the MGBG site on January 18, 2000. Appendix H.1 includes the checklist that was used as guidance in making observations for the ERA. The area was observed to be heavily vegetated with grasses/shrubs ranging from 1 to 5 feet high at the time of the site visit. Some small saplings were scattered over the site, but they did not exceed about 7 feet in height, except at the tree lines on the northern, eastern and southern edges of the site. The areas to the east and west of the site are vegetated with a very dense layer of shrubs and grasses. The land rolls off on the northeast edge of the site and toward the southwest of HWY 251. At the northeast end of the MGBG northern edge, a mound of earth with some scrap material was observed. Figures 1-3, 1-4, 1-7, and 1-19 are site photographs that depict the habitats located at the MGBG.

The area to the north of the site (including the northeast corner of the site) is heavily wooded with mature deciduous trees including oaks, maples, sycamore, and American beech. The understory in the forest consisted of sparse patches of vegetation (i.e., ferns, grasses, moss). The drainage channel north of the site was dry at the time of the site visit (with the exception of a few small shallow pools of standing water). Based on the scoured nature of the channel, it appears to experience heavy flows during rain events. The stream bed was approximately 10 feet wide, and the substrate was sand/exposed rocks. There were two primary drainage ditches (both were dry) leading from the site area to this intermittent drainage channel.

A few scrap piles with asphalt and concrete were visible between the MGBG and HWY 251 to the southeast of the site. The piles were approximately 2 to 5 feet high. There is a drainage ditch immediately north of, and parallel to, HWY 251 that lies between the road and the southern border of the MGBG. At least one culvert transports site runoff via the drainage ditch into the intermittent drainage channel located about 400 feet south-southwest of the MGBG. The ditch north of Hwy 251 was dry at the time of the site visit.

The area to the south of HWY 251 is heavily wooded with mature deciduous trees including oaks, maples, sycamore, and American beech. The understory in the forest consisted of various shrubs and vines.

Terrestrial Habitats:

Both the MGBG and NSWC Crane are generally heavily vegetated and forested. Relatively dense trees, brush, and grasses cover the MGBG. Deciduous trees present include oaks, maples, sycamore, sassafras, and American beech. Dominant tree species include black oak, white oak, pignut hickory, and yellow poplar. The wildlife habitats and vegetation types present at NSWC Crane (many stages of forest succession, streams, ponds, Greenwood Lake, and grassy open spaces) support a diverse terrestrial and aquatic fauna. The abundance of diverse wildlife on the site can be contributed to the mixture of landforms and vegetation types that occur over the area.

Terrestrial habitats at the site consist of wooded areas and grasses that provide shelter and food sources for a varied array of species. The white-tailed deer is the most conspicuous large wild mammal at the Facility. Other mammals include opossums, raccoons, rabbits, mice, bats, chipmunks, squirrels, beaver, groundhogs, gray foxes, coyotes, and long-tailed weasels. Foxes, coyotes, and hawks are carnivorous species whose presence indicates a healthy ecosystem because smaller mammals are present to provide a food source (NEESA, 1983).

Birds present at the MGBG are abundant and diverse. Previous studies at the Crane Facility have identified over 100 species present at the site during breeding seasons (Hengeveld, 1987). Because the Facility is largely forested, the species found at the site consist predominantly of those that frequent wooded habitat types. A large number of bird species frequent the non-forested grassland, oldfield, and scrub/shrub vegetation present over portions of the MGBG. A number of threatened, endangered, or bird species of special concern, such as the bald eagle, osprey, sharp-shinned hawk, red-shouldered hawk, broad-winged hawk, black and white warbler, hooded warbler, and the worm-eating warbler (B&R Environmental, 1997) use NSWC Crane and the MGBG as their home range.

Aquatic Habitats:

There are no surface water resources at the MGBG site or in the ditches that drain the immediate area. According to NSWC Crane personnel, the drainage ditch 450 feet north of the site and the drainage ditch 1,200 feet south of the site are dry except after recent rain events. Even under greater-than-average rainfall conditions, the two ditches are only intermittently wet. The generally dry conditions in these

ditches results in the absence of fish and permanent aquatic habitat, although some sediment-related invertebrates probably occur in the ditches. Surface water was present in both ditches during Round 2 sampling (June, 2002), which was conducted following an especially wet month (10.4 inches of rainfall in May; Table 1-1).

Threatened and Endangered Species:

An Endangered Species Management Plan for NSWC Crane was prepared in October 2000 (Comarco Systems, Inc., 2000). As part of this plan, the federal and state endangered and threatened species and species of special concern for the facility were identified. This was accomplished by the compilation of a large amount of information on species present at NSWC Crane. Information included in the Endangered Species Management Plan (Comarco Systems, Inc., 2000) was obtained from studies and surveys conducted by the Navy and other agencies and groups (such as research institutions). A small subset of these studies include the Inventory of Neotropical Migratory Birds, Mist Net and Radiotelemetry Surveys for the Indiana bat, Bobcat Trapping, Rattlesnake Survey, Purdue University Wildlife Studies, and several fish surveys and bird counts. These studies and others that were used in compiling a list of endangered species present at NSWC Crane are described in more detail in the Endangered Species Management Plan (Comarco Systems, Inc., 2000).

Numerous wildlife species are present throughout NSWC Crane. Of these species, some are listed as endangered and threatened species or species of special concern. NSWC Crane occupies Daviess, Greene, Lawrence, and Martin counties in Indiana, although only a very small portion of NSWC Crane is in Daviess, Greene, and Lawrence counties. The Fanshell pearly mussel, tubercled blossom, ring pink, and clubshell are listed as federally endangered species within Martin, Daviess and Lawrence counties. Additionally, the Northern riffleshell and rough pigtoe are listed as federally endangered species in Martin County. These invertebrate species are not likely to be present at SWMU 01 because they prefer medium to large rivers with moderate currents and gravel substrates as habitat. The preferred habitat that these species prefer is absent at NSWC Crane. Additionally, none of these species was identified in Comarco Systems Inc., 2000 as observed at NSWC Crane. The Indiana bat is listed as federally endangered in Greene, Lawrence, and Martin counties but not in Daviess County. Figure 8-2 presents capture locations from the misty net and radiotelemetry survey of the Indiana bat as NSWC Crane (see Section 8.2.4.1, Carnivorous Birds and Mammals, for a discussion on the likelihood that the Indiana Bat is present at SWMU 01). Only the bald eagle is listed as a federal threatened species in all four counties. The bald eagle is not likely to be present at SWMU 01 due to a lack of vast expanses of water (i.e., the preferred hunting habitat for the bald eagle) at this SWMU. There are no records of any other species at NSWC that are federally listed as endangered or threatened.

Ten species listed as endangered by the Indiana Department of Natural Resources have been recorded at NSWC and include the Indiana bat, bobcat, timber rattlesnake, bald eagle, osprey, loggerhead shrike, yellow crowned night heron, Virginia rail, king rail, and Henslow's sparrow (Comarco Systems Inc., 2000). No state-listed threatened species have been recorded at NSWC Crane. Bald eagles (as discussed above) and ospreys are not expected to occur at SWMU 01 due to the absence of preferred foraging habitat (large open waters). Similarly, the Virginia rail and king rail are found in marshes and mudflats, the Henslow's sparrow is found in damp fields, and the yellow crowned night heron is primarily a bird of swamps. These habitats are absent from SWMU 01. The loggerhead shrike prefers open fields with scattered trees, but is occasionally found in open woodlands. Thus, use of the site by the loggerhead shrike would be occasional at most. The prime timber rattlesnake habitat is forested land on higher dry ridges with a south or southwestern exposure. SWMU 01 is located on a high dry ridge, so it is possible that the timber rattlesnake is present at the SWMU. As discussed above, Boggs Creek discharges off-site to the East Fork of the White River. River otters, a state endangered species, are being reintroduced to Indiana. The otters are expanding from their original release sites into other watersheds including the East Fork of the White River (IDFW, 2000). Also, the East Fork of the White River is the site for an ongoing study of lake sturgeon populations, another state endangered species (IDFW, 2000). Finally, spotted darters, a state endangered species, has been found in the East Fork of the White River (IDFW, 2000). Note that other threatened, endangered, or special concern species also may be present in the water bodies just off-site of Crane, as well.

Some species that are listed as Federal species of concern in Comarco Systems, Inc. (2000) are also state endangered species (IDNR, 2002). These include the Northern Harrier (Daviess County), American bittern (Greene County), and sedge wren (Lawrence County). These species are not endangered in Martin County, where the majority of NSWC Crane occupies and so it is unlikely that operations at NSWC Crane are affecting these species' populations significantly. See Section 8.7.1 for a discussion of the uncertainties associated with not quantitatively evaluating risks to these species in the ERA.

The Rare Animals of Indiana list (Indiana DNR, 2002) was reviewed to verify that no change in status of these species had occurred since October 2000. This list is much larger than that presented in Comarco Systems, Inc. (2000) and is not reiterated here. It was verified that the species listed above did not experience a change in status. Also, the County Distribution of Indiana's Federally Threatened, Endangered, Proposed, and Candidate Species list (USFWS, 2002) was reviewed to verify that no change in status of these species had occurred since October 2000.

8.2.2 Physical and Chemical Characteristics

Chemicals detected in sediment and surface soil at the MGBG include VOCs, SVOCs, energetics, pesticides, PCBs, herbicides, inorganics, and radionuclides. Physical and chemical characteristics of contaminants affect their mobility, transport, and bioavailability in the environment. These characteristics include K_{OC}, K_{OW}, pH, and vapor pressure. Section 6.0 discusses these factors as they relate to the fate and transport of chemicals detected at the site. Appendix H.2 presents toxicity data for detected chemical constituents.

8.2.3 Potential Sources of Contamination and Associated Exposure Pathways

The MGBG was initially identified as an area warranting further investigation (TtNUS, 1999). For this reason, surface soil samples were collected from terrestrial habitats on the site, and sediment samples were collected from intermittent streams north and south of the MGBG. The samples were analyzed for VOCs, SVOCs, energetics, pesticides, PCBs, herbicides, inorganics, and radionuclides. Additionally, surface water samples were collected but were analyzed for VOCs only based on detections in Round 1 ground water samples. Analytical results for the samples are presented in Section 4.0. The nature and extent of contamination is discussed in Section 5.0.

Chemicals released from materials dumped in terrestrial areas of MGBG can initially contaminate surface soils. Natural precipitation can then cause the chemical contaminants to leach downward into the subsurface soils and ground water. Discharge of the ground water to the northern and southern drainage ditches can result in the contamination of surface water and sediment. Precipitation striking the soil surface can also dislodge contaminated surface soil and carry it suspended in the runoff into these surface waters. As mentioned in Section 8.2.1.2, the ditches are dry except after recent rain events, and thus aquatic receptors are generally absent. The nearest permanent streams are approximately 1.2 miles downgradient, where the ditches drain into Bogg's Creek.

Terrestrial ecological receptors such as plants, soil invertebrates, mammals, birds, reptiles, and amphibians can be exposed to contaminated surface soil through direct contact. Mammals, birds, reptiles, and amphibians can also ingest contaminated surface soil and food items in which contaminants have accumulated. Some terrestrial receptors such as burrowing mammals or deep-rooted trees could be exposed to shallow layers of contaminated subsurface soils or to shallow ground water, but most terrestrial receptors are not substantially exposed to subsurface soils or to ground water that has not discharged to surface water. After ground water is discharged via seeps, springs, or stream baseflow, terrestrial receptors can ingest or be directly exposed to contaminated surface water.

Aquatic ecological receptors such as fish and benthic macroinvertebrates can be exposed to chemical contamination through direct contact and ingestion of contaminated surface water or sediment. Fish and piscivorous (fish-eating) wildlife can also feed on other aquatic biota that have accumulated chemical contaminants from the surface water and sediment. This exposure pathway is essentially incomplete at the MGBG site due to the absence of permanent aquatic habitat at the site or in nearby ditches and drainage channels. As a conservative measure; however, the surface water/sediment pathway will be evaluated.

The potential pathways by which ecological receptors may be exposed to COPCs at MGBG were identified, along with the individual receptor species that could be adversely affected by these chemicals. The potential sources of contamination were caused by various activities that occurred at the site. Chemical contaminants released to soils at the site may have migrated to other media (i.e., ground water, surface water, and sediment). The following subsections discuss the applicable exposure pathways at MGBG.

8.2.3.1 Surface Soil

Based on historical site operations and available data, soil is the primary source of contamination at the MGBG. Several groups of terrestrial ecological receptors can be exposed to contaminants in surface soil. Invertebrates such as earthworms are exposed to contaminants through direct contact and can ingest soil particles. Plants are exposed to contaminants via direct contact as contaminants are absorbed through the roots and may then translocate to different parts of the plants (e.g., leaves, seeds). These pathways were evaluated for invertebrates and plants in the SERA.

Small mammals and birds may be exposed to contaminants in soil via several exposure routes. They may be exposed by direct contact as they search for food or (for mammals) as they burrow into the soil. However, exposure of terrestrial wildlife to contaminants in the soil via dermal contact is unlikely to represent a major exposure pathway because fur, feathers, and chitinous exoskeletons are expected to minimize transfer of contaminants across dermal tissue. Therefore, the dermal pathway was not evaluated for mammals and birds in the SERA. Small mammals and birds also may be exposed to contaminants in the soil via incidental ingestion of soil and ingestion of plants and/or invertebrates that have accumulated contaminants from the soil. These pathways were evaluated in the SERA.

Larger predatory species such as the red fox and red-tailed hawk can be indirectly exposed to soil contaminants by ingesting small mammals that have accumulated contaminants from soil. This pathway was not quantitatively evaluated in the SERA for reasons discussed in Section 8.2.5.

8.2.3.2 Ground Water

Ecological receptors are not directly exposed to contaminants in the ground water at the site. Exposure to ground water after discharging as a seep or directly to a surface water body however, does represent a complete exposure pathway and was evaluated as part of the surface water pathway.

8.2.3.3 Surface Water/Sediment

As mentioned above, contaminants in ground water could discharge as a seep that flows into surface water or discharges directly into a surface water body. Contaminants in soil could also enter surface water bodies via overland flow.

Two drainage ditches are present near the MGBG; one north of the former burial areas and one south of the former burial areas. It is unlikely that a complete exposure pathway exists between possible contamination at the MGBG and potential aquatic receptors because of the absence of permanent aquatic habitat. The ditches could be classified as intermittent streams, but during normal dry conditions, are incapable of supporting benthic macroinvertebrates and fish. Surface water and sediment were evaluated in both ditches as a conservative measure.

As mentioned in Section 8.2.3.2, it is possible that contaminants in ground water could discharge into surface water drainage channels. Some very limited evidence of this was found in sediment sampling of shallow drainage channels near the MGBG and is discussed in Sections 5.3, 5.4, and 6.3.2 of the draft RFI report. Section 6.3.2 indicates that there is no reason to believe that a ground water to surface water pathway exists. In addition, it is unlikely that a complete exposure pathway exists between the MGBG site and potential aquatic receptors due to the absence of permanent aquatic habitat. Boggs Creek, which is located 1.2 miles downstream of the MGBG, receives runoff from 70 percent of Crane, including the MGBG. However, low contaminant concentrations observed in MBGB drainage channel sediments, the limited volume of contaminated ground water near the MGBG, and the expected volatilization of organic chemicals from surface water in MGBG drainage channels suggest that no significant or even measurable concentrations of contaminants attributable to the MGBG could be found in Boggs Creek. The limited amount of contamination detected in any sediments would not be enough to create an unacceptable exposure condition, even if the sediment could be transported to Boggs Creek without

further dilution. This is also true for surface water. The data presented on Figure 5-10 indicate that no significant contamination attributable to the MGBG is leaving the MGBG area in surface water or sediment. The MGBG contaminated ground water plume is far enough (more than a mile) from Boggs Creek as to not pose any exposure threat to Boggs Creek.

8.2.3.4 Air

Although inhalation of particulates by mammals and birds may be a complete pathway, it is expected to be insignificant compared to other pathways such as ingestion of food items that have bioaccumulated contaminants from soil. Also, inhalation pathways typically are not evaluated in SERAs because of the uncertainty inherent in estimating exposure levels and toxicological effects. Therefore, the air inhalation pathway was not evaluated in this SERA.

8.2.4 Endpoints

8.2.4.1 Assessment Endpoints

Assessment endpoints are explicit expressions of the environmental value that is to be protected (U.S. EPA, 1997a). The selection of these endpoints was based on the habitats present, the migration pathways of probable contaminants, and the routes that contaminants may take to enter receptors.

The habitats at and adjacent to the site consist of forested areas, open fields with grasses, and intermittent streams. For this SERA, the initial assessment endpoints are the protection of the following groups of receptors from adverse effects of contaminants on their growth, survival, and reproduction:

- Soil invertebrates
- Terrestrial vegetation
- Herbivorous birds and mammals
- Carnivorous birds and mammals
- Omnivorous birds and mammals
- Benthic invertebrates
- Fish and other aquatic organisms

The following paragraphs discuss the assessment endpoints.

Soil Invertebrates - Soil invertebrates include earthworms, the juvenile life stages of many insects, and other small organisms that directly inhabit the surface soil. These organisms are expected to be present in the soil at the site. Soil invertebrates promote plant growth by aiding in the formation of soil and through redistribution and decomposition of organic matter. Soil invertebrates also serve as a food source for many mammals, birds, reptiles, and amphibians. Contaminants can bioaccumulate from the soil into the tissues of soil invertebrates used as a food source by these predators.

Terrestrial Vegetation - Terrestrial vegetation at the site consists of herbs (grasses, rushes, forbs, ferns, and other non-woody plants), shrubs, woody vines, and trees. These plants serve as a food source and provide shade and cover for many organisms, and they help prevent soil erosion and excessive surface runoff. Plants can also bioaccumulate some chemical contaminants from the soil, which can then be transferred to organisms that feed on plant tissue.

Herbivorous Birds and Mammals - Herbivorous birds and mammals (animals that consume only plant tissue) forage at the site. Their role in the community is essential because, without them, higher trophic levels could not exist. They may be exposed to and accumulate contaminants that are present in the plants they consume, and in soil that is incidentally ingested.

Carnivorous Birds and Mammals - Carnivorous birds and mammals consume invertebrates, fish, mammals, birds, reptiles, and amphibians. The term "carnivorous", in this sense, includes insectivorous and top-level carnivorous species. Insectivorous birds and mammals are present at the MGBG site. These are considered first-level carnivores, and they serve as a food source for higher trophic level carnivores. Carnivorous birds and mammals that feed on other birds and mammals are at the top of the food-chain. The top carnivores typically are less densely distributed than the herbivores and first-level carnivores because they require a larger area to hunt for their food. All the carnivores may be exposed to and accumulate contaminants that are present in food items and incidentally ingested soil.

Although the federally endangered Indiana bat has been recorded at NSWC Crane, Indiana bats have not been captured near SWMU 01 in either of two multi-night field surveys in which bats were collected at various locations using mist nets (Whitaker 1996, BHE 1999). Indiana bats (especially females and juveniles) forage primarily in riparian and floodplain forests. These habitats are absent from SWMU 01. Male Indiana bats also forage primarily in riparian and floodplain forests but are known to occasionally forage in upland forests and over old fields (U.S. FWS, 1999). Thus, while the presence of Indiana bats at SWMU 01 cannot be ruled out, the site does not provide preferred habitat for this species, and they have not been captured in either of two studies conducted near SWMU 01. Therefore, because of the

probable absence of the species at SWMU 01, the Indiana bat was not selected as a representative species in the food chain modeling.

Omnivorous Birds and Mammals - Omnivorous birds and mammals (that consume both plant and animal tissue) are present at the site in the different terrestrial habitats (i.e., forested, open field). They may be exposed to and accumulate chemicals that are present in the plants and animals they consume.

Benthic Invertebrates - Benthic invertebrates are similar to soil invertebrates in that they serve as a food source for higher trophic level organisms (i.e., fish, amphibians, birds, mammals). They can also accumulate some contaminants that can then be transferred to the higher trophic level organisms that consume invertebrates.

Fish and Aquatic Organisms - The two drainage ditches (north and south of the site) are usually dry. The nearest permanent aquatic habitat is approximately 1.2 miles downgradient of the point where site-runoff enters these ditches. Fish are absent in the ditches, but some sediment-related organisms probably occur there. These organisms could be exposed to and accumulate contaminants from the ephemeral surface water and/or sediment, and from contaminants in food items.

Not all the initial assessment endpoints were evaluated in the SERA. As indicated in U.S. EPA guidance (U.S. EPA, 1997a), "it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at a site. Instead, assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by contaminants from the site." Therefore, the SERA focused on the endpoints that would tend to yield the highest risks, which should then account for endpoints that would have lower risks.

Large carnivorous mammals and birds (e.g., red fox, red-tailed hawk) were not evaluated in the SERA because the greatest exposure to site contaminants was expected to occur to small mammals and birds that ingest invertebrates, fish, or plants. For example, organochlorine insecticides, which are known to greatly biomagnify in food chains, were not COPCs. In addition, large carnivores forage over areas hundreds of acres in size. Conservative data indicates a home range size of 150 ha (370 acres, southern Michigan fields and wood lots) for the red-tailed hawk and 78 ha (193 acres, Wisconsin marsh, forests, and prairies) for the red fox (U.S. EPA, 1993). The MGBG, however, is only 2 acres representing only a fraction of where these large carnivorous potentially hunt and feed. Thus, potential risk to these receptors from site-related COPCs would be less than for first-level carnivores. The uncertainties associated with not performing food-chain modeling for large carnivorous mammals at the site are presented in Section 8.6.1.

Omnivores were not selected as assessment endpoints because exposure to contaminants in plants is greatest for herbivores and exposure to contaminants in animals is greatest for insectivores. Therefore, omnivores will be protected by protecting herbivores and insectivores.

8.2.4.2 Measurement Endpoints

Measurement endpoints are estimates of biological impacts (e.g., mortality, growth, reproduction) that are used to evaluate the assessment endpoints. The following measures of effects were used to evaluate the assessment endpoints in this SERA, where applicable.

- Soil screening values - Mortality, growth, and reproduction of plants and soil invertebrates were evaluated by comparing chemical concentrations in surface soil to screening values designed to be protective of ecological receptors.

- No-observed-adverse effects levels (NOAELs) for representative wildlife species - Mortality, reproduction, and/or developmental effects to birds and mammals were evaluated by comparing estimated ingested doses of contaminants in surface soil, plants, and invertebrates to these NOAELs.

- Sediment screening values - Mortality and other adverse effects (e.g., reduced growth, reduced reproduction) of benthic macroinvertebrates were evaluated by comparing chemical concentrations in sediment to screening values designed to be protective of ecological receptors.

- Surface water screening values - Mortality and other adverse effects (e.g., reduced growth, reduced reproduction, altered behavior) of aquatic organisms were evaluated by comparing chemical concentrations in surface water to screening values designed to be protective of ecological receptors.

8.2.4.3 Selection of Receptor Species

Many receptors in soil and aquatic environments are adequately described in general categories such as soil invertebrates, vegetation, and sediment-dwelling (benthic) invertebrates. This is due to the nature of the threshold values, effects values, or water-quality criteria that are typically used to characterize risk for such organisms. For vertebrate receptors, selection of particular species is required so that intake through eating and drinking can be estimated.

Receptor identification is influenced by the contaminants, their likely mode of transport, ultimate fate, and toxicity. Most metals, for example, (with notable exceptions of cadmium and mercury) typically do not bioaccumulate. For contaminants that do not bioaccumulate, organisms that are in direct contact with soil and sediment (i.e., sediment- and soil-dwelling organisms and plants) and animals that may incidentally ingest soil particles are selected as receptors for metals if exposure pathways are complete. For contaminants that bioaccumulate, such as mercury compounds and chlorinated pesticides, effects on upper trophic level receptors must be assessed. Sensitivity to particular contaminants is also considered. For example, birds and mammals may have different sensitivities to organic compounds, so each group, or the most sensitive group for a particular contaminant, is assessed.

Ingestion is the primary route of exposure for most mammals and birds. The selection of species used to represent the receptor groups identified in Section 8.2.5 was based on considerations of their preferred habitat, body size, sensitivity, home range, abundance, commercial or sport utilization, legal status, and functional role (e.g., predators). For the purpose of being conservative, representative species were assumed to have small home ranges. The availability of exposure parameters such as body mass, feeding rate, and drinking rate was also a factor in selecting representative species. The following representative species were used for the food-chain modeling, which is discussed in Section 8.5.2:

- Herbivorous mammal: meadow vole
- Herbivorous bird: bobwhite quail
- Insectivorous bird: American robin
- Insectivorous mammal: short-tailed shrew

Receptor profiles for the above species are presented in Appendix H.3.

8.2.5 Conceptual Model

A conceptual model in problem formulation is a written description and visual representation of predicted relationships between ecological entities and the stressors to which they may be exposed (U.S. EPA, 1998b). The conceptual model consists of two primary components: predicted relationships among stressor, exposure, and assessment endpoint response and a diagram that illustrates the relationships (U.S. EPA, 1998b). The following risk questions describe these relationships and were evaluated as part of this ERA:

- Are contaminants in surface soil at MGBG causing increased mortality of plants and soil invertebrates?

- Are contaminants in surface soil at MGBG causing increased mortality, decreased reproduction, and/or developmental effects in birds and mammals?

- Are contaminants in the surface water or sediment at MGBG causing increased mortality of aquatic and benthic invertebrates and fish?

The primary sources of contamination at the site are contaminants in surface soil. These contaminants could potentially migrate to surface water, sediment, and ground water. Ecological receptors are not directly exposed to contaminants in ground water, but some ecological receptors could occasionally be exposed to contaminants in surface water and sediment. Secondary sources of contaminants are surface water and sediment. The primary receptors for contaminants in surface soil are plants and invertebrates, and the secondary receptors are birds and mammals. The primary receptors for contaminants in surface water and sediment are benthic invertebrates and to a lesser extent aquatic invertebrates and fish. Secondary receptors for surface water and sediment contamination are largely not applicable and were not evaluated. Figure 8-3 presents the ecological conceptual site model. As a conservative measure, the figure shows complete exposure pathways for sediment and surface water contaminants. In reality; however, these pathways are largely incomplete.

8.3 EXPOSURE CHARACTERIZATION AND THE SELECTION OF CONTAMINANTS OF POTENTIAL CONCERN

8.3.1 Screening Levels

The first step in the analysis phase was to select COPCs. This was done by comparing the maximum detected contaminant concentrations in sediment and surface soil samples to U.S. EPA Region 5 EDQLs (U.S. EPA, 1999b). No analytes were detected in surface water samples. Section 4.3 discusses the procedures that were used to select COPCs. The COPC selection process for surface soil and sediment is summarized below:

- For all chemicals except inorganics and radionuclides, a chemical was retained as a COPC if its maximum concentration exceeded its medium-specific Region 5 EDQL, or if a Region 5 EDQL was not available.

- Inorganics and radionuclides were retained as COPCs if their maximum concentrations exceeded both Region 5 EDQLs and background concentrations.

- Inorganics and radionuclides were retained as COPCs if a Region 5 EDQL was not available and the maximum concentration exceeded background concentrations.

- Calcium, magnesium, potassium, and sodium were not retained as COPCs.

The utilization of background concentrations to select inorganic and radionuclide COPCs was in accordance with the U.S. EPA-approved MGBG QAPP.

Detected chemicals that were not retained as COPCs were assumed to pose negligible risk to ecological receptors and were eliminated from further evaluation. If a chemical was not detected in any of the samples in a particular medium and the reporting limit exceeded the EDQL, the chemical was not quantitatively carried through the risk assessment as a COPC. However, the chemical, its reporting limit, and the EDQL were summarized in Tables 3-5 and 3-6 for surface soil and sediment, respectively, and qualitatively discussed in the uncertainty analysis. If a chemical was detected in at least one sample, one-half of the reporting limit was substituted for the non-detect results to calculate summary statistics (e.g., mean concentrations).

8.3.2 Risk Characterization

The risk characterization compares the exposure to the ecological effects. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor was initially evaluated.

An Ecological Effects Quotient (EEQ) approach was used to characterize the risk to terrestrial receptors. This approach characterizes the potential effects by comparing exposure concentrations to the effects data. The EEQs for terrestrial plants and invertebrates were calculated as follows:

$$EEQ = \frac{C_{ss}}{SSSL}$$

where:

C_{ss} = Contaminant concentration in surface soil (µg/kg or mg/kg)

Surface soil screening level (SSSL) = As used here, the SSSL is synonymous with the Region 5 EDQLs for surface soils (µg/kg or mg/kg)

The EEQs for aquatic receptors were calculated as follows:

$$EEQ = \frac{C_{sd}}{SdSL}$$

where:

C_{sd} = Contaminant concentration in sediment (µg/kg or mg/kg)

SdSL = Sediment Screening Level (µg/kg or mg/kg): synonymous with the Region 5 EDQLs for sediment

An EEQ of greater than 1.0 was considered to indicate potential risk. Such values do not necessarily indicate that an effect will occur but only that a low (i.e., conservative) threshold has been exceeded.

8.4 ECOLOGICAL SCREENING

The selection of ecological COPCs was presented in Section 4.3. COPC concentrations are included on tag maps (Figures 5-1, 5-2, and 5-11), and the nature and extent of COPCs were discussed in Section 5.0. Therefore, only a summary of the chemicals that were retained as COPCs is included in this section.

Surface soil, sediment, and surface water samples were collected at the site. Surface soil was collected from the 0 to 2 feet bgs depth interval. Sediment samples were collected from 0 to 6 inches bgs. No analytes were detected in surface water samples. For this reason, no COPCs for surface water were selected. Statistical comparisons to background concentrations are described in Sections 3.4.2.1 (surface soil) and 3.4.2.2 (sediment). Table 4-17 lists those chemicals retained as COPCs following the ecological screening.

8.4.1 Surface Soil

Table 4-15 is the screening table for chemicals detected in surface soil samples. One SVOC (isosafrole), one herbicide (2,4-D), and four inorganics (copper, selenium, vanadium, zinc) were retained as COPCs because they were detected at concentrations statistically exceeding site background (for inorganics) and exceeding corresponding EDQLs. Additionally, two inorganics (iron, aluminum) were retained as COPCs because they were detected at concentrations statistically exceeding site background and a corresponding EDQL was not available.

8.4.2 Sediment

Table 4-16 is the screening table for chemicals detected in the sediment samples at MGBG. Two VOCs (acetone, dichlorodifluoromethane), two SVOCs (acenaphthene, isosafrole), and one pesticide (Heptachlor) were retained as COPCs because they were detected at concentrations statistically exceeding upstream concentrations (for inorganics) and exceeding corresponding EDQLs. One energetic (HMX) was retained as a COPC because a corresponding EDQL value was not available.

8.5 SCIENTIFIC/MANAGEMENT DECISION POINT

The SERA includes the estimation of exposure levels and screening for ecological risks. The SERA is concluded by a Scientific/Management Decision Point (SMDP) at which point one of the following decisions is made (DON, 1999):

(1) Adequate information exists to conclude that ecological threats at a site are negligible; no further evaluations of ecological risks are necessary.

(2) Adequate information exists and there is a potential for adverse ecological effects. In this case, the decision can be to either conduct an interim cleanup (if cost-effective to do so) or continue to Step 3.

Included in the decisions listed above is an evaluation of the adequacy of the available information on which the decisions are based. Questions are answered during this evaluation such as: were adequate numbers of samples collected in the appropriate locations and were the samples analyzed for the appropriate parameters with sufficient sensitivity.

This section of the ERA describes whether or not the collected data are adequate for making ecological risk decisions for SWMU 01. Section 5.0 discusses the nature and extent of contamination at SWMU 01, while Figure 2-1 shows the site photographs (including select surface water and sediment sampling locations).

The NSWC Crane MGBG is an inactive waste burial site approximately 2 acres in size. The MGBG was used between the end of World War II and 1956 for disposal of materials such as mustard munitions and other select items (U.S. ACE WES, 1991). Disposal was in the form of shallow burials (pits), typically within 6 feet of the surface. Three types of hazards or potential hazards were identified at the site including aerial mustard bombs (without the explosives), thorium nitrate powder (in pyrotechnic flares),

and unspecified laboratory chemical wastes. The disposal was designed to encourage decomposition of the small amounts of chemical waste by effecting close contact with soil and moisture. On the eastern and southeastern sides of the MGBG, between the MGBG and HWY-251, a few debris piles comprising asphalt, concrete, and earth are visible among the trees. The piles are approximately 2 to 5 feet high and are not thought to be site-related. Additional detail concerning MGBG operational history is provided in Section 1.3.

The MGBG lies on a northwest/southeast-trending ridge crest with surface elevations ranging from approximately 660 to 680 feet amsl (Figure 1-5). The crest of the gently crowned MGBG is estimated to be 5 to 10 feet higher than HWY-251. Run-off from the MGBG drains into two unnamed tributaries of Goldsberry Hollow, which drains west-southwest to Boggs Creek (Figure 1-2). Boggs Creek then flows southward into a large reservoir located at the southern boundary of NSWC Crane, eventually joining the East Fork of the White River. The Boggs Creek Basin (Basin No. IV, Figure 1-2) drains approximately 70 percent of NSWC Crane. There are east-west drainages to the immediate north and south of the MGBG that flow to Goldsberry Hollow. Smaller drainage channels flow north and south from the MGBG to connect to those drainages. These drainage channels are presented in Figure 1-7.

8.5.1 Surface Soil

A total of 24 surface soil samples were collected over the two rounds at SWMU 01. Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, herbicides, inorganics, and radionuclides. Table 4-1 presents the summary of positive surface soil analytical results and Table 4-15 is the ecological risk screening table for surface soils. Five VOCs, 11 SVOCs, two pesticides, two herbicides, 24 inorganics, and 15 radionuclides were detected in surface soil samples. Of these, one SVOC, one herbicide, and four inorganics were retained as COPCs because their maximum detected concentrations exceeded EDQLs. Two inorganics, aluminum and iron, were additionally retained as COPCs because EDQLs were not available for these chemicals.

The SVOCs were detected at a low frequency (up to 3 detections in 24 samples), excluding isosafrole which was retained as a COPC. Isosafrole was detected in 6 of the 24 samples collected with a maximum EEQ of 4.6; however, it is not believed to be associated with site activities. Isosafrole is a precursor of safrole, a naturally occurring compound found in sassafras trees. Because sassafras trees exist at SWMU 01 the presence of isosafrole in surface soils at SWMU 01 is likely to be naturally occurring. Also, the disposal of isosafrole has not been documented at the site and sources of isosafrole at the base are not known. One herbicide, 2,4-D, was detected in five surface soil samples across SWMU 01 with a maximum EEQ of 7.7. As seen in Figure 5-1, two samples with 2,4-D detections were

located within the main burial area (35 µg/kg and 38 µg/kg), one sample was located outside of the SWMU boundary (69 µg/kg) and two were located in the southwest portion of the SWMU (130 µg/kg and 210 µg/kg). 2,4-D was not detected in the subsurface soil samples. It was determined in Section 5.1 that due to the nature of herbicide usage, low detected concentrations, and the spatial distribution of the detections, the presence of 2,4-D is most likely representative of topical applications rather than burial.

Copper, selenium, vanadium, and zinc were retained as COPCs because their maximum concentrations exceeded background concentrations and the EDQLs. EEQs for these metals are 6.3, 47, 28, and 10.2, respectively. Aluminum and iron EEQs are not available because EDQLs for these chemicals do not exist, therefore these metals were retained as COPCs. Concentrations of these six metals in surface soil are rather evenly distributed across the sampled locations of the MGBG suggesting that these metals are not related to site activities. Also, the ranges of detected values for these metals are similar to base-wide surface soil background concentrations (see the table below) indicating that the metals detections are probably a subset of the background soil not reflected in the base-wide data set and do not appear to be site related.

Metal	Site Samples Concentration Range (mg/kg)	Background Samples Concentration Range (mg/kg)
Aluminum	9,400 – 19,400	6,770 – 17,400
Copper	7.4 – 18.5	5.4 – 17.1
Iron	14,600 – 25,500	10,700 – 36,200
Selenium	0.49 – 1.3	0.51 – 0.64
Vanadium	22.8 – 44.5	17.1 – 40
Zinc	25.1 – 67.8	24.4 – 60.2

8.5.2 Sediment/Surface Water

To assess the potential risks associated with migration of chemicals from ground water and soil to surface water and sediment, surface water and sediment samples were proposed for collection. Two rounds of sediment data were collected. Round 1 data were collected in 2001 and Round 2 data were collected in 2002. Surface water samples were not collected during Round 1 due to the absence of surface water; however surface water samples were collected during the Round 2 event after a heavy rain event. The sediment data from both rounds were combined for evaluation in the risk assessments.

Sediment

Sediment samples were collected in an effort to assess the potential risks deriving from contamination by soil run-off and ground water discharge. During Round 1, eight sediment samples were analyzed for VOCs, SVOCs, energetics, pesticides, PCBs, herbicides, inorganics, and total radionuclides. During Round 2, additional sediment samples were collected to supplement the original sediment data set or to verify VOC concentrations measured in Round 1. The analyses of the Round 2 sediment samples included VOCs only because no other sediment contaminants were identified in Round 1. Sediment location 01SD01 was designated to be the upgradient location against which chemical concentrations measured downstream would be compared. Samples were collected from a small tributary located north of SWMU 01 and other small drainage pathways to the south, southeast, and north of SWMU 01 (see Figure 5-10). Table 4-4 presents the summary of the positive sediment results and Table 4-16 is the ecological risk screening table for sediment. Five VOCs, 12 SVOCs, one energetic, one pesticide, one PCB, two herbicides, 24 inorganics, and 3 radionuclides were detected in sediment samples at SWMU 01. Of these, two VOCs, two SVOCs, and one pesticide were retained as COPCs because their maximum detected concentrations exceeded the EDQLs. One energetic, HMX, was additionally retained as a COPC because an EDQL is not available for this chemical.

Two VOCs, acetone and dichlorodifluoromethane, were detected in six and four of 12 samples collected, respectively. The maximum EEQs for these chemicals were 1.4 and 6, respectively. Acetone is a common laboratory contaminant and could have been disposed at SWMU 01 with other laboratory chemicals. The presence of acetone could also be evidence of laboratory contamination during sample analysis. One indication that supports the latter hypothesis is that acetone was detected in Round 2 but not in Round 1 at the locations that were sampled in both rounds. As determined in Section 5.4, the dichlorodifluoromethane concentrations are bounded in the northern drainage channels because dichlorodifluoromethane was not detected in sediment sample 01SD1102, collected downstream of location sample 01SD1002. Also, dichlorodifluoromethane was detected in only one sample (01SD0801) to the south of the MBGB in the southern drainage channels. All the SVOCs detected are PAHs except for bis(2-ethylhexyl)phthalate and isosafrole. Many of the PAHs, including acenaphthene, have maximum detected concentrations in sample 01SD07. This sample is located along HWY-251. It was proposed in Section 5.4 that PAH concentrations in this sample and surrounding samples are possibly attributable to nearby debris piles and Highway-251. Both SVOC COPCs (acenaphthene and isosafrole) were detected in one of seven samples collected. EEQs for these chemicals were 21 and 1845, respectively. Isosafrole was also retained as a COPC in surface soil but it is believed to be naturally occurring (see Section 8.5.1). HMX was detected in four of seven samples collected and was retained as a COPC because an EDQL was unavailable for comparison. HMX was detected in a drainage pathway to the northern

tributary of SWMU 01 and in neighboring samples, 01SD04, 01SD03 (Round 1 only), and 01SD02. HMX was not detected, however, in downgradient samples indicating that any contamination is well defined. One pesticide, heptachlor, was detected in five of seven samples collected; however, with an EEQ of 4.2. Heptachlor was also detected in surface soil and ground water samples. As determined in Section 5.4 and above, the presence of this herbicide at SWMU 01 is most likely attributable to topical application rather than site activities (i.e., burial activities).

Surface Water

Surface water samples were not collected during Round 1 due to the absence of surface water; however surface water samples were collected during the Round 2 event after a heavy rain event. Four surface water samples were analyzed for VOCs because VOCs were the primary contaminants in the ground water samples from Round 1. Figure 1-11 displays the locations where surface water samples were collected. No VOCs were detected in surface water samples and therefore, no COPCs for surface water were selected.

8.5.3 Summary

In summary, a SERA was performed for SWMU 01. Based on the results of the collected data, adequate information exists to determine that potential risks are possible to receptors from exposure to the selected COPCs. Adequate numbers of samples were collected in areas where the contamination, if present, should be detected. The samples were analyzed for the appropriate parameters based on site history. Finally, based on the data quality review in Section 3.0, the data is of sufficient quality to proceed with the risk assessment. A further discussion of the data quality as it relates to the ecological risk assessment is included in Section 8.6.5. Therefore, the SERA is advancing to the Step 3a of the BERA – the refinement of the site-related COPCs.

8.6 STEP 3a – COPC REFINEMENT

Step 3a involves the re-evaluation of the chemicals retained as COPCs after Step 2 with less conservative but more realistic exposure assumptions and re-evaluating the analytical data using benchmarks that may be more appropriate for the assessment endpoints. This re-evaluation is conducted for each ecological receptor (i.e., plants, invertebrates, wildlife). The objective of Step 3a is to determine if any of the chemicals that were initially retained as COPCs can be eliminated as COPCs for further evaluation because risks are determined to be acceptable. The Step 3a evaluation is designed to eliminate chemicals from further evaluation for certain groups of receptors. For example, a chemical may

be eliminated as a COPC in soil based on risks to soil invertebrates and plants but may be retained as a COPC based on risks to wildlife.

Surface Soil

Chemicals selected as COPCs in surface soil were carried through three independent flow paths: 1) to further evaluate risks to plants, 2) to further evaluate risks to invertebrates, and 3) to further evaluate risks to wildlife (i.e., mammals and birds). This further evaluation was conducted to determine if there were potential risks from that chemical to all three receptor groups (i.e., plants, invertebrates, and wildlife), or to only one or two of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors with unacceptable risk. Because most of the Region 5 soil screening levels are based on risks to mammals or birds, potential risks to plants and invertebrates are not known. Therefore, the first step in the Step 3a evaluation was to compare the maximum chemical concentration in the soil to no-effects benchmarks for plants and invertebrates [i.e., U.S. EPA Ecological Soil Screening Levels (U.S. EPA, 2003)]. The following bullets outline decisions that were made based on this comparison:

- If the concentration was less than the no-effects benchmark, it was concluded that the chemical is not causing an unacceptable risk to plants and/or invertebrates so the chemical was eliminated as a COPC for further consideration.

- If the chemical concentration was greater than the no-effects benchmark (or the chemical does not have a no-effects benchmark), the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.]. Based on that evaluation, it was either determined that 1) risks were acceptable to plants and/or invertebrates so the chemical was eliminated as a COPC for further consideration or 2) risks were unacceptable to plants and/or invertebrates so the chemical was retained as a COPC for further consideration.

Concurrent with the evaluation of risks to plants and invertebrates, bioaccumulative chemicals that were retained as COPCs were further evaluated to determine if there are unacceptable risks to wildlife. Even though the conservative COPC screening level may have been based on risks to wildlife, risks to wildlife were further evaluated in Step 3a to calculate risks under a more realistic exposure scenario. The first step in the process was to determine if the COPC is bioaccumulative. A chemical was considered to be bioaccumulative if it is included in the list of important bioaccumulative chemicals in U.S.EPA (2000). If the chemical is not bioaccumulative, it was not carried through the food chain model and it was concluded

that the chemical is not causing an unacceptable risk to wildlife. If the chemical is bioaccumulative, it was carried through the food chain model. The following bullets outline decisions that were made based on the results of the food chain model:

- If the EEQ (see Section 8.6.2.1) is less than 1.0 using average contaminant concentrations and exposure factors and the NOAEL as the TRV, it was concluded that the chemical is not causing an unacceptable risk to wildlife and the chemical was not retained as a COPC further evaluation.

- If the EEQ was greater than 1.0 using average contaminant concentrations and exposure factors and the NOAEL) as the TRV, the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.]. Based on that evaluation, it was either determined that 1) risks were acceptable to wildlife so the chemical was eliminated as a COPC for further consideration or 2) risks were unacceptable to wildlife so the chemical was retained as a COPC for further consideration.

For chemicals that were further evaluated in Step 3a, the other Step 3a factors described below were used to determine if the risks were great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

Sediment

If the chemical was selected as a COPC in sediment, the chemical was carried through two independent flow paths: 1) to further evaluate risks to invertebrates, and 2) to further evaluate risks to wildlife (i.e., mammals and birds). This further evaluation was conducted to determine if there are potential risks from that chemical to both receptor groups (i.e., invertebrates and wildlife), or to only one of the receptor groups. This is important because if the site proceeds further in a BERA, the studies in the BERA should only focus on the receptors with unacceptable risk. Because many of the Region 5 sediment screening levels are based on equilibrium partitioning, the maximum contaminant concentration was compared to an alternate lower effects level following the order of preference listed below (as applicable):

- U.S.EPA (2003) Sediment Quality Benchmarks for dieldrin and endrin

- Consensus-based freshwater sediment quality guideline threshold effects concentration (TEC) (MacDonald, 2000)

- Canadian Sediment Guidelines Lowest Effects Levels (OMOE, 1993) or Threshold Effects Level (EC, 2002)

- Long and Morgan (1991) Effects-Range Low

- Long et al., (1995) Effects-Range Low

- Ecotox Thresholds (U.S.EPA, 1996) Sediment Quality Benchmarks

- Other values, as necessary and available

The following bullets outline decisions that were made based on this comparison:

- If the concentration was less than the lower-effects benchmark, it was concluded that the chemical is not causing an unacceptable risk to invertebrates and the chemical was eliminated as a COPC for further evaluation.

- If the concentration was greater than the lower-effects benchmark, the chemical was further evaluated in Step 3a to determine if the risks are great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.]. Based on that evaluation, it was either determined that 1) risks were acceptable to invertebrates so the chemical was eliminated as a COPC for further consideration or 2) risks were unacceptable to invertebrates so the chemical was retained as a COPC for further consideration.

As presented in Section 8.6.2, food chain modeling to piscivorous wildlife was not performed because although fish are potentially present during high flow conditions (i.e., heavy storm events), potential risk to piscivorous wildlife consuming fish is considered.

For chemicals that are further evaluated in Step 3a, the factors described in Section D.4.1 were used to determine if the risks were great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS), etc.].

Other Step 3a Factors

For chemicals that were evaluated further in Step 3a, the following factors were evaluated, as appropriate, to determine if the risks were great enough to warrant additional evaluations [i.e., proceed to a BERA, develop cleanup levels, proceed to a corrective measures study (CMS)].

- Magnitude of criterion exceedance: Although the magnitude of the risks may not relate directly to the magnitude of a criterion exceedance, the magnitude of the criterion exceedance may be one item used in a lines-of-evidence approach to determine the need for further site evaluation. The greater the criterion exceedance, the greater the probability and concern that an unacceptable risks exists.

- Frequency of chemical detection and spatial distribution: A chemical detected at a low frequency typically is of less concern than a chemical detected at higher frequency if toxicity and concentrations and spatial areas represented by the data are similar. All else being equal, chemicals detected frequently were given greater consideration than those detected relatively infrequently.

- Contaminant bioavailability: Many contaminants (especially metals) are present in the environment in forms that are typically not bioavailable, and the limited bioavailability was considered when evaluating the exposures of receptors to site contaminants. Contaminants with generally less bioavailability are considered to be less toxic than the more bioavailable contaminants, all other factors being equal.

- Habitat: Although exceedances of criteria may occur, potential risks to ecological receptors may be minimal if there is little habitat for those receptors. Therefore, the extent of habitat was used qualitatively when considering additional evaluation. Areas with little habitat were less of a concern than areas with suitable habitat to support the receptors of interest.

- Alternate benchmarks: These benchmarks are used to further evaluate risks to specific groups of ecological receptors (e.g., plants, invertebrates) because while EDQLs are useful for initial screening they are the most conservative values available for soil and sediment evaluation. Use of alternate benchmarks ensures that more realistic exposure assumptions are evaluated. However, some of the alternate benchmarks are overly protective for some receptors and may not have been in some cases. For example, the EDQLs for soil may be based on risks to small mammals. Therefore, an exceedance of that EDQL does not necessarily indicate that potential risks to plants or invertebrates exist, so other more appropriate benchmarks were used to evaluate potential risks to those receptors. Use of these alternate benchmarks was case-specific.

In addition to the general Step 3a factors above, other factors were evaluated in Step 3a for each receptor group. The following sections discuss the other factors than may be used, including the specific alternate benchmarks that may be used in Step 3a.

Terrestrial Plants and Invertebrates: The alternate benchmarks that were used to further evaluate risks to plants and invertebrates are listed below. The ecological endpoint for the each benchmark that is used in this step is provided in the ERA. For example, if a benchmark is based on a 25% reduction in growth to a lettuce plant, that information is presented in the ERA.

- Canadian Soil Quality Guidelines (CCME, 1997).
- Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision (Efroymson, et al., 1997a).
- ORNL Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision (Efroymson, et al., 1997b).

Additional sources of toxicity data from the literature may be used to evaluate potential risks to terrestrial vegetation and invertebrates from contaminants in the surface soil not evaluated in the above documents.

Sediment: In addition to the Step 3a factors presented above, additional evaluations for sediment included comparing the chemical concentrations in the sediment to higher effects levels to show the range of possible effects. The higher effects levels that were used to further evaluate risks to benthic invertebrates were extracted from the same sources listed in order of preference as described above. A description of what the higher effects level represents is provided in the ERA. For example, the probable effects concentrations (PECs) were intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms were expected to occur frequently (MacDonald, et al., 2000).

8.6.1 Terrestrial Plants, Terrestrial and Sediment Invertebrates

Potential risks to terrestrial plants, terrestrial and aquatic invertebrates, and fish from exposure to COPCs were evaluated using the methodologies described above. The following subsections discuss whether chemicals that were initially retained as COPCs are further retained as final Chemicals of Concern

(COCs) for terrestrial plants and invertebrates (Section 8.6.1.1) and sediment invertebrates (Section 8.6.1.2).

8.6.1.1 Terrestrial Plants and Invertebrates

Table 8-1 presents a summary of some of the common alternate benchmarks that were used in refining the list of COPCs in surface soil, along with a summary of the Step 3a evaluation. Other alternate benchmarks such as toxicity test data are presented below, as necessary. Also, the toxicological basis of the alternate benchmarks is presented below. As presented in Table 4-15 several chemicals were eliminated as COPCs because they were not detected at concentrations greater than background concentrations. For soil, these chemicals included antimony, arsenic, barium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, strontium, thallium, and thorium. Therefore, risks to these chemicals were not evaluated in the ERA, however, any risks would be within background risks and not related to site activities.

Isosafrole

Isosafrole was retained as a COPC because the maximum soil concentration (46,000 µg/kg) exceeded the EDQL of 9,940 µg/kg, which is based on risks to wildlife. Isosafrole was detected in six of 24 surface soil samples. Concentrations exceeded the EDQL in only one sample (01SS05), which is located slightly outside the northwestern perimeter of the site. Although this sample is not bounded, the location of 01SS05 is relatively distant from known burial areas and debris piles (Figure 5-1).

Numerous sassafras trees exist at the Facility and at the MGBG site, and are common around the edge of the site and beyond the site perimeter. Safrole is a naturally occurring compound found in sassafras trees, and is the principal component (80 percent) of sassafras oil (FNA, 1993). Since safrole is a precursor of isosafrole, its presence in some MGBG soil samples is likely to be naturally occurring, especially after reviewing the spatial distribution of the data as discussed in the next paragraph. Background soil samples were not analyzed for SVOCs, so this speculation cannot be verified by background data. However, the locations of all six samples in which this compound was detected were near the site perimeter, where sassafras trees are abundant.

In summary, no alternate benchmarks were located for isosafrole, so further quantitative evaluation of this chemical was not possible. However, isosafrole concentrations exceeded the EDQL in only one of 24 surface soil samples, with a relatively low maximum EEQ of 4.6 (Table 4-15). The 24 samples were located within and just outside the SWMU boundary (see Figure 5-1) and are adequate to characterize

the site. The sample location of the maximum concentration was distant from burial areas and debris piles, suggesting that its presence is due to natural conditions (see Figure 5-1). Also, the spatial distribution of the six detections (the samples were scattered throughout the site), and the fact that isosafrole was not detected in any of the five sample locations (surface and subsurface) in the primary burial area, further supports the suggestion that isosafrole is not related to site activities. For these reasons, site-related potential risk from isosafrole is probably negligible (or minor), and are considered acceptable. Therefore, isosafrole was eliminated as a COPC for risks to plants or invertebrates.

2,4-Dichlorophenoxyacetic Acid

2,4-Dichlorophenoxyacetic acid (2,4-D) was retained as a COPC because the maximum soil concentration (210 µg/kg) exceeded the EDQL of 27 µg/kg, which is based on risks to wildlife. Concentrations exceeded the EDQL in all five samples in which it was detected. Reporting limits in non-detect samples tended to be approximately three times greater than the EDQL. Reviews of numerous toxicity studies of 2,4-D indicate it has a low toxicity to soil invertebrates (Hammond, 1996; ITF, 2002). The 14-day no-observed-effect concentration (NOEC) for earthworms is 100 mg/kg (Hammond, 1996). The maximum concentration at MGBG (210 µg/kg = 0.21 mg/kg) is well below the earthworm NOEC. In summary, all detected concentrations, as well as reporting limits in non-detect samples, were much less than the NOEC for earthworms. It is assumed that this herbicide could pose potential risk to vegetation at the site, and its presence is probably a result of its deliberate application as a herbicide. However, the site is heavily vegetated and is unlikely to be impacted by this herbicide. Therefore, risks to plants and invertebrates from 2,4-D are unlikely so 2,4-D was eliminated as a COPC for risks to plants or invertebrates.

Aluminum

Aluminum was retained as a COPC because no EDQL was available for comparison. The maximum concentration of 19,400 mg/kg was the only sample in which aluminum exceeded the maximum background soil concentration for aluminum of 17,400 mg/kg (Table 4-15). Therefore, aluminum concentrations are not excessively greater than in background samples despite the statistically greater concentrations in MGBG samples relative to background. Also, and more important, according to the Ecological SSL for aluminum (U.S. EPA, November 2003a), potential ecological risks associated with aluminum in soils is identified based on the measured soil pH because soluble and toxic forms of aluminum are only present in soil under soil pH values of less than 5.5 S.U. The Eco SSL document then indicates that aluminum should be identified as a COPC only for those soils with a soil pH less than 5.5 S.U. Because seven of the soil samples measured for pH had values ranging from 5.0 to 7.8 S.U.,

with an average pH across the site of 6.0 S.U., risks to plants and invertebrates from aluminum are acceptable so aluminum was eliminated as a COPC for risks to plants or invertebrates.

Copper

Copper was retained as a COPC because the maximum soil concentration (18.5 mg/kg) exceeded the EDQL of 2.96 mg/kg and was statistically greater than background concentrations. However, because the EDQL is based on risks to small mammals, the following alternate benchmarks were used to evaluate risks to plants and soil invertebrates:

- Canadian Soil Quality Guideline (SQG) – 63 mg/kg [Canadian Council of Ministers of the Environment (CCME), 1997]
- Oak Ridge National Laboratory (ORNL) Plant – 100 mg/kg (Efroymson et al., 1997a)
- ORNL Earthworm – 60 mg/kg (Efroymson et al., 1997b)

The copper Canadian SQG of 63 mg/kg is the 25th percentile of effects and no effects data distribution for plants and invertebrates, which is the 17th of 69 data points and corresponds to an effect on radish seedling emergence (CCME, 1997). Therefore, some studies showed effects below 63 mg/kg but many more studies did not show effects at this concentration. The Canadian SQG for copper is similar to the ORNL benchmarks for plants and invertebrates, which were developed using fewer plant studies than were used to develop the Canadian SQG.

The copper ORNL benchmark for plants (100 mg/kg) was based on toxicity data from three studies. Two of the studies resulted in reductions in root and shoot weights of little bluestem grown on sandy soil to which 100 ppm copper (as copper sulfate) was added (Miles and Parker, 1979). The third study showed no effect on leaf and stem weights of bush beans grown in soil to which 100 ppm copper (as copper sulfate) was added, but leaf weight was reduced 26% when 200 ppm copper was added (Wallace et al., 1977). The copper ORNL benchmark for invertebrates (60 mg/kg) was based on toxicity data from 10 to 20 studies. The endpoints for most of the studies cited in Efroymson et al., (1997) are survival or reproduction (i.e., cocoon production, hatchling success). Because there were more than 10 studies the benchmark was based on a 10th percentile LOEC value. However, a review of the data in Appendix A.1 of Efroymson et al., (1997) shows that most of the studies cited in that document have NOECs that are greater than 60 mg/kg.

Copper concentrations below the Canadian SQG of 63 mg/kg are expected to be protective of plants and invertebrates. The copper sulfate, copper nitrate, and copper chloride that were used in the toxicity

studies are likely to be more bioavailable than the copper in the soils from the site. Copper in soil is likely to form relatively insoluble carbonates, oxides, and hydroxides. Also, as discussed above, although some studies showed measurable effects to plants and invertebrates at copper concentrations less than 63 mg/kg, the effects concentrations in many other studies were much greater than 63 mg/kg. Therefore, because the maximum detected copper concentration (18.5 mg/kg) is well below the Canadian SQG of 63 mg/kg, impacts to plants and invertebrates are not expected to occur from the observed levels of copper in MGBG soil.

Although the site sample set was statistically greater than the background sample set, concentrations at the MGBG site are similar to the range of background concentrations (5.4 - 17.1 mg/kg). Figure 8-4 shows a comparison of NSWC Crane background surface soil copper concentrations to MGBG surface soil copper concentrations. Similar to detections of arsenic in surface soil (see Section 3.4.4), copper concentrations are compressed into a distribution that is approximately half the range of concentrations observed across all of NSWC Crane. The majority of detected copper concentrations are within the detected background range with the upper end of the MGBG distribution comparable to the upper end of the NSWC Crane background concentrations. This suggests that the MGBG copper surface soil concentrations are a subset of NSWC Crane background surface soil concentrations and are probably not an indication of site-related contamination. As explained in Section 3.4.4, the background soils were collected from several widely scattered areas throughout the nearly 100-square-mile NSWC Crane facility. The 2-acre MGBG is a small fraction of the total background investigation area; therefore, it is quite plausible that the MGBG represents a subset of the overall base-wide background concentrations.

In summary, risks to plants and invertebrates from copper are acceptable so copper was eliminated as a COPC for risks to plants or invertebrates. Because copper is a bioaccumulative chemical, risks to wildlife from copper are evaluated in Section 8.6.2 of this ERA.

Iron

Iron was detected in all surface soil samples; it was retained as a COPC because an EDQL was not available. Iron is generally regarded as a non-toxic chemical and occurs frequently in the environment. The maximum concentration in surface soils at MGBG was 25,500 mg/kg. The maximum background concentration was 36,200 mg/kg for the soil type at the site. Figure 8-5 shows a comparison of NSWC Crane background surface soil iron concentrations to MGBG surface soil iron concentrations. Similar to detections of arsenic and copper in surface soil, iron concentrations are compressed into a tight distribution that is approximately half the range of concentrations observed across all of NSWC Crane. However, in this case, the maximum detected in site surface soils is well below the maximum background

soil iron concentration. This also suggests that the MGBG iron surface soil concentrations are a subset of NSWC Crane background surface soil concentrations and are probably not an indication of site-related contamination. As explained in Section 3.4.4, the background soils were collected from several widely scattered areas throughout the nearly 100-square-mile NSWC Crane facility. The 2-acre MGBG is a small fraction of the total background investigation area; therefore, it is quite plausible that the MGBG could represent a subset of the overall base-wide background concentrations.

Also, and more important, according to the Ecological SSL for iron (U.S. EPA, November 2003b), iron is essential for plant growth, and is generally considered to be a micronutrient and because plants regulate its uptake, iron is not expected to be toxic to plants in well aerated soils with pH levels between 5 and 8 S.U. (U.S. EPA, November 2003b). As presented above, seven of the soil samples measured for pH had values ranging from 5.0 to 7.8 S.U., with an average pH across the site of 6.0 S.U. Therefore, iron is not expected to be toxic to plants at the site. No toxicity data were located to evaluate risks to invertebrates from iron, however, because iron is generally considered a non-toxic metals, it is highly unlikely that soil invertebrates are being impacted by iron at concentrations similar to background levels.

In summary, risks to plants and invertebrates from iron are acceptable so iron was eliminated as a COPC for risks to plants or invertebrates.

Selenium

Selenium was retained as a COPC because the maximum soil concentration (1.3 mg/kg) exceeded the EDQL of 0.03 mg/kg and was greater than background concentrations. The evaluation of selenium in surface soil is hindered by the reporting limits in "non-detected" samples, all of which exceed the EDQL. However, because the EDQL is based on risks to small mammals, the following alternate benchmarks were used to further evaluate risks to plants and soil invertebrates.

- Canadian SQG –1 mg/kg (CCME, 1997)
- ORNL Plant – 1 mg/kg (Efroymson et al., 1997a)
- ORNL Earthworm – 70 mg/kg (Efroymson et al., 1997b)

The selenium Canadian SQG of 1 mg/kg is the lowest LOEC of the plants and invertebrate data set consisting of a minimum of three data points with one data point for each group of receptors (EC, 2001). The endpoint for the lowest LOEC was reduced shoot growth (approximately 60%) in sorgrass over a 42-day exposure period. An uncertainty factor was not applied because the LOEC was developed from a chronic study, more than three studies were consulted and three taxonomic groups were represented

(EC, 2001). The only study cited in the selenium Canadian SQG for earthworms listed a LOEC of 77 mg/kg based on a reduction in the number of cocoons per worm.

The ORNL benchmark for plants used the same studies as the Canadian SQG, which yielded the same level (1 mg/kg) (Efroymson et al., 1997a). The endpoints for all of the studies were growth endpoints as measured by shoot weight. The ORNL benchmark for earthworms used the one study cited in the Canadian SQG for a benchmark of 70 mg/kg (Efroymson et al., 1997b). There was a 69% reduction in cocoon production at 77 mg/kg selenium.

Three of the 24 detections of selenium were greater than 1.0 mg/kg with concentrations ranging from 1.1 to 1.3 mg/kg. One of the samples with a selenium concentration greater than 1.0 was located in the primary disposal area, but the other two samples were located at the eastern portion of the SWMU. Based on the relatively low concentrations of selenium compared to the concentrations in other samples spatially located across the site it does not appear that the selenium is related to site activities. Also, the samples with selenium concentration greater than 1.0 are located in areas with thick vegetative growth. Therefore, it does not appear that the selenium in the soil is reducing the growth of plants. That may be because the toxicity tests usually use bioavailable forms of metals in toxicity tests but the selenium in the site soils is likely to be in a less bioavailable form. Although there is only one toxicity study for earthworms, it appears that earthworms are less sensitive to selenium than plants. Therefore, because plants are not being impacted and because the maximum selenium concentration in the soil is much less than the LOEC for earthworm cocoon production, it is not likely that earthworms are being impacted by selenium at the site.

In summary, risks to plants and invertebrates from selenium are acceptable so selenium was eliminated as a COPC for risks to plants or invertebrates. Because selenium is a bioaccumulative chemical, risks to wildlife from selenium are evaluated in Section 8.6.2 of this ERA.

Vanadium

Vanadium was retained as a COPC because the maximum concentration (44.5 mg/kg) exceeded the EDQL of 1.6 mg/kg. However, because the EDQL is based on risks to small mammals, the following alternate benchmarks were used to further evaluate risks to plants and soil invertebrates.

- Canadian SQG – 130 mg/kg (CCME, 1997)
- ORNL Plant – 2 mg/kg (Efroymson et al., 1997a)

The vanadium Canadian SQG of 130 mg/kg is the 25th percentile of effects and no effects data distribution for plants and invertebrates, which is the 4th lowest of 14 data points and corresponds to an LOEC for lettuce seedling emergence (EC, 1999). The only study cited in the vanadium Canadian SQG for earthworms listed a NOEC of 207 mg/kg based on mortality after 14 days and a LOEC of 417 mg/kg. The ORNL benchmark for plants of 2 mg/kg was based on two studies (Efroymson et al., 1997a). In one study unspecified toxic effects were reported for plants grown in soil with the addition of 50 ppm vanadium and in the second study vanadium added at a concentration of 2.5 ppm was toxic to plants.

Some of the studies used for the Canadian SQG were conducted by Environment Canada and were designed to provide a range of effects (NOEC, EC_{25}, EC_{50}, and LOEC). Therefore, the Canadian SQG appears to be a more technically appropriate alternate benchmark for evaluating risks to plants than the ORNL plant benchmark.

The maximum vanadium detection of 44.5 mg/kg is well below the Canadian SQG. In fact, the concentration of 44.5 is less than the lowest NOEC of 55 mg/kg used to develop the Canadian SQG. Therefore, impacts to plants and invertebrates from vanadium in the soil are not expected. Also, even though the vanadium concentrations in soil were statistically greater than the concentrations in the background data set, the maximum vanadium concentration only slightly exceeded the maximum soil-type background vanadium concentration of 40 mg/kg indicating that it is unlikely that vanadium is site-related.

In summary, risks to plants and invertebrates from vanadium are acceptable so vanadium was eliminated as a COPC for risks to plants or invertebrates.

Zinc

Zinc was retained as a COPC because the maximum soil concentration (67.8 mg/kg) exceeded the EDQL of 6.6 mg/kg and was greater than background concentrations. However, even though the EDQL is based on risks to invertebrates, the following alternate benchmarks were used to further evaluate risks to plants and soil invertebrates:

- Canadian SQG – 200 mg/kg (CCME, 1997)
- ORNL Plant – 50 mg/kg (Efroymson et al., 1997a)
- ORNL Earthworm – 100 mg/kg (Efroymson et al., 1997b)

The zinc Canadian SQG of 200 mg/kg is the lowest LOEC of the plants and invertebrate data set and is based on an effect on seedling emergence for radish (EC, 1999). The weight-of-evidence method was not used to develop the SQG because greater than 50 percent of the "effects" data were dominated by median effective or median lethal concentrations (EC, 1999). As presented in Appendix VI of the Canadian SQG document (EC, 1999), all of the earthworm effects and no-effects data (with the exception of one test in one study) were equal to or greater than 200 mg/kg, indicating that earthworms appear to be less sensitive to zinc than plants.

The zinc ORNL benchmark for plants (50 mg/kg) was based on toxicity data from fewer plant studies than were used to develop the Canadian SQG. The majority of the studies had NOEC and LOEC values greater than 50 mg/kg, with many greater than 100 mg/kg and several greater than 200 mg/kg. Therefore, the ORNL plant benchmark appears to be somewhat conservative. As indicated in Efroymson et al., (1997b), the ORNL benchmark for invertebrates (100 mg/kg) is lower than concentrations at which effects have been observed. This is further supported by the toxicity test data presented in the Canadian SQG document for earthworms.

The maximum zinc detection of 67.8 mg/kg is well below the Canadian SQG, and only slightly greater than the ORNL plant benchmark. As discussed above, it is likely that the ORNL plant benchmark is conservative so impacts to plants in soil at concentrations just slightly greater than the ORNL plant benchmark are not expected. Based on the relative low concentrations of zinc compared to the concentrations in other samples spatially located across the site it does not appear that the zinc is related to site activities. This is further supported by the maximum detection of zinc which is just slightly greater than the maximum background soil concentration of 60.2 mg/kg. Also, the samples with zinc concentration greater than 50 mg/kg are located in areas with thick vegetative growth. Therefore, it does not appear that the zinc in the soil is adversely impacting plants. That may be because the toxicity tests usually use bioavailable forms of metals in toxicity tests but the zinc in the site soils is likely in a much less bioavailable form. None of the zinc detections are greater than the ORNL earthworm benchmark, and in fact, none of the detections are greater than the no-effects levels for earthworm as cited in both ORNL earthworm benchmark document and the Canadian SQG document for zinc. Therefore, zinc at the site is not expected to impact soil invertebrates.

In summary, risks to plants and invertebrates from zinc are acceptable so zinc was eliminated as a COPC for risks to plants or invertebrates. Because zinc is a bioaccumulative chemical, risks to wildlife from zinc are evaluated in Section 8.6.2 of this ERA.

Summary

Four metals and two organic compounds were present in surface soils at MGBG at concentrations that exceeded EDQLs. These chemicals were retained as COPCs. Two additional metals were retained as COPCs because EDQLs were not available. The majority of the EDQLs were based on risks to mammals so the risks to plants and invertebrates were further evaluated during Step 3a of the risk assessment process. Based on this evaluation, even though a few chemicals were detected at concentrations that exceeded concentrations that may impact plants, the samples where this occurred were located in a heavily vegetated area of the site (see Figures 1-3 and 1-4 for site photographs). Also, the chemical concentrations in the soil are at levels that are expected to cause no or minimal impacts to soil invertebrates. Finally, although the concentrations of the metals that were retained as COPCs were statistically greater than background, the maximum concentrations were similar to or less than the maximum background concentration and close review of the data indicated that the metal concentrations are likely to represent subpopulations of the background data distributions.

For these reasons risks from all the chemicals detected in the soil were determined to be acceptable so no chemicals in the surface soil were retained as COPCs for further evaluation regarding risks to plants or invertebrates; risks to wildlife from the bioaccumulative chemicals are further evaluated in Section 8.6.2 of the ERA.

8.6.1.2 Sediment Invertebrates

Table 8-2 presents a summary of the common alternate benchmarks that were used in refining the list of COPCs in sediment, along with a summary of the Step 3a evaluation. As presented in Table 4-16, several chemicals were eliminated as COPCs because they were not detected at concentrations greater than background concentrations. For sediment, these chemicals included aluminum, antimony, arsenic, barium, beryllium, chromium, copper, iron lead, manganese, nickel, selenium, strontium, thallium, thorium, tin, and vanadium. Risks to these chemicals were not evaluated in the ERA, however, any risks would be within background risks and not related to site activities.

Acetone

Acetone was retained as a COPC because the maximum detected concentration (630 µg/kg) exceeded the EDQL of 454 µg/kg. The maximum detected concentration only slightly exceeded the EDQL with an EEQ of 1.4 (Table 4-16). Acetone is a common laboratory contaminant and due to its volatility, is rarely present in environmental samples. Also, the fact that acetone was found at a concentration of 290 µg/kg in the upgradient sample, combined with the fact that all of the elevated detections were in samples

collected in 2002 (see Table 4-4) (the samples collected in 2001 all had low concentrations of acetone), indicates a laboratory source of acetone. Most of the locations with elevated acetone detections were in dry drainage channels where there is little to no aquatic habitat. Therefore, acetone is likely not to be present in the sediment at concentrations that will impact benthic invertebrates (i.e., risks are acceptable) so acetone was eliminated as a COPC for risks to sediment invertebrates.

Dichlorodifluoromethane

Dichlorodifluoromethane was detected in four of 12 samples and was retained as a COPC because the maximum detected concentration (8 µg/kg) exceeded the EDQL of 1.33 µg/kg. Note that the most recent Region 5 ESL table does not have a sediment screening level for dichlorodifluoromethane. No alternate benchmarks were located for dichlorodifluoromethane and so further quantitative evaluation of this chemical was not possible. However, no clear pattern of dichlorodifluoromethane contamination exists. The maximum dichlorodifluoromethane detection was in sample 01SD08 which is located in a dry drainage ditch south of the site. Dichlorodifluoromethane was not detected in any surface soil samples or ground water sample. Furthermore, dichlorodifluoromethane was detected in samples 01SD02, 01SD03, and 01SD10, but not in the downgradient sample 01SD11. Because there is a lack of toxicity data for dichlorodifluoromethane, risks from this chemical cannot be quantified. However, because it does not appear that dichlorodifluoromethane is related to site activities, and because of the relatively low detected concentrations, it is determined that any potential risks to aquatic organisms would be acceptable. For that reason, dichlorodifluoromethane was eliminated as a COPC for risks to sediment invertebrates. The uncertainties involved in not having toxicity data available are discussed in Section 8.6.

Acenaphthene

Acenaphthene was retained as a COPC because the sole detected sediment concentration (139 µg/kg) exceeded the EDQL of 6.71 µg/kg (EC, 2002). The EDQL is based on the Threshold Effects Level (TEL) developed by Environment Canada (EC, 2002). The TEL is calculated as the square root of the product (i.e., the geometric mean) of the lower 15th percentile concentration of the effect data set and the 50th percentile of the no-effect data set (CCME, 1999). The TEL is calculated to consistently determine a range of sediment chemical concentrations that is dominated by no-effect data entries (i.e., adverse biological effects are never or almost never observed below the TEL) (CCME, 1999). The probable effects level (PEL) for acenaphthene is 88.9 µg/kg (EC, 2002). The PEL represents the lower limit of the range of chemical concentrations that are always or usually associated with adverse biological effects (CCME, 1999).

The maximum detected concentration is greater than the PEL (with an EEQ of 1.6) so adverse ecological effects to benthic invertebrates are possible. However, acenaphthene was detected in only one of seven sediment samples at the MGBG (at 01SD07). The sediment sample from 01SD07 was dry when collected and water is likely to be present in the ditch only during rain events. Therefore, the habitat is poor for aquatic receptors. 01SD07 is located near HWY-251 and the acenaphthene detection could be associated with highway runoff or vehicular traffic. Also, the sample is also located downgradient of asphalt piles not associated with the mustard gas burial activities, which also may be the source of the PAHs such as acenaphthene. Finally, no other PAHs had concentrations that exceeded their respective screening levels indicating that PAHs, in general, are not a concern at this SWMU. Although the acenaphthalene was detected in one sediment samples at a concentration that may cause adverse effects to benthic organisms, the poor habitat in the drainage ditch makes the likelihood of actual risks small. By taking this into account with the indication that acenaphthalene is not site-related, then risks are considered acceptable so acenaphthene was eliminated as a COPC for risks to sediment invertebrates.

Isosafrole

Isosafrole was retained as a COPC in sediment at the MGBG because the detected concentration (7,600 µg/kg) exceeded the EDQL of 4.12 µg/kg. Note that the most recent Region 5 ESL table does not have a sediment screening level for isosafrole. Isosafrole was detected relatively infrequently (one of seven samples) at 01SD06. As can be seen on Figure 5-10, several sediment samples were located downgradient of 01SD06 but isosafrole was not detected in any of those samples. Also, the sediment sample from 01SD06 was dry when collected and based on site observations and the topography, water is likely to be present in the ditch only during rain events. Therefore, the habitat is poor for aquatic receptors. No alternate benchmarks were located for isosafrole and so further quantitative evaluation was not possible. As discussed in Section 8.6.1.1, numerous sassafras trees exist around the edge of the MGBG site and beyond the site perimeter. Safrole is a naturally occurring compound found in sassafras trees, and is the principal component (80 percent) of sassafras oil, a flavorant in foods (FNA, 1993). Since safrole is a precursor of isosafrole, its presence in one MGBG sediment sample is likely to be due to natural conditions. Isosafrole was not detected in either of two background (upgradient) sediment samples collected from a single location (Table 4-4), but the small upgradient data set prevents positive conclusions regarding isosafrole in background areas. The single sample in which this compound was detected (01SD06) was located just north of the PBA, where sassafras trees are abundant.

Because there is a lack of toxicity data for isosafrole, risks from this chemical cannot be quantified. However, because it appear that isosafrole present because of natural conditions, any potential risks to

aquatic organisms would be acceptable. Therefore, isosafrole was eliminated as a COPC for risks to sediment invertebrates. The uncertainties involved in not having toxicity data available are discussed in Section 8.6.

HMX

HMX was retained as a COPC in sediment because an EDQL was not available for comparison. Only one toxicity study was located in the literature for HMX; it was based on a freshwater benthic invertebrate, a selected assessment endpoint. In that study, survival of *Chironomus tentans* was not statistically different ($p<0.05$) from control samples at concentrations as high as 146 mg/kg (Steevens et al., 2002). The maximum detected concentration of 0.422 mg/kg in sample 01SD0301 was significantly lower than the NOEC of 146 mg/kg for survival. For this reason, risks to sediment invertebrates were viewed to be acceptable so HMX was eliminated as a COPC for risks to sediment invertebrates.

Heptachlor

Heptachlor was retained as a COPC because the maximum detected concentration (2.5 µg/kg) exceeded the EDQL of 0.6 µg/kg. The EDQL of 0.6 is based on the TEL for heptachlor epoxide, as presented in MacDonald et al., (1999). Also, as presented in MacDonald et al., (2000), the TEL of 0.6 was included in the calculation of the consensus-based sediment guidelines. Therefore, the consensus-based Threshold Effects Concentration (TEC) of 2.47 µg/kg is a more appropriate screening benchmark for heptachlor because the TECs are preferentially selected as the Region 5 sediment ESLs. The TEC is intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected. The probable effects level (PEC) for heptachlor epoxide is 16 µg/kg. The PEC is intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently.

The maximum detection is essentially the same as the TEC so risks to benthic invertebrates from heptachlor in the sediment are unlikely. In addition, because most of the detections, including the maximum detection, were in samples from dry drainage ways where there is little or no aquatic habitat, risks from heptachlor are considered acceptable. Therefore, heptachlor was eliminated as a COPC for risks to aquatic receptors.

Summary

Five organic compounds were present in sediments at concentrations that exceeded EDQLs and were retained as COPCs. HMX was retained as a COPC because an EDQL was not available. The COPCs

were evaluated during Step 3a of the SERA process. Factors considered during the Step 3a evaluation included frequency of detection, comparisons to alternative screening levels, spatial analysis of detections, and habitat quality. Although the concentrations of some COPCs exceeded the conservative screening levels, the chemicals are not likely to impact benthic invertebrates for reasons discussed above. Also, it is not clear that all of the COPCs are related to site activities based on the overall low concentrations of those chemicals and spatial distribution. Finally, most of the sediment samples were collected in dry drainage ditches with little or no aquatic habitat. For these reasons risks from all the chemicals detected in the sediment were determined to be acceptable so no chemicals in the sediment were retained as COPCs for further evaluation regarding risks to aquatic receptors.

8.6.2 Terrestrial Food-Chain Modeling

The alternate benchmark values provided in Section 8.6.1 are not designed to evaluate risks to wildlife ingestion of soil, sediment, surface water, plants, invertebrates, and fish. Therefore, a terrestrial wildlife intake model was used to estimate the exposure of terrestrial receptors to the COPCs. The food-chain modeling was conducted only for chemicals identified by U.S. EPA in the following publication as important bioaccumulative chemicals: Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment, Status and Needs. EPA 823-R-00-001, Office of Water, Office of Solid Waste, EPA 823-R-00-001, February, 2000. The only chemicals that were retained as COPCs but were not carried through the food-chain model were isosafrole, aluminum, iron, and vanadium. No bioaccumulation data have been identified for isosafrole, and based on the high water solubility in Table 6-1, it is unlikely that this chemicals would be bioaccumulative. The three metals listed above are not considered to be bioaccumulative under typical site conditions and there is nothing to suggest that conditions at the site would make these metals bioaccumultive in ecological receptors. Section 8.6.2.1 describes the food-chain model methodology, while Section 8.6.2.2 presents and discusses the results of the food-chain modeling for the surrogate species. Although fish are potentially present during high flow conditions (i.e., heavy storm events), potential risk to piscivorous wildlife consuming fish is insignificant as discussed in Sections 8.2.3 and 8.2.5. The overall contribution to the diet of piscivorous wildlife in these cases is miniscule and therefore, food-chain modeling was not performed.

8.6.2.1 Methodology

Chemicals evaluated in the terrestrial food-chain model were limited to those identified by the U.S. EPA as bioaccumulative (U.S. EPA, 2000a). The primary reason for including only bioaccumulative chemicals in the food chain model is based on the assumption that although wildlife can be exposed to chemicals that do not accumulate in food items (i.e., plants, invertebrates), via direct ingestion of the media (i.e.,

soil), the exposure of the animal consuming that chemical will be low if the chemical is not accumulating in the food item. Risks to terrestrial receptors from bioaccumulative COPCs in the soil were evaluated by estimating the chronic daily intake (CDI) and comparing the CDI to toxicity reference values (TRVs) representing acceptable daily doses in mg/kg/day. The TRVs were developed from NOAELs and LOAELs obtained from wildlife studies. The majority of the TRVs were obtained from the ORNL Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996). Appendix H.4 presents the TRVs that are used in this report and the derivation of mammal TRVs using the body-weight scaling equation presented below. The appendix also presents the ecological endpoints for the TRVs.

For avian species, the NOAEL (or LOAEL) for the test species was used as the NOAEL (or LOAEL) for the surrogate species in accordance with Sample et al. (1996). For mammalian species, the NOAEL (or LOAEL) from the test species was adjusted to a NOAEL (or LOAEL) for the representative species using the following body-weight scaling equation from Sample et al. (1996) and Sample and Arenal (1999):

$$NOAEL_W = NOAEL_t * (bwt/bww)$$

Where:

$NOAEL_W$ = NOAEL for the representative wildlife species
$NOAEL_t$ = NOAEL for the test species
bwt = Body weight of the test species
bww = Body weight of the representative wildlife species

The body-weight scaling was performed in accordance with the MGBG QAPP because studies have shown that, for mammals, numerous physiological functions such as metabolic rate, as well as responses to toxic chemicals, are a function of body size (Sample et al., 1996). However, Sample et al. (1996) indicated that physiological scaling factors may not be appropriate for birds. Therefore, no body weight scaling was used for birds in this SERA. Table H.3-1 in Appendix H.3 presents the body weights that were used for the surrogate and test species.

When a sub-chronic study was used to develop the TRV, the final value was multiplied by a factor of 0.1 to account for uncertainty between sub-chronic and chronic effects. When an LOAEL study was used to develop the NOAEL TRV, the LOAEL was multiplied by a factor of 0.1 to estimate the NOAEL.

Total exposure of the terrestrial receptors to COPCs in the surface soil was determined through food-chain modeling by estimating the daily doses in mg/kg/day using exposure equations. The following equation describes the generic food-chain model that was used for the selected representative species:

$$CDI = \frac{[(Cs * BAF * IR) + (Cs * Is) + (Cw * Iw)] * H}{BW}$$

Where:

CDI	=	Chronic daily intake (mg/kg-day)
Cs	=	Contaminant concentration in surface soil (mg/kg)
Cw	=	Contaminant concentration in unfiltered surface water (mg/L)
BAF	=	Bioaccumulation factor (unitless – see discussion below)
IR	=	Ingestion rate of food (kg/day)
Is	=	Rate of incidental surface soil ingestion (kg/day)
Iw	=	Ingestion rate of surface water (L/day)
H	=	Portion of food intake from the contaminated area (unitless)
BW	=	Body weight (kg)

Contaminant concentrations in food items were calculated using bioaccumulation factors (BAFs) from published sources. The following sources of BAFs were used in the SERA:

- Plant BAFs (Organics): Toxicity and Chemical-Specific Factors Database (ORNL, 2002).
- Plant BAFs (Inorganics): Empirical Model for the Uptake of Inorganic Chemicals from Soil by Plants (ORNL, 1998).
- Soil Invertebrate BAFs: Development and Validation of Bioaccumulation Models for Earthworms (Sample et al., 1998).

Table H.2-1 in Appendix H.2 presents chemical-specific BAFs that were used in this SERA. A default value of 1.0 was used for the BAF if chemical-specific data were not available in the above sources.

Some of the BAFs presented in the above sources estimate the tissue concentrations in dry weight. These values were converted to wet weight for use in exposure estimation in the food-chain models by multiplying the BAF by the average proportion of dry matter content of the organism (Sample et al., 1997). The following table presents the proportions of dry matter that were used to adjust the BAFs to wet weight values (Sample et al., 1997).

Food Type	Percent Water Content	Percent Dry Weight
Terrestrial Invertebrates (earthworms)	84	16
Terrestrial Plants (monocots-young grass)	70	30

Food of the meadow vole and bobwhite quail was assumed to consist of only vegetation, while food of the short-tailed shrew and American robin was assumed to consist of only terrestrial invertebrates. Therefore, chemical concentrations in food items of the meadow vole and bobwhite quail were estimated by multiplying each COPC surface soil concentration by its associated soil-to-vegetation BAF. Chemical concentrations in food items of the short-tailed shrew and American robin were estimated by multiplying each COPC surface soil concentration by its associated soil-to-invertebrate BAF.

Two food-chain model scenarios were used for each species. The first scenario was conservative and used the following assumptions:

- 95 percent UCL concentration in soil.
- 90th percentile BAFs.
- Conservative receptor body weight.
- Conservative receptor ingestion rate.
- Receptors spend 100 percent of their time at the site.

The second scenario was more representative of conditions at MGBG and used the following assumptions:

- Average soil concentration.
- Median BAFs.
- Average receptor body weight.

- Average receptor ingestion rate.
- Receptors spend 100 percent of their time at the site. The EEQs reflect this assumption; however, receptors' home ranges were qualitatively taken into account in Section 8.5.2.2.

The exposure assumptions (i.e., ingestion rate, body weight) were obtained primarily from the Wildlife Exposure Factors Handbook (U.S. EPA, 1993c); other sources were used when necessary and are presented in Table 8-3. A more complete discussion of how the values in Table 8-3 were generated is included in Appendix H.3. The EEQs for the terrestrial wildlife model were calculated as follows:

$$EEQ = \frac{CDI}{TRV}$$

where:

EEQ = Ecological Effects Quotient (unitless)
CDI = Chronic Daily Intake Dose (mg/kg-day)
TRV = Terrestrial Reference Value (NOAEL or LOAEL) (mg/kg-day)

Four terrestrial wildlife EEQs were calculated in the SERA to present a range of potential risk:

- $NOAEL_{max}$: EEQ using maximum exposure assumptions and NOAEL
- $LOAEL_{max}$: EEQ using maximum exposure assumptions and LOAEL
- $NOAEL_{avg}$: EEQ using average exposure assumptions and NOAEL
- $LOAEL_{avg}$: EEQ using average exposure assumptions and LOAEL

The $NOAEL_{max}$ is considered the most conservative because it is based on conservative assumptions and NOAEL toxicity values. The $LOAEL_{avg}$ is considered the least conservative because it is based on less conservative assumptions (i.e., average COPC concentrations) and LOAEL toxicity values. The $LOAEL_{avg}$ was used in Step 3a to further refine the list of COPCs identified during the ecological screening.

8.6.2.2 Results and Discussion

Appendix H.5 presents the food-chain modeling calculations for the surrogate species. Table 8-4 summarizes the NOAEL- and LOAEL-based EEQs under the conservative food-chain scenario and Table 8-5 summarizes the NOAEL- and LOAEL-based EEQs under the average food-chain model scenario.

Table 8-6 summarizes the Step 3a refinement for the food chain model. Separate discussions are provided below for evaluations of potential risk to the herbivorous and insectivorous receptors.

Herbivorous Receptors

Under the conservative (i.e., maximum exposure) food-chain scenario, all EEQs were less than 1.0 for representative herbivorous receptors. Therefore, risk to herbivores receptors from soil contaminants is considered to be negligible. Food-chain modeling for these receptors using average exposure assumptions was unnecessary and was not performed.

Insectivorous Receptors

Under the conservative (i.e., maximum exposure) food-chain scenario, the NOAEL-derived EEQ for zinc was 12.0 for the American robin, while all EEQs were less than 1.0 for the shrew. The NOAEL-derived EEQ for selenium equaled 1.0 for the American Robin, while the LOAEL-derived EEQ was less than 1.0. Under the average exposure scenario for the robin, the NOAEL-derived EEQ for selenium was less than 1.0 (Table 8-5). The NOAEL-based EEQ for zinc, however, was greater than 1.0 under the average exposure scenario (2.3), but the LOAEL-based EEQ for zinc was less than 1.0 (Table 8-5). Food-chain modeling using average exposure assumptions for the quail was unnecessary and was not performed.

Under the assumptions used in the conservative-exposure scenario, food chain EEQs exceeded 1.0 only for the American robin; no EEQs were greater than 1.0 for the shrew. The MGBG is relatively small (two acres). The American robin's home range while nesting is typically 0.5 to 2.0 acres, but robins forage over much larger areas during other seasons (U.S. EPA, 1993c). Similar circumstances for breeding versus non-breeding home ranges would exist for other insectivorous birds represented by the American robin. Average COPC concentrations are more realistic exposure point concentrations (EPCs) for birds than maximum concentrations because insectivorous birds are exposed to COPC concentrations throughout the SWMU, rather than a single location. Surface samples were collected at 21 soil borings scattered throughout the 2 acre SWMU so there is adequate spatial coverage within the exposure area of the robin making it appropriate to calculate an average concentration as the EPC.

Using the average scenario, only zinc had an EEQ slightly greater than 1.0 using the NOAEL (EEQ = 2.3); the EEQ using the LOAEL was less than 1.0. The avian NOAEL and LOAEL for zinc were developed from a study in which no adverse effects were observed among hens consuming 48 and 228 mg/kg Zn, but where egg hatchability was <20% of controls among hens consuming 2,028 mg/kg zinc (Sample et al., 1996). Because the study was greater than 10 weeks in duration and considered

exposure during reproduction, the 228 mg/kg dose was considered a chronic NOAEL (14.5 mg/kg-day) and the 2,028 mg/kg dose was considered a chronic LOAEL (131 mg/kg-day).

The EEQs would be considerably less than the values in Tables 8-4 and 8-5 if home range factors had been incorporated in the food chain modeling. Therefore, because the EEQ for only a no-effects level was exceeded, there is some uncertainty as to whether there will be an actual risk to insectivorous birds. However, when the other conservative factors are considered such as the robins will not likely obtain all of their food from the MGBG, the low EEQ being based on a no-effects level, and the likelihood that the soil zinc will be less bioavailable than the zinc used to conduct the toxicity test to establish the NOAEL, it is unlikely that insectivorous birds will be impacted. For that reason, and because as discussed in Section 8.6.1.1, it does not appear that zinc is related to site activities, risks from zinc are acceptable so zinc is eliminated are a COPC for further evaluation regarding risks to wildlife.

8.7 UNCERTAINTY ANALYSIS

Uncertainties were associated with most steps of the SERA, including selecting endpoints, collecting data, and evaluating toxicity to the receptors. The following sections describe the uncertainty associated with this ERA.

8.7.1 Endpoints

Measures of effects were used to evaluate the assessment endpoints that were selected for the ERA. For this ERA, the measures of effects were not the same as the assessment endpoints. Therefore, the measures were used to predict effects to the assessment endpoints by selecting surrogate species that were evaluated. For example, a decrease in reproduction of a robin was used to assess a decrease in the reproduction of the insectivorous bird population. However, predicting a decrease in reproduction to a robin may have either under or overprotected the insectivorous bird population based on differences in ingestion rates, toxicity, food preferences, etc. among different bird species.

Several endpoints were not quantitatively evaluated in this SERA. Risks to burrowing animals were not quantitatively evaluated because the methods for quantifying risks to these species have not been well developed. Small reptiles and amphibians may be prevalent at the MGBG and among ecological receptors most exposed to surface soil, sediment, and surface water (intermittently) at this site because of their limited home ranges. However, risks to reptiles and amphibians were not evaluated because exposure factors are not established for most species and toxicity data are limited (see below for a discussion of potential risks to the timber rattlesnake).

Food-chain modeling was not conducted for large carnivorous mammals and birds for several reasons including the uncertainty of estimating contaminant uptake into the diet source (small mammal tissue) and the large home range for carnivorous wildlife. Six chemicals were detected in the surface soil at concentrations that exceeded EDQLs; Isosafrole, 2,4-D, and four metals. Herbicide detections such as 2,4-D are typical of spot applications rather than burial activities associated with SWMU 01. 2,4-D does not have a high potential for accumulating in animal tissue based on its log K_{ow} of 0.45 (converted from K_{ow} of 2.81 in Table 6-1) which is below the log K_{ow} threshold (>3.5) that is commonly used to identify bioaccumulative chemicals (U.S. EPA, 2000a) . Also, the low detection frequency and relatively low concentration does not warrant concern for carnivorous mammals and birds. Isosafrale has a low log K_{ow} value of 2.66 (converted from K_{ow} of 457 in Table 6-1) which is also below the log K_{ow} threshold (>3.5). Therefore, neither of these two organic chemicals are bioaccumulative and do not need to be carried through the food-chain model for large carnivorous wildlife. Three of the inorganic chemicals that were detected in the surface soil at concentrations that exceeded EDQLs (copper, selenium, and zinc) are considered important bioaccumulative chemicals (U.S. EPA, 2000a). However, metals typically do not biomagnify in terrestrial systems (Newman, 1998), thereby limiting the exposure to carnivorous wildlife. Also, carnivorous birds and mammals are expected to obtain only a small portion of their food from SWMU 01 [the area of SWMU 01 is approximately 2 acres and home ranges of the red fox and red-tailed hawk are 193 acres and 370 acres, respectively (U.S. EPA, 1993)]. The food-chain EEQs assumed that the small herbivorous or insectivorous mammals and birds at SWMU 01 obtain all of their food from the site. Therefore, risks to carnivorous birds and mammals are expected to be much lower than the risks to small herbivorous or insectivorous mammals and birds.

For the reasons discussed above, food-chain modeling to upper trophic level receptors were not conducted as part of the ERA.

As discussed in Section 8.2.1.2, several endangered and threatened species or species of special concern are present at NSWC Crane, and potentially may inhabit SWMU 01. Risks to these species were not specifically calculated so the uncertainties of not calculating risks to these species are presented here. As discussed above, risks to large carnivorous mammals and birds are expected to be negligible so risks to the bobcat, bald eagle, Northern harrier, and osprey are expected to be negligible, as are risks to carnivorous reptiles such as the timber rattlesnake. Loggerhead shrikes and the sedge wren consume mostly aboveground insects such as caterpillars, beetles, spiders, and flies, as opposed to the worms that are consumed by the American robin in the food-chain model. Because worms are in direct contact with exposure to the soil, it is expected that they would have greater levels of contaminants at SWMU 01 than

aboveground insects; therefore, risks to the robin from consuming worms are expected to be greater than risks to the loggerhead shrike and sedge wren from consuming aboveground insects. Risks to the worm eating American robin from chemicals in the surface soil and surface water were determined to be low; therefore, risks to the loggerhead shrike and sedge wren also are expected to be even lower than risks to robins. The American bittern is a marshland loving bird that feeds on fish, frogs, eels, insects, and water snakes. Because there is very little aquatic habitat present at SWMU 01, the presence of the American bittern is unlikely.

8.7.2 Exposure Characterization

During the initial screening, maximum detected concentrations are compared to the U.S. EPA Region 5 EDQLs. Periodically, these screening values are reviewed and updated as new studies and toxicological information become available. In addition, as new information becomes available U.S. EPA may revise the methodology used to prepare risk assessments. Changes in the toxicity data or risk assessment methodology may result in changes in the screening levels used to select COPCs, which may introduce uncertainty into the selection of COPCs. These changes may result in an underestimation or overestimation of risk. The contaminant dose to terrestrial wildlife was calculated using an equation that incorporates ingestion rates, body weights, BAFs, and other exposure factors. These exposure factors were obtained from literature studies or predicted using various equations. Ingestion rates and body weights vary among species, especially among species inhabiting different areas. For example, the food ingestion rate for the robin was 0.89 g/g-day in a California study and 1.52 g/g-day in a Kansas study (U.S. EPA, 1993c). Therefore, there is uncertainty in applying exposure factors from the literature to the species at NSWC Crane.

Bioaccumulation of contaminants into various biological media (i.e., plants and invertebrates) depends on characteristics of the media such as pH, organic carbon, etc. Therefore, actual BAFs at the site may be different than those used in the ERA, which were obtained from the literature.

There is uncertainty in the chemical data collected at the site. Several sample locations were biased toward locations with a higher expectation of being contaminated. Therefore, the concentrations do not actually represent the site, rather they represent the higher concentrations at a site. As such, predicted exposure doses to upper level receptors were probably higher than actual exposure doses, and risk was probably overestimated.

No surface water resources exist at the MGBG site except in times of heavy rain events. Proposed surface water samples were not collected during the Round 1 sampling event because stream beds and smaller

drainage channels were dry at the time of sampling. However, surface water samples were collected during Round 2 where water was present in intermittent pools at the time of sample collection. Round 2 sampling was conducted during an unusually wet month. As indicated in Section 5.0 of this RFI report, the analyses selected for 2002 samples were based on the results of the 2001 sampling and the need to fill data gaps for the RFI. Because the contaminants of primary interest were VOCs in ground water, surface water samples were analyzed only for VOCs, in accordance with the EPA-approved RFI QAPP. It was believed that analysis of VOCs in surface water samples would satisfy the potential ground water to surface water migration pathway. This is unlikely to represent a significant data gap in ecological risk evaluation of surface water because of habitat considerations. Fish are not likely to be present in the intermittent, shallow pools where surface water samples were collected, and risks to aquatic invertebrates are better characterized through the evaluation of sediment data at this site because of the intermittent nature of the surface water. Based on the above, the surface water and sediment data adequately characterizes exposure conditions associated with surface water at SWMU 01.

As indicated in Section 8.5.2, the surface water samples were only analyzed for VOCs because those were the primary contaminants detected in the ground water samples. However, because other chemicals were detected in the ground water, it is possible that they may have been present in the surface water samples. Table 8-7 presents a comparison of the chemical concentrations detected in the ground water samples (except for the VOCs) to selected water quality screening values. VOCs are not included on Table 8-7 because the surface water samples were analyzed for VOCs. Two EEQs are calculated on the table; one for a comparison to the screening values directly and one for a comparison to the screening values after the screening values were multiplied by a dilution factor of 100. The dilution factor of 100 is conservative because the drainage channels receive very little ground water discharge and typically only flow after there is a significant rainfall event. As indicated by the black shading on the table, several chemicals exceed the screening values before the dilution factor was applied, but none of the chemicals exceeded the screening values after the dilution factor was applied. Because the dilution factor of 100 is considered to be conservative, risks to aquatic receptors from chemicals in the surface water (other than VOCs) are negligible. Therefore, the fact that the surface water samples were only analyzed for VOCs does not affect the results of the ERA.

Surface soil was collected from the 0 to 2 feet bgs depth interval. Background surface soil data were collected from the 0 to 1 foot bgs depth interval as a compromise depth from all NSWC Crane projects for which a variety of surface soil depths may be used. There is uncertainty in this approach depending on the source of contamination and how it was disposed at the site (i.e., deposited on the surface as a result of burning activities, buried, etc.) because the two different depth intervals represent slightly different soil populations. Under the conservative scenario, terrestrial wildlife are assumed to live and feed only at the

site. This assumption tended to over-predict risk because it is unlikely that most wildlife receptors obtain all their food from within the site boundaries and from the most contaminated areas. Risk also may have been over-predicted in the average scenario, where home range is taken into account, because of the biased sampling in the most contaminated areas.

8.7.3 Ecological Effects Data

There was uncertainty in the ecological screening values. Potential adverse impacts to aquatic receptors from constituents in sediment were evaluated by comparing COPC concentrations in sediment to screening values (SSLs). The SSLs have more uncertainty associated with them than do the surface water screening levels (SWSLs) because the procedures for developing SSLs are not as well established and for many chemicals there are fewer sediment toxicity data than surface water toxicity data. Sediment characteristics (i.e., pH, acid volatile sulfide, TOC) also will have a large impact on the bioavailability and toxicity of constituents. Finally, screening values based on equilibrium partitioning have uncertainty associated with log K_{ow} values including: the assumed relationship between K_{ow} and K_{oc} and the assumption that pore water exposure is the most important route for sediment-dwelling organisms.

Adverse impacts to terrestrial plants and invertebrates from constituents in surface soil were evaluated by comparing COPC concentrations to surface soil screening values (SSSLs). The SSSLs are similar to the sediment screening values in that they are less established than SWSLs. Fewer studies and less data are available for establishing SSSLs than SSLs, and many of the SSSLs are based on the results of only a few studies. In addition, the SSSLs are based on different end points depending on the preference of the agency that developed them. Therefore, they have more uncertainty than surface water and sediment screening levels.

The NOAELS and LOAELs that were selected for the representative wildlife species were based on species commonly used in laboratory studies (i.e., rats, mice, ducks). There was uncertainty in the application of toxicity data among species because the contaminant may be more or less toxic to the wildlife species in question than it was to the test species.

The toxicity of chemical mixtures is not well understood. The toxicity data used in the SERA to evaluate risk to ecological receptors was for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals because of synergistic or antagonistic effects.

Finally, toxicological data for some COPCs are sparse. Therefore, there was uncertainty in any conclusions involving the potential impacts to ecological receptors from these constituents.

8.7.4 Risk Characterization

Unacceptable risks are possible if an EEQ is greater than 1.0. However, the magnitude of effects to ecological receptors cannot always be accurately inferred based on the magnitude of the EEQ. Rather, an EEQ greater than 1.0 simply indicates that the dose used to derive the TRV was exceeded. Finally, there was uncertainty in how the predicted risks to a species at the site translated into risk to the population in the area as a whole.

Background comparisons were used in the selection of COPCs for inorganics and radionuclides in environmental media. Only chemicals with detected concentrations greater than the background concentrations and that also exceeded the screening levels were retained as COPCs in surface soil and sediment. Tables 4-15 and 4-16 indicate the chemicals that were not retained as COPCs in surface soil and sediment, respectively, because the site concentrations did not exceed the background concentrations. There may be non-site-related risks associated with some of those chemicals because many of them were detected at concentrations that exceeded their respective EDQLs. However, in accordance with the EPA-approved RFI QAPP, these risks were not quantified as part of this ERA.

8.7.5 Uncertainty in Analytical Data

As discussed in Section 3.3, results for some samples were rejected. Therefore, the lack of data from these locations creates some uncertainty. Many organic chemicals, including 1,4-dioxane, 4-nitroquinoline-1-oxide, 2-butanone, acrolein, acetonitrile, isobutanol, methacrylonitrile, pronamide, and propionitrile, were rejected in most surface soil, sediment, and/or surface water samples. This is not believed to have significantly impacted the ERA, however, because these chemicals are not expected to be related to site activities. In addition, a few pesticides, herbicides, and PAHs results were rejected in few samples creating data gaps in these sample locations. Whereas these chemicals are potentially of greater concern based on historical activities, the ERA is not significantly affected due to the high number of acceptable data for these chemicals. Also, as indicated from table 4-15, none of the pesticides and PAHs that were detected exceeded the EDQLs, indicating that these chemical classes are not of ecological concern. 2,4-D was rejected in two surface soil samples. The concentrations of 2,4-D exceeded the EDQL in the five samples in which it was detected. However, as indicated in sections 8.5.1.1 and 8.5.2.2, risks from 2,4-D in the detected samples were low, therefore, impacts from the rejected data are expected to be minimal.

Additionally, some chemicals in surface soil and sediment had detection and reporting limits that exceeded the established risk-based target levels. Tables 3-5 and 3-6 present the minimum detected values, the

minimum and maximum non-detected values, the nominal MDL, and the lower of the risk-based target levels for ecological and human health receptors for surface soil and sediment samples, respectively. As seen on the tables, the MDL and non-detected values for several metals were greater than the target levels. This is important in that for the statistical comparisons, one-half the non-detected values for non-detected sample results is used. Therefore, elevated detection limits for these samples create some uncertainty potentially biasing data from sample locations as high or low. Also, those chemicals that are U-qualified as non-detected for all samples in a media are not evaluated as part of the ERA. Two situations where detection limits exceeding the EDQLs exist:

1. Chemicals with MDLs greater than the EDQLs may be present at the MGBG. These chemicals could not be, and were not, quantitatively included in the ERA because no measure of quantitation exists below the MDL for these chemicals. Some metals and SVOCs in soil (Table 3-5) and explosives, herbicides, metals, SVOCs, VOCs, and pesticides/PCBs in sediment (Table 3-6) had MDLs greater than the associated EDQLs in at least some samples. This did not significantly impact the conclusions of the risk assessment because most of these chemicals were detected at greater or similar concentrations in other soil samples that were used in the COPC selection. Additionally, most of the remaining chemicals are considered to be of little significance related to the MGBG and were not detected in any samples.

2. In cases where chemicals were detected above the MDL but below the reporting limit, the chemicals were still reported by the laboratory and evaluated in the COPC selection process. This was the case for herbicides, some metals, some SVOCs, VOCs, and pesticides in soil and explosives, herbicides, SVOCs, and pesticides/PCBs in sediment.

Some compounds produced low recoveries during analysis. This creates uncertainty in that reported chemical concentrations may be lower than what is actually present at the site. One herbicide (dinoseb), four PAHS (acenaphthene, acenaphthalene, dibenzo(a,h)anthracene, and naphthalene), two pesticides (endosulfan I and II), one metal (antimony), and one VOC (ethyl methacrylate), exhibited recoveries considered extremely low to moderately low during analysis. Of these, only acenaphthene, dibenzo(a,h)anthracene, and antimony were detected in any sample and evaluated against the risk-based target screening levels. See discussion above for the uncertainties involved with evaluating non-detected data. LCS and MS recoveries ranged from 49 to 57 percent for acenaphthene and 39 to 47 percent for dibenzo(a,h)anthracene. The mean MS percent recovery for antimony soil and sediment samples was 57% in round 1 samples. Recoveries were acceptable in round 2 sediment samples. This indicates the actual concentrations for these chemicals could possibly be greater than the reported concentrations. This does not affect the evaluation of these chemical in surface soil in the ERA as the reported concentrations are less

than approximately 10,000 times the EDQL for acenaphthene and 3,000 times the EDQL for dibenzo(a,h)anthracene. It is unlikely that actual concentrations at the site are 3,000 to 10,000 times the reported concentrations. Additionally, acenaphthene was retained as a COPC in sediment and evaluated as part of the step 3a refinement. Other PAHs produced acceptable recoveries during analysis and were detected relatively infrequently at the MGBG in concentrations below the EDQL. Antimony was detected at a maximum concentration of 1.7 mg/kg, which exceeded the EDQL but was below background. Although it is possible that antimony would be greater than background if the samples recovered higher, recoveries for background antimony concentrations were also moderately low at approximately 75% (TtNUS, 2001a). For these reasons, the uncertainty involved with chemicals exhibiting poor LCS and MS recoveries is not believed to adversely impact the results of the ERA.

8.8 ECOLOGICAL RISK SUMMARY AND CONCLUSIONS

An ERA was performed for SWMU 01, the MGBG. Surface water was only present at some of the locations during the Phase II sampling event; no surface water was present at any of the locations during the Phase I sampling event. No analytes were detected in surface water. Also, because the drainage channels are dry most of the year, the habitat for aquatic receptors is poor.

Two organic compounds and six metals were retained as surface soil COPCs and six organic compounds were retained as sediment COPCs after the initial screening in Step 2. Based on the re-evaluation in Step 3a, it was determined that surface soil COPC concentrations at the 2-acre MGBG site pose acceptable risks to terrestrial ecological receptors, so all chemicals were eliminated as COPCs in surface soil for further evaluation regarding risks to plants and invertebrates. Similarly, based on the re-evaluation in Step 3a it was determined that sediment COPC concentrations pose acceptable risks to ecological receptors, so all chemicals were eliminated as COPCs in sediment for further evaluation regarding risks to sediment invertebrates. Finally, risks to wildlife were acceptable so all chemicals were eliminated as COPCs in surface soil for further evaluation regarding risks to mammals or birds.

TABLE 8-1

STEP 3A EVALUATION FOR RISKS TO PLANTS AND INVERTEBRATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	FOD	Maximum Detection (mg/kg)	Screening Level (mg/kg)	Max. EEQ[1]	Number of Samples > Screening Level[2]	Step 3a Evaluation: Alternate Benchmarks: Eco SSL Plant	Eco SSL Earthworm	ORNL Benchmarks[3] Plant	ORNL Benchmarks[3] Earthworm	Canadian SQG[3]	Other Step 3a Factors Considered in Evaluation[4]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COC?
Isosafrole	6/24	46	9.9	4.6	1	NA	NA	NA	NA	NA	- No additional toxicity data was found - New ESL document does not have a screening level for isosafrole - Presence in samples likely due to presence of numerous sassafras trees - Spatial distribution of data suggests that it is not related to site activities - One location that exceeded the screening level is distant from the burial areas	Acceptable	No
2,4-D	5/18	0.21	0.027	7.8	5	NA	NA	NA	NA	NA	- 14-Day NOEC for earthworms is 100 mg/kg - All sample concentrations below the NOEC - Herbicide could pose a risk to vegetation but site is heavily vegetated and unlikely impacted	Acceptable	No
Aluminum	24/24	19,400	NA	NA	NA	pH<5.5 S.U		NA	NA	NA	- pH values ranged from 5.0 to 7.8 S.U. with an average pH of 6.0 S.U. - Within range of Eco SSL - Unlikely to be site-related - 1 sample slightly exceeded the max. background concentration (17,400 mg/kg)	Acceptable	No
Copper	24/24	18.5	2.96	6.3	24	NA	NA	100	60	63	- Maximum detection well below all alternate benchmarks - Site concentrations similar to background concentration range (5.4 to 17.1 mg/kg)	Acceptable	No
Iron	24/24	25,500	NA	NA	NA	pH<5-8 S.U (plants) No SSL for earthworms		NA	NA	NA	- pH values ranged from 5.0 to 7.8 S.U. with an average pH of 6.0 S.U. - Within range of Eco SSL - No samples exceeded the maximum background concentration (36,200 mg/kg) - Unlikely that invertebrates are being impacted by iron at concentrations similar to background	Acceptable	No
Selenium	16/24	1.3	0.03	43	16	NA	NA	1	70	1	- 3 of 24 detections slightly greater than Canadian SQG, which is based mostly on plant data - Site is heavily vegetated so significant impacts to vegetation are not likely - Based on one toxicity study, it appears that earthworms are less sensitive to selenium than plants	Acceptable	No
Vanadium	24/24	44.5	1.6	28	24	NA	NA	2	NA	130	- Canadian SQG is more technically appropriate based on toxicity test data used to develop the value - The maximum detection is well below the Canadian SQG - The maximum detection only slightly exceeded the maximum background concentration (40 mg/kg)	Acceptable	No
Zinc	24/24	67.8	6.6	10	24	NA	NA	50	100	200	- ORNL plant benchmark appears to be conservative - only benchmark that is exceeded - Site is heavily vegetated so significant impacts to vegetation are not likely - All concentrations below benchmark data for earthworms	Acceptable	No

1 - Maximum EEQ = Maximum detection divided by the screening level
2 - Number of samples with concentrations greater than the screening level
3 - If the Eco SSL was greater than the ORNL Benchmarks or the Canadian SQG than the ORNL Benchmarks and the Canadian SQGs were not applicable and not presented.
If the Eco SSL was less than the ORNL Benchmarks or the Canadian SQG than the ORNL Benchmarks and the Canadian SQGs were not applicable and not presented.
4 - See section 8.6.1.1 for a more detailed Step 3a evaluation

2,4-D - 2,4-Dichlorophenoxyacetic Acid
EEQ - Ecological Effects Quotient
FOD - Frequency of Detection
NA - Not available or not applicable
SGQ - Soil Quality Guideline
S.U. - Standard Units

TABLE 8-2

STEP 3A EVALUATION FOR RISKS TO BENTHIC ORGANISMS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	FOD	Maximum Detection ug/kg)	Screening Level (ug/kg)	Max. EEQ[1]	Number of Samples > Screening Level[2]	Step 3a Evaluation: Alternate Benchmarks: Lower Effects Level (ug/kg)	Step 3a Evaluation: Alternate Benchmarks: Higher Effects Level (ug/kg)	Step 3a Evaluation: Other Step 3a Factors Considered in Evaluation[3]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COC?
Acetone	6/12	630	453	1.4	3	NA	NA	- No other toxicity data located - Common laboratory contaminant - 290 ug/kg in upgradient sample - Only detections were in 2002 samples - indicates a laboratory source of acetone - Little aquatic habitat	Acceptable	No
Dichlorodifluoromethane	4/12	8	1.33	6.0	3	NA	NA	- New ESL document does not have a screening level for dichlorodifluoromethane - No other toxicity data located - No clear pattern of contamination exists - detected in 4 of 12 samples - Not detected in soil or groundwater samples - Little aquatic habitat	Acceptable	No
Acenaphthene	1/7	139	6.71	21	1	6.71	88.9	- Locaton of sediment sample is a dry drainage ditch - poor aquatic habitat - Detection unlikely site related - adjacent to road and downgradient of asphalt piles - No other PAHs exceeded screening level indicating PAHs are not a concern	Acceptable	No
Isosafrole	1/7	7600	4.12	1845	1	NA	NA	- New ESL document does not have a screening level for isosafrole - No other toxicity data located - Presence in samples likely due to presence of numerous sassafras trees	Acceptable	No
HMX	4/7	422	NA	NA	NA	NA	NA	- NOEC for survival for midge was 146,000 ug/kg in literature - max detection well below this value	Acceptable	No
Heptachlor	5/7	2.5	0.6	4.2	5	2.47	16	- Maximum detection similar to lower effects level - Little aquatic habitat	Acceptable	No

1 - Maximum EEQ = Maximum detection divided by the screening level
2 - Number of samples with concentrations greater than the screening level
3 - See section 8.6.1.1 for a more detailed Step 3a evaluation

EEQ - Ecological Effects Quotient
FOD - Frequency of Detection
NA - Not available or not applicable

TABLE 8-3

EXPOSURE PARAMETERS FOR THE TERRESTRIAL WILDLIFE MODEL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Species/Exposure Inputs	Conservative Inputs		Average Inputs		Source
	Values	Units	Values	Units	
Meadow Vole					
Body Weight = BW	3.290E-02	kg	3.663E-02	kg	USEPA, 1993
Food Ingestion Rate = If	1.280E-02	kg/day	1.190E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	7.700E-03	L/day	6.400E-03	L/day	USEPA, 1993
Soil Ingestion Rate - Is	3.070E-04	kg/day	2.860E-04	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		3.000E-02	acres	USEPA, 1993
Short-Tailed Shrew					
Body Weight = BW	1.525E-02	kg	1.687E-02	kg	USEPA, 1993
Food Ingestion Rate = If	1.620E-02	kg/day	1.030E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	4.300E-03	L/day	3.800E-03	L/day	USEPA, 1993
Soil Ingestion Rate - Is	2.106E-03	kg/day	1.339E-03	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		9.700E-01	acres	USEPA, 1993
American Robin					
Body Weight = BW	7.730E-02	kg	8.100E-02	kg	USEPA, 1993
Food Ingestion Rate = If	1.231E-01	kg/day	9.760E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	1.210E-02	L/day	1.130E-02	L/day	USEPA, 1993
Soil Ingestion Rate - Is	1.280E-02	kg/day	1.015E-02	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		1.190E+00	acres	USEPA, 1993
Bobwhite Quail					
Body Weight = BW	1.620E-01	kg	1.770E-01	kg	USEPA, 1993
Food Ingestion Rate = If	1.640E-02	kg/day	1.440E-02	kg/day	USEPA, 1993
Water Ingestion Rate = Iw	2.310E-02	L/day	1.840E-02	L/day	USEPA, 1993
Soil Ingestion Rate - Is	1.345E-03	kg/day	1.181E-03	kg/day	Beyer, 1993
Home Range = HR	Assume 100% on site		2.860E+01	acres	USEPA, 1993

See Appendix H-3 for a discussion of the derivation of these values.

TABLE 8-4

TERRESTRIAL WILDLIFE MODEL CONSERVATIVE EEQS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

	Meadow Vole		Short-Tailed Shrew		American Robin		Bobwhite Quail	
Parameter	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ	NOAEL EEQ	LOAEL EEQ
Herbicides								
2,4-D	3.1E-03	6.2E-04	4.6E-03	9.2E-04	NA	NA	NA	NA
Inorganics								
Copper	3.7E-03	2.9E-03	8.9E-03	6.9E-03	1.6E-01	1.2E-01	7.9E-03	6.0E-03
Selenium	1.6E-01	9.7E-02	8.0E-02	4.8E-02	1.0E+00	5.0E-01	2.0E-01	9.9E-02
Zinc	7.6E-03	3.8E-03	3.9E-02	1.9E-02	1.2E+01	1.3E+00	2.1E-01	2.4E-02

Notes:
- Cells are shaded if the EEQ is greater than 1.0
NA - an EEQ could not be calculated because a NOAEL or LOAEL was not available
EEQ - Ecological Effects Quotient
NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

TABLE 8-5

TERRESTRIAL WILDLIFE MODEL AVERAGE EEQS
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Parameter	American Robin	
	NOAEL EEQ	LOAEL EEQ
Inorganics		
Selenium	4.7E-01	2.4E-01
Zinc	2.3E+00	2.5E-01

Notes:

- Cells are shaded if the EEQ is greater than 1.0
- This table only presents the EEQs for contaminants that had EEQs greater than 1.0 using the maximum input parameters.

EEQ - Ecological Effects Quotient
NOAEL - No Observed Adverse Effects Level
LOAEL - Lowest Observed Adverse Effects Level

TABLE 8-6

STEP 3A EVALUATION FOR RISKS TO PLANTS AND INVERTEBRATES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

Chemical	FOD	Max. Det. (mg/kg)	Avg. Conc. (mg/kg)	NOAEL EEQ > 1.0 After Refinement	Species	LOAEL EEQ > 1.0 After Refinement	Species	Basis of Wildlife Toxicity Reference Value	Other Step 3a Factors Considered in Evaluation[1]	Risk Determination (Acceptable/ Unacceptable)	Retained as a COC?
Selenium	16/24	1.3	0.6	None	NA	None	NA	NA	NA	Acceptable	No
Zinc	24/24	67.8	44.8	2.3	Robin	None	NA	egg hatchability <20% of controls (LOAEL)	- Robins are unlikely to obtain all of their food from MGBG - Zinc may not be related to site activities - Likely the zinc in soil/worms will be less bioavailable tha zinc used in toxicity test (zinc sulfate) - Only NOAEL EEQ was greater than 1; LOAEL EEQ = 0.25 - NOAEL EEQ would likely be <1 if home range and bioavailability are taken into account	Acceptable	No

1 - See section 8.6.2.2 for a more detailed Step 3a evaluation

EEQ - Ecological Effects Quotient
FOD - Frequency of Detection
NA - Not available or not applicable

TABLE 8-7

COMPARISON OF GROUND WATER DATA TO SELECTED WATER QUALITY VALUES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Detection Frequency (1)	Water Quality Screening Value			Water Quality Screening Value X100	
							Value		Ecological Effects Quotient (2)	Value	Ecological Effects Quotient (2)
SVOCs (ug/L)											
100-02-7	4-Nitrophenol	15	J	15	J	1/13	35	(4)	0.43	3500	0.004
83-32-9	Acenaphthene	0.0793	J	0.108	J	3/13	9.9	(4)	0.01	990	0.0001
208-96-8	Acenaphthylene	0.763	-	0.763	-	1/13	4840	(4)	0.0002	484000	0.000002
117-81-7	bis(2-Ethylhexyl) phthalate	5	J	15	J	3/13	2.1	(4)	7.14	210	0.071
85-68-7	Butyl Benzyl Phthalate	9	J	9	J	1/13	49	(4)	0.18	4900	0.002
86-73-7	Fluorene	0.0593	J	0.0593	J	1/13	3.9	(4)	0.02	390	0.0002
67-72-1	Hexachloroethane	5	J	5	J	1/13	30.5	(4)	0.16	3050	0.002
91-20-3	Naphthalene	0.0796	J	0.579	-	3/13	44	(4)	0.01	4400	0.0001
Energetics (ug/L)											
118-96-7	2,4,6-Trinitrotoluene	0.127	J	0.127	J	1/13	90	(5)	0.001	9000	0.00001
88-72-2	2-Nitrotoluene	0.202	J	0.202	J	1/13	NA		NA	NA	NA
19406-51-0	4-Amino-2,6-Dinitrotoluene	0.263	J	0.275	J	2/13	NA		NA	NA	NA
2691-41-0	HMX	0.201	J	0.201	J	1/12	330	(5)	0.001	33000	0.00001
Pesticides/PCBs (ug/L)											
5103-74-2	gamma-Chlordane	0.025	J	0.075	J	2/13	0.0043	(3,6)	17.44	0.43	0.174
76-44-8	Heptachlor	0.017	J	0.023	J	2/13	0.0038	(3)	6.05	0.38	0.061
Total Metals (ug/L)											
7429-90-5	Aluminum	46.3	-	5700	-	14/37	87	(3)	NA	NA	NA
7440-36-0	Antimony	1.9	-	3.1	-	4/37	31	(4)	0.10	3100	0.001
7440-38-2	Arsenic	2.2	J	7.9	-	4/37	150	(3)	0.05	15000	0.001
7440-39-3	Barium	5.4	J	258	-	37/37	5000	(4)	0.05	500000	0.001
7440-41-7	Beryllium	0.59	-	0.7	J	2/37	7.6	(4)	0.09	760	0.001
7440-43-9	Cadmium	0.74	-	0.94	-	2/37	0.25	(3)	3.76	25	0.038
7440-70-2	Calcium	7640	-	344000	-	37/37	NA		NA	NA	NA
7440-47-3	Chromium	0.7	-	7.1	J	9/37	11	(3,7)	0.65	1100	0.006
7440-48-4	Cobalt	1.2	-	126	J	23/37	5	(4)	25.20	500	0.252
7440-50-8	Copper	0.94	-	14.5	J	4/37	9	(3)	1.61	900	0.016
7439-89-6	Iron	22.1	-	44600	-	31/37	1000	(3)	44.60	100000	0.446
7439-92-1	Lead	4.3	-	8.2	J	2/37	2.5	(3)	3.28	250	0.033
7439-95-4	Magnesium	2720	-	250000	-	37/37	NA		NA	NA	NA
7439-96-5	Manganese	1.5	-	9600	-	37/37	120	(8)	NA	NA	NA
7439-97-6	Mercury	0.1	-	0.24	-	9/37	0.77	(3)	0.31	77	0.003
7440-02-0	Nickel	1.4	-	273	-	28/37	52	(3)	5.25	5200	0.053
7440-09-7	Potassium	446	-	15500	J	37/37	NA		NA	NA	NA
7440-22-4	Silver	0.65	J	1.1	-	7/37	1	(4)	1.10	100	0.011
7440-23-5	Sodium	1510	-	117000	-	37/37	NA		NA	NA	NA
7440-24-6	Strontium	33.1	J	3990	J	37/37	NA		NA	NA	NA
7440-28-0	Thallium	2.5	-	5.1	-	9/37	0.56	(4)	9.11	56	0.091
7440-28-0	Thallium - GF	0.6	UJ	3	UJ	0/4	NA		NA	NA	NA
CALC004	Thorium-Calc	0.16	-	1.50	-	5/16	NA		NA	NA	NA
7440-62-2	Vanadium	0.53	-	11.8	-	7/37	19	(4)	0.62	1900	0.006
7440-66-6	Zinc	3.9	-	103	-	15/37	120	(3)	0.86	12000	0.009

TABLE 8-7

COMPARISON OF GROUND WATER DATA TO SELECTED WATER QUALITY VALUES
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

CAS Number	Chemical	Minimum Concentration (1)		Maximum Concentration (1)		Detection Frequency (1)	Water Quality Screening Value			Water Quality Screening Value X100	
							Value		Ecological Effects Quotient (2)	Value	Ecological Effects Quotient (2)
Dissolved Metals (ug/L)											
7429-90-5	Aluminum	146	-	146	-	1/11	87	(3)	NA	NA	NA
7440-36-0	Antimony	2.1	J	2.1	J	1/11	31	(4)	0.07	3100	0.001
7440-38-2	Arsenic	1.7	J	2.3	-	2/11	150	(3)	0.02	15000	0.0002
7440-39-3	Barium	5.4	J	215	-	11/11	5000	(4)	0.04	500000	0.0004
7440-70-2	Calcium	60500	J	349000	-	11/11	NA		NA	NA	NA
7440-47-3	Chromium	1.1	-	1.1	-	1/11	11	(3,7)	0.10	1100	0.001
7440-48-4	Cobalt	1.7	-	96.8	J	7/11	5	(4)	19.36	500	0.194
7439-89-6	Iron	51.7	J	20300	-	10/11	1000	(3)	20.30	100000	0.203
7439-95-4	Magnesium	5430	J	254000	-	11/11	NA		NA	NA	NA
7439-96-5	Manganese	10.4	-	9650	-	11/11	NA		NA	NA	NA
7439-97-6	Mercury	0.1	-	0.1	-	1/11	0.77	(3)	0.13	77	0.001
7440-02-0	Nickel	4.6	-	208	-	6/11	52	(3)	4.00	5200	0.040
7440-09-7	Potassium	1100	J	15200	-	11/11	NA		NA	NA	NA
7440-23-5	Sodium	5000	J	70700	-	11/11	NA		NA	NA	NA
7440-24-6	Strontium	96.5	J	4040	J	11/11	NA		NA	NA	NA
7440-28-0	Thallium	5.4	-	7.7	J	2/11	0.56	(4)	13.75	56	0.138
7440-62-2	Vanadium	0.77	-	0.77	-	1/11	19	(4)	0.04	1900	0.0004
7440-66-6	Zinc	7.1	-	65.6	-	4/11	120	(3)	0.55	12000	0.005
Total Radionuclides (pCi/L)											
TTNUS006	Gross Alpha	1.36	J	10.5	J	21/34	NA		NA	NA	NA
TTNUS007	Gross Beta	1.69	-	50.2	J	24/35	NA		NA	NA	NA
14274-82-9	Thorium-228	0.0329	-	0.172	-	3/16	NA		NA	NA	NA
TTNUS097	Thorium-232	0.0235	-	0.157	-	3/16	NA		NA	NA	NA

Shaded cells indicate that the specified criterion was exceeded and the chemical was selected as a COPC.

Footnotes:

1 Sample and duplicate are counted as two separate samples when determining the minimum and maximum detected concentrations.
2 The Ecological Effects Quotient is the maximum concentration divided by the water quality screening value.
3 National Recommended Water Quality Criteria, Freshwater chronic criteria. (USEPA, 2002)
4 Region 5 Ecological Data Quality Levels (EDQLs). 1999.
5 Nitroaromatic Munition Compounds: Environmental Effects and Screening Values. (Talmage et al., 1999)
6 Based on value for chlordane
7 Based on value for hexavalent chromium
8 Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 Revision (Suter and Tsao, 1996)

Definitions:

CAS = Chemical abstract services.
COPC = Chemical of Potential Concern.
GF = Graphite furnace atomic absorption reanalysis.
J = Estimated value.
NA = Not Analyzed / Not Applicable.
[illegible] Estimated detection limit.

Navy Ecological Risk Assessment Tiered Approach

RPM Input and Risk Management Consideration[3]

Step 8: Risk Management

Tier 1. Screening Risk Assessment (SRA): Identify pathways and compare exposure point concentrations to bench marks.

Step 1: Site visit; Pathway Identification/Problem Formulation; Toxicity Evaluation

Step 2: Exposure Estimate; Risk Calculation (SMDP)[1]

Proceed to Exit Criteria for SRA

Exit Criteria for the Screening Risk Assessment: Decision for exiting or continuing the ecological risk assessment.

1) Site passes screening risk assessment. A determination is made that the site poses acceptable risk and shall be closed out for ecological concerns.

2) Site fails screening risk assessment: The site must have both complete pathway and unacceptable risk. As a result the site will either have an interim cleanup or moves to the second tier.

Tier 2. Baseline Ecological Risk Assessment (BERA): Detailed assessment of exposure and hazard to "assessment endpoints" (ecological qualities to be protected). Develop site specific values that are protective of the environment.

Step 3a: Refinement of Conservative Exposure Assumptions[2] (SRA)----**Proceed to Exit Criteria for Step 3a**

Step 3b: Problem Formulation - Toxicity Evaluation; Assessment Endpoints; Conceptual Model; Risk Hypothesis (SMDP)

Step 4: Study Design/DQO - Line of Evidence; Measurement Endpoints; Work Plan and Sampling & Analysis Plan (SMDP)

Step 5: Verification of Field Sampling Design (SMDP)

Step 6: Site Investigation and Data Analysis (SMDP)

Step 7: Risk Characterization

Proceed to Exit Criteria for BERA

Exit Criteria Step 3 a Refinement

1) If re-evaluation of the conservative exposure assumptions (SRA) support an acceptable risk determination then the site exits the ecological risk assessment process.

2) If re-evaluation of the conservative exposure assumptions (SRA) do not support an acceptable risk determination then the site continues in the Baseline Ecological Risk Assessment process. **Proceed to Step 3b.**

Exit Criteria Baseline Risk Assessment

1) If the site poses acceptable risk then no further evaluation and no remediation from an ecological perspective is warranted.

2) If the site poses unacceptable ecological risk and additional evaluation in the form of remedy development and evaluation is appropriate, proceed to third tier.

Tier 3. Evaluation of Remedial Alternative (RAGs C)

a. Develop site specific risk based cleanup values.

B. Qualitatively evaluate risk posed to the environment by implementation of each alternative (short term) impacts and estimate risk reduction provided by each (long-term) impacts; provide quantitative evaluation where appropriate. Weigh alternative using the remaining CERCLA 9 Evaluation Criteria. Plan for monitoring and site closeout.

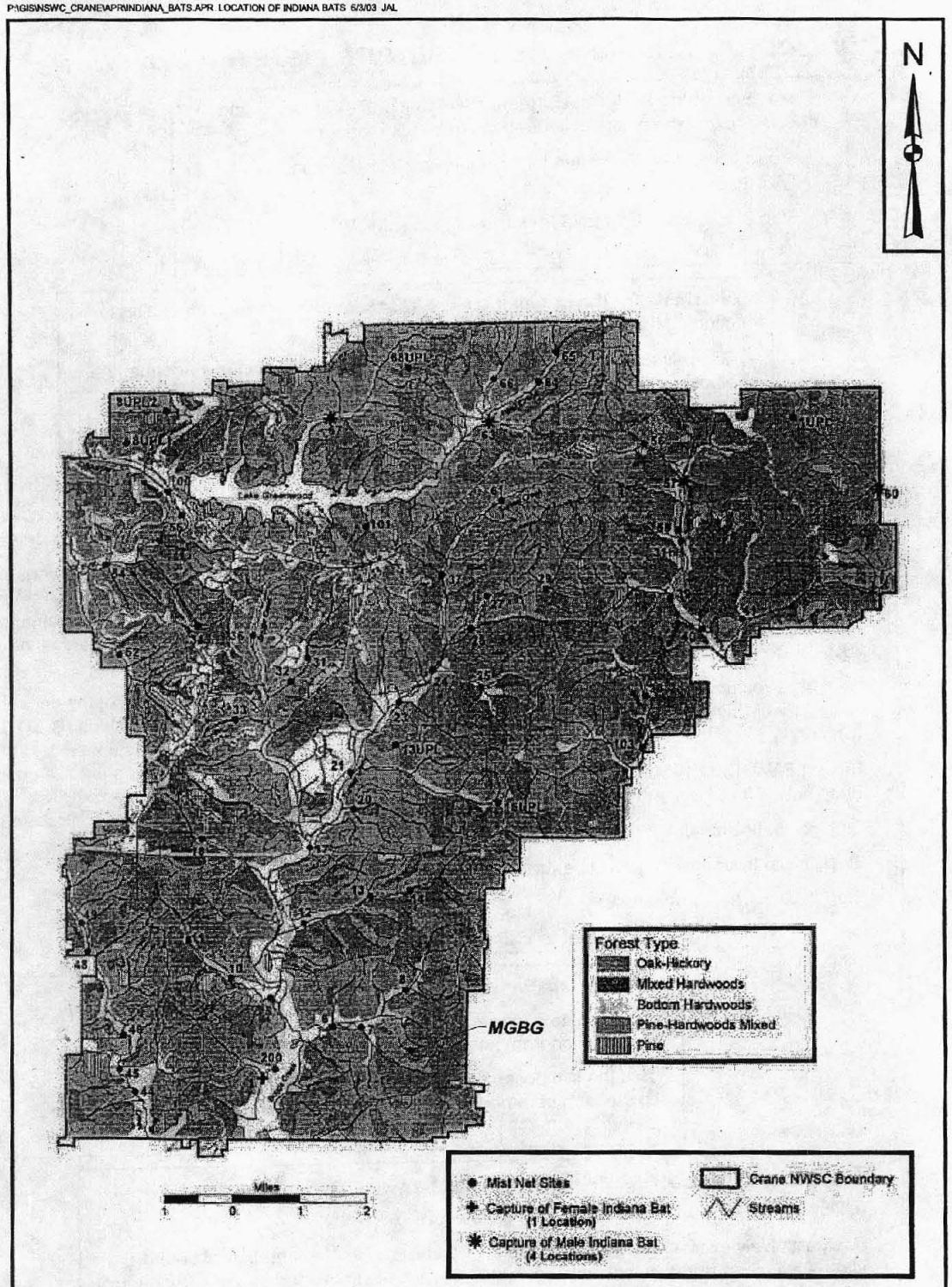
Notes: 1) See EPA's 8 Steps ERA Process for requirements for each Scientific Management Decision Point (SMDP).

2) Refinement Includes but is not limited to background, bioavailability, detection frequency. Etc.

3) Risk Management is incorporated throughout the tiered approach.

FIGURE 8-1
NAVY TIERED APPROACH
MUSTARD GAS BURIAL GROUND
CRANE, INDIANA

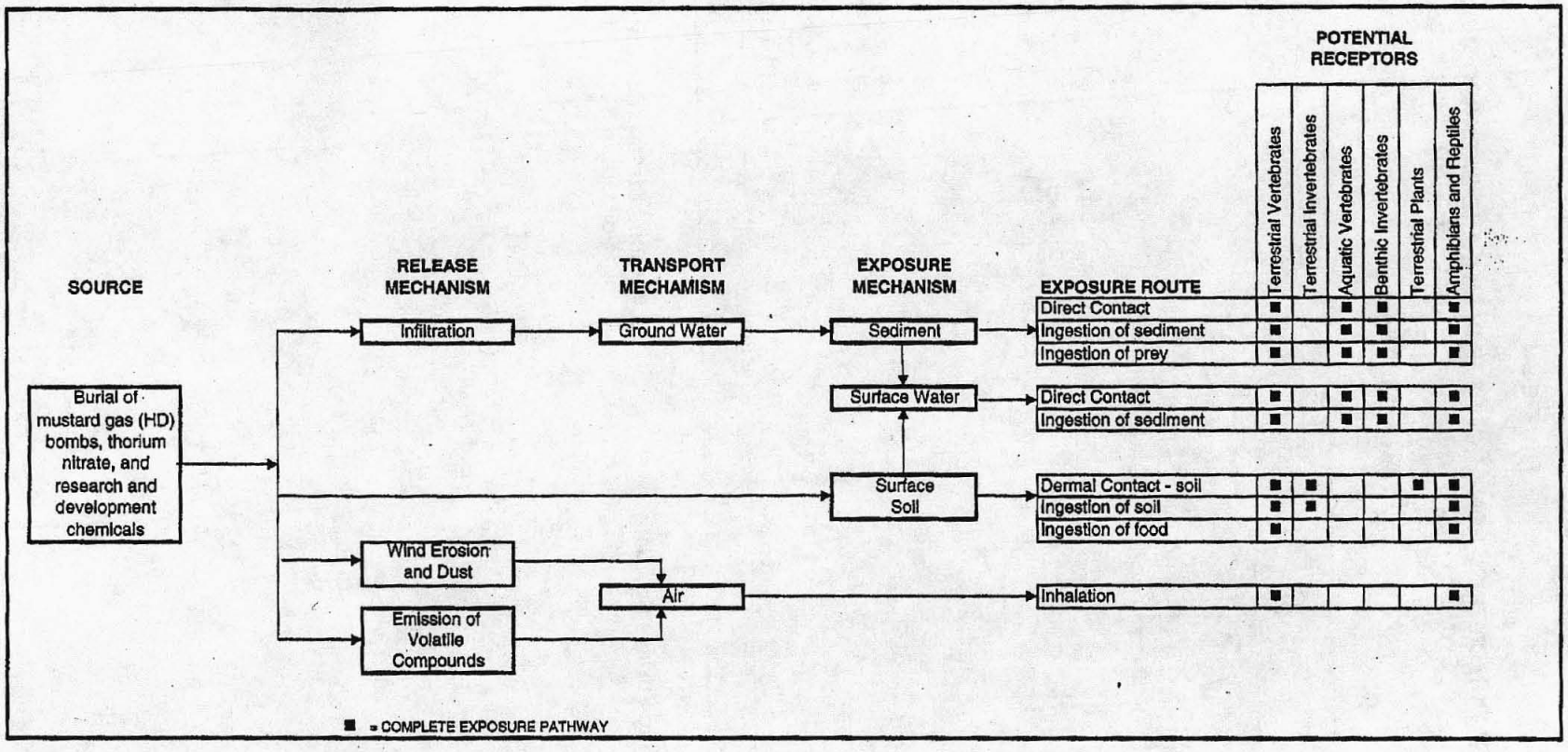
P:\GIS\NSWC_CRANE\APR\INDIANA_BATS.APR LOCATION OF INDIANA BATS 6/3/03 JAL



DRAWN BY J. LAMEY	DATE 6/2/03	LOCATION OF INDIANA BATS CAPTURED AT NSWC CRANE DURING 18 MAY - 11 JULY 1998 SWMU 01 - MUSTARD GAS BURIAL GROUND NAVAL SURFACE WARFARE CENTER CRANE CRANE, INDIANA	CONTRACT NUMBER 3959
CHECKED BY J. GOERDT	DATE 6/2/03		APPROVED BY T. JOHNSTON — DATE 6/2/03
REVISED BY —	DATE —		APPROVED BY — — DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 8-2 — REV 0

FIGURE 8-3

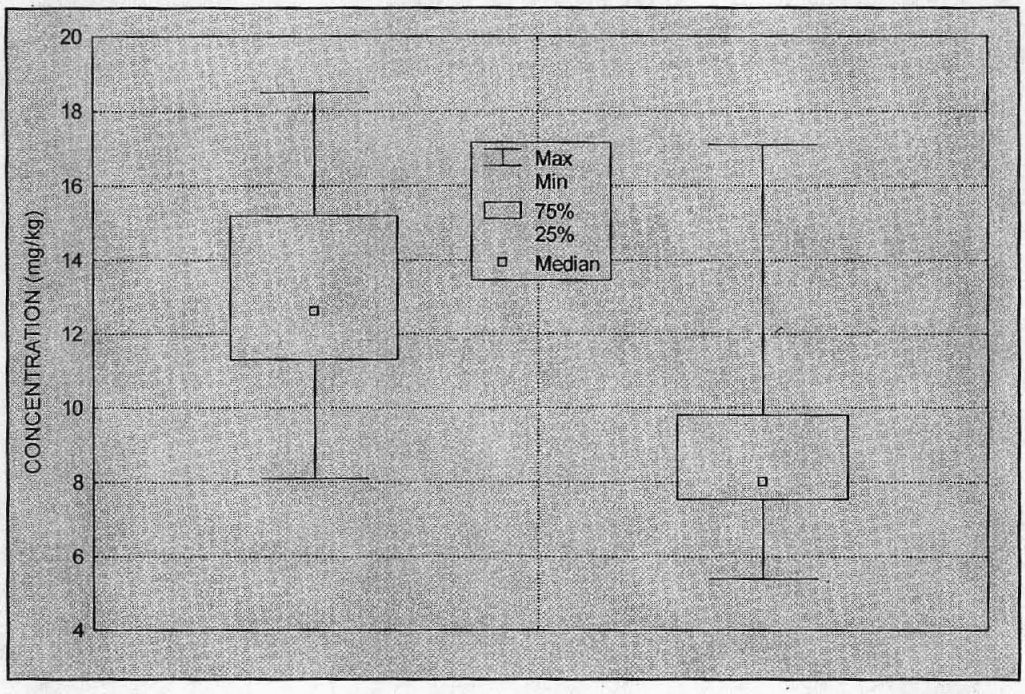
ECOLOGICAL CONCEPTUAL SITE MODEL
SWMU 01 - MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA



Blank space indicates incomplete exposure pathway or relatively insignificant or not applicable potential exposure.

FIGURE 8-4

CONCENTRATION DISTRIBUTION OF COPPER IN SITE AND BACKGROUND DATA
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA

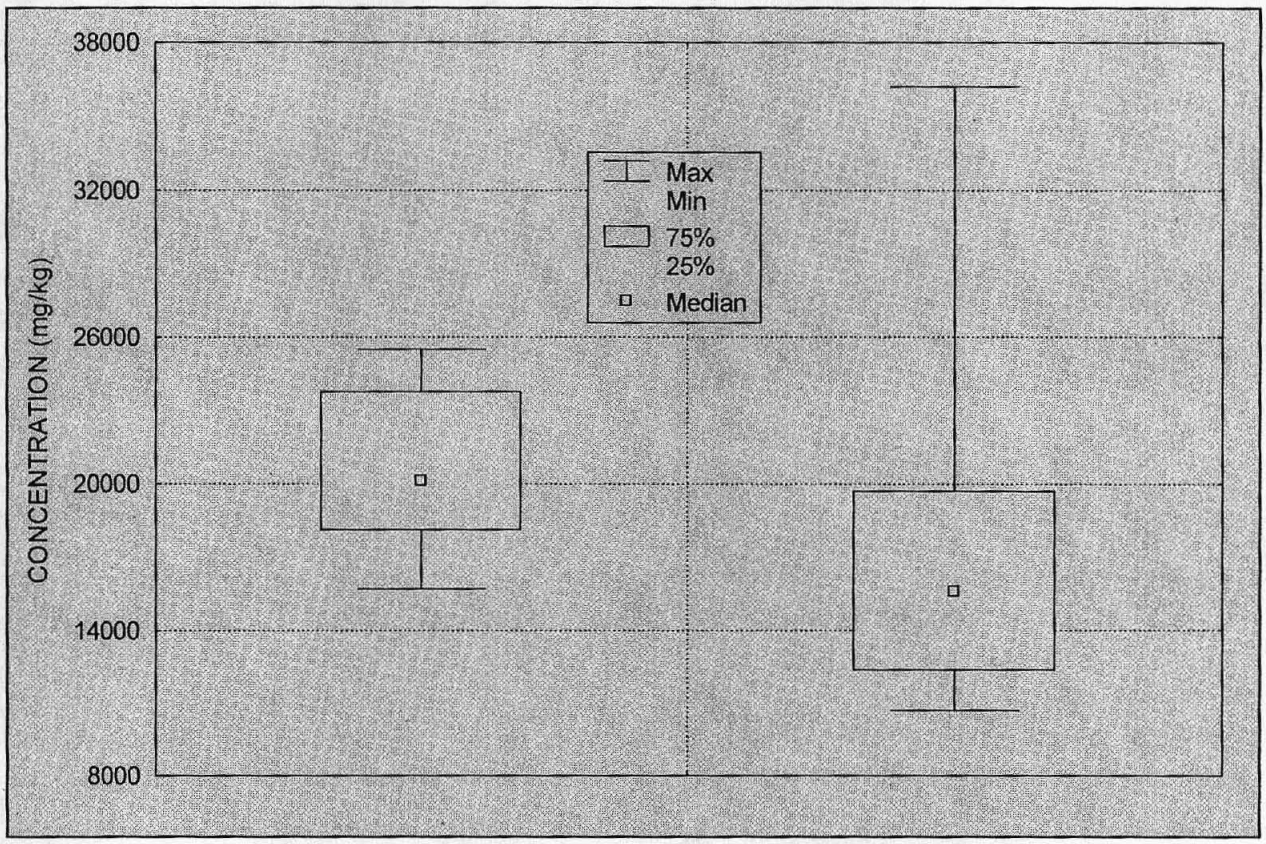


Site Surface Soil Data

Background Surface Soil Data
Soil Group 3

FIGURE 8-5

CONCENTRATION DISTRIBUTION OF IRON IN SITE AND BACKGROUND DATA
SWMU 01 – MUSTARD GAS BURIAL GROUND
NSWC CRANE
CRANE, INDIANA



Site Surface Soil Data

Background Surface Soil Data
Soil Group 3

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

A summary of medium-specific COPCs is presented in Table 4-17. These chemicals were the focus for evaluating the extent of contamination, the fate and transport of contaminants, and risk to humans and ecological receptors, although additional detected chemicals were discussed, when necessary. Mustard gas was not detected in any media. Radioactive thorium, which was also reported to have been buried at the MGBG was detected at concentrations indicative of background levels. Several COPCs did not appear to be site-related contaminants but those chemicals were conservatively retained as COPCs for evaluation in the risk assessments and contributed insignificantly to the risks (Sections 5.0 through 8.0).

The primary MGBG contaminants are VOCs in ground water. Those contaminants appear to be confined to bedrock, which is overlain by unsaturated overburden ranging in thickness from about 5 to 30 feet in the area of the MGBG and the associated ground water monitoring well field. Most bedrock depths were within 10 feet of ground surface at the MGBG. Historical and more recent ground water VOC concentrations have been in the tens and hundreds of thousands of µg/L in some wells. These concentrations are great enough to suggest a possible presence of DNAPLs, especially historically, however no direct evidence for the existence of DNAPLs has been observed. DNAPLs that might be present are expected to have been released directly to bedrock or to have migrated from soil to bedrock.

Contaminants are well bounded in all media with few exceptions. The exceptions, described in Section 5.0, were isolated locations in soil and sediment, and the western edge of the shallow ground water VOC plume. Although VOC concentrations at the western edge of the site are not less than detection limits, further investigation to better define the extent of VOC contamination is not expected to change the selection of a corrective action, nor would it aid in defining the risks to humans or ecological receptors. VOC concentrations show a consistent decreasing trend from the plume source area to the plume perimeter in all directions. Most perimeter concentrations are less than detection limits and MCLs. The VOCs in ground water are not anticipated to contaminate any surface water bodies because the ground water flows in the direction of intermittent drainage channels, which are normally dry. Ground water VOCs have moved approximately 800 feet in 20 years or more. The average overall migration rate is less than 40 feet per year. No evidence has been obtained to suggest that ground water VOCs are continuing to migrate at an appreciable rate, however continued monitoring (e.g., as part of a CMS) may be warranted to verify future contaminant concentrations. An overall decrease in VOC concentrations has been observed since the 1980s. Large variations in the measured concentrations of VOCs in the interior

of the ground water VOC plume have also been observed. These variations make the estimation of concentration trends difficult, but there is little doubt that VOC concentrations are decreasing over time. No mechanism has been ascribed to the observed concentration decreases, although evidence of natural chemical degradation (natural attenuation) has been detected (Section 6.0).

The data in Table 7-10 show that the reasonable maximum and central tendency exposure ILCRs for the future adult and child resident were estimated to exceed the range of 10^{-6} to 10^{-4} established by the U.S. EPA as acceptable. The values ranged from 4.9E-13 for the maintenance worker who would have limited exposure to site contaminants to 4.5E-02 for future adult resident. Non-carcinogenic reasonable maximum and central tendency exposure hazard estimates for the construction worker, the future child resident, and the future adult resident for the ground water exposure pathway were greater than unity for the MGBG. The values ranged from 2.0E-03 for the maintenance worker to 2.8E+03 for future child resident. Therefore, the risk is unacceptable to humans. The only environmental medium contributing significantly to these estimates is ground water. The chemicals that contribute the greatest risk in that medium are VOCs, especially chlorinated VOCs. Trichloroethene and 1,1,2,2-tetrachloroethane were the most frequently detected VOCs with the greatest concentrations.

The SERA of an array of representative sensitive species, revealed that risks to terrestrial plants and invertebrates from organic and inorganic chemicals in the surface soil in the MGBG were estimated to be low to negligible. Risks to aquatic receptors from organic and inorganic chemicals in surface water and sediments were estimated to be low to negligible. No significant aquatic habitat exists in drainage channels associated with the MGBG. Risks to birds and mammals from organic and inorganic chemicals in surface soil sediments were estimated to be low to negligible.

9.2 RECOMMENDATIONS

The recommended course of action is to enter a CMS to evaluate potential corrective actions for the ground water VOC contamination. As part of a CMS, consideration should be given to additional monitoring to verify that the VOC plume is stable with regard to location and size. Because the plume appears to be static or even shrinking, monitoring could be infrequent. Concentrations, while expected to continue to decrease, are not expected to change rapidly over the next five years. A round of samples collected at the beginning of the CMS for VOC and natural attenuation parameter analyses is recommended. The large concentration fluctuations in the plume interior have no effect on estimating the ground water VOC contamination boundaries.

The array of possible corrective measures is expected to be limited. Low hydraulic conductivities observed at the site are expected to limit the utility of active remedies that require the pumping of liquids into, or out of, bedrock. Corrective actions are expected to focus on the most concentrated portion of the VOC plume, which is located at, or near to, the PBA.

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